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RESEARCH ARTICLE

An ethnomedicinal survey of traditionally used medicinal plants for the treatment of snakebite in Morigaon district of Assam, India

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Abstract: In this study we documented the medicinal plants traditionally used for the treatment of snakebite patients in Morigaon district of Assam, North East India. Groups of villagers (both male and female) in the age group of 40-75 years and traditional medical practitioners were interviewed. We identified 19 medicinal plants that are use in treatment of snakebite cases. One each species belonging to families of Amaranthaceae, Apiaceae, Araliaceae, Asparagaceae, Bignoniaceae, Cactaceae, Colchicaceae, Compositae, Euphorbiaceae, Piperaceae, Polygonaceae, Rutaceae, two each belonging to Phyllanthaceae and Leguminosae, and three belonging to Lamiaceae. Most of these plants are grown in wild except a few of them are cultivated either as a source of food or as an ornamental plant. The leaf is the most common part for medicinal use; however, fruits, seeds, roots and tubers are also frequently used for treating the snakebite patients. Some of these plants are also found to be used as medicine for other ailments. The method of preparation of the medicine is aqueous extraction of desired plant parts or preparation of the paste which is then administered orally or applied topically to the bite site. The dose and time of administration of these medicinal plants as antidote for treatment of snakebite depends on the severity and time of accident.

Keywords: Snakebite therapy; Medicinal plants; Traditional knowledge; Ethnobotany.

Introduction

Snakebite is a public health hazard and needs immediate medical attention. This problem is more acute in rural populations of the tropical countries such as India, Bangladesh, Pakistan, Myanmar, Thailand etc. (Harrison et al. 2009). Recently, WHO in 2009 has declared snakebite as a "Neglected Tropical Disease" and therefore, it is a major health concern for the tropical countries (www.who.int/neglected_diseases/diseases/en). The problem of snakebite is more acute in Asia particularly in the South East Asia. In India, it has been estimated that around 1,300 to 50,000 people are bitten by poisonous snakes (Swroop and Grab 1954;Chippaux 1998;Kasturiratne et al. 2008). It has recently been reported that people in the age group of 15-29 years are the major victims in India. A comparison showed males (59%) are more bitten by snakes as compared to the females (41%). Maximum snakebite incidence takes place during the months of June to September (Mohapatra et al. 2011). Due to lack of properly coordinated epidemiological survey programme, most of the snakebites which occur in rural areas are unreported; hence the hospital data might be less than the actual incidence of snakebite cases. Therefore, lack of true data results in an underestimation of snakebite cases (Fox et al. 2006; Gutierrez et al. 2010). Till date, the best available therapy for treatment of snakebite cases is immediate administration of polyvalent antivenom. However, this therapy has many limitations like serum sickness and anaphylactic reactions (Gilon et al. 1989; Russell et al. 1985). Moreover, it has also been reported that antivenom does not provide complete protection against haemorrhage, necrosis, nephrotoxicity induced during envenomation (Sutherland 1992; Stahel et al. 1985; Thwin et al. 2010; Theakston et al. 2003). Therefore, finding ways to neutralize the multiple toxicities generated post envenomation is a major challenge to the clinicians, and hence search for an alternative to antivenom therapy for treating the snakebite cases is inevitable.

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India has a rich heritage of medicinal plants. Perusals of literature show that plants have been used as source of medicine by the local healers and traditional practitioners for the treatment of various diseases including snakebite. This traditional knowledge or "know how", is transferred from generation to generation by word of mouth, and has been practiced by traditional unregistered medical practitioners locally known as "Bej". It is noteworthy to mention that majority of such traditional medicines have been in practice from many years without any proper documentation and scientific validation. Thus ethnobotanical survey of local medicinal use can be a major driving force for preserving this traditional heritage of the indigenous people and harnessing of these natural resources may aid substantially in plant based novel drug discoveries. During the last few decades, many researchers throughout the world have explored the medicinal plants for identification and isolation of active components from such plants for use as antidote against snakebite (Mahanta and Mukherjee 2001; Mukherjee et al. 2008; Chatterjee et al. 2006; Da Silva et al. 2008; Shirwaikar et al. 2004). However, such work may further be extended for exploring the vast amounts of traditional knowledge of the indigenous people.

North-east region of India is considered as one of the "hot-spot" or "mega biodiversity" regions of the world, thus harbouring many unexplored flora and fauna. The aim of the present study is ethnobotanical survey of the use of medicinal plants for the treatment of snakebite cases by the traditional practitioners in Morigaon district of Assam, North-East India. Over the time, this oral traditional knowledge which is limited to only a certain group of indigenous people is gradually diminishing for many reasons. One major reason is, the traditional practitioners are protective of their knowledge and are hesitant to share this knowledge with the other community members. Secondly, the younger generation does not express interest in this traditional practice. Thus documentation of this traditional knowledge will help us to validate their claim of medicinal properties including proper conservation of such plants. Further, such documentation will have far reaching effect in realizing the importance of preservation and cultivation of medicinal plants, which are being destroyed due to deforestation and urbanization.

