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A Pharmacological and Phytochemical Evaluation of Medicinal Plants Used by the Harbang Clan of the Tripura Tribal Community of Mirsharai Area, Chittagong District, Bangladesh

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Abstract

Background: Recent years have witnessed a continual decline of medicinal plant availability as well as a decline in the numbers of tribal traditional healers and their medicinal knowledge in Bangladesh. Yet these medicinal plants used for treatment of various ailments by tribal traditional healers can be of considerable interest to modern science in their potential for discovery of lead compounds, which can lead to better drugs.
Objective: The primary objective of the present study was to conduct an ethnomedicinal survey among the traditional healers of the Harbang clan (Tripura tribe) of Mirsharai to gain information on medicinal plants used to treat various ailments with the further objective of evaluating the efficacy of these medicinal plants when compared with known phytochemicals and modern-research-based pharmacologic activity studies on these plants.
Methods: Semistructured interviews and guided field-walk methods were used to gather information on medicinal plants used by the Tripura traditional healers. Along with plants, information was also collected on plant parts used, formulations, and dosages. Information on phytochemicals as well as pharmacologic activity studies on these plants (if any) was obtained from several data bases.
Setting: The survey was conducted among the traditional healers of the Harbang clan (Tripura tribe) residing in Mirsharai, Chittagong district, Bangladesh.
Results: The traditional healers of the Tripura tribal community of Mirsharai use 64 plant species distributed into 38 families for treatment of various ailments.
Conclusions: Information on phytochemicals and pharmacologic activity studies conducted on a number of the plants (used by Tripura tribal healers) by modern scientific methods validated the traditional use of a number of plants and suggested that they can form a good source of newer drugs. The survey further highlighted the importance of gathering such ethnomedicinal information for effective conservation of tribal medicinal knowledge and medicinally important plant species.

Introduction

Many tribal communities throughout the world still rely on medicinal plants and their own traditional healers for treatment of various ailments. The Miskitu people of Nicaragua obtain more than 77% of their medicines from the forest.[1] Plants are used as medicines by the main tribes of Sonora, Mexico (i.e., Yaqui, Mayo, Pima, Seri, Papago, and Guarijio[2]). An instance can also be cited of various tribes of India, who have been reported to use approximately 7500 medicinal plant species.[3] The tribal healers usually administer decoction, pills, or paste of medicinal plants or plant parts as full or partial treatment of ailments. It has been observed that in many instances the sources of pharmaceutically important modern drugs have been plants used by indigenous people.[4] In fact, it has further been explained that the discovery of

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modern medicine was possible on the basis of use of plants by traditional people.[5] Adequate documentation of healing practices by traditional healers of ethnic groups is a necessity, for such knowledge can become an important source for discovery of newer drugs.

