A quantitative ethnobotanical approach to assess knowledge richness on the use of plants among the Santal Medicine Men of Birbhum district, West Bengal, India

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Research

Abstract

Background: Documentation of folk tradition on the use of medicinal plants is being carried out by the ethnobotanist from different parts of the world. The present study aims to measure medicinal plant use-knowledge among the Santal tribal people of Birbhum district. In terms of quantitative ethnobotany, this study is the first attempt from the district of Birbhum, West Bengal. The quantitative analysis in this research work identifies potential medicinal plants and plants which demand priority for immediate conservation.

Methods: This ethnomedicinal survey was done in the tribal pockets of Birbhum district from August 2019 to August 2021. In this study 31 tribal informants were selected employing purposive sampling method and interrogated by throwing semi-structured questionnaires. *In-situ* (Inventory interview, guided tour) and *ex-situ* (visual stimuli, photographic documentation of preserved herbal drugs along with questionnaire) methods were applied during data collection. Free and Prior Informed Consent (PIC) has been taken. Recorded data were analysed by conventional (qualitative) and quantitative ethnobotanical (Informants Consensus Factor, Relative Frequency of Citation and Fidelity Level) techniques. Finally, the IUCN Red List was scrutinized for the global status of the documented species and conservation aspects were highlighted based on quantitative techniques.

Results: A total of 40 ethnomedicinal plant species were recorded which belong to 33 families and 40 genera were recorded. These plants were formulated in curing about 34 different diseases and ailments of human and veterinary animals. Herbaceous plants (35%) were mostly used in remedy preparations. Decoction (N=22) is the preferred form of medication followed by poultice and ointment (N = 11), massage (N = 4), Chewing (N = 1), powder (N = 1). Commonly used plant parts were underground parts like roots, rhizome and pseudobulb (N=20) followed by leaf (N=10), stem bark (N=7), flower (N=2), whole plant (N=1). Fic value of 12 disease categories range from 0.31-0.764, among them respiratory disorders got the highest value. Quantitative analysis following Relative Frequency of Citation(RFC) and Fidelity Level(FL%) indices showed that some taxa were getting maximum Fidelity Level (100%) and RFC (1), namely *Euphorbia fusiformis*, *Madhuca longifolia* var. *latifolia*, *Cleistanthus collinus*, etc. The IUCN status of 40 reported medicinal plant species showed 5 % species are presently

Vulnerable (*Jatropha nana*, *Cleistanthus collinus*),15 % Least Concern (*Eclipta prostrata, Hellinia speciosa, Litsea glutinosa, Pterospermum acerifolium, Rivea hypocrateriformis, Woodfordia fruticosa*), while the status is unknown for 80% of the documented species.

Conclusion: The study concluded that some important ethnomedicinal species like *Woodfordia fruticosa, Premna herbacea, Pterospermum acerifolium, Ruellia suffruticosa, Cleistanthus colliinus, Hellinia speciosa*, etc. are frequently used in tribal medicine of the Birbhum district as identified on basis of their high RFC and FL values. It caters for the scope of further study with these plants in the line of pharmacognosy, phytochemistry and pharmacology. There is also an urgent need to acknowledge Local Knowledge Holders and preservation of associated phytoresources of the study area which has not been addressed till date. Medicinal plant species such as *Jatropha nana* and *Cleistanthus collinus* are Vulnerable and many others could be included in the threatened category in near future due to overexploitation. So conservation priority and conservation measures should be set up through in-depth study of diversity and population of the medicinal plants which are unsustainably harvested.

Keywords: Ethnomedicinal flora, Birbhum district, High Fidelity, crude drug, pharmacognosy, IUCN status, conservation

Background

The recent and most welcome principle in natural products research that leads to bioprospection, and drug development is mainly based on botanical knowledge, skills, practices and beliefs on folk medicinal plants. Reports from World Health Organization (WHO 2023) reckoned about 88 percent of the world's population exclusively depend on traditional medicines based on local phytoresources for their daily healthcare needs. This dependence is due to beliefs in own culture, reliability of effective curing properties of medicinal herbs and difficulties in availing modern medical facilities mainly due to pitiable economic status. Now-a-days, about 25% of the total plant drugs used in therapeutics comes from plant sources (Ayyanar & Ignacimuthu 2011). Balick & Cox (1996) mentioned that most of the important pharmaceuticals are developed from plants being used by indigenous people. However, the success scenario in medicinal plant research is still not commanding (Gertsch 2009). The lower success rate is primarily due to disorganized, even inappropriate methods of data collection and inadequate interpretation in most of the existing ethnobotanical studies (Alburquerque *et al*. 2014a). For last few decades, quantitative ethnobotanical approach has got considerable attention among the ethnobotanists (Cox & Balick 1994, Jain2017a). This approach helps to obtain greater objectivity towards standardization of the pharmacological and toxicological properties of phytotherapies practised in different ethnic cultures (Leonti & Casu 2013, Sharma *et al*. 2014).

India is not only a biodiversity rich country, but it has a significant wealth of socio-cultural traditions and associated knowledge system developed from time immemorial. A rich tradition on medicinal uses of plants among the ethnic people makes India as one of the ethnobotanical hotspots of the world. The tribal people of the country mainly harvest non-timber forests products and traditionally employ those in different medicinal preparations for effective recovery from diseases. Last few years, ethnobotanical survey of medicinal plants has got huge momentum, but till date a few of such studies followed systematic strategies based on the quantitative ethnobotanical approach for the documentation of plant-use knowledge. Quantitative Ethnobotany provides an ingenious scientific way to document medicinal plants resources in the light of traditional believes. That is why a systematic data collection from authentic and knowledge-rich person and its logical interpretation is the keys to the desired outcome of the ethno-guided study of medicinal plants which has been followed in our present study on the medicinal plant use by the Santal tribal people of Birbhum district, West Bengal. Very recently, some interesting quantitative ethnobotanical research works have carried out from India (Haq & Singh 2020, Haq *et al.* 2022, Laldingliani *et al*. 2022, Hassan *et al*., 2022, Silambarasan *et al.* 2023) and abroad (Umair *et al*. 2017, Huang *et al*. 2022, Amin *et al*. 2023, Tahor *et al*., 2023). However, literature survey revealed that, till date, almost all of the studies made from the state of West Bengal including Birbhum district were focused on simple documentation of plant use knowledge emphasizing floristic studies (Sur *et al.* 1992, Rahaman & Pradhan 2011, Pradhan & Rahaman 2011, Mondal & Rahaman 2012, Mondal & Rahaman 2013, Pradhan & Rahaman 2014, Das & Rahaman 2014, Rahaman *et al*. 2015, Konar and Mondal, 2022) and a few ethnomedicinal studies with application of some statistical tools(Mandal & Rahaman 2022, Subba *et al*. 2023). Therefore the huge essence of knowledge for biodiversity prospecting is largely unexplored in the studied area in terms of standard quantitative ethnobotanical approach. In this view, we designed our study in two orientations-

a. Documentation of Traditional Herbal Knowledge from the Birbhum district.
b. Scientific study of indigenous medicines in order to provide clues for bioprospecting of indigenous remedies in a quantitative ethno-directed approach.

Materials and Methods

Study area

Birbhum district of West Bengal is floristically rich and traditionally sound on the plant use knowledge (Paul & Gupta 2016, Pradhan & Rahaman 2019). The district lies between 23°32'30" and 24°35'00" North latitude and 88°01'40" and 87°05'25" East longitude (Figure 1) and extends over an area of 4,550.94 km^2. The district vegetation is a tropical dry deciduous type with a few representatives of the evergreen type occurring here and there. The climate of the district is characterized by an oppressive hot summer, high humidity and well distributed rainfall during the monsoon. The annual average temperature is 38.3°C and annual average rainfall is 1098mm. The district is inhabited by 34,34,075 population, of which 10,45,194 belong to Scheduled Castes, 2,49,762 Scheduled Tribes and 21,39,119 number of people belongs to general category. The major tribal groups are Santals, Kora and Oraons(Census of India 2011).The Santal is a most dominating tribal community in this district and culturally they use large number of plants for their daily needs (Barman & Ghosh 2015).

