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Ethnomedicinal plants used to treat bone fracture from North-Central Western Ghats of India

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ABSTRACT

Ethnopharmacological relevance: North Central Western Ghats in India comprises rich bio-cultural diversity and is also home to varied ethnomedicinal practices. The study was taken up for documentation and analysis of traditional knowledge regarding the practice and use of plants in the treatment of bone fracture. This is an effort to preserve the vanishing wealth of traditional knowledge.
Materials and methods: Key informants identified in a preliminary survey and collection of information was through semi structured, open ended interviews. The details on age, place of practice, experience of key informants and learning of practice, disease they treat and mode of diagnosis, storage and usage of plants were collected. The identity of plants and their information was confirmed through repeated guided transect walks in different seasons with the informants and focus group discussions. Identified plants were deposited at the herbaria of Regional Medical Research Centre, Belgaum.
Results: Forty four key informants providing treatment for bone fracture in this region were identified. Thirty eight plant species belonging to 24 families have been documented in the present study. Highest number of species representation is found in families Euphorbiaceae and Fabaceae. The habit of the species showed that 45% of the herbal drugs were obtained from trees, followed by herbs, shrubs and climbers and majority of plants used were collected from wild (76%). The stem or stem bark (33%) was most commonly used plant part to prepare medicine. Twenty six formulations of 30 plant species were directly used in treating bone fracture, where *Cissus quadrangularis* has the highest use-value (0.14). Eleven plants were found to be administered for bone strengthening, pain relieving, inflammation reduction and speedy recovery and *Gmelina arborea* has the highest use value (0.27).
Conclusions: The results indicated the importance of traditional herbal practices in community for their health needs. Both conservational strategies and further validation studies are the need of the hour for better utilization and sustenance of the documented knowledge.

1. Introduction

In spite of enormous progress in modern medical system, about 80% of the world population still depends on traditional systems of medicine for primary health care, which is true in Indian scenario also (Anonymous, 2002). Medicine in contemporary India is a fascinating blend of traditional system with conventional one and often been used for various historical, cultural and ecological and socio economical reasons (Khan, 2006; Kunwar et al., 2010). Even though the rate of medicinal plant utility is ever increasing, very little is known about its use patterns. It is very important to document, analyze and evaluate this knowledge not only for their cultural reasons, but also for their commercial value, as ethnomedicinal uses of plants is one of the most successful criteria used by the pharmaceutical industry in finding new therapeutic agents (Cox and Balick, 1994).

The traditional system of medicine, especially the herbal medicine, in India is directly linked to its rich floral diversity. The Western Ghats of India is one such high bio-cultural diversity region, which is one of the global biodiversity hot-spots (Myers et al., 2000). Several attempts have been made to document the vast ethnobotanical information from the region in the form of general documentation (Bhandary and Chandrashekar, 2002; Parinitha et al., 2004; Rajasab and Isaq, 2004; Siddamallayya et al., 2004; Prakasha and Krishnappa, 2006; Upadhya et al., 2009; Prakasha et al., 2010; Rajakumar and Shivanna, 2010), tribal case studies (Bhandary et al., 1995; Harsha et al., 2002) and selected ailments (Harsha et al., 2003; Hebbar et al., 2004; Hegde

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et al., 2007). Only hand full of references (Lal, 1988; Venkataratnam and Venkataraju, 2008) are available, which have attempted to study and understand medicinal plants used in treatment of bone fracture. The present work is an effort to document and analyze the traditional knowledge regarding the practice and use of plants in treatment of bone fracture.

2. Materials and methods

2.1. Study area

Two districts from North-West Karnataka in Southern India, Belgaum and Uttara Kannada (Fig. 1) have been selected for the study (latitude 13°55 to 16°58′ N. and longitude 74°5′ to 75°28′ E). The total area of these two districts is approximately 23,635 km^2, which is in the heart of North Central Western Ghats. The topology of the area comprises of hilly and semi-hilly tracts and plains. The average rainfall varies from 350 mm to 2741 mm as one moves from plain to hilly region. The varied geography and rainfall pattern is reflected in its vegetation, which varies from scrub and thorny forest, dry and moist deciduous to semi-evergreen and evergreen forest types.