Numerous articles on ethnobotany published in diverse journals have emphasized that traditional healing practices are disappearing because of modern civilization and the advent of allopathic medicine. The spread of human habitat is also causing widespread destruction of forests with consequential loss or endangerment of important medicinal plant species. Thus, at the same time both plants and traditional knowledge about medicinally important plants are getting lost. This is an unfortunate situation, because with the emergence of antibiotic-resistant microorganisms as well as serious side-effects of quite a few allopathic medicines, interest has refocused on the importance of plants as sources of potentially novel drugs, which can overcome these problems. The cost of modern drugs and the increasing presence of chronic and degenerative diseases are other factors behind the renewal of interest in indigenous alternatives.[6] It has been conservatively estimated that about 250,000 higher plant species (angiosperms and gymnosperms) are present in the world; of these, about 6% only have been screened for biological activity, with another 15% screened for phytochemicals.[7] As a result, loss of these floral species can turn into a serious loss in the quest for discovery of plant-based drugs, which form an important component of modern allopathic medicine.[8] Although the tribal population of Bangladesh is less than 2% of the total population, there are over 30 tribal groups existing at present in the country. The Tripuras form the third largest tribal group residing mostly in the Chittagong Hill Tracts region of Chittagong Division in the southeast of Bangladesh (although some Tripura tribal communities are also present in Chittagong district of Chittagong Division, Bangladesh). The Tripuras call themselves Tipara as well as Tipra and are considered by many to be descendants of the Bodo group of people, who are in turn considered as forefathers of the peoples of Assam (India), Myanmar, and Thailand. Besides Bangladesh, groups of Tripuras are also settled in India. Overall, the tribe is divided into at least 36 groups (clans), of which 16 are in Bangladesh. A group can have subgroups, with each group or subgroup having their own dialect. Thus, intercultural differences exist between the groups and subgroups, and this difference exists in the use of medicinal plants by their traditional or tribal healers (M. Rahmatullah, unpublished observation). Most Tripuras prefer their own tribal healers to be their primary health care providers, rather than allopathic medical practitioners. This is more so because modern hospitals, clinics, and doctors are virtually nonexistent in the forest regions where the Tripuras dwell. The Tripura writing script and their language (Kokborok) are also fast disappearing due to lack of use and because the tribal culture is slowly becoming assimilated into the mainstream culture of the Bangladesh people, who have settled in the forest regions once exclusively inhabited by the Tripuras. The forest regions are also shrinking quickly through these settlements and in the process leading to endangerment, if not outright extinction, of a variety of flora and fauna.

The objective of this study was to conduct an ethnomedicinal survey among the tribal healers of the Harbang clan (Tripura tribe, a clan is known as *Dofa* in the Tripura dialect), who have settled at Mirsharai Upazilla (subdistrict) in Chittagong district, Bangladesh. To our knowledge, there had been no previous ethnomedicinal surveys among this tribe in Bangladesh, and particularly of the Harbang community settled at Mirsharai. The Harbang clan of the Tripura tribe will be referred to as the Tripuras throughout the rest of the article. The Chittagong district and Chittagong Hill Tracts region in a broad sense comprises the districts of Rangamati, Bandarban, Cox's Bazar, Khagrachari, and Chittagong district and is especially rich in the diversity of floral species. The various tribes settled in these areas are considered quite knowledgeable about medicinal plant uses. It was felt that an ethnomedicinal survey of the Tripura tribe, which has a rich heritage, can yield important information on medicinal plants. At the same time, mere information gathering does not serve enough purpose, and most ethnobotanical reports neglect the aspect of validating the use of a medicinal plant through comparisons with established scientific findings. The prospects of drug discovery from medicinal plants cannot be advanced unless such ethnobotanical knowledge is matched with knowledge of phytochemicals present in the plants, as well as any known pharmacologic activities associated with the whole plant, plant extracts, or isolated phytochemicals. Thus, our second objective was to make such comparative studies utilizing the existing scientific databases. Any fruitful finding, in that manner, cannot only validate the use of a particular medicinal plant by Tripura traditional healers and position the plant to be used as an alternative therapy to allopathic drugs (having serious side-effects), but also can go a long way toward effective conservation of such species and the plant habitat through highlighting the importance of that plant species.

Materials and Methods

Area of survey

Chittagong district is in the southeast of Bangladesh. Mirsharai Upazilla falls within this district and is located in the northwest part of the district roughly between 91°30′–91°40′E and 22°40′–22°50′N. The Upazilla has an area of 482.88 km^2. The present survey was conducted among the Harbang clan of the Tripura community of Uttar Talbaria village, Tripura Para, Mirsharai Upazilla. The whole clan consisted of about 400 persons. This Tripura community currently practices the Hindu religion along with traditional animist rituals side by side with worship of several Hindu and a number of traditional forest gods and goddesses. It is to be noted that other Tripura communities (Fatong, Naitong, Kaiboing, Khaigora, and Kaigora clans) present in different areas of Chittagong district and Chittagong Hill Tracts practice their ancient animist form of religion but also have accepted either Buddhist or Christian faiths. A few of them have also in recent times become Muslims. Adopting other religions has not, however, precluded the various communities from practicing their traditional animist rituals, and both traditional rituals and the adopted new religious rituals somehow coexist together.

