

Wild Harvesting and Management of Some Medicinal Plants in the Natural Forest of Central India

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ABSTRACT

The overexploitation of herbal resources in unscientific manner by unskilled labor and poor natural regeneration has resulted in a virtual extinction of certain vital species of herbal flora. Present study shows that out of four selected species, the present position of *Chlorophytum tuberosum* (Safed musli) and *Celastrus paniculatus* (Malkangni) in the natural forest areas is very alarming in terms of less plant density, poor regeneration and low tuber/seed yield per hectare. Both the species found under critically endangered category in the natural forests of Bhopal and Mandla (East) Forest Divisions in the state of Madhya Pradesh. The condition of selected plants is critical in Bhopal forest division due to various factors like- human interference, cattle pressure, over harvesting and market demand etc. On the other hand, Mandla (East) is a Tribal dominated area, far from big market, traders etc. The other reasons of immature harvesting found in the study area are- competition for early collection among locals, unscientific method of tuber, fruit harvesting, middleman exploitation etc. Paper discusses various causes of population decline and present harvesting practices adopted by the local gatherers.

Key Words: Harvesting, Regeneration, Density, Tubers, *Baichandi*, *Musli*

INTRODUCTION

In the absence of scientific system of collection and fostering regeneration of such plants, several species have been completely lost or have become endangered and / or on the verge of extinction with varying degrees (Mishra and Kotwal, 2009a). This is serious genetic erosion and causing loss of biodiversity of resource areas. Researches in herbs and medicinal plants have focused on their biologically active compounds and evaluating their remedial properties, but little attention has been paid to the sustainable management of these plants in Madhya Pradesh (Mishra, 2009b). The cases where reproductive organs (fruit, flower seeds) or the vegetative organs (root, rhizome) are used, the species are much more endangered in comparison to a species from which only leaves have been collected. This may be exemplified in case of *Dioscoreas* which is a source of steroids (Marker et al., 1943) and whose tubers have been over exploited. In Patalkot (Chindwara district) species like *Gymnema sylvestre*, *Curcuma* spp., *Gloriosa superba*, *Hemidesmus indicus*, *Tylophora indica* etc. are reported to be endangered (Prasad et al., 1990; Acharya, 2006). Ecological status of selected NTFPs in Madhya Pradesh was assessed through a CAMP (Conservation Assessment and Management Plan) workshop held in 1998 at Indian Institute of forest Management, Bhopal. The assessment was based on IUCN categories of 1994. Out of 40 species assessed from the state of M.P which

consists of 60% of total recorded NTFP wealth of the country, 2 species were found to be critically endangered; 9 species were found endangered; 14 species found vulnerable; 9 species with lower risk least concern (Prasad and Patnaik, 1998). They also reported that some of most important medicinal plants (*Curcuma caesia* and *Rauvolfia serpentina*) have already disappeared from many natural forest areas on Madhya Pradesh. In the forests of Madhya Pradesh Sargandha, Aonla, Chironji, Safed musli were common in the past but due to unsustainable harvests and over exploitation problems they gradually decreased in the natural forests. These species are also being collected for being used in the preparation of Ayurvedic tonic and medicines (Prasad et al. 2002).

Mishra (2000), and Prasad et al., (2001) has done detailed study on the status, distribution, harvesting practices and existing market channel of few medicinal plants i.e. *E. officinalis* (Aonla), *C. borivilianum* (Safed musli), *C. caesia* (Kali haldi), *R. serpentina* (Sargandha) in undivided Madhya Pradesh state. They found that present harvesting practices of these species in the natural forests of Madhya Pradesh is very deteriorating because of high price of product in the market and immature harvest by the local tribals. They also observed that these species occurring commonly in the state are vanishing speedily because of immature harvesting and

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poor regeneration. Bisen *et al.*, (2000), Mishra, (2010) also found that due to overexploitation several valuable medicinal plants are becoming rare in their natural habitat. They reported few medicinal plant species under threatened category. Later on Mishra (2011), also found that besides over harvesting (unscientific collection of underground part of medicinal use), several other regions of threats are – habitat destruction, over grazing, deforestation and fire.

