Tribal Relation to Spatio-Temporal Variation of Wild Mushrooms in Eastern Lateritic Part of India

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Research

Abstract

Mushrooms are one of the most significant biodiversity components from both an ecological and economic point of view. They are not only a good source of nutrients and medicine but also function in nutrient recycling and act as a niche for several animal resources. The eastern lateritic part of India with its distinct seasonality and undulated topography, harbors mosaic macrofungal resources on the forest floors with distinct spatio-temporal variation. Among 18 species related to tribal use, the most usable species were *Astraeus hygrometricus* (Pers.) Morgan, *Amanita vaginata* var. *alba* (De Seynes) Gillet, *Amanita banningiana* Tulloss, *Russula nigricans* Fr., *Termitomyces eurrhizus* (Berk.) R. Heim, and *Termitomyces microcarpus* (Berk. & Broome) R. Heim. Monsoon and post-monsoon periods which fall during the second half of August are found to be the optimum time for the production of 11 wild edible mushrooms. Out of the total calculated production, 47.2% of the same was noted during this time. These regions with tribal populations, especially the Santals in the forest fringes, have traditional knowledge related to mushrooms. This paper discusses the patterns of utilization in relation to spatio-temporal distribution of macrofungal diversity, fungal habitat, and traditional tribal knowledge of ecology, use, and other fungal characteristics.

Introduction

Wild edible mushrooms (WEMs) are important contributions to rural and tribal livelihoods (Christensen *et al*. 2008). For many years various macrofungal species have been used worldwide in preparing dishes with high protein and mineral content. Despite this, WEMs are seldom included in valuation of tropical forests, which has traditionally been mostly based on a financial appraisal of timber stock. Assessments have occasionally compared forest value *vis-à-vis* land conversion for agricultural or livestock production (Anderson & Ioris 1992, Dove 1983), though they mostly overlooked the importance of wild resources. WEMs are an important and major component, performing roles both in subsistence use and economic generation for forest fringe communities. These have been overlooked partly due to the lack of knowledge about the resource quantities available and suitable inventory or survey methods to initially assess resource status (Baker 2000, Wong *et al*. 2001) as the production of WEMs may vary from year to year (Cai *et al*. 2011). But more intensive and long term research (at least for three years) on production quantity available in the forests and spatio-temporal patterns of fructification, would solve this problem.

Studies from most regions of the world document widespread subsistence use of fungi and maintain a conservative estimate of 1,069 mushroom species being used as food (FAO 2004). A number of wild fungal species are known to occur in British Columbia, Canada, where

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approximately 50 species are reportedly purchased by mushroom buyers (Berch & Cocksedge 2003). Food mushrooms currently account for the largest volume and value of NTFP mushroom harvests (Ehlers *et al*. 2003). Tribes of many countries usually wake up early in the morning to look for WEMs. Mushroom hunting and gathering is considered to be an interesting, competitive, rewarding, and profitable venture especially among the women. The collected edible species are usually cooked for consumption or sold in a local market (Jonathan 2002). In Nigeria, edible mushrooms are used for medicinal purposes, and these fungi also serve as important sources of food (Oso 1977).

In India, there are a number of studies on mushroom diversity especially on Amanitaceae and Russulaceae (Bhatt *et al*. 2003, Das & Sharma 2005). Sharma *et al*. (2009) recorded 11 species of edible macrofungi from the upper hilly region of Shimla, Himachal Pradesh. In some local markets of Orissa the average selling price of WEMs was 15 rupees per kg, with prices varying summer to winter from 15–22 rupees per kg (Mahapatra & Tewari 2005). Important findings on the diversity, edibility, and nutritional property of mushrooms in eastern Himalaya were made during last decade (Acharya & Acharya 2001, Acharya *et al*. 2002, 2004, Rai *et al*. 2007).