Ethnobotanical methods

A total of five Harbang (Tripura) healers along with the Headman (Chief) were interviewed during the survey. Three

(3) healers were above 50 years of age and had considerable experience in traditional healing. The 2 other healers were between 30 and 40 years of age. The Headman (who spoke both Bangla and Tripura language) acted as an interpreter and was 55 years of age (interviews and data collection were conducted by a team of 5 authors who spoke in the Bangla language, which the Headman translated into the Tripura language; information from the Tripura healers was translated back into the Bangla language by the Headman). The Headman also possessed considerable familiarity with medicinal plants and their uses. The Tripura healers were interviewed as a group as per their preference. Ethnobotanical methods such as semistructured interviews were employed to obtain the necessary information. The basic method employed is termed "guided field walk," which according to Martin[9] and Maundu[10] involves observation while interviewing the informant. Plant specimens were collected as pointed out by the traditional healers and detailed information taken as to plant parts used, ailments, formulations, and dosages. Informed consent was obtained from every informant prior to interview. The purpose of the survey was clearly explained. It was also agreed during the discussions with the Tripura healers and the Headman that any financial benefit accruing from the work from any source will be utilized in the Tripura community in a manner agreeable to them. It was also agreed that any scientific validation of use of plants obtained in the present survey will be reported to them by us. The informants agreed to have the results of the survey disseminated or published in a general manner both nationally and internationally.

Plant specimens were photographed as well as collected, pressed, and dried in the field. Local names of the plants were obtained from the informants and double-checked with other members of the Tripura community. Plant specimens were identified at the Bangladesh National Herbarium, where voucher specimens were deposited.

Results

Plants and their distribution into families

Our survey indicated that 64 plants are used by the Tripura tribal healers for treatment of various ailments. These medicinal plants belong to 38 families. The Fabaceae family yielded the maximum number of plant species (seven). Other notable families included Asteraceae (five plant species), Malvaceae (four plant species) and the Amaranthaceae, Combretaceae, Labiatae, Poaceae, and Verbenaceae families (three plant species each). The results are shown in Table 1. All medicinal plants were collected from the wild. The healers mentioned that some plants, which are locally becoming rare to find, were collected from the adjoining border state of Tripura, India.

Plants parts used and mode of preparation

The various plant parts used included whole plants, leaves, roots, stems, rhizomes, bark, gum, fruits, and seeds. Among the plant parts, leaves were used on most occasions (41) followed by roots (10), stems (6), and whole plants (5). Of the total number of plants, only one plant, *Polygonum hydropiper*, was used as fish poison, the rest being used to treat human ailments. Plants or plant parts were used in a number of ways, the majority being crushing of whole plant or plant part followed by oral or topical administration of the juice or paste obtained. Exceptions included plants like *Combretum decandrum* (leaves were burned over a fire followed by topical application of ash), *Mimosa diplotricha* (a small piece of root was tied to the body), *Terminalia arjuna* (small pieces of bark were soaked in water followed by drinking of water only), *Phyllanthus emblica* (fruits were soaked in water followed by drinking of the water only), and *Hyptis suaveolens* (seeds were soaked in water followed by drinking of the water only). There were three instances where the plant was either inhaled directly or smoke from a burning plant part was inhaled. The whole plant of an unidentified *Eleusine* species was inserted into the nostrils and the odor was inhaled as treatment for nosebleed or formation of abscess within the nose. Smoke from burning leaves of *Justicia adhatoda* was inhaled as a treatment for asthma. The leaves of *Pogostemon auricularis* were burned over a fire and the smoke was inhaled as treatment of fever.