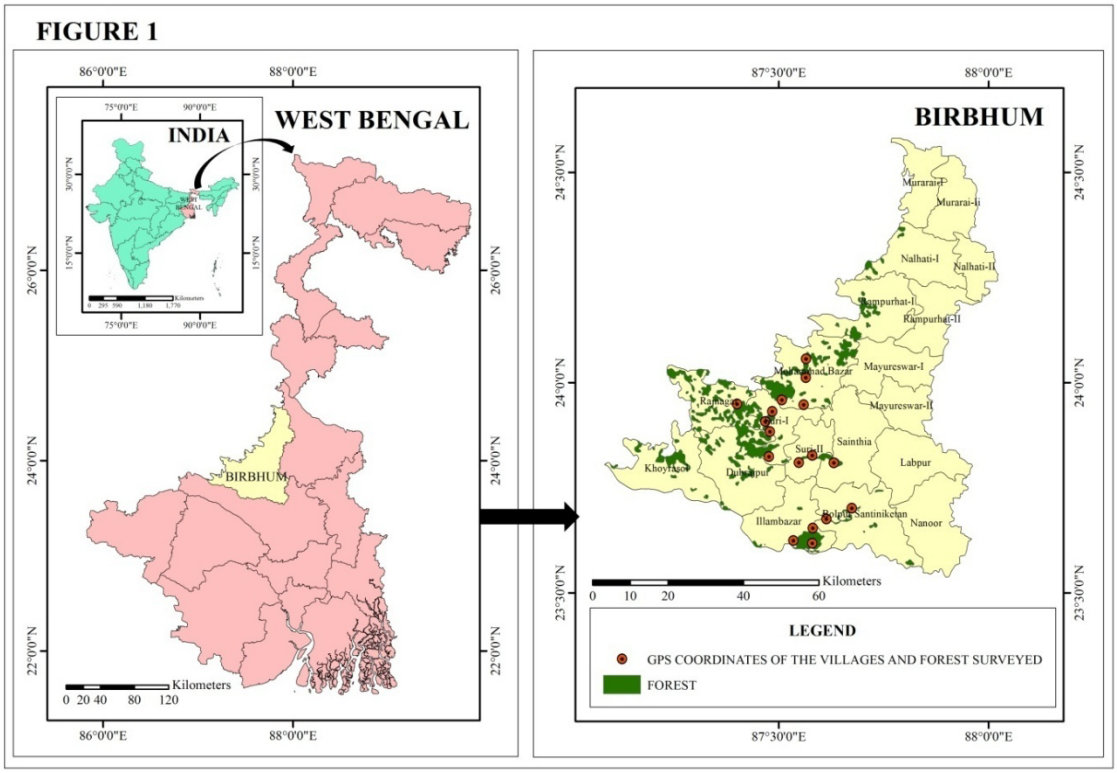

Figure 1**.** Map of the study area showing location of the survey in Birbhum district, West Bengal.

Data collection

Ethnobotanical data on medicinal plants were collected from 2019 to 2021 by employing semi-structured interviews in Bengali language with medicine men belonging to the Santal tribal community of Birbhum district. The people of the community are quite accessible, friendly and besides the native Santali language, they understand the Bengali language very well. For data collection, we made a good rapport with the tribal people of different villages of Birbhum district. When they became amicable, we applied purposive sampling technique (Tongco 2007) and recognized 31 local knowledgeable medicine men from different tribal localities. Free and Prior Informed Consent (FPIC) has been taken verbally from each of the informant before all photographic documentations and written documentation of socio-demographic characters and knowledge. The questionnaires were prearranged on two aspects - the first is dealt with the basic socio-demographic characters (age, marital status, level of education, etc.) and the final was about the plant-use knowledge including data on local and tribal names of the plants, parts used, mode of preparation and their uses have been recorded. We took photographs of medicine people and of the packets and containers having dried and fresh plant parts (crude drugs) preserved in their house-holds (*Ex-situ* data collection) (Figure 2 A, B, C). To confirm the authenticity of the information it has always been cross-checked by interviewing other tribal medicine men of the same and different localities by applying visual stimuli methods (Figure 2A) either showing photographs or freshly of the collected plants and herbarium specimens (Meideros *et al*. 2014). 'Guided tour' in the forest (Figure 2 D, E, F) with one or more knowledgeable escort informants was conducted for *in loco* identification of plants (Cotton 1996, Albuquerque *et al*. 2014b).

Figure 2. Data collection strategies. *Ex-situ* data collection: Visual stimuli by showing live collections of plant species (A), Questionnaire interviews (B & C). *In-situ* data collection: Inventory interview through guided tour in Ganpur forest locality (D), Plant collection in Illambazar forest area (E), guided tour (F).

Identification and deposition of the voucher specimens

The collected plant specimens were identified with the help of Floras (Prain 1903, Sanyal 1994, Anonymous 1997, Paul *et al*. 2015, Ranjan *et al*. 2016, Lakhminarasimhan *et al*. 2019). Voucher specimen of the plant twigs have been prepared and preserved by following standard ethnobotanical method (Martin 1995) and deposited in the Herbarium section of the affiliated institutions of both authors. The nomenclature and correct author citation for all species were thoroughly checked and updated following the databases of Plant of the World Online (https://powo.science.kew.org/) and The World Flora Online (http://www.worldfloraonline.org/).

IUCN-Conservation status of the identified plants

Identified plant specimens were checked for their present conservation status by searching the web database of International Union for Conservation of Nature (IUCN) -Red List of Threatened Species (https://www.iucnredlist.org/).

Disease categorization

In the present study; tribal terminology of different diseases and ailments were documented during the survey and their medical terms were identified by consultation with government registered medical practitioner. Finally all the diseases were categorized and tabulated following the standard method of Cook (1995) with some necessary modifications based on the findings of the present survey.

Informants Consensus Factor (F_{ic})

F_{ic} is employed to quantify the informants' consensus for identifying the disease categories prevalent in an ethnic culture and its effective plant-based therapies by a number of healers in the study area.

$$\mathrm{Fic} = \frac{\mathrm{Nur} - \mathrm{Nt}}{\mathrm{Nur} - 1}$$

where, N_{ur} is the number of use reports from informants for a particular plant usage category where, use report is a single record for use of a plant mentioned by an informant. N_t is the number of taxa or species that are used for a particular plant usage category. Fic value ranges between 0 and 1, where value close to '1' indicates the highest level of informants' consent regarding the use of plants in curing a disease (Heinrich *et al*. 1998).

Relative Frequency of Citation (RFC)

RFC values for each medicinal plant species were calculated using the formula proposed by Tardio and Pardo-de-Santayana (2008):

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}}$$

Where FC= Frequency of Citations by informants and N= number of all informants took part in the interview. The RFC value ranges from 0 to 1. Here '0' indicates nobody referred to a plant as useful whereas '1' designates all informants referred to a plant as useful.

Fidelity Level (FL)

To measure the reliability of the principal therapeutic uses of plants for a particular ailment by the medicine men of the study area, the FL value is used. It is calculated using the following formula (Friedman *et al*. 1986):

$$\mathrm{FL}(\%) = \frac{\mathrm{Np}}{\mathrm{N}} \times 100$$

Where, N_P is the number of informants that claim a use of a plant species to treat a particular disease and N is the number of informants that use the plants as a medicine to treat any given diseases. Highest fidelity level means maximum agreement regarding the use of a species.

Results and Discussion

Socio-demographical status of the informants

In the present study, altogether 31 selected folk healers were consulted with. From the investigation of socio-demographic characters of medicine men of the district Birbhum, it has been found that all of the informants belong to the Santal tribal community. The percentage of male informant was 87.09% and only 12.90% of the informants were women. A good number

of the informants were culturally experienced and senior members of the society having the age group of above the 50 years (38.70%) whereas the rest of the informants (61.29%) were middle-aged. The socio-economic condition of the informants is not good, and they are below the poverty level. Most of the informants (77.41%) earn their living from cultivation and herbal drug practice. Exclusively herbal medicine prescription brings very poor earnings for them and that is why we found only 7 medicine men (22.58%) dedicatedly practice herbal medicine. This is one of the major causes for getting less interested in folk medicinal drug practice and dependence on cultivation and other source of income including temporary jobs in government and non-government sectors to meet their dire financial status.