The lateritic part of eastern India is an important region for WEMs and the related traditional tribal knowledge. Growth of mushrooms in this region is highly dependent on environmental variables like seasonality, soil type, rainfall, temperature, relative humidity, and many biological factors like forest type and mycorrhizal association (Hall *et al*. 1998). Tribal peoples—mainly Santals of forest fringe areas—are a potential source for traditional knowledge of mushrooms. Apart from the studies on biodiversity of WEMs, in depth studies on spatio-temporal patterns of mushroom production and the traditional tribal knowledge related to their collection, mode of utilization, and other cultural practices is wanting in this region. The present study deals with the ethnic knowledge in relation to availability of WEMs in the eastern lateritic part of India.

Study Area

The eastern part of India with its varied topography and climatic condition harbors various forest types associated with different ethnic groups such as the Santal, Lodha, and Dhangar. The undulated lateritic portion of this area is actually the Chotonagpur Plateau, extending from Bihar, Orissa, Chhattisgarh, and Jharkhand up to the western part of West Bengal, and is occupied in patches by tribal peoples (Figure 1). The temperature ranges from 11°C to 42.9°C with an average annual rainfall of 109 mm. Tropical climatic conditions with distinct seasonality (summer, monsoon, post-monsoon, and winter) and soil type creates various micro-climatic conditions for diverse floristic resources. The forest is dominated by plants like *Shorea robusta* Gaertn. (**sal**), *Madhuca latifolia* (Roxb.) J.F. Macbr., *Buchanania cochinchinensis* (Lour.) M.R. Almeida, *Semecarpus anacardium* L.f., *Diospyros melanoxylon* Roxb., *Phoenix acaulis* Roxb., *Ziziphus oenopolia* (L.)