MATERIALS AND METHODS

Study Sites

Bhopal Forest Division: Bhopal lies in the heart of the state of Madhya Pradesh. Bhopal city forms the capital of the state. It occupies an area of 2772.40 sq km. Bhopal is a hilly area, located on the Malwa plateau, has an area of 284.9 sq. km and the land rises towards the Vindhya Range to the south. The altitude of this city is 523 meters above sea level. The average annual rainfall is reported to be about 919 mm. The recent meteorological records reveal that the temperature in summer (March to June) varies from the lowest minimum of 14⁰ c to the highest maximum of 44.4⁰ in April - June being the hottest period. Winter (December to February) from 4.1⁰c during December to 3.6⁰c during the month of February, usually January being the coldest month. Bhopal is endowed with rich and diverse forest resources and it is a reservoir of biodiversity. There are many important Non Timber forest Products (NTFP) found in the forests of Bhopal forest division i.e. Tendu leaves (*Diospyros melonoxylon*), Harra (*Terminalia chebula*), Gum, Chironji (*Buchanania lanzan*), flower and seeds of Mahua (*Madhuca indica*) and flowers, seeds, bark & roots of various plant species.

Selected forest ranges: Berasia: Berasia forest range is situated about 45 km from Bhopal. The total area of range is 28389.09 ha with 64.93 % forest area. Berasia Forest is one of the best forest areas of Bhopal division and possesses a variety of rare and critically endangered plants like *Dioscorea pentaphylla*, *D. deltoidea*, *D. oppositifolia*, *Curcuma angustifolia*, *Boerhaavia diffusa* Linn., *Plumbago zeylanica*, *Gardenia gummifera*, *Helicteres isora*., *Woodfordia fruticosa*, *Nyctanthes arbor-tristis*, *Semecarpus anacardium* etc.

Samardha: Samardha forest range mostly covered the around the forest of Bhopal city. The total area of range is 15330.22 ha with 35.07% forest area. Several medicinal plants were found in this forest range and largely collected by the local peoples.

Mandla (East) Forest Division: Mandla district is located in the east-central part of the Madhya Pradesh. It lies between the latitude 22° 2' and 23° 22' north and longitude 80° 18' and 81° 50' east. The head quarter of east Mandla forest division is located in the Mandla town (district H.Q.). All the forest area fall under division comes under Bicchiya tehsil which constitute of Bicchiya, Mohgaon, Mawai and Gughari development blocks. Mandla is situated 96 km away from Jabalpur by road on Jabalpur – Raipur national highway. The division boundaries connected with Dindori forest division in north side, Rajnada and Dindori in East Side, Kanha National Park in south side. May is the hottest month with the mean daily minimum temperature at 41.30 °C and the mean daily maximum at 24⁰C. On individual days during the summer season the day temperature may go above 44⁰C. Tribals of the district especially Gonds and Baigas, use a variety of tubers, leaves, flowers and fruits derived from the forest. The area is rich in medicinal plant varieties which is the main provision of medicine for the local villagers.

Selected forest ranges: Mawai: This forest range is situated about 45 km from Mandla. The total area of range is 27749.70 ha with 21.13 % forest area. Mixed forest of this range provides vast number of Non Timber Forest Produce (NTFP) that support tribal livelihood. Some critically endangered species found in this forest range are: *Curcuma caesia*, *C. borivilianum*, *Dioscorea bulbifera*, *Tylophora indica* etc.

Bicchiya: This forest range is small in size and near to the forest of Mandla district. The total area of range is 12343.00 hectare with 9.40% forest area. This range has a good variety of trees including Teak(*Tectona grandis*), Palas (*Butea frondosa*), Harra/Myrabolam (*Terminalia chebula*), Mahua (*Madhuca latifolia*), Achar (*Buchanania lanzan*).