Material and methods

Study area

Morigaon district of Assam, India is located between 89° 42′ E to 96° E longitude and 24° 8′ N to 28° 2′ N latitude, covering an area of 1,450.02 square km. This area was chosen for the study because every year, around 5-10 people are brought to the district hospital for the treatment of snakebite cases. After interviewing local people it was recorded that as many as 15-20 snakebite cases occur annually, particularly during the monsoon season. People living in the rural areas, away from the district hospital, have to be dependent on traditional medicine. Moreover, many of the people from this region have a strong faith on traditional medicines. Therefore, the initial treatment for snakebite patients from different parts of this region is to consult traditional practitioners for treatment.

Data collection

People between the age group of 40–75 years were interviewed for information on traditional practitioners involved in treatment of snakebite patients. Data on use of medicinal plants for the treatment of snakebite patients were also collected from this age group of people using open questionnaires. Identified traditional practitioners were interviewed for information on medicinal plants used for the treatment of snakebite patients, as well as the number of snakebite patients that were treated by them for the last 5 years. The questionnaires were prepared to record the local names of the plant species, medicinal uses, parts used and methods of preparation, dose and route of administration. Further, information on methods of harvesting such plant materials for antidote preparation was also recorded. Plant specimens were identified with the help of the practitioners and photographed using a digital camera (Canon D1000). Plant specimens were collected and herbarium sheets were prepared for proper identification and preservation.

Results

Collection of medicinal plants

During the present study 19 medicinal plant species belonging to 15 families have been identified and collected based on the information obtained from the local people and the traditional practitioners of Morigaon districts which are commonly used for the treatment of snakebite patients (Table 1 & Figure 1). In addition to this they use these plants for treatment of various other ailments such as skin disease, fever, indigestion, wound healing etc (Table 2). These plant species belonging to families of Amaranthaceae, Apiaceae, Araliaceae, Asparagaceae, Bignoniaceae, Cactaceae, Colchicaceae, Compositae, Euphorbiaceae, Piperaceae, Polygonaceae, Rutaceae, Phyllanthaceae Leguminosae, and Lamiaceae. Most of these plants grow in the wild either near to the villages or in the forests. However, few of them are also cultivated either to get the fruit from plants or the whole plant is edible. The parts of the plant used for treatment of the snakebite patients include mature and immature leaves, seeds, fruits as well as roots and tubers. Use of leaves as antidote was found to be 63% followed by seeds, root, tuber and fruits (Figure 2).

Table 1: List of medicinal used for the treatment of snakebite in Morigaon district of Assam.

S No	Scientific name	Family	Habitat	Vernacular name	Parts used	Methods of preparation	Route of administration
1	*Psoralea coryfolia* L.	Leguminosae	Wild	Somraji	Seeds	Paste by crushing fresh seeds	Topical
2	*Pogostemon parviflorus* Benth	Lamiaceae	Wild	Sukloti	Roots	Paste by crushing fresh roots	Topical
3	*Amaranthus viridis* L	Amaranthaceae	Wild	Kata Khutura	Leaves	Paste by crushing fresh leaves	Topical
4	*Xanthium strumarium* L	Compositae	Wild	Agora	Leaves	Paste by crushing fresh leaves	Topical
5	*Glycosmis pentaphyla* (Retz.) DC	Rutaceae	Wild	Sauldhuwa	leaves	Paste by crushing fresh leaves	Topical
6	*Acacia pennata* (L.) Willd	Leguminosae	Wild	Kusia lota	Leaves	Paste by crushing fresh leaves	Topical
7	*Heterophragma adenophyllum*	Bignoniaceae	Wild	Dhupa paroli	Leaves	Paste by crushing fresh leaves	Topical
8	*Leucas linifolia* (Roth) Spreng	Lamiaceae	Wild	Doron	Immature leaves	Extraction of juice by crushing	Eye drop
9	*Foeniculum valgare* Mill	Apiaceae	Cultivated	Guamuri	Seed	Extraction of juice by crushing	Oral
10	*Baccaurea ramiflora* Lour	Phyllanthaceae	Cultivated	Leteku	Fruit	Extraction of juice by crushing	Oral
11	*Antidesma acidam* Retz	Phyllanthaceae	Wild/cultivated	Abutenga	Leaves	Extraction of juice by crushing	Oral
12	*Heteropanax fragrans* (Roxb.) Seem	Araliaceae	Wild/cultivated	Keseru	Leaves	Extraction of juice by crushing	Oral
13	*Gloriosa superb* L	Colchicaceae	Wild	Ulot sandal	Tuber	Extraction of juice by crushing	Oral
14	*Polygonum bracteatum* Spreng	Polygonaceae	Wild	Bihlongoni	Leaves	Decoction	Oral
15	*Mentha viridis* (L) L.	Lamiaceae	Cultivated	Pudina	Leaves	Decoction	Oral
16	*Piper longum* L	Piperaceae	Cultivated	Pipali	Seed	Decoction	Oral
17	*Acalypha indica* L	Euphorbiaceae	Wild	Muktajuri	Leaves	Decoction	Oral
18	*Sansevieria lourentii* De Wild	Asparagaceae	Wild/cultivated	Dopana	Root and Leaves	Decoction	Oral
19	*Opuntia dillenii* (Ker Gawl.) Haw	Cactaceae	Wild/cultivated	Sagarfena, nagfena	Stems.	Decoction	Oral