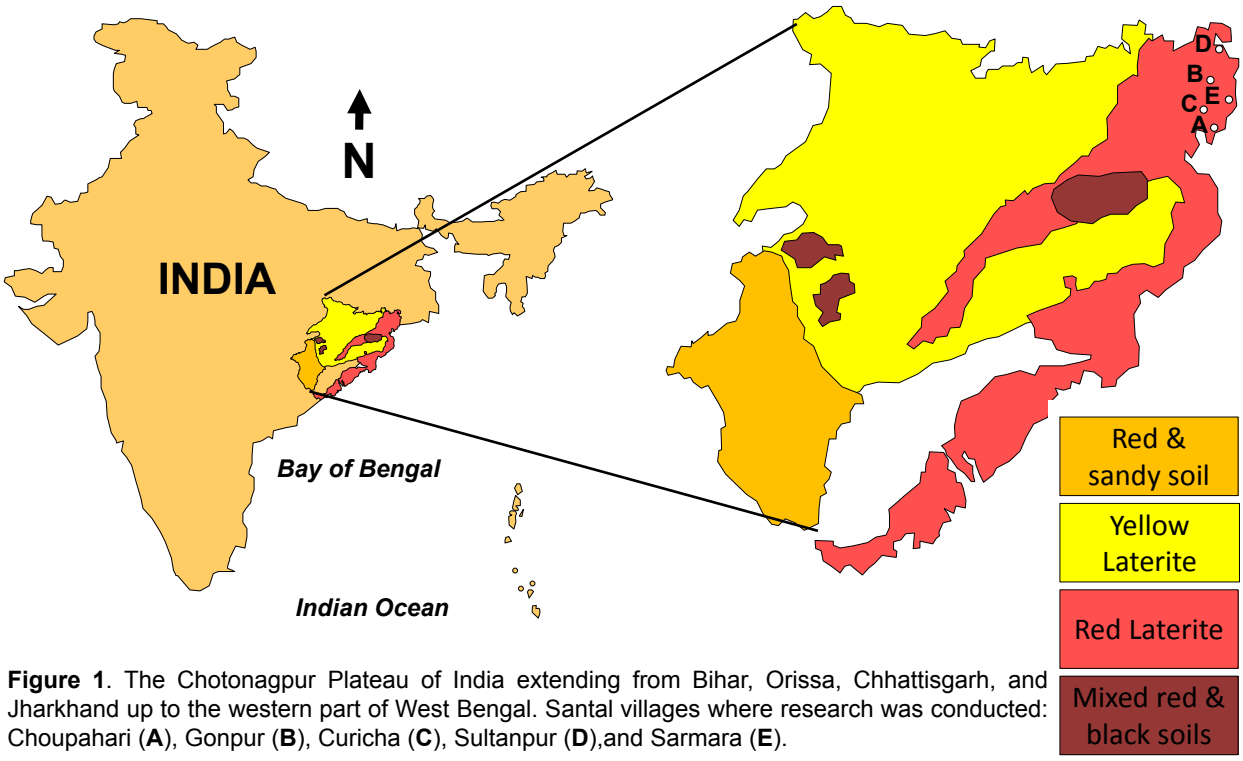

Figure 1. The Chotonagpur Plateau of India extending from Bihar, Orissa, Chhattisgarh, and Jharkhand up to the western part of West Bengal. Santal villages where research was conducted: Choupahari (**A**), Gonpur (**B**), Curicha (**C**), Sultanpur (**D**),and Sarmara (**E**).

Mill., and *Dillenia pentagyna* Roxb., admixed with several climbers and lianas. Shady moist forest beds with rich decomposed leaf litter are havens for several WEMs especially during the monsoon and post-monsoon period. Most of them grow in *Shorea* forests and a few in *Eucalyptus* forest floors. The Santal community of this area has traditions of ethnic use of different plants as well as wild edible forest mushrooms.

Methods

As most of the Santal villages are situated in the forest and its fringe areas, villages were selected for study in five general locations: Choupahari (23°38'23.63"N, 87°35'47.07"E), Gonpur (24°03'08.73"N, 87°39'21.96"E), Curicha (24°59'33.45"N, 87°29'8.12"E), Sultanpur (24°22'19.22"N, 87°03'36.36"E), and Sarmara (23°51'5.43"N, 87°28'44.33"E). Seventy-five villages including twenty-five in Choupahari, eighteen in Gonpur, sixteen in Curicha, six in Sultanpur, and nine in Sarmara were selected for the study during 2008. Information related to WEMs (local name, distribution, accessibility of use, traditional cooking process, other uses, etc.) was collected through group discussions, questionnaires, and participatory observation method. Group discussion was arranged twice (July–September, 2008 and 2009). Discussion involved 15–20 persons from each village, about 70% of which were female as they were found to be the principal mushroom collectors. Those mushrooms most used by the villagers during sprouting season were the main focus of discussion. On the basis of availability of the mushrooms as known from group discussions, a questionnaire was developed (local language translated into English in Table 1) and distributed among the villagers of each village (including 25–30 mushroom collectors). Seventy to seventy-five percent duly filled out questionnaires that were returned and used for further analyses. Participatory observations were performed during the harvesting, preservation, and cooking of the WEMs in the villages. To get information about medicinal use of wild mushrooms, personal meetings were also arranged with locally resident medicine men.

Mushrooms were collected during monsoon and post-monsoon (July to September 2009) from different parts of five forest regions allied with local tribal people. Fruit bodies were removed from their habitat with great care to avoid damage to the base of the stipe and reveal any volva, rotting base, bulb, or attachment to a sclerotium or buried substrata including cones, fruits, and other fungi. Soil was removed using a soft brush (Stojchev *et al*. 1998). The morphological characters of the macrofungi were noted (Kaya 2005, Peksen & Karaca 2003) and photographed for diagnosis (Demirel & Uzen 2002). The specimens were collected in plastic bags or boxes for further identification in the laboratory (Afyon *et al*. 2005). The specimens were wrapped in aluminum foil, and care was taken to avoid distortion of fruit bodies and to label the specimen. The habitat condition (e.g., forest type, associated plants (if any), pattern of fructification

Table 1. Questionnaire form used to collect folk information related to wild usable mushrooms in the Chotonagpur Plateau of India.