Total population of the area is 6,215,313 (Census, 2010), which comprises of several communities, tribes and castes such as Agasa, Banjara, Bant, Beda, Bedara, Bhois, Gonda, Gouli, Halakki Vokkaliga, Holayas, Kurubaru, Naikdas, Kumbis, Kunabi, Siddhi and Valmiki. More than half of the population is residing in rural areas, which has an easy access to traditional herbal medicine than the modern medicine facilities.

2.2. Selection of key informants

The traditional practitioners, as recommended by WHO (Anonymous, 1976) were considered as the 'Key Informants'. As the present work is confined to bone fracture, the traditional practitioners offering treatment for bone fracture and related complications, who are ready to share their practicing knowledge, have been considered as 'Key Informants'.

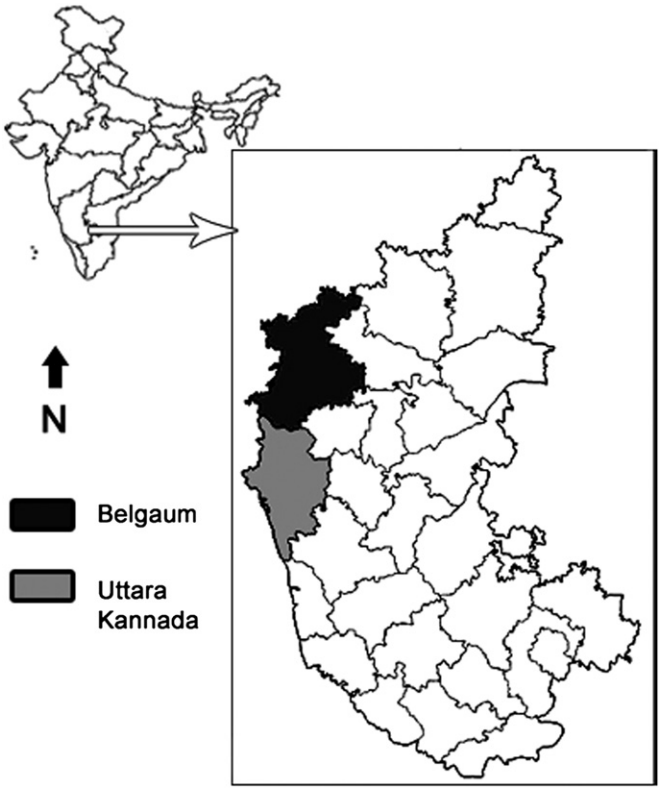

Fig. 1. Map of Karnataka showing study area.

2.3. Ethnomedicinal survey

The contact of key informants in the area have been collected from various sources like local Non-Government Organizations, village chiefs, crude drug venders, school and primary health center staff and patients attending to traditional practices. Once the rapport with key informants has been built up, the aim and objectives of the study has been explained to them in local languages to obtain their consent.

The collection of information was through semi-structured, open-ended interviews as suggested by Martin (1995). The details on age, place of practice, learning of practice, disease they treat and mode of diagnosis, storage and usage of plants were collected during interviews. The identification and confirmation of the medicinal plant species used by key informants were made through specimen display method (Bhattarai et al., 2006). The identity and information was confirmed through repeated guided transect walks in different seasons with the informants and focus group discussions (Martin, 1995; Maundu, 1995).

2.4. Plant identification and herbaria

Flowering plant specimens, mentioned for treatment, were collected during the guided transect walk by a group of researchers comprising of botanist (Mr. Vinayak Upadhya), pharmacognosist (Dr. Pramod J. Hurkadale), taxonomist (Dr. Harsha V. Hegde and Dr. G.R. Hegde) and community medicine (Mr. Shripad Bhat). The plant specimens were botanically identified using published floras (Cooke, 1901–1908; Saldanha, 1984; Yadav and Sardesai, 2002) and authenticated by comparing with the earlier collections at Regional Medical Research Centre (ICMR), Belgaum. Voucher specimens were prepared and deposited at the herbaria of Regional Medical Research Centre (ICMR), Belgaum.