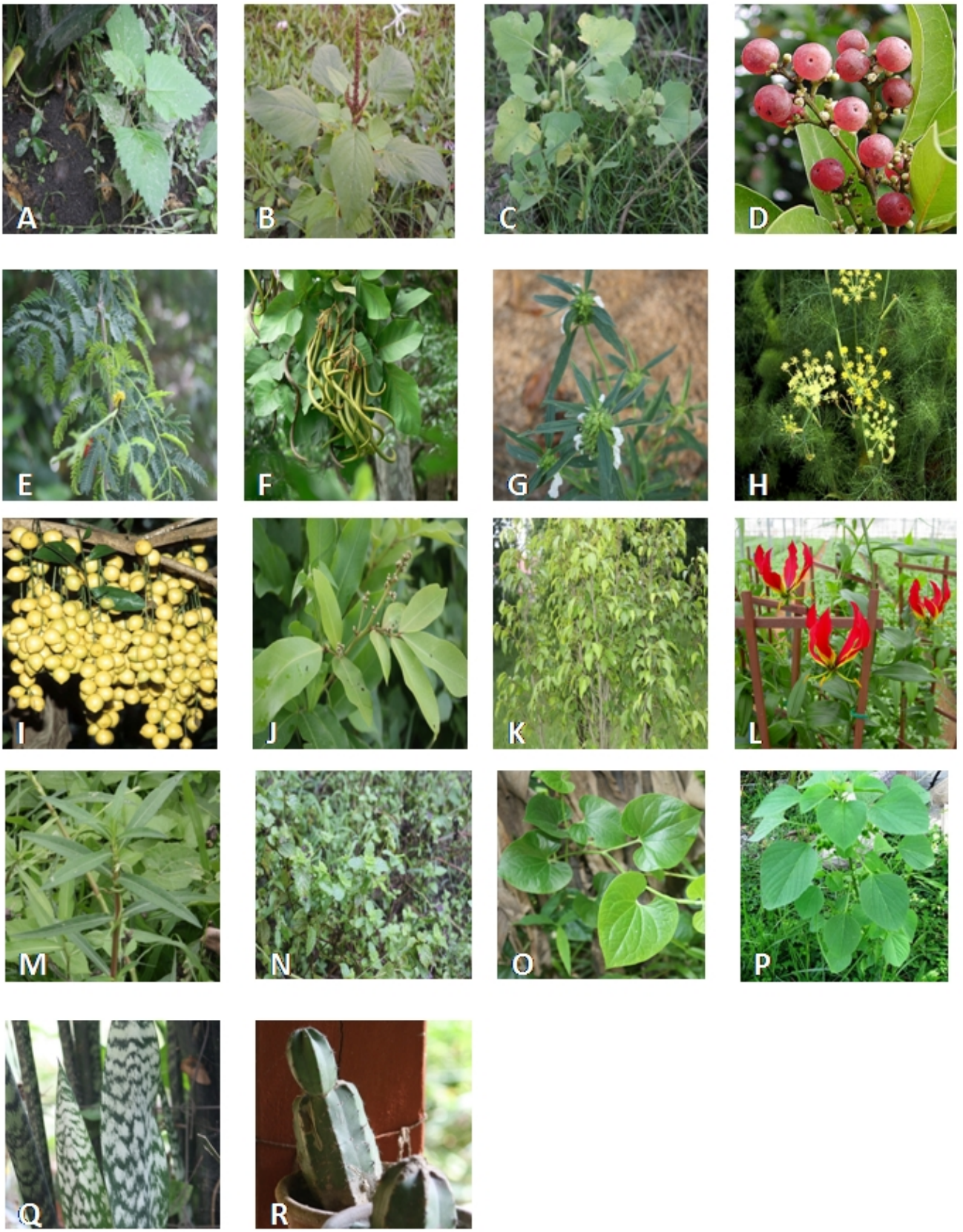

Figure 1: Photographs of medicinal plants. A: *Pogostemon parviflorus* B: *Amaranthus viridis*. C: *Xanthium strumarium*. D: *Glycosmis pentaphyla*. E: *Acacia pennata*. F: *Heterophragma adenophyllum*. G: *Leucas linifolia* H: *Foenieulum valgare*. I: *Bacccaurea ramiflora*. J: *Antidesma acidam*. K: *Heteropanax fragrans* L: *Gloriosa superb* M: *Polygonum bracteatum* N: *Mentha viridis* O: *Piper longum* P: *Acalypha indica* Q: *Sansevieria lourentii* R: *Opuntia dillenii*.

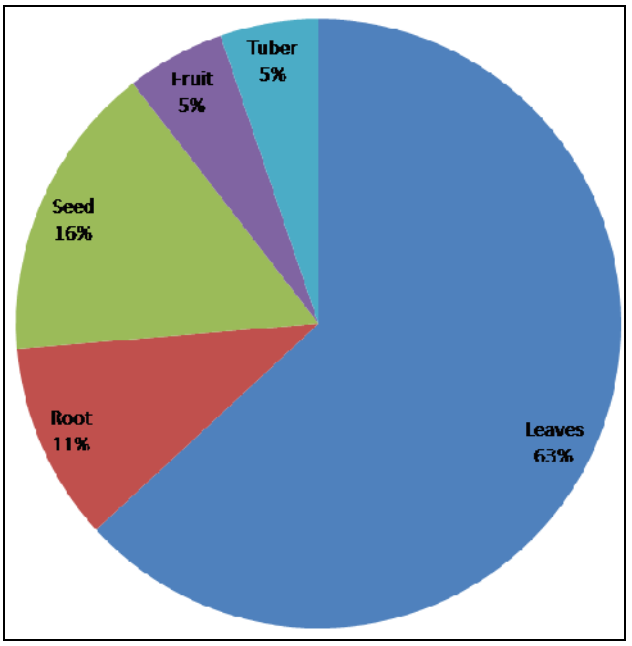

Figure 2: Plant parts used as antidote.

Traditional use

Traditionally, preparation of antidote for snakebite treatment includes (a) crushing of freshly collected plant parts using water (aqueous extraction), (b) preparation of paste or extraction of juice, and (c) in some cases preparation of decoction (Table 1). The method of treatment includes both oral administrations of decoction and/or topical application at the site of the bite to get relief from the pain. Normally, paste prepared from the medicinal plant is applied topically at the bite site if swelling is observed. This is followed by oral administration of juice prepared from crushing the leaves or decoction. For preparation of decoction, the plant parts are chopped into smaller pieces, boiled and concentrated into the extract, and then it is administered orally. In some cases the plant is boiled with other medicinal plants to prepare the medicine, which the traditional practitioners declined to reveal the combination, as well as the ratio of these different plants and other ingredients used for the preparation of the medicine.

Discussion

North East India is one of the biodiversity hot spot regions of the world and is rich in both plant and animal species. Only from Assam, more than 200 plant species have been reported to possess medicinal properties useful against various diseases (Bhattacharya et al. 1991). In addition to treating snakebites, the leaf has been reported to be the most common part for treating various other diseases as well (Amri and Kisangau 2012;Samy et al. 2008). Most bioactive compounds have been isolated and purified from leaves, owing to the fact that leaves are easy to collect and good source of compounds like ellagic acid, tannins, polyphenols, flavanoids and other alkaloids (Vishwanath et al. 1987;Mukherjee, Doley, and Saikia 2008;Biondo et al. 2003;Cavalcante et al. 2007;Shirwaikar, Rajendran, Bodla, and Kumar 2004).