Motinala: This forest range is big in size and near to the Kanha national park. The total area of range is 30332.10 hectare with 23.10% forest area. Within this area 18 species of threatened flowering plants have been recorded. There is a steady decline in the existence of the tree species i.e. *Sterculia urens*, *T. arjuna*, *Acacia catechu*, *Pterocarpus marsupium*, *Boswellia serrata* etc., besides several other medicinal and aromatic plants.

Data Collection

The study incorporated both primary and secondary data. The primary data was collected through various field surveys and the secondary data was sourced from forest department records, village Panchayat record, local Ayurvedic practitioners, IIFM library, Internet etc. The

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field-based study was carried out in two selected districts viz. Bhopal and Mandla (East) in Madhya Pradesh State. Total 25 villages, 5 villages in each of 5 ranges i.e. two in Bhopal and 3 in Mandla district were selected for the study. The study closely examined present harvesting practices, ecological and socio-economic status etc. of selected medicinal plants- *Chlorophytum tuberosum* (Safed Musli), *Celastrus paniculata* (Malkangni), *Curculigo orchoides* (Kali musli), *Dioscorea bulbifera* (Baichandi).

Table 1. Details of the two selected study sites.

Sampling unit	Numbers
Districts	2
Forest Ranges	5
Number of villages at each Range	5
Total Villages	25
Respondent	15%

The field investigations and forest survey was conducted during February 2008 to March 2010, with the assistance from local people and forest department officials. Random sampling employed for collection of data and 15 per cent households were surveyed from each selected village. The data on seasonal and monthly availability of medicinal plants were collected by interaction with local people with the help of structured schedule.

Density Enumeration

The five sample plots (transects) were laid randomly in each forest compartment (selected forest ranges). The size of sample plots (transect) was 50m. X 5 m. The individuals of selected species in each quadrat were recorded and analyze (Misra, 1968). The data work out the density (number /ha) of selected medicinal plants. Qualitative and quantitative data species were also recorded.

Regeneration Assessment

Seedlings of the selected species were recorded within each of transect at each selected site. The seedlings of selected medicinal plants were recorded (within the transect plots) during September to December.

Harvesting Period and Mode

The time of harvesting varies from species to species and place to place. Generally primary collectors collect plant parts before maturation. Hence the team visited the study area repeatedly to know the current harvesting period of selected medicinal plants. Harvesting period (time), days, months, collection time were also recorded during field

visits. Primary collector went to the forest for collection of medicinal plants (parts or whole plants) with conventional harvesting tools. The information on plant/parts harvesting methods adopted by the local villagers/ gatherers was collected by interviewing local people engaged in collection.

Per Plant Yield of Tuber/Seed

Quadrat method of quantitative estimation was followed. After ripening of the fruits, tubers etc. quadrates of 5m x 5 m size were laid and numbers of plants were recorded. Seeds, tuber etc. were also collected from individual plants and converted into per plant yield by multiplying density of species multiply by per plant weight on per hectare basis.

Formula: Plant density X plant weight÷ total area (Ha.)= per plant yield/Ha. .

Causes of Population Decline

Data for causes of population decline was collected from different sources like forest department personals, local people, NTFP collectors, herbal practitioners etc. regarding previous/earlier years (last decade) conditions of the selected plants, over harvesting from natural forests, biotic and abiotic factors etc.

RESULTS

Table 2 shows plant density per hectare, production and per plant yield of wet *C. tuberosum* tubers per hectare in the two selected forest divisions. The plant density (no. per hectare) was more in the natural forests of Mandla East (Avg.9.33/Ha.) while less in Bhopal (Avg.7/Ha.) division. However, maximum density of *C. tuberosum* was found in the natural forests of Mawai range (12/Ha.) of Mandla E. forest division while minimum in Samardha range (06/ha.) of Bhopal division. On the other hand, poor regeneration was observed in both the divisions (<1.00/ha and 1.33/Ha.), respectively.