Medical applications

The data showed that with some exceptions, in most cases a single plant part or whole plant was used by the Tripura healers to treat ailments. Exceptions, where a combination of plant parts were used, included *Alternanthera sessilis*, *Laportea crenulata*, and *Pouzolzia zeylanica* (both leaves and roots were mixed together and used), *Crinum asiaticum* (leaf was used with rhizome), and *Lygodium flexuosum* and *Sida rhombifolia* (leaves were used with stems). One (1) plant was usually used to treat a specific ailment; however, there were instances of use of multiple plants to treat an ailment. For instance, the leaves of *Ageratum conyzoides* was mixed with leaves of *Ocimum tenuiflorum* and used to treat asthma. The stems of *Cuscuta reflexa* were mixed with leaves and roots of *Amaranthus spinosus* to treat diabetes. The leaves of *Cajanus cajan* were mixed with leaves of *Vitex negundo* and *Azadirachta indica* and used as treatment of typhoid. It was also observed that occasionally the healers may use a single plant to treat diverse ailments, which were totally unrelated to one another. The stems of *Colocasia nymphaeifolia* were used to treat both snake bites as well as to increase lactation after childbirth. However, for snake bites, use of the plant was topical and in the latter case the administration route was oral. The use of sugar, black pepper, or salt along with plants or plant parts was noted in a number of cases to increase the palatability of the medication. Several plants such as *Colocasia nymphaeifolia*, *Coccinia grandis*, *Leucas aspera*, and *Urena lobata* were cooked and eaten as a vegetable.

The ailments treated by the Tripura healers were mostly common ailments such as gastrointestinal disorders (stomachache, bloating), respiratory tract disorders (cough, mucus, asthma), cuts and wounds, pain, and skin disorders (itches, scabies, eczema, and boils). Sixteen (16) plants were used to treat gastrointestinal disorders, 10 to treat respiratory tract disorders, and 7 to treat skin disorders. Three (3) plants were used to treat snake bites, which is common in the forest regions where the Tripuras dwell. Two (2) plants, *Cuscuta reflexa* and *Coccinia grandis*, were used to treat diabetes. Diabetes was explained by the Tripura healers as sweetness of urine and was discerned by thirsts, frequent desire for

Table 1. Medicinal Plants Used by the Harbang Clan of the Tripura Tribe of Mirsharai Area, Chittagong, Bangladesh Along with Mode of Use

Serial no.	Scientific name	Family	Local name	Part(s) used	Indication	Procedure
1	*Justicia adhatoda* L.	Acanthaceae	Bashok	Leaf	1. Cough, mucus	1. Boiled leaves along with black pepper is taken twice daily for 7 days.
					2. Asthma	2. Smoke from burning leaves is inhaled as treatment for asthma.
2	*Achyranthes aspera* L.	Amaranthaceae	Wish-lenga	Root	Jaundice	Crushed roots are taken 2–3 times daily for 10–15 days.
3	*Alternanthera sessilis* (L.) DC.	Amaranthaceae	Lilonchi	Leaf, root	Stomachache	A mixture of leaf and root juice is taken twice daily for 3 days.
4	*Amaranthus spinosus* L.	Amaranthaceae	Kanta-maira	Leaf	Stomachache	Crushed leaves are taken in the morning and evening.
5	*Curculigo recurvata* W. T. Aiton synonym *Molineria recurvata* (Dryand.)	Amaryllidaceae alternate Hypoxidaceae	Nengri pata	Rhizome	Cuts and wounds	A paste of crushed rhizomes is applied to affected area.
6	*Holarrhena antidysenterica* (L.) Wall. ex A. DC.	Apocynaceae	Kuruch gach	Leaf	Stomachache	Leaves are crushed with black pepper in a little amount of warm water. One teaspoonful of the decoction is taken every morning and evening for 3 days.
7	*Acorus calamus* L.	Araceae	Botth	Root (rhizome)	Children's cough, asthma	Juice from crushed leaves is mixed with black pepper. One teaspoonful is taken twice daily.
8	*Colocasia nymphaeifolia* Vent.	Araceae	Bish-kochu, Gandori	Stem	1. Snake bite	1. Juice from crushed stem is applied 2–3 times daily to bitten area.
					2. To increase lactation after childbirth	2. Stems are cooked with salt and pepper and taken as vegetable.
9	*Calotropis procera* (Ait.) Ait.f.	Asclepiadaceae	Akondo	Leaf	Rheumatic and any sort of body pain	The leaves are slightly warmed and applied to affected areas.
10	*Ageratum conyzoides* L.	Asteraceae	Chammo-nang	Leaf	Asthma	Juice from crushed leaves is mixed with *Ocimum tenuiflorum* leaves and black pepper. One teaspoonful is taken once daily.
11	*Eclipta prostrata* L.	Asteraceae	Kay-eecha gach	Leaf	Removing dandruff, cooling of head, blackening of hair	Leaf juice is applied to head once daily for 2–3 days.
12	*Eupatorium odoratum* L.	Asteraceae alternate Compositae	Dhumki lota	Stem	Wounds (stop bleeding), ulcer	Crushed stems are applied and taken 1–2 times daily for 2–3 days.
13	*Mikania cordata* (Burm. f.) B. L. Robinson	Asteraceae	Tufan lota	Leaf	Cuts, wounds, stomachache	Crushed leaves are taken (half cup) on an empty stomach for 3 days.