In this region the most common venomous snakes found are *Naja kaouthia* (Monocled cobra), *Naja naja* (Spectacle cobra) and *Bungarus faciatus* (Banded krait) and mildly venomous snake *Rhabdophis subminiatus* (Red neck keel back). The local practitioners identify the bite of a particular snake by looking at the bite site and appearance of symptoms after envenomation. If two distinct spots are observed at the bite site, the patient could have been bitten by either *Naja kaouthia* or *Naja naja*. If two round spots are found at the bite site it might be due to krait bite (personal communication). Normally, paste prepared from the medicinal plant is applied topically at the bite site if swelling is observed. This is followed by oral administration of juice prepared from crushing the leaves or decoction. Fresh leaves of *Psoralea coryfolia L, Pogostemon parviflorus Benth, Amaranthus viridis L, Xanthium strumarium L, Glycosmis pentaphyla (Retz.) DC, Acacia pennata (L.) Willd* and *Heterophragma adenophyllum* are crushed to make the paste. This paste is immediately applied topically at the site of bite. Whereas juice is extracted from the plant parts of *Leucas linifolia (Roth) Spreng, Foeniculum valgare Mill, Baccaurea ramiflora Lour, Antidesma acidam Retz, Heteropanax fragrans* (Roxb.) Seem, and *Gloriosa superb L* . and administered orally. Interestingly, the juice extracted from the immature leaves of *Leucas linifolia* is administered as eye drop. If the bite site is on the left side of the body, the right eye will be the recipient of the juice and *vice versa*. Leaf extract is prepared as a decoction from

Polygonum bracteatum, *Mentha viridis* and *Acalypha indica* which is then administered orally to the snakebite patients. Seeds of *Foeniculum valgare*, is crushed to extract the juice, while decoction is prepared from the seed of *Piper longum*, and stem of *Opuntia dillenii* for administration through oral route. For preparation of decoction, the plant parts are chopped into smaller pieces, then boiled and concentrated to prepare the extract, and then it is administered orally. In some cases the plant is boiled with other medicinal plants to prepare the medicine, which the traditional practitioners declined to reveal the combination, as well as the ratio of these different plants and other ingredients used for the preparation of the medicine. Further, it has also been observed in the present study that in almost all snakebite cases, part of single plant has found to use for treating the snakebite patients but some of the plants are recommended by more than one person for snakebite treatment. For example *Xanthium strumarium* have been found to be used by 25% of the traditional healers followed by *Baccaurea ramiflora*, *Antidesma acidam*, *Glycosmis pentaphyla* and *Amaranthus viridis* (Figure 3). In addition to this, these plants are commonly used by the traditional healer for treatments of other diseases like skin disease, fever, indigestion, wound healing etc (Table 2).