Name of the mushroom collector: Sex: Name of the village:

Sl. No.	Vernacular mushroom names	Harvesting period				Used as/ Used in			Availability			Remarks
		June	July	August	September	Edible	Medicinal	Edible & Medicinal	High	Medium	Low	
1	**Putko**											
2	**Tarmal Onth**											
3	**Sosang Tormal**											
4	**Budhi Onth**											
5	**Tumbe Onth**											
6	**Lutur Onth**											
7	**Hende Onth**											
8	**Ontai Onth**											
9	**Sim Onth**											
10	**Pitthe Onth**											
11	**Simsindhe Onth**											
12	**Murgi Onth**											
13	**Murgi Onth**											
14	**Orto Onth**											
15	**Sik Onth**											
16	**Parab Onth**											
17	**Bulung Onth**											
18	**Busub Onth**											

(solitary or troops)) of each mushroom was observed and studied in the field. The fungal taxa were identified with literature (Adhikari 2000, Bessey 1978, Hawksworth *et al*. 1983, Ramsbottom 1965, Singer 1986, Zoberi 1972) and updated using the International Index Fungorum.

To visualize the temporal trend of production of WEMs in a forest, species were harvested from randomly selected unit areas (sampling units) of five forest regions during the years 2009, 2010, and 2011 (Ludwig & Reynolds 1988). Fresh material of each of the WEMs harvested from each of the sampling units was weighed and counted separately in the field. During 2009 to 2011, 450 randomly selected 4.57 × 4.57 m quadrats were laid out in each forest (except for *Astraeus hygrometricus* (Pers) Morgan where 2.13 × 2.13 m quadrats were used due to its small size and subterranean nature) (Ludwig & Reynolds 1988). This harvest method was applied randomly in each of the forests with a 2 day interval throughout the July to September growing period (total 45 days out of 90 days of the growing period in each year). Quadrats were assessed early morning (5 am to 7 am) in the forests to reduce the chance of harvest of mushrooms from the allotted sampling spot by the local community. Density of these wild mushrooms were estimated following standard procedures (Gopikumar *et al*. 2005, Magurran 1988).

Results

People of traditional societies of the eastern lateritic part of India are knowledgeable of the biodiversity on which they depend. As soon as the monsoon comes, Santal women start collecting the species during very early morning in the forests in large bamboo baskets (**khanchi**). From every family at least one person generally enters the forest and there exists a healthy competition for collection in WEMs among the collectors of different families. Most of the Santal do not collect fruit bodies in excess of what they could consume in a day. They intentionally leave some parts of the fruit bodies at the site of collection for sustenance. More than 88 ± 4% of WEMs are directly consumed by the Santal people without flowing into local markets.

The present study revealed that there were eighteen species of wild edible and medicinal mushrooms in seven families (Table 2) traditionally used by the forest fringe Santal communities. Among them 15 species were exclusively used as food, with one species, *Pisolithus arhizus* (Scop.) Rauschert, used only medicinally, and another species, *Termitomyces clypeatus* R. Heim, used for both food and medicine. Species were found growing from July to the first week of October (monsoon and post-monsoon) with 25% of production in July, 28% in August, and 27%

Table 2. Wild edible mushroom diversity and related tribal knowledge in the Chotonagpur Plateau of India. Vernacular names (VCN). Phenology (PH) (July-7, August-8, September-9). Villages: Gonpur (GP), Choupahari (CH), Curicha (CU), Sultanpur (SU), Sarmara (SA).