14	*Spilanthes acmella* (L.) Murray	Asteraceae	Gha-gota gach	Leaf	Toothache, oral lesions	Crushed leaves are applied to the gums 2–3 times daily until cure.
15	*Heliotropium indicum* L.	Boraginaceae	Hatishur	Whole plant	Dog bite	1 glass of juice obtained from crushed whole plant is taken and the crushed plant is applied to the bitten area.
16	*Opuntia dillenii* (Ker-Gawl.) Haw.	Cactaceae	Monsha	Leaf	Paralysis	Crushed leaves are taken twice daily for 7–10 days.
17	*Combretum decandrum* Jacq.	Combretaceae	Kal-chihara	Young leaf	Itches	Leaves are burned over a fire and the resultant powder is applied to affected areas 3 times daily for 7–10 days.
18	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	Arjun	Bark	Any type of heart disorders (e.g., pain, abnormal palpitations or beatings of heart, chest pain developing after any type of exertion or work)	Small pieces of bark are soaked overnight in water followed by drinking of the water the following morning on an empty stomach. This is followed once daily for 2 weeks.
19	*Terminalia belerica* (Gaertn.) Roxb.	Combretaceae	Bogra, Bohera	Leaf	Cough, mucus, asthma	Crushed leaves are taken twice daily until cure.
20	*Commelina nairobiensis* Faden	Commelinaceae	Kanaiya	Young stem	Stye disease	1–2 drops of juice obtained from crushed young stems are applied to eyes.
21	*Cuscuta reflexa* Roxb.	Convolvulaceae alternate Cuscutaceae	Shunnyo lota	Stem	Diabetes	Stems are mixed with leaves and roots of *Amaranthus spinosus* and crystallized sugar and taken 2–3 times.
22	*Ipomoea fistulosa* Mart. ex Choisy	Convolvulaceae	Gira kolmi	Plant exudate (gum)	Scabies, boils, itch	Plant exudate (gum) is applied to affected areas.
23	*Kalanchoe pinnata* (Lam.) Pers.	Crassulaceae	Thanda pata	Leaf	Burning sensations in the stomach, cough and mucus in children	1 crushed leaf is taken 2–3 times daily.
24	*Coccinia grandis* (L.) J. Voigt	Cucurbitaceae	Kala-kochu	Leaf	Diabetes, dizziness	The leaves are cooked and eaten as vegetable.
25	*Carex pseudocyperus* L.	Cyperaceae	Chakana	Seed	Stye disease	Juice obtained from crushed seeds is applied to eyes (1–2 drops, 2–3 times daily until cure).
26	*Phyllanthus emblica* L.	Euphorbiaceae	Amloki	Fruit	Sudden unconsciousness (i.e., if somebody falls unconscious without any apparent reason, frequent bouts of unconsciousness)	Fruits are soaked in water and the water is taken after the patient has revived. The treatment is intended to prevent episodes of unconsciousness. It is possible that this ailment can be epilepsy and the treatment can be the equivalent of an anticonvulsant.