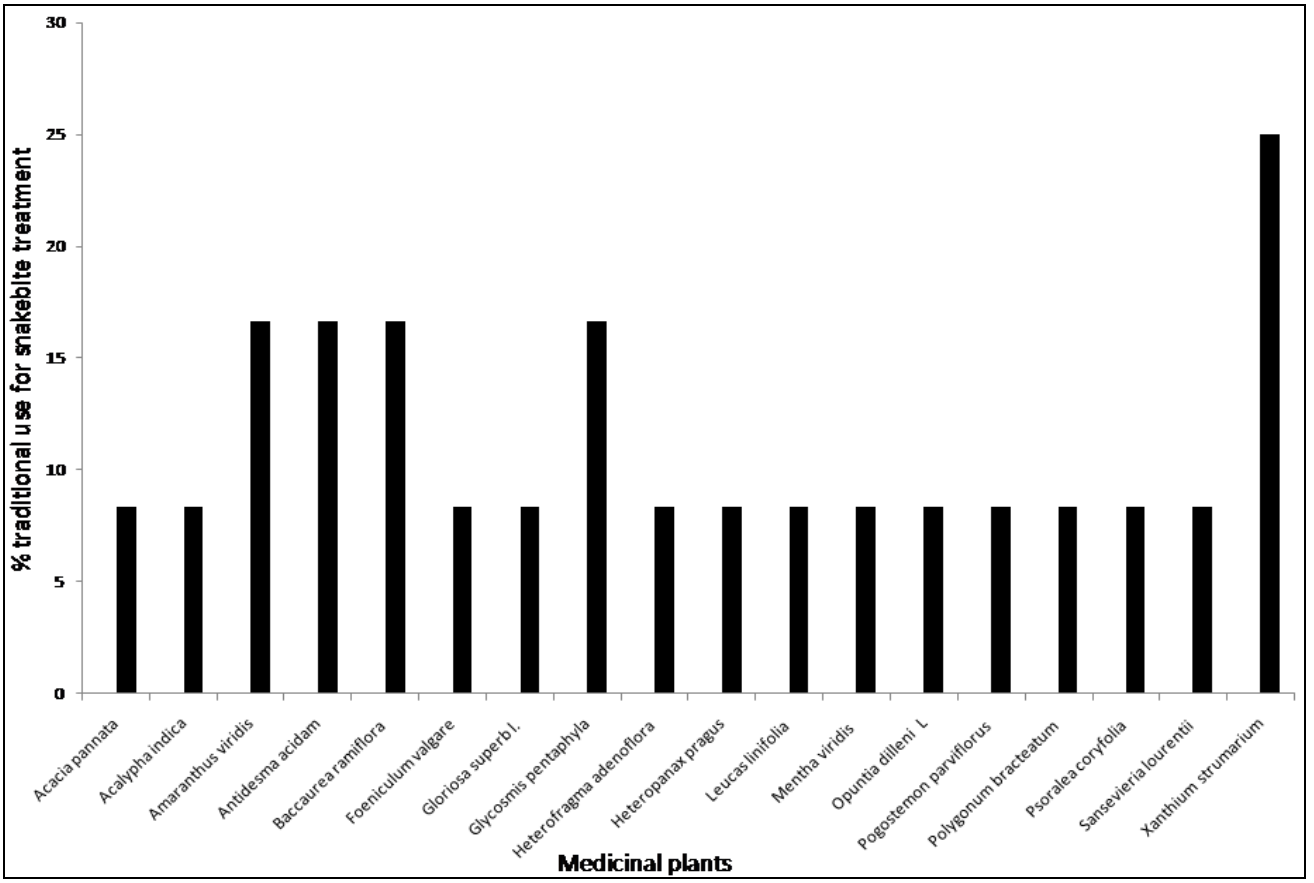

Figure 3: Percentage (%) of medicinal plant used by traditional healers for treatment of snakebite patients in Morigaon district of Assam, India.

The dose of oral administration of juice prepared from the plant parts vary with the severity of the envenomation and actual time of the accident. In fact, the dose is determined by the traditional practitioner based on his/her past experience of treating the snakebite cases. In case of the topical application of the paste, it is applied on the bite site and tightly wrapped with a clean piece of cloth to hold the paste (Personal communication). As reported by the practitioners the efficacy of these medicinal plants is more significant if the patients arrive within 4 h of the snakebite. This claim has scientific merit because intracellular receptors have been identified for many of the snake venom components. Once these components bind to their respective

receptors of the cells, they sometime cause irreversible cellular damage and exert the toxicity. Therefore, even a late antivenom therapy may not save the life of a patient.

To validate the claimed medicinal properties of these plants, pharmacological screening of extracts, the whole plants and/or their parts, both *in-vitro* and in *in-vivo* conditions using a suitable animal model, is essential. This will lead to the isolation and characterization of the active ingredient(s) present in these plants which may be explored further for formulating the antidote. However, since snake venom is a cocktail of various proteins and polypeptides which act individually or in combination to induce various pharmacological affect on victims/prey; therefore, a single active compound from plant may not be effective in neutralizing the toxic effect of venom components. Hence, an alternative approach would be to isolate the active natural compounds, then prepare a mixture of these active components in a predetermined ratio for use as effective antidote against snakebite. In this process of identification and characterization of active components from plants, the variation in venom composition of different families/species of snakes and the neutralization of a particular venom type (hemotoxic, neurotoxic) by isolated plant product(s) must be taken into consideration (Daltry et al. 1996). Currently we are investigation these plants extract for its ability to neutralize venom protein's toxic effects.