2.5. Data analysis

The information such as botanical name, family, local name, habit and habitat nature, parts used, mode of preparation, number of citation per plant as per key informants, use value and voucher number were provided to each plant species. The results were tabulated separately in to plant species directly used in treating bone fracture and plants used for bone strengthening, pain relieving, reducing inflammation and speedy recovery purposes.

The data in each table was analyzed separately. The use value (UV) was calculated for each species (adapted from Phillips et al. (1994)), which demonstrates the relative importance of species known locally. Use value of species was calculated using the formula $UV = \sum U/n$, where: U was the number of citations per species; n was the number of informants. The assumption was that every informant had equal chance of mentioning any of the species used in medicinal purpose in the area. Hence the use value was based objectively on the importance attributed by the informants and does not depend on the opinion of the researcher. The botanical family use value (FUV) was calculated using the formula $FUV = \sum UV/nf$, where UV was use value of the species in the family and nf was the number of species reported in the family (Muthee et al., 2011).

3. Results and discussion

3.1. Knowledge of informants

Among the 235 identified traditional practitioners, 44 were considered as key informants who provide treatment for bone fracture. The less number of women folk in traditional medicinal practice was observed from various regions earlier (Teklehaymanot et al., 2007; Muthee et al., 2011) is true in the present study also, as only three among the key informants were women. Average age of the informants was 55 years, similar to observations of Muthee et al. (2011), with maximum age of 85 years and minimum of 28. The knowledge transfer from one generation to the next was in verbal mode, maybe in the same family, same community or to the interested outsider, as a global phenomenon (Bhishaw, 1990; Teklehaymanot et al., 2007; Nanyingi et al., 2008). As per the informants, the learning of practice begins normally at the age of 15–20 and it takes about 10–15 years to acquire the full knowledge of the practice. The average citation of medicinal plant per informant was more than two, which indicate the good knowledge of informants about medicinal plants. Further, it was found that 11% of informants examine the x-ray reports either before setting the fractured bone or after bone setting. It was also observed that informants use both fresh plant materials and stored drugs for treatment. About 95% of the informants use bamboo sticks for supporting and immobilizing the bone after application of herbal preparation. Most of the informants were ready to teach the methodology of treatment; however the ground reality was that no younger generation has interest to take up and practice further (Namsa et al., 2011). This was one of the major reasons for diminishing of precious knowledge from the region.

3.2. Statistical analysis of the plants used

In all, 38 plant species belonging to 24 families have been documented in the present study (Tables 1 and 2). Highest number of species representation was found in families Euphorbiaceae and Fabaceae with five species each. This deviation from the existing general trend of medicinal plants, where Asteraceae leads with more medicinal species (Mac et al., 2005; Mia et al., 2009; Namsa et al., 2011) may be due to the easy availability of perennial trees and shrubs rather than annual, seasonal Asteraceae members for the usage. The value of the botanical family was highest for Verbenaceae, though represented by only one species, followed by Menispermaceae and Vitaceae with two species each. Thirty six genera were represented in the study where *Cissus* and *Tinospora* were represented by two species each. The habit of the species showed that 45% of the herbal drugs were obtained from trees, followed by herbs (26%), shrubs (16%) and climbers (13%). Majority of plants used were collected from wild (76%) indicating the species diversity and abundance in the study area. This also indicates the need for conservation measures, especially for those plants with high use value. The stem or stem bark (33%) was most commonly used plant part to prepare the medicine, followed by leaf (29%), root (13%), whole plant (11%), fruit or seed (9%) and gum or latex (4%). However, in few preparations it was observed that more than one part of the plant was used for medicinal preparation.