Among the informants, 26 individuals did not come under the conventional education system (≈83%) and they were among the non-school going people whereas rest of the informants have primary education(>16%) (Table 1). Poor economic condition and its impact on family is one of the major causes which restrict the younger generation getting privilege to higher education. However it was found that no one among the medicine men shared information about their income in terms of money. The truth is, somehow they were leading a life with minimum amenities.

Table 1. Socio-demographical details of the Santal medicine men of Birbhum district

Variables	Categories	Total number of informant	Percentage %
Gender	Male	27	87.09
	Female	4	12.90
Age	Middle-aged(35 – 50 years)	19	61.29
	Old-aged(51 -65 years)	12	38.70
Marital status	Married	25	100
	Unmarried	0	0
Literacy	Primary (Kinder Garten to Standard 4)	4	12.90
	Upper primary(Standard 5 to 8)	1	3.22
	Non-School going	26	83.87
Primary source of income	Cultivation and herbal medicine practice	24	77.41
	Herbal medicine practice	7	22.58

During the survey, it was found that herbal knowledge passed down from generation to generation. The flow of the knowledge follows vertical mode of transfer among the tribal informants. Knowledge flow in a society depends on a number of factors, such as people's mentorship and headship in a family, socio-economic status, availability of needed resources in the locality, etc.(Reyes-Garcia *et al*. 2007). It has been found in the present study that the younger generation belonging to age up to 35 is found absent in participation of knowledge sharing during the survey. Some ethnopharmacological survey works in India also indicate that folk practices of plants were being confined mostly to elders (people belongs to age of above 40 years) whereas it is dwindling among the younger generation (Bruschi *et al.* 2019). This is due to acculturation and modernization of the society concerned and lack of interests in nurturing the medicine-culture learned from the elder members of the family. As a result major half of the people, particularly the younger generation of the society is not familiar and or serious to know about surrounding floristic composition and their local identity and uses. So it is very much possible that the existing knowledge could fade away in near future from the ethnic-culture of Birbhum district, West Bengal with the demise of the aged-knowledge holders who were actually concerned about this divine folk-practice.

Enumeration of ethnomedicinal plants

A total of 40 plant species belonging to 27 families 34 genera 34 species of dicot and 6 families, 6 genera and 6 species of monocot has been recorded from the district (Table 2; Figure 3). Habitually most of the plants used as medicine were herbs and trees. Here, herbaceous plants show the maximum percentage (35%) whereas a lower percentage (10%) is shown by shrub population (Table 3, Figure 4). The choice of plant ingredients and their amount for formulation of different ethnomedicines were very specific. It is found that flowers of 2 plants, stem bark of 7 plants, leaves of 10 plants and underground parts like roots, rhizomes, pseudobulbs of 20 plant taxa and the whole plant of 1 species have been employed in 40 different medicinal formulations in curing about 34 different diseases and ailments (Figure 5). Underground parts like root, bulb, etc. were the highest used part(50%) by the medicine men for remedy preparation which corresponds to similar findings reported in earlier studies from different countries including India (Mall 2009, Mondal & Rahaman 2012, Wanjohi *et al*. 2020, Uğur *et al*. 2021, Ayyanar & Ignacimuthu 2022, Karmakar & Rahaman 2022, Swain *et al.* 2022). The maximum reliability on the use of root is scientific since the underground plant parts were the site for synthesis of different secondary

metabolites (Bais *et al.* 2001). We found leaf is the second-best choice (25%) for remedy preparation. Preference of leaves as ingredient in folk medicine have also been documented in some research ethnobotanical works from India (Laldingliani *et al.* 2022, Silambarasan *et al*. 2023) and abroad (Senouci *et al*. 2019, Bachar *et al*. 2021). A traditional belief on the use of leaves in ethnomedicine is very much logical and acceptable since leaf is the site of accumulation of minerals through different physiological processes like ascent of sap and synthesis of different metabolites through different major biochemical processes including photosynthesis.

Table 2. Ethnomedicinal uses of plant species found in Birbhum district, West Bengal

Family	Local name/ Vernacular name	Scientific name (Voucher specimen)	Habit	Parts used	RFC	FL%	IUCN status	Mode of application in curing diseases
Acanthaceae	**renuran**	*Ruellia suffruticosa* Roxb. ; Illambazar, B.Pradhan 456	Herb	Root	0.75	100	NA	Decoction of fresh root made into decoction and taken orally to cure stomach problem and acidity
Amaryllidaceae	**ban piyaj**	*Crinum asiaticum* L. ; Chorchor, S. Mondal 78	Herb	Root	0.77	60	NA	Paste prepared from fresh tubers made into paste and applied externally as ointment to cure infection due to burn and insect bite
Apocynaceae	**anantamul**	*Hemidesmus indicus* (L.) R. Br.; Illambazar, B.Pradhan 208	Climber	Root	1	97	NA	2 teaspoonful decoction of fresh root taken orally with water to cure stomachache and snake venom poisoning
Aristolochiaceae	**gad / isormul**	*Aristolochia indica* L.; Illambazar, B.Pradhan140	Climber	Root	0.5	25	NA	1-2 teaspoonful of decoction of fresh root administered orally to cure stomachache
Asaparagaceae	**satamuli**	*Asparagas recemosus* Willd; Chorchor, S.Mondal 113	Climber	Root	1	95	NA	1-2 teaspoonful decoction of fresh root taken orally to cure urinary problem
Asteraceae	**kesut**	*Eclipta prostrata* (L.)L.; Chorchor, S.Mondal306	Herb	Leaf	1	100	LC	Juice extracted from fresh leaf boiled with coconut oil and applied externally on hair as massage oil to retard hair loss
Bignoniaceae	**banhata**	*Oroxylum indicum* (L.) Benth. ex Kurz; Chorchor, B.Pradhan305	Tree	Stem bark	0.65	75	NA	Dried stem bark made into paste and applied externally as massage to cure body –ache
Celastraceae	**kujori**	*Celastrus paniculatus* Willd.; Ganpur, B. Pradhan 114	Climber	Leaf	0.7	50	NA	Paste prepared from fresh leaf applied externally on forehead as poultice to cure headache
Commelinaceae	**kosmul**	*Cyanotis tuberosa* (Roxb.) Schult. & Schult.f.; Illambazar, S. Mondal 87	Herb	Root	0.4	60	NA	Decoction of fresh root orally administered to cure dysentery
Convolvulaceae	**kolu**	*Argyreia nervosa* (Burm.f.) Boj; Illambazar, B.Pradhan130	Climber	Leaf	0.31	27.5	NA	Decoction of fresh leaves orally administered to cure loose motion of veterinary animals
Convolvulaceae	**keduara**	*Rivea hypocrateriformis* Desr. (Choisy); Chorchor, S. Mondal300	Climber	Leaf	0.68	70	LC	Half cup of decoction made from fresh leaf orally administered with water for 3-4 days to cure oligospermia and leaf applied as poultice to cure hydrocele
Convolvulaceae	**kari/ keri**	*Erycibe paniculata* Roxb.; Ganpur, B.Pradhan123	Climber	Stem bark	0.5	62.5	NA	Dried stem bark made into paste using water and externally applied as poultice to cure headache and inflammation during menstruation period