Similarly, per plant tuber yield (wet) was observed more (Avg.18.33 gms/plant) than those collected from Bhopal forest division (Avg.16.60 gms/plant). As a result, the wet yield per hectare (estimated) was observed also more in the plants collected from Mandla E. (Avg.171.02kg/Ha.) whereas less in Bhopal (Avg.116.2 kg/Ha.) forest division.

The data depicted in the Table-3 shows plant density, plant yield and estimated production of wet tubers of *D. bulbifera* in the selected ranges of Bhopal and Mandla E.divisions. The plant density was found more in the natural forests of Mandla East (62.66/ha.), whereas less

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in Bhopal (46.00/ha.) division. However, maximum density of *D. bulbifera* was found in the Mawai range (345/Ha.) of Mandla E. while minimum in Samardha range (42/ha.) of Bhopal forest division. The wet tuber yield per plant is higher (279 kg/plant) in Mandla E. than those collected from Bhopal forest division (156.5 gms/plant). As a result, production (wet yield) per hectare was also more (17.48 kg/ha.) in the Mandla E., while less (7.19 kg/Ha.) in Bhopal forest division. Very poor regeneration was observed in both the forest divisions (1.50/ha and 2.66/Ha.), correspondingly. The data presented in Table 4 reveals plant density of *C. paniculatus* was considerably higher in the natural forests

of Mandla E.(62.66/ha.) division than Bhopal (26.00/ha.) division. The maximum plant density was found in the Motinala range (72/ha.) of Mandla E. while minimum in Samardha range (56/ha.) of Bhopal forest division. Fewer differences were observed in case of wet yield per plant (1.82 & 1.34 kg/ha.) in both the forest divisions, respectively. Maximum *C. paniculatus* seed yield per hectare was recorded in the natural forests of Mandla E. (80.85/ha.) while very less in Bhopal forest division (47.32 kg/ ha.). In Motinala range of Mandla E., the production per hectare of Malkangni seeds was recorded exceptionally higher (108kg/ha.) whereas least in Berasia range of Bhopal forest division (34.72 kg./ha.).

Table 2. Various ecological observations, yield of Safed musli tubers in the study area.

Forest Divisions	Selected Forest ranges	Plant Density No./Ha.	Regeneration No./Ha.	Per plant tuber yield (in gram)	Yield of wet tubers/ha. (in kg.)
Bhopal Forest Division	Berasia	10.00 (± 0.28)	<1.00 (± 0.11)	16.40 (± 0.08)	164.00 (± 0.13)
	Samardha	04.00 (± 0.19)	Nil	16.80 (± 0.25)	67.20 (± 0.32)
	Average	7.00		16.60	116.20
Mandla East Forest Division	Mawai	12.00 (± 0.49)	2.00 (± 0.21)	20.00 (± 0.28)	240.00 (± 0.58)
	Bichhiya	06.00 (± 0.22)	<1.00 (± 0.07)	16.60 (± 0.10)	99.60 (± 0.28)
	Motinala	10.00 (± 0.36)	1.00 (± 0.05)	18.40 (± 0.24)	184.00 (± 0.19)
	Average	09.33	1.33	18.33	171.02

Table 3. Plant Density, yield and production of Baichandi tubers (wet) in the study area.

Forest Divisions	Selected Forest ranges	Plant Density No./ha	Regeneration No./ha.	Per plant tuber yield (in gram)	Yield of wet tubers/ha. (in kg.)
Bhopal Forest Division	Berasia	50.00 (± 0.34)	2.00 (± 0.12)	185.00 (± 0.41)	9.25 (± 0.15)
	Samardha	42.00 (± 0.23)	1.00 (± 0.08)	128.00 (± 0.11)	5.37 (± 0.36)
	Average	46.00	1.50	156.50	7.19
Mandla East Forest Division	Mawai	88.00 (± 0.17)	4.00 (± 0.09)	345.00 (± 0.29)	30.36 (± 0.65)
	Bichhiya	48.00 (± 0.43)	3.00 (± 0.22)	222.00 (± 0.13)	10.65 (± 0.33)
	Motinala	52.00 (± 0.10)	1.00 (± 0.08)	270.00 (± 0.32)	14.04 (± 0.56)
	Average	62.66	2.66	279.00	17.48