Among 26 formulations prepared from 30 plant species, only five formulations contained two herbal ingredients, while the rest were single herb preparations (Table 1). All the preparations were applied externally as paste or poultice as a plaster. Application of the prepared drug depends on the portion of fracture, severity and physical appearance of an individual. The broken bones were set together to right position and were supported by bamboo sticks and tied with rope. Duration of bandage varies from 7 to 60 days with a reapplication of herbal preparation once in 15 days. A few of the documented plant species in the present study have been mentioned for bone fracture treatment by earlier workers (Table 1). *Cissus quadrangularis* has the highest use-value (0.14) followed by *Baliospermum solanifolium* (0.10), *Persea macrantha* (0.07), *Tinospora cordifolia* and *Tinospora sinensis* (0.06), demonstrating their importance in local herbal medical practice. It should be noted that the low citation by informants for a particular species does not mean that it was having a less medicinal property, but it may be because other reasons such as of disappearance of knowledge or unavailability of the plants in their vicinity. When compared to the earlier study reports (in Table 1) 17 species of plants have been added to list of plants in the treatment of bone fracture during the present study.

Eleven plant species belonging to 10 families are found to be used for bone strengthening, pain relieving, inflammation reduction and speedy recovery (Table 2). The administration routes were both oral (58%) and external application (42%). The external applications were for pain relieving or to reduce the inflammation, whereas oral administration was preferred for bone strengthening and speedy recovery. Decoctions and juices were the normal mode of preparations, mostly using water. Again the dosage depends on several factors. In each case, fistful of plant parts was used for preparation which accounted for about 250 mg. *Gmelina arborea* has the highest use value (0.27) among the recorded plants, indicating its wide usage. The utility of the same was mentioned earlier for treatment of bone fracture in both humans (Venkataratnam and Venkataraju, 2008) and animals (Harsha et al., 2002; Rajakumar and Shivanna, 2010).

Cynodon dactylon, *Tinospora cordifolia* and *Tinospora sinensis* were the three species which were administered both externally and internally (Tables 1 and 2). The latter two species were common in the region and on several occasions, the informants identify both *Tinospora* species as same (Amruta Balli or Amrut vel). Even though the utility of *Tinospora sinensis* as a substitute for *Tinospora cordifolia* was reported earlier (Sinha et al., 2004; Udayan et al., 2004), further scientific studies are required to prove its safety and efficacy in the treatment of bone fracture.

Healing of fractured bone is a natural proliferative physiological process within the body (Chen et al., 2010). In the present study it was observed that, key informants relocate the dislocated bone back and immobilize it with the help of bamboo sticks. This practice will help in proper joining of the bones. It is believed that the application of plant drug have some beneficial effects, especially in faster recovery of fractured bone. The plant *Cissus quadrangularis* has been well studied in this regard and its bone fracture healing ability was established (Udupa and Prasad, 1962, 1964a, b; Chopra et al., 1976; Deka et al., 1994). Similarly beneficial effects of b-ecdysone isolated from *Tinospora cordifolia* on joint, epiphyseal cartilage tissue and trabecular bone was also well documented (Kapur et al., 2008, 2010).

Several species used in the present study like *Abrus precatorius* (Anam, 2001), *Cassia fistula* (Bhakta et al., 2000; Ilavarasan et al., 2005; Rajeswari et al., 2006), *Senna tora* (Maity et al., 1998), *Cynodon dactylon* (Sindhu et al., 2009), *Ficus benghalensis* (Patil et al., 2009; Thakare et al., 2010), *Glochidion heyneanum* (Chaitanya et al., 2011), *Moringa oleifera* (Cáceres et al., 1992), *Nyctanthes arbor-tristis* (Saxena et al., 1984), *Ocimum basilicum* (Selvakkumar et al., 2007; Singh, 1999), *Peristrophe paniculata* (Rathi et al., 2003), *Persea macrantha* (Kulkarni et al., 2009; Tatiya and Saluja, 2011), *Millettia pinnata* (Singh and Pandey, 1996; Srinivasan et al., 2001), *Terminalia cuneata* (Halder et al., 2009; Biswas et al., 2011) and *Tinospora sinensis* (Li et al., 2003) were proved to have anti-inflammatory activities. These species could be taken up for further studies on their efficacies in treating bone fracture. These scientific studies not only support their usage in

Table 1
Plants used for treating bone fracture.