Costaceae	**kemuk**	*Hellinia speciosa* (J.Koenig) S.R. Dutta; Illambazar, S Mondal 345	Shrub	Root	0.85	95	LC	2 teaspoonful decoction of freshly collected root taken orally for the treatment of menorrhagia
Dioscoreaceae	**kanalu/ kapu**	*Dioscorea bulbifera* L. ; Illambazar, B.Pradhan 124	Climber	Rhizome	0.9	50	NA	Freshly collected rhizomes were boiled in water and consumed as soup(decoction) to cure malnutrition
Euphorbiaceae	**parashi**	*Cleistanthus collinus* (Roxb) Benth & Hook. f. ; Illambazar, B.Pradhan 116	Tree	Stem bark	0.85	100	VU	Dried stem bark made into paste using water and applied as external ointment to cure skin infection
Euphorbiaceae	**dudhmul**	*Euphorbia fusiformis* Buch.-Ham. ex D.Don; Ganpur, S.Mondal 612	Herb	Root	1	100	NA	300- 500g fresh root given as fodder to increase lactation of veterinary animals
Euphorbiaceae	**aanguti**	*Glochidion multiloculare* (Rottler ex Willd.) Voigt; Illambazr, B. Prahan 456	Shrub	Leaf	0.9	100	NA	Decoction of fresh leaf prescribed as an ear drop to cure ear pain.
Euphorbiaceae	**bireradom**	*Jatropha nana* Dalz. & Gib.; Chorchor, S.Mondal 330	Herb	Root	0.35	20	VU	Fresh root given as galactagogue fodder for milking cows to increase lactation
Fabaceae	**bansan**	*Crotalaria verrucosa* L. ; Dascalgram, B.Pradhan18	Herb	Leaf	0.4	23	NA	Paste of fresh leaf applied topically as ointment to cure skin infection
Fabaceae	**vuikumra**	*Pueraria tuberosa* (Roxb. ex Willd.) DC.; Chorchor,S. Mondal58	Climber	Rhizome	0.68	80	NA	Fresh rhizome given as fodder to cure malnutrition of cows
Flacourtiaceae	**bara baichi**	*Flacourtia jangomas (*Lour.) Raeusch. ; Illambazar, B.Pradhan 315	Tree	Leaf	0.67	67	NA	1-2 teaspoonful decoction of fresh leaf taken orally to cure dysentery[9]
Hypoxidaceae	**talmuli**	*Curculigo orchioides* Gaertn.; Ganpur, B.Pradhan 24	Herb	Root	0.9	80	NA	Half cup decoction of fresh root taken orally to cure leucorrhea
Lauraceae	**baghlal**	*Litsea glutinosa* (Lour.) C.B.Robins.; Chorchor, B.Pradhan 480	Tree	Leaf	0.5	20	LC	Fresh or dried leaves made into paste with water and applied externally as poultice to cure body ache
Lecythidaceae	**kumbhi**	*Careya arborea* Roxb.; Illambazar, B. Pradhan 69	Tree	Stem bark	0.5	32.5	NA	Dried stem bark applied externally as poultice to cure body ache
Lythraceae	**echecharek**	*Woofordia fruiticosa* Kurz; Ganpur, S.Mondal 48	Shrub	Flower	0.95	90	LC	Dried flower made into powder, mixed with water and 1-2 teaspoonful soup(decoction) administered orally to cure stomach problem and infertility
Malvaceae	**muchkunda**	*Pterospermum acerifolium* (L.)Willd.; Chorchor,S.Mondal 300	Tree	Flower	0.77	70	LC	Decoction of fresh flower given orally with water to cure oligospermia
Meliaceae	**raktororha**	*Soymida febrifuga* A.Juss.; Ganpur, S. Mondal 300	Tree	Stem bark	0.87	75	NA	Dried bark made into paste by mixing water and paste topically applied as massage cream to cure cuts and wounds, muscular cramps

Menyanthaceae	**sada saluki**	*Nymphoides cristata* Roxb.(Kuntze); Ganpur, S.Mondal210	Herb	Whole plant	0.7	55	NA	Fresh and water cleaned whole plant made into decoction and orally administered in curing urination problem
Nymphaeaceae	**lalsaluk**	*Nymphaea nauchali* Burm. f. ; *Ganpur,* S. Mondal 325	Herb	Root	0.8	58	NA	1-2 tea spoonful decoction made from fresh root taken orally to cure menorrhagia and infertility
Ochnacaceae	**bhuichampa**	*Ochna obtusata* DC.; Ganpur, S. Mondal 300	Tree	Root	0.82	70	NA	2 teaspoonful decoction of fresh root taken orally to cure irregular menstrual cycle
Olacaceae	**kokoaru**	*Olax scandens* Roxb.; Illambazar, B.Pradhan 650	Shrub	Root	0.25	38	NA	1 teaspoonful decoction fresh root taken orally for women to recovery from anaemia
Orchidaceae	**gite**	*Eulophia explanata* Lindl.; Illambazar, B.Pradhan 324	Herb	Psuedo bulb	0.78	66.6	NA	Decoction of freshly collected or dried of pseudobulbs consumed orally with water to cure oligospermia and sexual impotency and same is applied as poultice in case of joint pain(gout)
Orchidaceae	**gaehamla**	*Geodorum laxiflorum* Griff.; Ganpur,S. Mondal 37	Herb	Pseudo bulb	0.55	60	NA	1-2 teaspoonful decoction of fresh or dried pseudobulbs taken orally to cure muscular pain
Polygalaceae	**nilkathi**	*Polygala crotalarioides* Buch.-Ham. ex DC.; Ganpur, S.Mondal 79	Herb	Root	0.71	78	NA	Freshly collected root prescribed for chewing to cure normal cough and cold and whooping cough
Rubiaceae	**kasmi**	*Mitragyna pervifolia* (Roxb.)Korth.; Chorchor, B.Pradhan 475	Tree	Leaf	0.5	15	NA	Decoction of fresh leaf consumed orally as instant energy booster
Salicaceae	**biridaru**	*Casearia nigrescens* Tul.; llambazar, B.Pradhan 16	Tree	Leaf	1	42.5	NA	Dried leaf powder mixed in water bodies as fish poison
Sapotaceae	**moul**	*Madhuca longifolia* var. *latifolia* (Roxb.) A. Chev; Ganpur, S.Mondal311	Tree	Stem bark	0.75	100	NA	Freshly extracted or dried stem bark made into an paste by mixing and grinding with water and applied externally as antiseptic ointment on burn infected body part to reduce infection
Smilacaceae	**kumarika**	*Smilax ovalifolia* Roxb. ex D.Don.; Chorchor, S.Mondal 476	Climber	Root	0.65	55	NA	Decoction of fresh root given orally to cure Oligomenorrhea, abdominal worm of domestic animals
Symplocaceae	**lodha**	*Symplocos racemosa* Roxb.; Illambazar, B. Pradhan 329	Tree	Stem bark	0.4	30	NA	Paste of fresh stem bark applied externally as ointment on eye infection
Verbenaceae	**bhojpatra/ gitiya**	*Premna herbacea* Roxb. ; Illambazar, S.Monda l57	Herb	Root	0.8	94	NA	Dried root made into paste by mixing water and externally applied as massage cream to cure gout