Scientific validation of the active ingredient(s) from the medicinal plants for protection against envenomation would be an advantage over commercially available antivenom because the former might overcome the side effects of antivenom therapy. Further, the plant derived antidote preparation would be stable at room temperature for a longer period of time. Whereas commercially available polyvalent antivenom requires refrigerator for storage however refrigeration facility is not available in most of the rural primary health centres where the most snakebite incidences take place. Further, use of plant materials as antidote will definitely reduce the use of raising animals for the antivenoms, which is a painful process for the animal.

Table 2: Traditional use of the medicinal plants other then snakebite treatment.

Medicinal plants	Parts	Traditional uses for the treatment other ailments
Acacia pennata (L.) Willd	Leaves and roots	Cough, bronchitis, diarrhea, dysentery and piles.
Acalypha indica L	Barks and leaves	Cough, bronchitis, asthma, pneumonia and rheumatism.
Amaranthus viridis L	Leaves	Diarrhea, and gastroenteritis
Antidesma acidam Retz	Fruits and leaves	Indigestion and dysentery.
Baccaurea ramiflora Lour	Seeds and barks	Constipation and indigestion.
Foeniculum valgare Mill	Seeds	Fever, wounds, dysentery, eye infection
Gloriosa superb L	Flowers and tubers	Fever, expectorant, piles.
Glycosmis pentaphyla (Retz.) DC	Seeds	Skin dryness or rashes
Heterophragma adenophyllum (Wall. ex G.Don) Seem. ex Benth. & Hook.*f*	Entire plants	Skin disease and boil.
Heteropanax fragrans (Roxb.) Seem	Leaves	Pain easing.
Leucas linifolia (Roth) Spreng	Leaves and immature leaves	Insect bites and other skin disease.
Mentha viridis (L.) L	Leaves and Dry root	Asthma, pains in joints, jaundice and vomiting.
Opuntia dillenii (Ker Gawl.) Haw	Flowers and fruit juice	Bronchitis and asthma.
Pogostemon parviflorus Benth	Leaves and roots	Wound healing.
Polygonum bracteatum Spreng	Leaves and stem	Skin disease, boils and wound.
Piper longum L	Leaf and Seeds	Toothache, inflammations, muscular pains.
Psoralea coryfolia L	Leaves and stems	Skin diseases, diuretic and stomach ache.
Sansevieria lourentii De Wild	leaves	Skin infection, boil and wounds.
Xanthium strumarium L	Seed and leaves	Malaria.