Scientific name	VCN	PH	Habitat	Extent used in villages					Used as/ Used in
				GP	CH	CU	SU	SA	
Amanitaceae									
Amanita banningiana Tulloss	**Sosang Tormal**	7–9	Growing in solitary or scattered form on shady, moist **sal** forest floor with ectomycorrhizal connection with **sal**. It is uncommon and scanty in the region.	18	25	12	3	7	Can be stored under soil (maximum 3–4 days) for daily use.
Amanita vaginata (Bull.) Lam.	**Budhi Onth**	8–9	Very common on the moist floor of **sal** forest and especially growing at the base of **sal** with ectomycorrhizal association. Grows in fairy ring.	0	12	0	0	0	Boiled and fried with mustard oil, onion, and garlic.
Amanita vaginata var. *alba* (De Seynes) Gillet	**Tarmal Onth**	7–9		18	23	13	6	9	
Diplocystidiaceae									
Astraeus hygrometricus (Pers.) Morgan	**Putko**	7–9	Growing in solitary or in aggregation in the moist **sal** forest floor with ectomycorrhizal association with **sal**. Very abundant in the **sal** forest belt.	18	25	16	6	9	Can be stored under soil (maximum 3–4 days) for daily use.

Scientific name	VCN	PH	Habitat	Extent used in villages					Used as/ Used in
				GP	CH	CU	SU	SA	
Pleurotaceae									
Pleurotus ostreatus (Jacq.) P. Kumm. *sensu lato*	**Lutur Onth**	7–8	Growing in groups or solitary on the moist shady floor of **sal** forest.	4	3	5	2	1	Yellow-colored spores are used as medicine for the treatment of wounds.
Pluteaceae									
Volvaria volvacea (Bull.) Singer	**Busub Onth**	7–9	Abundant on decaying heaps of straw and other plant debris like saw dust or wood remnants during rainy season mostly in village and its adjacent areas.	10	13	9	6	7	Boiled and fried with mustard oil, onion, and garlic.
Russulaceae									
Russula sp.	**Pitthe Onth**	7–9	Growing in solitary or scattered form on shady, moist **sal** forest floor. It is uncommon and scanty in the region.	2	0	0	0	0	Boiled in water; after discarding the water, cooked with spices.
Russula cyanoxantha (Schaeff.) Fr.	**Murgi Onth**	8–9		4	0	0	0	0	
Russula delica Fr.	**Ontai Onth**	7–9	Grow in group on the moist shady floor of the Sal forest having ectomycorrhizal association with **sal**. Very common.	15	25	12	5	9	
Russula emetica (Schaeff.) Pers.	**Murgi Onth**	8–9		5	7	2	2	3	
Russula nigricans Fr.	**Hende Onth**	7–9	Growing in isolated condition on the moist shady floor of the **sal** forest having ectomycorrhizal association with **sal**.	17	23	15	5	4	
Russula rosea Pers.	**Sim Onth**	7–9		15	22	9	4	5	
Russula sanguinea Fr.	**Sim-sindhe Onth**	7–9		11	14	5	3	5	
Sclerodermataceae									
Pisolithus arhizus (Scop.) Rauschert	**Tumbe Onth**	7–9	Abundant on the *Eucalyptus* and *Acacia auriculiformis* Benth. plantations. Abundant on the moist soil either exposed or associated with some prostrate herbs.	3	0	0	0	0	Yellow-colored spores are used as medicine for the treatment of wounds.

Scientific name	VCN	PH	Habitat	Extent used in villages					Used as/ Used in
				GP	CH	CU	SU	SA	
Tricholomataceae									
Termitomyces clypeatus R. Heim	**Orto Onth**	7–9	Growing on the sandy soil or on the shaded **sal** forest floor in association with the termite mound, some time also found on open space on village and road side.	14	11	8	5	7	Boiled in water and then fried with onion and mustard oil. Used as anti-helminthic. Paste of fruit body applied externally to treat chicken pox by the Santals of Gonpur forest fringe villages.
Termitomyces eurrhizus (Berk.) R. Heim	**Sik Onth**	9	Usually growing solitary, sometimes in association with termite nest.	18	20	12	4	6	
Termitomyces heimii Natarajan	**Parab Onth**	8–9	Frequent on the shady and moist floor of the **sal** forest.	16	25	13	5	7	
Termitomyces microcarpus (Berk. & Broome) R. Heim	**Bulung Onth**	8–9	Growing in troops on termite nest consisting laterite to sandy loam soil in the **sal** forest.	18	22	13	4	1	Boiled in water and then fried with onion and mustard oil.