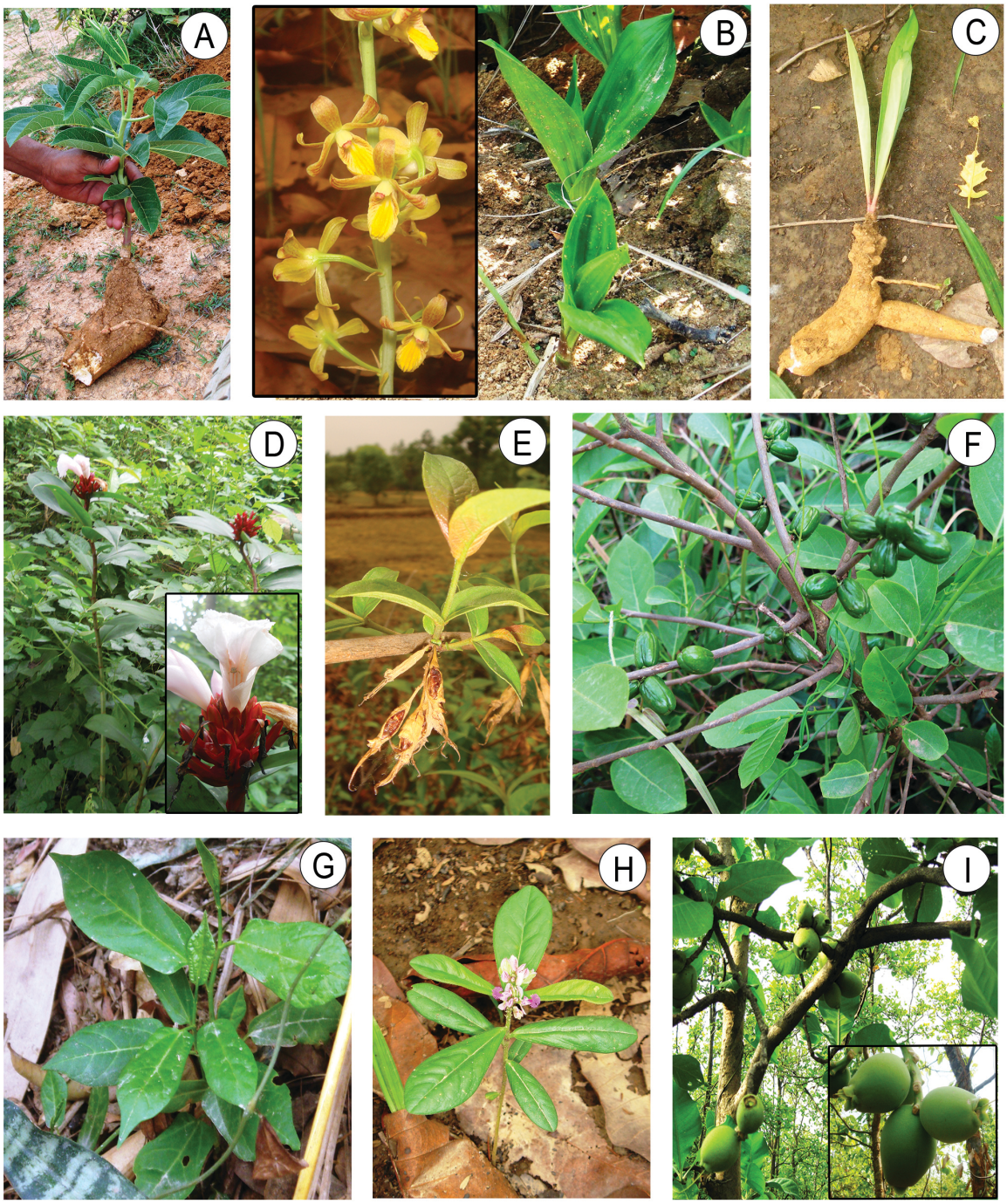

Figure 3. Some ethnomedicinal plants of the study area. Dugout live plant of *Jatropha nana* Dalz. & Gib.(A), *Eulophia explanata* Lindl. [inset: inflorescence scape](B), Dugout live plant of *Euphorbia fusiformis* Buch. –Ham. ex D. Don. (C), *Hellinia speciosa* [inset: close up of a flower] (D), *Woodfordia fruiticosa* Kurz(E), Twigs of *Casearia nigrescens* Tul. bearing fruits(F), *Aristolochia indica* L.(G), *Polygala crotalarioides* Buch.- Ham. ex DC.(H), *Careya arborea* Roxb.[inset: fruits](I).

Table 3. Percentage of different habits of recorded plant species used in herbal medicine preparation.

Habit	Number	Percentage (%)
Herb	14	35
Tree	12	30
Climber	10	25
Shrub	4	10

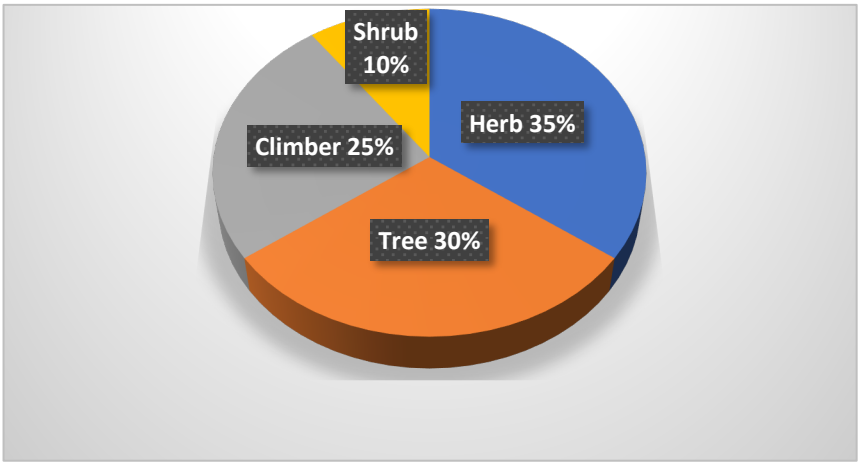

Figure 4. Distribution of plant species and their different habits

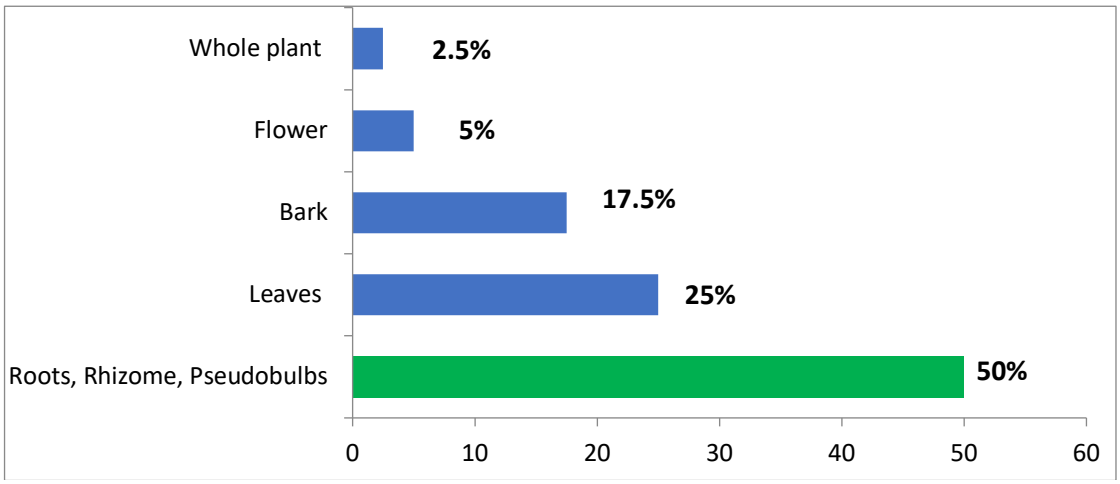

Figure 5. Use of plant parts as crude drugs expressed in percentage

Methods of administration of crude drugs

It is observed during the survey that, exclusively fresh ingredients were used in 28 cases (70%), in 8 cases entirely dried forms were used in the preparation of ethnomedicines (20%) whereas both fresh and dried ingredients were used in 4 cases (10%). Use of dry plant part indicates scientific rationale of the use of drugs with no fungal contaminations, while there is an added chance of fungal contamination which may spoil the quality and effectiveness of drug which is freshly collected. The fresh form remedies were not preserved, however dried crude drugs were preserved in air-tight wooden or plastic containers and packets (Figure 6). The main reasons behind preservation of the crude drugs in dried forms were non-availability of the source plants in nearby forest localities, rarity of the species and seasonal availability of certain drugs. In this study six different methods of preparation of ethnomedicine have been recorded, such as decoction, fodder, chewing, poultice and ointment, massage, powder. Topical route administration is preferred (29 cases; 72.5%) to the oral route (21 cases; 52.5%). In case of topical administration, poultice and ointment (26 cases) were mostly used preparation for administration of dose followed by, decoction (17 cases), fodder (3 cases), massage (1 case) , chewing (1 case) and powder as fish poison(1 case) through oral route administration(Table 4, Figure 7). However, two species- *Eulophia explanata* and *Rivea hypocrateriformis were* used in both topical (poultice) and oral (decoction) administrations. It is observed that crude drugs used as poultice is a common practice among the tribal as also reported by Roosita *et al.*(2008) and Upadhyay *et al.* (2010). Various active drug molecules of topical dosage forms were quite effectively absorbed through the biological membrane and work onto the target site of the affected tissue (Garg *et al*. 2014). That is why the topical administration process of herbal drugs is preferred for treatment of different ailments of muscular and skin related disorders which were in accordance with folk-claims documented in some ethnobotanical studies (Wirth *et al*. 2005, Ayyanar & Ignacimuthu 2011, Rahaman & Karmakar 2015, Shedoeva *et al.* 2019). The choice of oral administration has been found in common consent among the informants due to effectiveness and quick recovery from some diseased condition where topical route administration is not applicable. Some diseases like gastro-intestinal problems, menstrual and other related health problems, poor lactation, urinogenital diseases, respiratory problems, physical weakness, etc. were the preferences for application of remedies through oral route. This information is also found similar to some other ethnobotanical studies in India (Savitharamma *et al.* 2016, Raj *et al.* 2018). A

low dose (one teaspoonful) in the prescription is preferred for children belonging to the age group 1 to 10 years for a particular disease and for adults one to two teaspoonfuls of drug were used to treat the same disease. None of the healers mentioned on the side effect to the remedies during or after its administration.