Table 4. Plant Density, yield and production of Malkangni seeds in the study area

Forest Divisions	Selected Forest range	Plant Density no/ha	Regeneration No./Ha.	Per plant seed yield (in kg.)	Yield of Seeds/ha. (in kg)
Bhopal Forest Division	Berasia	28.00	2.00	1.24	34.72
		(± 0.17)	(± 0.02)	(± 0.09)	(± 0.31)
	Samardha	24.00	<1.00	2.40	57.60
		(± 0.10)	(± 0.06)	(± 0.03)	(± 0.19)
	Average	26.00	1.50	1.82	47.32
Mandla East Forest Division	Mawai	60.00	1.00	1.36	69.60
		(± 0.33)	(± 0.08)	(± 0.11)	(± 0.10)
	Bichhiya	56.00	3.00	1.16	64.96
		(± 0.14)	(± 0.05)	(± 0.13)	(± 0.30)
	Motinala	72.00	1.00	1.50	108.00
		(± 0.11)	(± 0.07)	(± 0.08)	(± 0.22)
	Average	62.66	1.66	1.34	80.85

Table 5. Plant Density, yield and production of Kali musli tubers in the study area

Forest Divisions	Selected Forest range	Plant Density no/ha	Regeneration No./Ha.	Per plant tuber yield (in gram)	Yield of wet tubers/ha. (in kg)
Bhopal Forest Division	Berasia	94.00	21.00	10	0.940
		(± 0.15)	(± 0.13)	(± 0.41)	(± 0.37)
	Samardha	86.00	16.00	07.00	0.600
		(± 0.38)	(± 0.22)	(± 0.11)	(± 0.12)
	Average	90.00	18.50	8.50	0.760
Mandla East Forest Division	Mawai	109.00	14.00	13.00	1.417
		(± 0.19)	(± 0.11)	(± 0.30)	(± 0.26)
	Bichhiya	81.00	13.00	15.00	1.215
		(± 0.18)	(± 0.22)	(± 0.13)	(± 0.28)
	Motinala	100.00	21.00	16.00	1.600
		(± 0.33)	(± 0.40)	(± 0.17)	(± 0.44)
	Average	96.66	16.00	14.66	1.417

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Not much significant difference was observed in the plant density of *C. orchiodes* tubers collected from Bhopal (Avg.90/Ha.) and Mandla E. forest divisions (Avg.96.66/Ha.), respectively (Table-5). However, regeneration was found slightly higher in Bhopal (Avg.18.50/ha.) than Mandla E. forest division (Avg.16/Ha.). On the contrary, per plant yield was more (Avg.14.66 gm) while less yield was recorded from Mandla (E.) forest divisions. Consequently, per hectare yield of seeds was found also more in Mandla (Avg.1.417 Kg./Ha.), while less in Bhopal (Avg.0.760 Kg./Ha.)

DISCUSSION

Selected plants *C. tuberosum* (Safed musli), *C. paniculatus* (Malkangni) and *D. bulbifera* (Baichandi) occurs in special habitat conditions in the studied area covering two districts. Presence of one or two species in all the areas indicates suitability of site as well as geo-climatic conditions and moisture availability in the region that are suitable to the species. The plant density of selected species are very deficient in the natural forest areas of Bhopal and Mandla E. which are otherwise known for good medicinal plant bearing forests of Central India. The selected plants are also getting depleted in the natural forests because of immature collection, uprooting of whole plant, by the people involved in the plant collection. The current harvesting practices of premature plant (seeds, rhizome, tuber) collection by uprooting whole plant in case of *C. tuberosum* and *D. bulbifera* and felling, lopping of branches of Malkangni climber to collect fruits/seeds in the natural forests was found to be unsustainable. Forest floor has no chance of receiving mature and viable seeds due to immature plant collection. This appears to support poor quality as well as quantity of selected species in both the forest divisions.