in September. The most widely used species was *A. hygrometricus*, and the least used was *Russula* sp. (Table 3). The habitat preference of these mushrooms showed that most of them were growing on moist organic materials on the forest floor (Singh & Joshi 1982). Out of the four species of *Termitomyces*, only *Termitomyces microcarpus* (Berk. & Broome) R. Heim was found growing profusely on termite mounds, although others were found on the forest floor nearer to mounds. Except *P. arhizus* (abundant in *Eucalyptus* and *Acacia auriculiformis* Benth. forest) and *Volvaria volvacea* (Bull.) Singer (abundant on decaying heaps of straw and other plant debris), all species were found to grow in *S. robusta* forest floor.

Temporal variation of wild edible mushrooms

Just at the onset of the monsoon *Amanita vaginata* var. *alba* (De Seynes) Gillet started to flourish on the forest floor, and within 7–10 days, 70% of its annual production is completed. Simultaneously *A. hygrometricus*, *Russula rosea* Pers., and *P. arhizus* display enormous fructification, and within July these three species completed more than 50% of their annual production (Figure 2). From the first week of August, 11 species of WEMs were found to be in fructification. Among them *T. microcarpus* completed 100% of its production within a 10 ± 2-day stretch during mid-August. On the other hand *Termitomyces eurrhizus* (Berk.) R. Heim chose mid-September to complete 100% fructification. *Russula* sp. and *Amanita vaginata* (Bull.) Lam. also primarily emerge in the same month for 49% and 65% of annual production. Except for *Pleurotus ostreatus* (Jacq.) P. Kumm. *sensu lato*, which completed its total production during the months of July and August, all other species were found to occur in a very low and fluctuating pattern up to the first week of October (Figure 2).

Table 3. Percentage of wild usable mushroom utilization in the forest fringe villages in the Chotonagpur Plateau of India.

Scientific name	%
Astraeus hygrometricus (Pers.) Morgan	100
Amanita vaginata var. *alba* (De Seynes) Gillet	93
Russula delica Fr.	89
Termitomyces heimii Natarajan	89
Amanita banningiana Tulloss	88
Russula nigricans Fr.	86
Termitomyces eurrhizus (Berk.) R. Heim	81
Termitomyces microcarpus (Berk. & Broom) Heim	78
Russula rosea Pers.	74

Scientific name	%
Termitomyces clypeatus R.Heim	61
Volvaria volvacea (Bull.) Singer	61
Russula sanguinea Fr.	51
Russula emetica (Schaeff.) Fr.	26
Pleurotus ostreatus (Jacq.) P. Kumm. *sensu lato*	20
Amanita vaginata (Bull.) Lam.	16
Russula cyanoxantha (Schaeff.) Fr.	5
Pisolithus arhizus (Scop.) Rauschert	4
Russula sp.	3