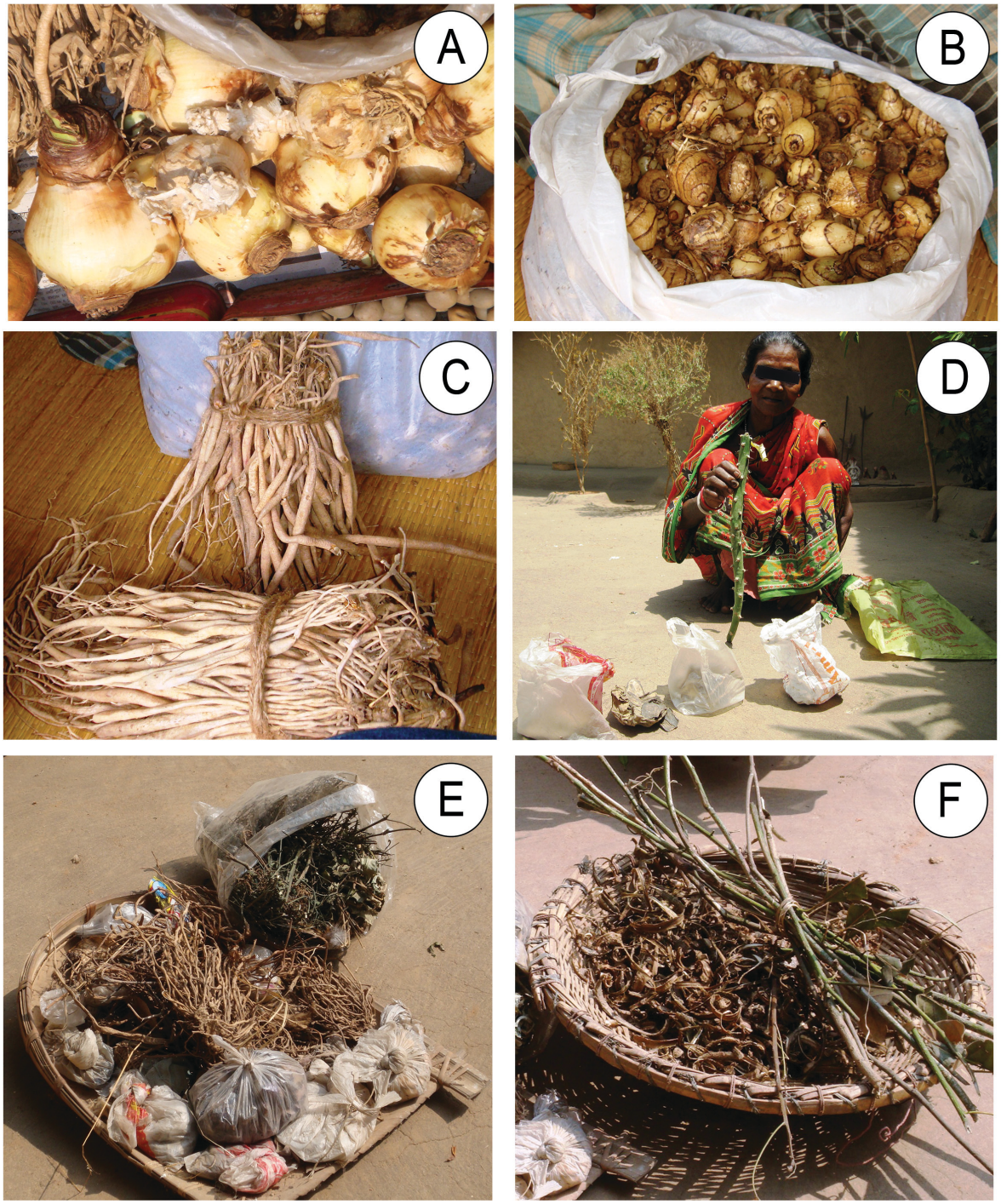

Figure 6. Photographs of some dried crude drugs. Dried bulbs of *Crinum asiaticum* L.(A), Fresh psuedobulbs of *Eulophia explanata* Lindl.(B),Bundles of fresh collection of roots of *Asparagas recemosus* Willd(C), A tribal medicine woman of Ganpur forest showing her collection of plant parts(D), Multiple collections of herbal drugs of tribal medicine men preserved in packets and bamboo stem made containers(E & F)

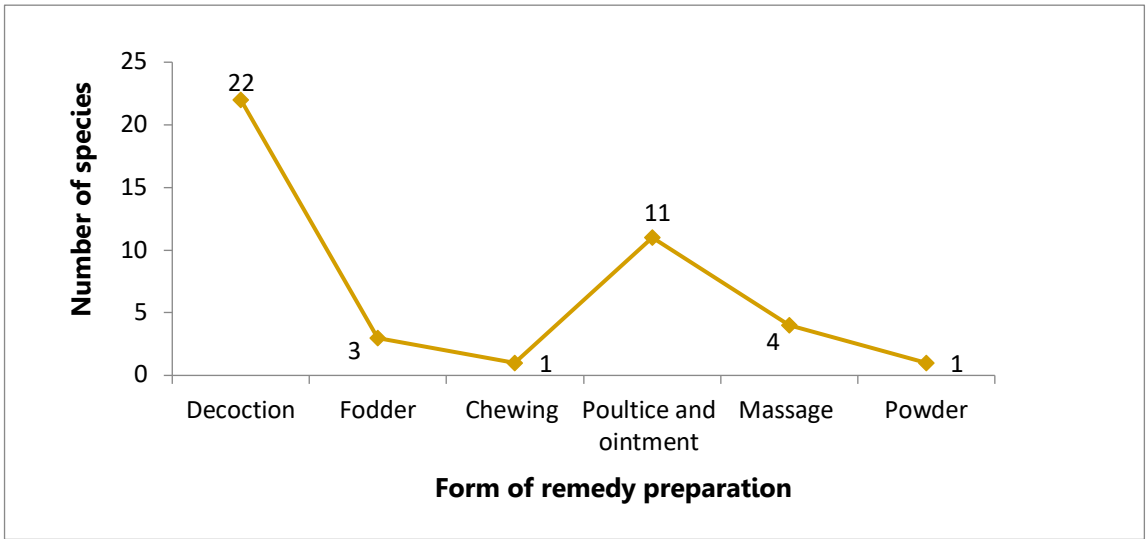

Figure 7. Number of species used in different remedy preparation

Table 4. Percentage of Plant species used in various mode of remedy preparation

Mode of remedy preparation	Number of Plant species used	Percentage of Plant species
Decoction	22	55
Fodder	3	7.5
Chewing	1	2.5
Poultice and Ointment	11	27.5
Massage	4	10
Powder as fish poison	1	2.5

A review of standard ethnobotanical literature revealed that except *C. nigrescens,* the use of 13 ethnomedicinal species *viz*. *Ruellia suffruticosa*, *Hellinia speciosa*, *Pueraria tuberosa, Ochna obtusata, Pterospermum acerifolium, Rivea hypocrateriformis*, *Eulophia explanata, Erycibe paniculata, Geodorum laxiflorum*, *Cyanotis tuberosa, Nymphaea nauchali, Nymphoides cristata, Smilax ovalifolia* documented from the study area are exclusively new to Indian Ethnobotany in respect of their parts used, mode of administration and medicinal uses(Chopra *et al*. 1956, Kirtikar & Basu 1975, Santhosa & Kar 2017, Khare 2007, Jain & Jain 2016, Jain *et al*. 2017b). So, the present study suggests that the tribal people of Birbhum district were culturally very sound regarding the knowledge on different aspects of herbal dose preparations and their rational administration.

Informants' consensus factor

Informants' consensus factor (F_{ic}) value is a measurement from which one can easily understand the occurrence of common diseases in the study area and also elucidate the frequent use of reliable remedies employing a number of medicinal plants for the treatment of different diseases. In this study, except accidental wounds, cuts and poisoning, most of the other diseases are prevalent in the tribal society of Birbhum district due to different socio-cultural factors including economic constraints, lack of awareness and poor educational status, unbalanced diet intake etc. (Ghosh *et al.* 2014, Sarkar & Singha 2019).