In a nutshell, out of the 19 medicinal plants recorded in Morigaon district of Assam, India, 11 of the medicinal plants was found in the wild (forest) where as the rest of the plants are cultivated. Scientific validation of these plants will establish their importance in the treatment of

snakebite patients. This will also encourage the native people to cultivate these plants as a source of income in addition to the preservation and conservation of these plants. Further, it has been observed that the traditional practitioners are the custodian of this traditional knowledge and they have their own reservation to pass on this unwritten traditional knowledge to their next generation. Hence, proper method must be adopted to document this traditional knowledge of the local practitioners. Ways must be found to retain the claim of their intellectual property, so these people may not be debarred from the financial benefit generated from the commercialization of their knowledge.

Conclusion

Survey conducted only in a single district resulted in 19 different plants used for the treatment of snakebite cases. This indicates that many more plant species may be in for the treatment of various diseases, including snake bites in the rural tropics of India. Topical application of the paste and oral administration of the juice prepared from medicinal plant parts are the common practice of the traditional healers. Tis region has a rich heritage and culture of traditional knowledge on medical practice which need further attention.. Over the years the rich biodiversity of North East India has attracted many researchers for identification and isolation of active compound from the medicinal plants of this region. However it is an alarming situation that traditional knowledge is vanishing as time passes and therefore, the need for a proper documentation of these plants is crucial. This will not only help us in preservation and conservation of this valuable traditional knowledge and culture, but it may also show us the path for green medicine for treatment of snakebite patients and also for scientific exploration of these plants for novel drug discovery (Mukherjee 2012).

Author's contributions

DK and JS carried out the field survey and drafted the manuscript, AKM participated in the design of the study, redefining the data analysing as well as enriching the manuscript. RD designed the study, participated in data collection and drafted the manuscript. All authors read and approved the final manuscript.

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References

Amri, E. and Kisangau, D. P. 2012. Ethnomedicinal study of plants used in villages around Kimboza forest reserve in Morogoro, Tanzania. J. Ethnobiol. Ethnomed. 8: 1.

Bhattacharya, P. C., Muzumder, R., and Dev Sarmah, G. C. 1991. Rare medicinal plants of assam. Anc. Sci. Life 10: 234-238.

Biondo, R., Pereira, A. M., Marcussi, S., Pereira, P. S., Franca, S. C., and Soares, A. M. 2003. Inhibition of enzymatic and pharmacological activities of some snake venoms and toxins by *Mandevilla velutina* (Apocynaceae) aqueous extract. Biochimie 85: 1017-1025.

Cavalcante, W. L., Campos, T. O., Pai-Silva, M., Pereira, P. S., Oliveira, C. Z., Soares, A. M., and Gallacci, M. 2007. Neutralization of snake venom phospholipase A2 toxins by aqueous extract of *Casearia sylvestris* (Flacourtiaceae) in mouse neuromuscular preparation. J. Ethnopharmacol. 112: 490-497.

Chatterjee, I., Chakravarty, A. K., and Gomes, A. 2006. *Daboia russellii* and *Naja kaouthia* venom neutralization by lupeol acetate isolated from the root extract of Indian sarsaparilla *Hemidesmus indicus* R.Br. J. Ethnopharmacol. 106: 38-43.

Chippaux, J. P. 1998. Snake-bites: appraisal of the global situation. Bull. World Health Organ 76: 515-524.

Da Silva, S. L., Calgarotto, A. K., Chaar, J. S., and Marangoni, S. 2008. Isolation and characterization of ellagic acid derivatives isolated from *Casearia sylvestris* SW aqueous extract with anti-PLA(2) activity. Toxicon 52: 655-666.

Daltry, J. C., Ponnudurai, G., Shin, C. K., Tan, N. H., Thorpe, R. S., and Wuster, W. 1996. Electrophoretic profiles and biological activities: intraspecific variation in the venom of the Malayan pit viper (*Calloselasma rhodostoma*). Toxicon 34: 67-79.