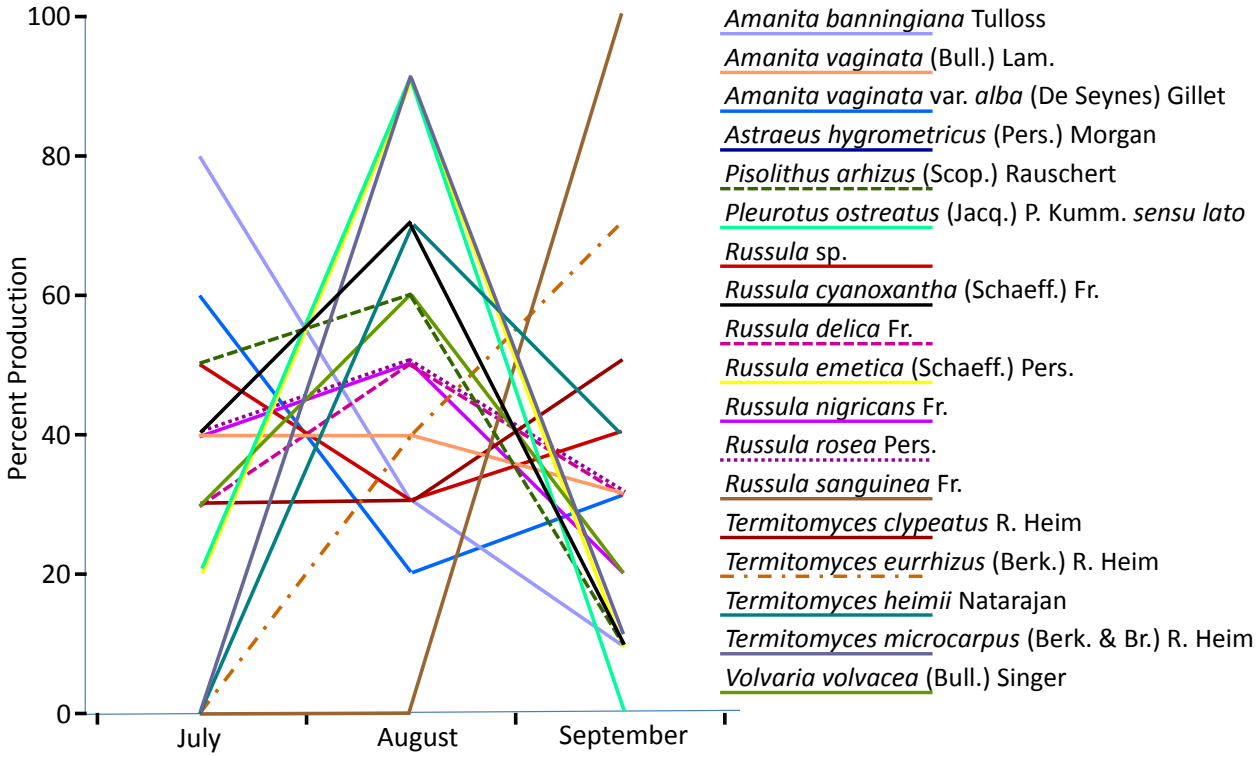

Figure 2. Annual production pattern of different wild edible mushrooms in the forests of the Chotonagpur Plateau of India.

Variation of tribal utilization in relation to spatiality of wild edible mushrooms

Astraeus hygrometricus exhibited highest density followed by *Russula nigricans* Fr. and *Russula rosea* Pers. in all the five study sites. On the other hand *Russula emetica* (Schaeff.) Pers. followed by *Termitomyces heimii* Natarajan showed minimum density throughout all of the study areas (Table 4). A single species of *Russula* was sporadic throughout the study area. It is only found to occur in a patch of Gonnpur forest near Ulpahari village (Tables 2, 4), thus the knowledge of utilization is restricted to that particular village. The same case was noted for the species of *Russula cyanoxantha* (Schaeff.) Fr. which was sporadically noted in other parts of the study area except near Ghaga village of Gonpur forest (Tables 2, 4), so the knowledge of its utilization was also confined to only some villages of that area (Table 2). On the other hand *A. vaginata* and *P. tinctorius* were found to be growing in all *Shorea* and *Eucalyptus* forests of eastern lateritic regions (Table 4), but the knowledge of utilization of the former was concentrated to some villages of Choupahari, and the latter to the Ghaga and Choughata villages of the Gonpur forest area. *Termitomyces clypeatus* was used as food by people throughout the study area, but its medicinal property is restricted to Managerpara and Ghaga villages near the Gonpur forest.

Discussion

The development of fruit bodies of *A. vaginata* var. *alba* is indicative of the starting period of rice cultivation to the Santals as they believe the rate of fructification of this species is directly proportional to heavy rainfall with thundering and lightening. They thus perform mushroom harvesting from the forest the morning following a night with heavy rainfall and thunder.

Restriction of several species of WEMs in some localities causes restriction of the knowledge of their use to those areas. As the taste of different species of mushrooms differs, Santals have their own choice in the collection of species. Selection is possible when many species are simultaneously available in the forest (e.g., during the month of August) which may be the reason of localized utilization of some of the WEMs, despite their broad distribution.