In this ethnomedicinal study, F_{ic} analysis of 12 disease categories was performed which shows a F_{ic} range between 0.448 to 0.764. F_{ic} values along with the number of taxa and use reports are included in the Table 5 and graphically presented in Figure 8. A higher value of F_{ic} indicates the greater agreement regarding the uses among informants whereas a lower value indicates lesser agreement on it. Among the 12 disease categories 11 categories achieved F_{ic} value of >0.5, whereas 1 disease category, i.e. Infection has F_{ic} value of < 0.5. The highest value of F_{ic} for respiratory disorders indicates that the Santal people of the district are very susceptible to respiratory diseases. Cultural practice of ethnomedicines for curing female diseases among the Traditional Knowledge Holders is very popular and it is confirmed by some ethnomedicinal studies in West Bengal (Mondal & Rahaman 2013, Rahaman & Karmakar 2015, Karmakar & Rahaman 2022). In our study, we found gynaecological disorder category stood first (use reports =85) employing 29 plant taxa. It shows the prevalence of female gynaecological problems sustaining quality knowledge on the use of plants used to cure such diseases. A reasonable value of F_{ic} (0.545) was also found for under general healthcare category which proves that people of the study area are very much concerned with their general health care like weakness, malnutrition and anaemia. The incidence of such health conditions is quite common

in the Santal tribal society of Birbhum (Stiller *et al*. 2020). Genital diseases, Infection, poisoning due to animal bites etc. are also prevalent among the people of the study area, mostly due to unhygienic living environments and habits and of course, lack of awareness.

Table 5. Informants consensus factor (Fic) for different disease categories.

Disease categories	**Number of use reports (N_{ur})**	**Number of taxa (N_t)**	**F_{ic}**
Respiratory disorders: General cough and cold, whooping cough	35	9	0.764
Urino-genital disorders: Urination problem, hydrocele	12	4	0.727
Injuries: burn, cuts and wounds	52	16	0.705
Skeleto-muscular disorders: Muscle pain, cramp, body ache, gout	59	19	0.689
Gynaecological disorders : Menorrhagia, leucorrhoea, inflammation due to menstruation, irregular menstruation, infertility	85	29	0.666
Veterinary medicine: Loose motion, galactagogue, abdominal worm	10	4	0.666
Poisonous animal bites: Insect bite, snake venom poisoning	18	7	0.647
Nervous system disorders: Headache	18	8	0.588
General health care: Weakness, hair loss, malnutrition , anaemia, energy booster	12	6	0.545
Digestive system disorders: Abdominal acidity, stomach ache	42	20	0.536
Infection: Ear pain, skin infection, eye infection, itching, infection due to cuts	37	20	0.472
Andrological disorders: Oligospermia, sexual impotency	30	17	0.448

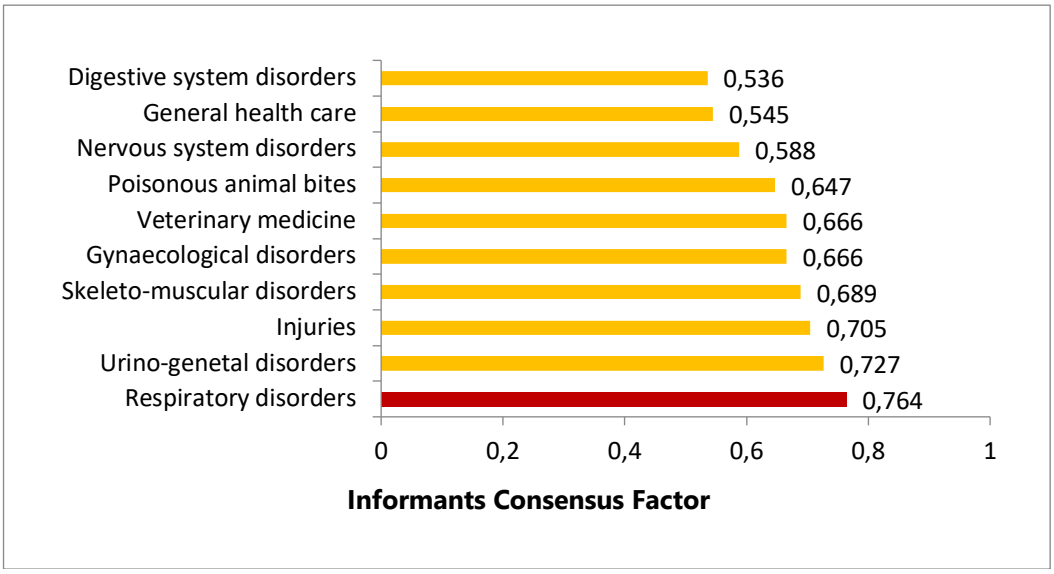

Figure 8. Disease categories and their F_{ic} values

To safeguard privacy of women of their own community, the people of the study area turned out to be very choosy to approach local medicine men of their own community to share their health-related problems and avoid approaching the healers who belong to other communities. The ethnoveterinary medicine practice is also very common in the state of West Bengal including Birbhum district as previously reported (Mandal & Rahaman 2022). In the present study, we found that 4 medicinal plants were used for the treatment of different veterinary disorders (F_{ic}= 0.666). It draws an ethno-artistic bondage between man and veterinary animals and their reliance on the local flora for the treatment of diseases.

Relative Frequency of Citation

The Relative Frequency of Citation (RFC) values of reported plant taxa are listed in Table 6.The highest RFC value 1, scored by five species namely, *A. recemosus*, *H. indicus, E. fusiformis, C.nigrescens, E. prostrata.* Moderate RFC value (0.5) was observed for 6 species (*A .indica*, *C. arborea*, *G. laxiflorum, L. glutinosa, M. pervifolia, E. paniculata*) followed by the lowest value of RFC (i.e. below 0.5) was observed for 5 species (C*. verrucosa*; *C. tuberosa*; *J. nana*; *O. scandens*; *S. racemosa*). Rest of the 24 species remains very close to RFC value 1 (Figure 9). The higher values of RFC indicate that these species are most familiar and harvested very frequently from the habitat whereas the lowest value indicates the comparatively low use pressure on those species.

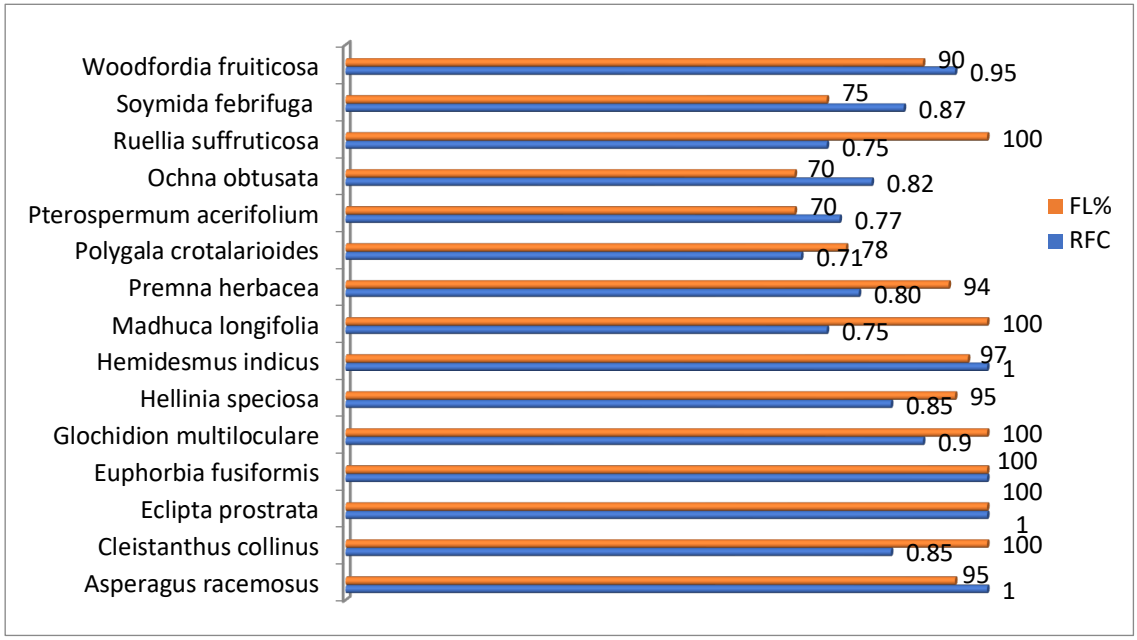

Figure 9.Comparison of medicinal plants for their higher values of RFC(0.7 to 1) and FL(70 to 100%)