(*continued*)

Table 1. (Continued)

Serial no.	Scientific name	Family	Local name	Part(s) used	Indication	Procedure
27	*Cajanus cajan* (L.) Millsp.	Fabaceae	Ol	Leaf	Typhoid	Leaves of this plant are mixed with leaves of *Vitex negundo* and leaves of *Azadirachta indica*, crushed, and the juice obtained is taken 2–3 times daily for 7–10 days.
28	*Cassia alata* L.	Fabaceae	Dadh-raaj	Leaf	Eczema, any type of skin disorder	Crushed leaves are applied to affected areas. At the same time, pills made from leaves are taken (two pills twice daily).
29	*Cassia fistula* L.	Fabaceae	Honalu gach	Fruit	Bloating, urinary problems, stoppage of urination	One teaspoonful of juice from ripe fruits is taken once daily for 7 days.
30	*Cassia sophera* L.	Fabaceae	Mui-tarabi	Leaf	Burning sensations during urination, piles, burning sensation in anus, clarification of urine (to make urine clear)	Two cups of boiled leaves are mixed with 1 teaspoonful sugar and taken twice daily in the morning and evening.
31	*Dalbergia sissoo* Roxb. ex DC.	Fabaceae	Shishu gach	Leaf	Jaundice	One teaspoonful leaf juice is taken once daily for 3 days. At the same time, leaf paste is applied all over the body.
32	*Mimosa diplotricha* C. Wright synonym *Mimosa invisa* C. Martius ex Colla	Fabaceae	Shada lojjaboti	Root	As protection from snake bite	A small piece of root is kept tied to the body.
33	*Moghania macrophylla* (Willd.) Kuntze	Fabaceae	Hath-bhanga gach	Leaf	Fractures in hand or leg	Crushed leaves are applied to the fractured area twice daily until cure. (Crushed leaves are wrapped around the fractured area and the fractured area is then tightly bound with a piece of cloth.)
34	*Leucas aspera* (Willd.) Link	Labiatae	Dolon gach	Leaf	Cough, mucus	Leaves are cooked and taken as vegetable. Alternately, 1–2 teaspoonsful of leaf juice is mixed with sugar or honey and taken for 2–3 days.
35	*Ocimum gratissimum* L.	Labiatae	Bon tulshi	Leaf	1. Eczema	1. Leaf paste is mixed with salt and applied to affected area twice daily for 3 days.
					2. Cough, mucus	2. Leaf juice is mixed with honey and taken once daily for several days.

36	*Pogostemon auricularius* (L.) Hassk.	Labiatae alternate Lamiaceae	Shoigla-loijor	Leaf	Fever	One handful of leaf is burned over a fire and the smoke inhaled once daily for 3–4 days.
37	*Hyptis suaveolens* (L.) Poit.	Lamiaceae	Tokma	Seed	Constipation	The seeds are soaked in water overnight and the water is taken every morning as sherbet.
38	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	Menda	Bark	1. Clarification of urine	1. Juice from boiled bark is taken 3 times daily.
					2. To stop bleeding from cuts and wounds	2. Juice from crushed bark is applied to cuts and wounds.
39	*Crinum asiaticum* L.	Liliaceae	Bonyo-roshun	Leaf, rhizome	Kidney disorders, debility	Leaf juice is taken with powdered rhizome twice daily until cure.
40	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Bandorer-tala	Leaf, stem	Induce sleeping	Crushed mixture of leaves and stems is taken once daily for 3 days.
41	*Lawsonia inermis* L.	Lythraceae	Mehedi gach	Root	Bloating	Crushed roots are taken 2 times in 1 day.
42	*Sida acuta* Burm.f.	Malvaceae	Murong-marong	Leaf	Scabies, itches	Paste of crushed leaves is mixed with red soil from oven and applied to affected areas.
43	*Sida cordata* (Burm.f.) van Borss.Waalk.	Malvaceae	Tak pata gach	Whole plant	Chronic dysentery	Two teaspoonsful of juice from crushed whole plant is taken once daily for 7 days.
44	*Sida rhombifolia* L.	Malvaceae	Ballorim gach	Young leaf, young stem	Fever with trembling, stomachache	Crushed leaves and stems are taken 2–3 times.
45	*Urena lobata* L.	Malvaceae	1. Shanta	1. Root	1. Diarrhea	1. Juice from crushed roots is taken with black pepper 3 times.
			2. Lilonchi	2. Leaf	2. Blackening of hair, abscess, boils	2. ½ cup leaves are cooked as vegetable and taken once daily to cause blackening of hair. Leaf juice is applied to boils or abscesses for 5–7 days.
46	*Azadirachta indica* A. Juss.	Meliaceae	Neem	Leaf	1. Skin diseases	1. Crushed leaves are applied to the whole body twice daily and water in which leaves have been soaked is used for bathing once daily until cure.
					2. Helminthiasis	2. Pills made from leaves are taken (2 pills daily for 4–5 days.)
47	*Stephania japonica* (Thunb.) Miers	Menispermaceae	Muich-chali lota	Leaf	Diarrhea in children	Juice from crushed leaves is taken for 2–3 days.