Mishra (2000), Prasad et. al. (2001) and Mishra & Kotwal (2011) studied phenology, harvesting practices and marketing of critically endangered species *Curcuma caesia*, *Rauwolfia serpentina*, *Dioscorea spp.* and *C. borivilianum* in the natural forests of central India. It was reported that the harvesting practices of all the species were quite unsustainable and deteriorating because of high price of product in the national and international markets. Immature tuber collection, over harvesting, low density & poor regeneration, competition among collectors are the main reasons of population decline. Besides this, various biotic interferences like fires, cattle pressure, soil compaction, habitat loss are also affecting

the density and regeneration of these endangered species in the natural forests of central India. Later on Mishra (2007) and Mishra and Kotwal, (2009) reported less density and tuber yield of *D. daemona*, *C. tuberosum* and *C. paniculatus* in the natural forests of Madhya Pradesh due to different reasons i.e. unhealthy competition among collectors to collect more and more tubers as soon as possible, immature harvesting damaging the mother plants, collection of tubers before flowering and fruiting etc. It was further suggested that 1/3 of the total useful material should be left in situ for ecosystem consumption, growth and regeneration of mother plant as well as health and vitality of ecosystem.

Causes of population decline of selected medicinal plants in Bhopal & Mandla E. Forest Divisions:

C. tuberosum (Safed musli): Due to heavy market demand of different useful parts (seeds, tubers) of this valuable medicinal plant, their availability is continuously decreasing at a faster rate from the natural forests. During the interactions with the villagers/local people, it was noted that earlier the plant was abundant in the adjoining natural forests of both the division. But now, due to its over harvesting from the natural forests during the last decade, the species is going to be vanished in the near future from both the Forest Divisions. The survey conducted revealed that due to its unique medicinal properties, its demand is increasing very fast in Indian and international market. This increasing demand has created an exploitation pressure in the natural forests of Bhopal and Mandla (E.) forest divisions. The competition for early collection among the locals living around the natural forests of Bhopal was observed more intense. In the natural forest *C. tuberosum* is regenerated through tubers. Once the roots are harvested, the whole plants die and reseedling never occurs at that place. The local traders operative in the area are also forcibly exploit this valuable medicinal species in the study area. Due to commercial exploitation, the availability of the species is decreasing and obnoxious weeds like *Parthenium* and *Lantana camara* are taking its place.

C. paniculatus (Malkangni): This is an important species in terms of medicinal properties present in the seeds of this woody climber. During the discussion with the local health practitioners and villagers of both the divisions, it was found that earlier the climber density was high in the adjoining natural forest of both the division. In former years there were no large-scale collection and market demand of this species. But during the last decade due to unsustainable harvesting and felling of the large climbers the plant density decreased considerably. The market demand of seed oil suddenly increased manifold due its

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diverse medicinal properties and uses. Besides villagers use indigenous techniques of seed oil extraction which is very time consuming, crude, laborious and not used commonly and largely by common peoples. Due to felling of large climbers, the natural forests of Bhopal division are devoid of this plant and hence, at present no local market is available for the sale and purchase of its seeds.

D. bulbifera (Baichandi): During the interaction with the local villagers it was noted that in past, the density of this species was very high in Bhopal forest division. Earlier, the local collectors largely collect its tubers for domestic (edible) purposes in both the divisions. This plant is a major source of income to the local tribal peoples living around the forests of both the divisions. Now owing to unsustainable harvesting for edible and medicinal purposes, the population declined considerably. The yield and quantity also declined in recent year due to various ecological causes like, habitat destruction, poor availability, less regeneration and growth, frequent forest fires, droughts etc. The competition for early collection among the locals living around the forests was more intense, particularly in Bhopal forest division. Decreasing availability of plant in the natural forests forced collectors to move deep in the forest in search of plant and take more pain, time while uprooting its tubers. It was also observed that the collectors were getting less price of the produce that was collected from the natural forests by painstaking, time consuming and laborious method of harvesting.