All of the species of *Russula* and *Amanita* are found to grow in the moist forest floor of *S. robusta* forests as they have ectomycorrhizal association with this species (Lee 1992, Natarajan *et al*. 2005).

Different environmental (e.g., soil type, temperature, relative humidity, rainfall) and biotic factors (e.g., microbial decomposition of leaf litter, associated plants) directly impact the fructification of different species of WEMs through regulating their micro-climatic conditions, result-

Table 4. Density of wild edible mushrooms in study site villages: Gonpur (GP), Choupahari (CH), Curicha (CU), Sultanpur (SU), Sarmara (SA) in the Chotonagpur Plateau of India.

Species	Density in the forest				
	GP	CH	CU	SU	SA
Astraeus hygrometricus (Pers.) Morgan	0.6621	0.6026	0.6028	0.5660	0.5475
Amanita banningiana Tulloss	0.0185	0.0165	0.0175	0.0141	0.0089
Amanita vaginata (Bull.) Lam.	0.0251	0.0238	0.0204	0.0047	0.0021
Amanita vaginata var. *alba* (De Seynes) Gillet	0.0204	0.0345	0.0288	0.0210	0.0246
Pisolithus arhizus (Scop.) Rauschert	0.0190	0.0281	0.0198	0.0657	0.0201
Pleurotus ostreatus (Jacq.) P. Kumm. *sensu lato*	0.0009	0.0011	0.0020	0.0020	0.0010
Russula sp.	0.0398	0	0	0	0
Russula cyanoxantha (Schaeff.) Fr.	0.0498	0	0	0	0
Russula delica Fr.	0.0452	0.0428	0.0438	0.0364	0.0352
Russula emetica Fr.	0.0001	0.0003	0.0005	0.0002	0.0003
Russula nigricans Fr.	0.0559	0.0479	0.0526	0.0355	0.0274
Russula rosea Pers.	0.0365	0.0251	0.0264	0.0266	0.0275
Russula sanguinea Fr.	0.0104	0.0100	0.0100	0.0094	0.0101
Termitomyces clypeatus R. Heim	0.0157	0.0131	0.0151	0.0090	0.0108
Termitomyces eurrhizus (Berk.) R. Heim	0.0018	0.0015	0.0007	0.0008	0.0015
Termitomyces heimii Natarajan	0.0001	0.0004	0.0001	0.0004	0.0004
Termitomyces microcarpus (Berk. & Broome) R. Heim	0.0045	0.0046	0.0040	0.0029	0.0029
Volvaria volvacea (Bull.) Singer	0.0037	0.0078	0.0070	0.0033	0.0055

ing in the spatio-temporal variations. Mid- to late August can be considered as the optimum period of wild edible mushroom production in the forest floor of the eastern lateritic part of India as different micro-habitat regulating factors create an ideal micro-climatic condition in this period for these 11 WEMs.

Polynomial patterns of wild edible mushroom production may be directly related to the rainfall, relative humidity, and the first rain of the year. This happens because mushroom production is directly proportional to the decomposition rate of forest litter which is related to the water content in the forest floor, relative humidity, and temperature (Osborne & Maucauley 1988, Singh & Joshi 1982). For example, WEMs like *A. vaginata* var. *alba*, *A. hygrometricus*, *R. rosea*, and *P. arhizus* are generally found to flourish at the onset of monsoon. This may indicate that they do not need much decomposed leaf litter to begin reproducing unlike others.

Santal tribal people in the forest fringes of Birbhum district, a poorer section of the community, are largely dependent on the wild mushrooms growing in the forests and its vicinity for food and traditional medicines. The fruit bodies of different macrofungal species emerge within a short three-month duration. The traditional folk or tribal knowledge relating to the diversity, use, ecology, and management of wild mushrooms is not only important for biodiversity conservation but also key to further research for general human welfare.

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