(*continued*)

Table 1. (Continued)

Serial no.	Scientific name	Family	Local name	Part(s) used	Indication	Procedure
48	*Ludwigia octovalvis* (Jacq.) Raven	Onagraceae	Kulbidal	Leaf	Any sort of injury to the body	About 250 g leaf is boiled in water and the liquid portion is discarded. The rest is mixed with pepper and taken like chutney. This is done once daily until cure.
49	*Eleusine sp.*	Poaceae	Goa durba	Whole plant	Nosebleed, abscess within the nose	Whole plant is inserted into nostrils and the odor inhaled.
50	*Imperata cylindrica* (L.) Beauv.	Poaceae	Mai-bana	Leaf	Asthma, cough with asthma	One teaspoonful of crushed juice from leaves is taken twice daily.
51	*Thysanolaena maxima* Roxb.	Poaceae	Dhuli	Leaf	Eye wounds, to protect eyes from going blind	Young leaves are made into a paste and applied to eyes.
52	*Polygonum hydropiper* L.	Polygonaceae	Bish katali	Whole plant	Fish poison	Crushed whole plant is thrown into ponds to kill all fish in the pond.
53	*Hedyotis* spp.	Rubiaceae	Sham gach	Leaf	Elephantiasis, tumor	Crushed leaves are applied to all sides of the scrotum (in case of elephantiasis) or tumor 2–3 times daily for 5–6 days.
54	*Glycosmis pentaphylla* (Retz.) Corr.	Rutaceae	Mot-ki-la	Leaf	Helminthiasis	Crushed leaves are taken twice daily for 5 days.
55	*Scoparia dulcis* L.	Scrophulariaceae	Bon-dhonnya	1. Root	1. Cough in children	1. Crushed roots are taken with sugar on an empty stomach for 3 days (cough in children).
				2. Whole plant	2. Diarrhea	2. Whole plant juice is taken for diarrhea.
56	*Datura metel* L.	Solanaceae	Kalo dhutura	Fruit, seed	Cough, headache, dizziness, bloating	A small amount of fruits and seeds are crushed and taken once daily with black pepper. (For 3–4 hours after eating, the patient will behave as if insane, but then will be completely cured.)