C. orchoides (Kali musli): The plant was commonly found in the natural forests of Bhopal and Mandla E. forest divisions. There is no big threat on the natural population because the natural forests are rich in Kali Musli. The local collectors hesitate to spent time to harvest its tubers from natural forests due to lesser prices and there were no purchasers in the local market also. It was also observed that harvesting of tubers is judicious and each plant contain only one tuber and digging of tuber is also difficult in the natural forest due to inaccessibility of the area. The plant is not under cultivation and collection from natural habitat is the sole source for its use as medicinal raw material. The collection of the raw material is of destructive type as the whole plant is dug up for the root. However, sometimes gatherer collects its tubers based on demand from local Vaidyas and health practitioners.

Among the four selected species, condition of *C. tuberosum* and *C. paniculatus* plants in the natural forests of Bhopal and Mandla E. Forest Divisions is very

precarious and needs immediate attention not only for conservation but also for propagation. Present study clearly shows that the position of both the selected species in the natural forest areas is very alarming in terms of less number of plants per hectare, and poor plant quantity and quality. Both the species found under critically endangered category in the natural forests of Mandla E. and Bhopal Forest divisions. The natural regeneration is also adversely affected due to immature harvesting. However, the status of *C. orchoides* shows slightly better condition in the natural forests of both the divisions. The *D. bulbifera* climber falls under vulnerable category mainly due to its edible and medicinal properties. Surprisingly, the natural population of *C. tuberosum* is decreasing at alarming rates while *C. orchoides* relatively common is abundant in both the forest divisions. It was also observed that the local collectors largely collect *D. bulbifera* tubers for domestic (edible) purposes in both the divisions. This plant is a major source of income to the villagers/tribals living adjoining to the forests. Peoples generally make *D. bulbifera* chips from its tuber after processing like cleaning, boiling etc and sell in the market. Due to the high market demand of its tuber for medicinal & domestic edible purposes, the collector's get less price of the produce that was collected from the natural forest by painstaking, time consuming and laborious method of harvesting.

On the basis of above observations the following strategies were suggested for achieving ecological and social sustainability: The period of plant collection should be after October and no collection should be permitted before this, particularly for *C. tuberosum* and *C. orchoides*. For the climbers like *C. paniculatus*, fruit should be harvested between December and January and for *D. bulbifera*, tubers be harvested in the month of April (after maturation). Atleast 50 per cent plants should be left on ground after harvesting. Felling, lopping and uprooting of climbers like *D. bulbifera* and *C. paniculatus* for collecting tubers need to be immediately stopped. Proper training of people for collecting tubers/seeds by scientific methods (like plucking of *C. paniculatus* fruits by bamboo stick after maturation) should be given to the local peoples. Processing of *D. bulbifera* tubers (mature) by peeling, chopping, frying and making chips at household level may enhance rural income.

Non destructive method of harvesting should be proposed by the forest department through local communities (VFCs, FPCs etc.). The unhealthy competition for immature plant collection within the villagers must be

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stopped for which awareness camps at village level should be organized. *Ex-situ* gene banks of the selected species need to be encouraged and germplasm bank should be developed at regional level. The efforts of certifiers to develop certification standards for wild harvested plant material (of the selected species) need to be supported as well as the approaches of industry to set up self-binding products quality standards.

ACKNOWLEDGEMENT

The authors are thankful to the Divisional Forest Officers (DFOs) and field staff of forest department of Bhopal and Mandla (East) forest divisions for providing field facilities and valuable suggestions. We are also thankful to the then Director, and Dr. R B Lal for his kind inspiration.

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