Species/voucher specimen number	Local name	Habit/habitat	Parts	Type	Ct[a]	UV[b]	References
Acanthaceae							
Blepharis integrifolia (L.f.) E.Mey. & Drege ex Schinz. RMRC1011	[K]Harida hacchaga	H/W	Whole plant	Poultice	1	0.01	
Dicliptera paniculata (Frossk.) I.Darbysh. RMRC1032	[K]Eluvu sandhi	H/W	Leaf	Paste	1	0.01	
Anacardiaceae							
Holigarna grahamii (Wight) Krtz. RMRC1024	[M]Padagus	T/W	Bark	Paste	1	0.01	Upadhya et al. (2009)
Araceae							
Amorphophallus paeoniifolius (Dennst.) Nicolson RMRC1003	[K]Suvarna gadde	H/C	Corn	Paste	1	0.01	
Pothos scandens L. RMRC1034	[M]Bendurli	H/W	Whole plant	Paste	2	0.03	Das et al. (2008)
Combretaceae							
Terminalia cuneata Roth RMRC1040	[K]Arjuna	T/W	Stem bark	Paste	1	0.01	Kirtikar and Basu (1999); Phondani et al. (2010)
Ebenaceae							
Diospyros montana Roxb. RMRC1023	[K]Balagane	T/W	Leaf	Slimy paste	2	0.03	
Euphorbiaceae							
Antidesma acidum Retz. RMRC1002	[K]Hulimajjige kolu	Sh/W	Bark	Paste and poultice	1	0.01	
Bridelia stipularis (L.) Blume RMRC1009	[K]Bolatatle naru	Sh/W	Bark		1	0.01	
Baliospermum solanifolium (Geiseler) Suresh RMRC1010	[K]Nagadanti	Sh/W	Root	Paste	7	0.10	Ignacimuthu et al. (2006)
Glochidion heyneanum (Wight & Arn.) Wight RMRC1027	[M]Moodi	T/W	Stem	Paste	1	0.01	
Fabaceae							
Abrus precatorious L. RMRC1001	[K]Gulagangi [M]Gunja	H/W	Root/seeds	Paste	2	0.03	Anam (2001)
Cassia fistula L. RMRC1015	[M]Bava, [K]Kakke mara	T/W	Stem bark		2	0.03	Basha and Sudarshanam (2010); Venkataratnam and Venkataraju (2008)
Senna tora (L.) Roxb. RMRC1014	[K]Tagache	H/W	Leaf	Paste	2	0.03	Upadhya et al. (2009)
Millettia pinnata (L.) Panigrahi & Murti RMRC1033	[M]Karang [K]Honge	T/C	Leaf	Paste	2	0.03	
Tamarindus indica L. RMRC1035	[K]Hunasi	T/C	Leaf	Paste	1	0.01	
Flacourtiaceae							
Casearia tomentosa Roxb. RMRC1013	[M]Modi, [K]Chinagi gida	T/W	Leaf	Paste	2	0.03	Upadhya et al. (2009)
Lamiaceae							
Ocimum basilicum L. RMRC1030	[K;M]Tulasi	H/C	Leaf	Paste	1	0.01	
Lauraceae							
Cinnamomum wightii Meisn. RMRC1028	[K]Dalchini	T/W	Bark		2	0.03	
Persea macrantha (Nees) Kosterm. RMRC1026	[K;M]Gulamavu	T/W	Stem/bark	Paste or poultice	5	0.07	
Menispermaceae							
Tinospora cordifolia (Willd.) Miers RMRC1044	[K]Amruta balli [M]Amrut vel	Cl/W	Stem/leaf	Paste	4	0.06	Chakraborty and Bhattacharjee (2006); Kirtikar and Basu (1999)
Tinospora sinensis (Lour.) Merr. RMRC1045	[K]Amruta balli [M]Amrut vel	Cl/W	Stem/leaf	Paste	4	0.06	
Moraceae							
Ficus benghalensis L. RMRC1025	[K]Aala	T/W	Leaf	Paste	1	0.01	
Moringaceae							
Moringa oleifera Lam. RMRC1018	[K]Nugge	T/C	Gum and root		2	0.03	Anisuzzaman et al. (2007); Mia et al. (2009)
Oleaceae							
Nyctanthes arbor-tristis L. RMRC1029	[K]Parijata	T/C	Root	Paste	1	0.01	Meena and Rao (2010)
Poaceae							
Cynodon dactylon (L.) Pers. RMRC1022	[K]Garike	H/W	Whole plants	Paste	3	0.04	Britto et al. (2010)
Rutaceae							
Citrus limon (L.) Burm.f. RMRC1005	[K]Nimbe hannu	Sh/C	Fruit		1	0.01	
Zanthoxylum rhetsa (Roxb.) DC. RMRC1004	[K]Jumma	T/W	Seeds	Crushed	3	0.04	
Vitaceae							
Cissus quadrangularis L. RMRC1020	[K]Mungagorli	Cl/W	Stem	Paste	10	0.14	Kirtikar and Basu (1999); Mia et al. (2009); Rahmatullah et al. (2011)
Cissus sp. RMRC1021	[K]Mungagorli	Cl/W	Stem	Paste	3	0.04	