Fox, S., Rathuwithana, A. C., Kasturiratne, A., Lalloo, D. G., and de Silva, H. J. 2006. Underestimation of snakebite mortality by hospital statistics in the Monaragala District of Sri Lanka. Trans. R. Soc. Trop. Med. Hyg. 100: 693-695.

Gilon, D., Shalev, O., and Benbassat, J. 1989. Treatment of envenomation by *Echis coloratus* (mid-east saw scaled viper): a decision tree. Toxicon 27: 1105-1112.

Gutierrez, J. M., Williams, D., Fan, H. W., and Warrell, D. A. 2010. Snakebite envenoming from a global perspective: Towards an integrated approach. Toxicon 56: 1223-1235.

Harrison, R. A., Hargreaves, A., Wagstaff, S. C., Faragher, B., and Lalloo, D. G. 2009. Snake envenoming: a disease of poverty. PLoS. Negl. Trop. Dis. 3: e569.

Kasturiratne, A., Wickremasinghe, A. R., de Silva, N., Gunawardena, N. K., Pathmeswaran, A., Premaratna, R., Savioli, L., Lalloo, D. G., and de Silva, H. J. 2008. The global burden of snakebite: a literature analysis and modelling based on regional estimates of envenoming and deaths. PLoS. Med. 5: e218.

Mahanta, M. and Mukherjee, A. K. 2001. Neutralisation of lethality, myotoxicity and toxic enzymes of *Naja kaouthia* venom by *Mimosa pudica* root extracts. J. Ethnopharmacol. 75: 55-60.

Mohapatra, B., Warrell, D. A., Suraweera, W., Bhatia, P., Dhingra, N., Jotkar, R. M., Rodriguez, P. S., Mishra, K., Whitaker, R., and Jha, P. 2011. Snakebite mortality in India: a nationally representative mortality survey. PLoS. Negl. Trop. Dis. 5: e1018.

Mukherjee, A. K. 2012. Green medicine as a harmonizing tool to antivenom therapy for the clinical management of snakebite: The road ahead. Indian J. Med. Res. 136: 10-12.

Mukherjee, A. K., Doley, R., and Saikia, D. 2008. Isolation of a snake venom phospholipase A2 (PLA2) inhibitor (AIPLAI) from leaves of *Azadirachta indica* (Neem): mechanism of PLA2 inhibition by AIPLAI in vitro condition. Toxicon 51: 1548-1553.

Russell, F. E., Sullivan, J. B., Egen, N. B., Jeter, W. S., Markland, F. S., Wingert, W. A., and Bar-Or, D. 1985. Preparation of a new antivenin by affinity chromatography. Am. J. Trop. Med. Hyg. 34: 141-150.

Samy, R. P., Thwin, M. M., Gopalakrishnakone, P., and Ignacimuthu, S. 2008. Ethnobotanical survey of folk plants for the treatment of snakebites in Southern part of Tamilnadu, India. J. Ethnopharmacol. 115: 302-312.

Shirwaikar, A., Rajendran, K., Bodla, R., and Kumar, C. D. 2004. Neutralization potential of Viper russelli russelli (Russell's viper) venom by ethanol leaf extract of *Acalypha indica*. J. Ethnopharmacol. 94: 267-273.

Stahel, E., Wellauer, R., and Freyvogel, T. A. 1985. Poisoning by domestic vipers (*Vipera berus* and *Vipera aspis*). A retrospective study of 113 patients. Schweiz. Med. Wochenschr. 115: 890-896.

Sutherland, S. K. 1992. Antivenom use in Australia. Premedication, adverse reactions and the use of venom detection kits. Med. J. Aust. 157: 734-739.

Swroop, S. and Grab, B. 1954. Snakebite mortality in the world. Bull. World Health Organ 10: 35-76.

Theakston, R. D., Warrell, D. A., and Griffiths, E. 2003. Report of a WHO workshop on the standardization and control of antivenoms. Toxicon 41: 541-557.

Thwin, M. M., Samy, R. P., Satyanarayanajois, S. D., and Gopalakrishnakone, P. 2010.

Venom neutralization by purified bioactive molecules: Synthetic peptide derivatives of the endogenous PLA(2) inhibitory protein PIP (a mini-review). Toxicon 56: 1275-1283.

Vishwanath, B. S., Kini, R. M., and Gowda, T. V. 1987. Characterization of three edema-inducing phospholipase A2 enzymes from habu (*Trimeresurus flavoviridis*) venom and their interaction with the alkaloid aristolochic acid. Toxicon 25: 501-515.