Fidelity Level

Fidelity Level (FL) values have been determined for the documented plants which were employed in curing about 36 types of different diseases and ailments of human and veterinary animals like disorders of nervous system, general heath, digestive system, andrological, skeletomuscular, gynaecological, respiratory, urino-genital, etc. From FL value it will be easy to recognize most reliable and potent medicinal plants found in the study area or used by the local herbalist for making prescriptions for patients. FL value also indicates the cultural acceptance and popularity of plants for their ethnomedicinal uses. The higher percentage value of FL is an indicator of a very frequent use of a plant by the local people of the studied area for their health care as those plants are very potent in curing diseases. Out of 40 taxa documented in this study, complete fidelity level was found for 6 species, *viz. C. collinus, E. prostrata, E. fusiformis, G. multiloculare, M. longifolia* var. *latifolia, R. suffruiticosa*. Moderate value of FL (50- 55 %) was found for 4 species (*C. paniculatus, D. bulbifera, N. cristata, S. ovalifolia*). 20 species are found to have above moderate to very close to 100% fidelity which is also a very significant value (Table 2). However, the rest of the 10 species qualified for lower FL values (below 50 %), which does not mean that these 10 plants are not therapeutically potent. It is reported that, less frequently cited plants might also be good stuffs for pharmacological research (Albuquerque *et al*. 2014a). For example, *A. indica, C. arborea, C. nigrescens, D, bulbifera, C. paniculatus, L. glutinosa, M. pervifolia* scored moderate to low values of FL, but all of them qualified with moderate to higher RFC values. It is also noticeable that, some of the cited species might have recently introduced in local medicine system or it is very rare or occasional in a season or not easily found in the forest floor due to their ephemeral nature. From a comparative analysis with higher RFC and FL values we found 15 species which scored higher RFC and FL values (RFC = 0.7 and FL= 70 percent and above) (Figure 9). It is quite obvious that these species will be exploited from the wild much higher rate than the other 25 documented species. Furthermore, out of these 15 species, 10 species are herbaceous (*A. racemosus, C. orchioides, E. fusiformis, H. indicus, P. herbacea, P. crotalarioides, O. obtusata, R. suffruticosa, S. febrifuga, W. fruticosa*) and these herbaceous species are very prone to be wiped out from the habitat in near future due to over exploitation, anthoropogenic activities and due to lack of awareness of sustainable harvesting practices.

Frequent citation of the species proves their huge cultural recognition, reliability and promising scopes for research in an ethno-directed way. In this regard, the documented species could be considered promising candidates for bioprospecting. On the contrary, the plants which are highly cited might face extinction threat in near future due to a huge use-pressure building. Such extinction of a species might be coupled with the permanent loss of the therapeutic knowledge among the ethnic people.

IUCN status and conservation aspects of the reported medicinal plants

The current IUCN Red List Status of the 40 reported medicinal plant species was scrutinized and tabulated in Table 2. It has been found that out of a total 40, two taxa- *C.collinus* (https://www.iucnredlist.org/species/34271/9855293) and *J. nana* (https://www.iucnredlist.org/search?query=Jatropha%20nana&searchType=species) are presently included under Vulnerable (VU) category therefore facing a high risk of extinction from the forest localities of the district, whereas 6 species:
E. prostrata (https://www.iucnredlist.org/species/164051/121894451),
H. speciosa (https://www.iucnredlist.org/search?query=hellinia%20speciosa&searchType=species),
L. glutinosa (https://www.iucnredlist.org/species/145824211/153621601),
P. acerifolium (https://www.iucnredlist.org/species/61786850/61786854),
*R. hypocrateriformis (*https://www.iucnredlist.org/species/150129474/150219659),
W. fruticosa (https://www.iucnredlist.org/species/39058/10160263)
came under Least Concern (LC) category, and the status of remaining 32 species is not assessed till date following the IUCN criteria for Red Listing(Figure 10). Therefore, a good possibility is that these 32 species are quite available in the surveyed localities and currently not under any serious threat. However, plants which come under VU category need special concern and measures for immediate conservation as they are exploited for medicinal uses. The plants which presently come under LC category might fall in any of the core IUCN threat categories in near future.

Conclusion

The present study first time documented traditional knowledge on 40 valuable medicinal plants used by the folk-healers belonging to Santal community of district Birbhum, West Bengal using various quantitative ethnobotanical tools. The study will enrich the existing People's Biodiversity Register and ethnomedicinal database of the state as well as for India. It will also cater better option to select medicinal plants for their bioactivity studies and development of effective and eco-friendly drugs. Unfortunately a huge gap of knowledge transmission from the older to the younger generation is prevailing in the society. Therefore we believe there is a need of government initiatives for giving recognition to the Medicine Men of Birbhum district. This endeavour will boost up the traditional knowledge flow among the younger generation of the concerned society.

Repeated citation of large number of plants and their way of utilization to treat different kinds of ailments like urino-genital, skeleton-muscular, gynaecological, respiratory etc. clarify that a bulk amount of plant parts are collected by the informants. It undoubtedly pointed huge collection pressure on the medicinal forest flora of the district. Some plants like *J. nana, C. collinus* require special attention under conservation priority program as their populations are presently threatened and at the same time precious to the medicine culture of the study area. A collaborative effort by taxonomists, ethnobotanists, pharmacologist and conservation biologist will boost the success rate in bioprospecting studies for the discovery of lead molecules and development of potential plant based- drugs while conserving the valuable resources through *in-situ* and *ex-situ* conservation measures.

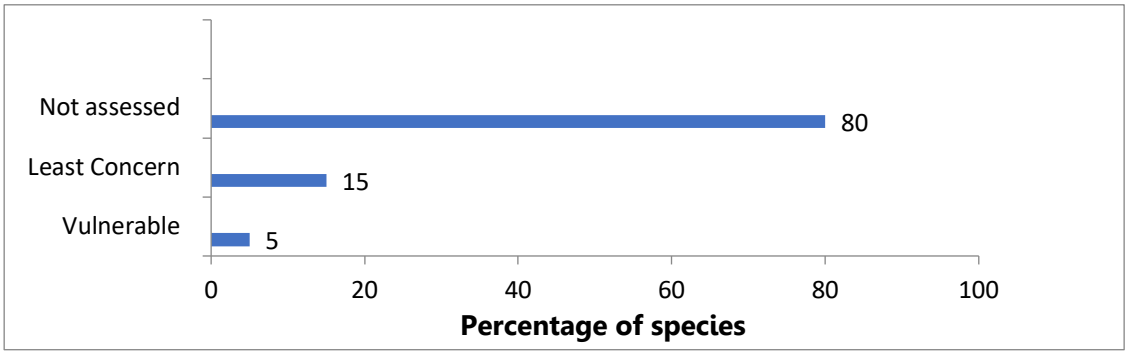

Figure 10. IUCN Red List status of the reported medicinal plant species

Declarations

List of abbreviations: WHO (World Health Organization), **IUCN** (International Union for Conservation of Nature & Natural Resources), **POWO** (Plant Of the World Online), **WFO** (World Flora Online), $\mathbf{F_{ic}}$(Informants' Consensus Factor), $\mathbf{N_{ur}}$ (Number of Use Report), $\mathbf{N_t}$ (Number of Taxa), **FL** (Fidelity Level),**RFC**(Relative Frequency of Citation), **FC** (Frequency of Citation), **VU** (Vulnerable), **LC** (Least Concern), **NA** (Not Assessed).

Ethics approval and consent to participate: All participants gave oral prior informed consent.

Consent for publication: Free and Oral permission.

Availability of data and materials: Plant Samples (herbarium) were submitted in the herbarium section of the affiliated colleges of both authors. Rest details available in this manuscript.

Competing interests: No potential conflict of interest was reported by the authors.

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Authors' contributions: B. Pradhan and S. Mondal designed the study, carried out field survey, collected and analyzed ethnomedicinal data, finalized result descriptions and figures. S. Mondal wrote and edited the manuscript to its final shape. Both the authors read and critically checked the manuscript and finally agreed for the submission of this manuscript.

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