[K]Kannada; [M]Marathi; W—Wild; C—Cultivated; T—Tree; Cl—Climber; H—Herb; Sh—Shrub.

[a] Number of citations.

[b] User value.

Table 2
Plants used for bone strengthening, pain relieving and inflammation reduction.

Species/voucher specimen number	Local name	Habit/ habitat	Part	Application/ route	Purpose	Ct[a]	UV[b]
Asclepidaceae							
Calotropis procera (Aiton) Dryand. RMRC1012	[K]Ekke	Sh/W	Latex	Latex/E	For Bone hardening & pain reliever	1	0.02
Caricaceae							
Carica papaya L. RMRC1007	[K]Pappayi	T/C	Fruit	Paste/E and Juice/Slice/I	Applied and given orally for speedy recovery	4	0.08
Euphorbiaceae							
Ricinus communis L. RMRC1017	[M]Eranda	Sh/W	Leaf	Paste/E	Pain reliever	2	0.04
Liliaceae							
Asparagus racemosus Willd. RMRC1042	[K]Shatavari	C/W	Root	Decoction/I	For speedy recovery	3	0.06
Malvaceae							
Urena lobata L. RMRC1008	[K]Kadu bende	H/W	Whole plant	Decoction/I	For bones hardening after bone setting.	3	0.06
Menispermaceae							
Tinospora cordifolia (Willd.) Miers RMRC1044	[K]Amruta balli [M]Amrut vel	Cl/W	Stem/Leaf	Decoction/I	For bone strengthening	6	0.13
Tinospora sinensis (Lour.) Merr RMRC1045	[K]Amruta balli [M]Amrut vel	Cl/W	Stem	Decoction/I	For bone strengthening	6	0.13
Pedaliaceae							
Sesamum indicum L. RMRC1031	[K]Ellu	H/C	Seed	Oil/E	Pain reliever	4	0.08
Poaceae							
Cynodon dactylon (L.) Pers. RMRC1022	[K]Garike	H/W	Whole plant	Decoction/I	For speedy recovery.	3	0.06
Sapotaceae							
Madhuca longifolia (J. Konig ex. L.) J.F.Macbr. RMRC1016	[K]Eppemara	T/W	Seed	Ghee/E	Used as massage oil to set the broken bones.	3	0.06
Verbenaceae							
Gmelina arborea Roxb. RMRC1036	[K]Shivane	T/W	Leaf	Juice/I	For bone strengthening after bone setting	13	0.27

[K]Kannada; [M]Marathi; W—Wild; C—Cultivated; T—Tree; Cl—Climber; H—Herb; Sh—Shrub; I—Internal; E—External.

[a] Number of citations.

[b] User value.

traditional medicine, but also provide value addition for their use in the treatment of bone fracture.

4. Conclusion

Even though the very objective of the present study is documentation of the diminishing wealth of traditional knowledge for future, it opens up an array of opportunities for further studies. The scientific validation of the claims in the present study is priority among them, which not only authenticate the age old practice, but also contribute towards possible new drugs from herbal sources. Efforts in this direction may provide the benefit of regional information to the global community.

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