57	*Grewia microcos* L. (*Microcos paniculata* L.)	Tiliaceae	Fishla gach	Leaf	Twisted or sprained leg	Leaves are warmed and applied to affected area 3 times daily for 7 days.
58	*Centella asiatica* (L.) Urb.	Umbelliferae	Adamoni	Leaf	Helminthiasis, stomachache	Crushed leaves are taken 2–3 times daily.
59	*Laportea crenulata* Gaudich	Urticaceae	Boro-shotta pata	Leaf, root	Snake bite (extremely effective)	Crushed leaves and roots are applied to bitten area. This is continued even after the bitten area is healed until complete cure.
60	*Pouzolzia zeylanica* (L.) Benn. & R.Br.	Urticaceae	Aguni-bolla gach	Leaf, root	Rheumatic pain, paralysis	Leaves and roots are crushed thoroughly, mixed with 1 spoonful of sugar, and a glass of the resultant mix is taken every morning on an empty stomach for 7 days.
61	*Clerodendrum indicum* L.	Verbenaceae	Biaich gach	Leaf	To remove spots or scars from face and body	Juice from crushed leaves along with the leaves is applied to affected areas 3 times daily for 7–10 days.
62	*Clerodendrum viscosum* Vent.	Verbenaceae	Bite gach	Root	Feeling of weakness during time of menstruation	Crushed roots are taken 3 times daily for 2–3 days.
63	*Premna esculenta* Roxb.	Verbenaceae	Orai-darlo	Leaf	Body pain, insect and animal bites	Leaves are boiled and taken with pepperlike chutney. This is done 1–2 times daily for 3 days.
64	*Kaempferia galanga* L.	Zingiberaceae	Holka	Leaf	Itches	Leaves are soaked in water and the water is used for bathing (once daily). This is continued for 7 days.

Table 2. Relevant Phytochemicals and Pharmacologic Activities of Plants or Plant Parts Used by the Harbang Clan of the Tripura Tribe of Mirsharai Area, Chittagong, Bangladesh

Serial number (as in Table 1)	*Scientific name*	*Relevant pharmacologic activity findings in medicinal plants used by the Tripuras*	*Relevant phytochemicals and their pharmacologic activities in medicinal plants used by the Tripuras*
1	*Justicia adhatoda* L.	Potential treatment for asthma[11]; antitussive activity in guinea pigs and rabbits.[12]	Isolated alkaloid–vasicinone (bronchodilator).[13]
2	*Achyranthes aspera* L.	Antiviral activity[14]; antiinflammatory activity[15]; protective role against hepatic lipid peroxidation.[16]	Quercetin-3-*O*-galactoside (hyperoside or hyperin) possessing significant anti-hepatitis B virus activities[17–19]; the compound also possess significant antioxidant and free-radical scavenging activity.[20,21]
4	*Amaranthus spinosus* L.	Antiinflammatory, central and peripheral analgesic activity.[22]	α-Spinasterol[23,24]—possessing analgesic activity[25–27]; rutin[28]—possessing significant analgesic and antiinflammatory activity,[29,30] mild relaxant activity on stomach muscle,[31] protective action against gastric lesions.[32,33]
6	*Holarrhena antidysenterica* (L.) Wall. ex A. DC.	Antibacterial, antidiarrheal.[34–39]	Alkaloids including connessine, isoconnessine, kurchessine, antdysentericine and conimine[40–42] possessing antimicrobial, amoebicidal, antidysenteric, and antidiarrheal properties.[34, 42–44]
9	*Calotropis procera* (Ait.) Ait.f.	Protective effect against Freund's Complete Adjuvant induced monoarthritis in rats[45]; analgesic effect of flowers[46] and antinociceptive effects of latex in mice[47]; antiinflammatory and analgesic effects in rats.[48,49]	
12	*Eupatorium odoratum* L.	To enhance blood coagulation (active ingredient - 4′,5,6,7-tetramethoxyflavone).[50]	
13	*Mikania cordata* (Burm. f.) B. L. Robinson	Protective effect against physical and chemical factors-induced gastric ulcer in rats[51]; anti-ulcerogenic effect in diclofenac sodium-induced gastrointestinal lesions in rats.[52, 53]	
14	*Spilanthes acmella* (L.) Murray		Olefinic alkamide–spilanthol possessing antiinflammatory properties.[54]
15	*Heliotropium indicum* L.	Wound-healing activity.[55]	
18	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Effective in chronic stable angina[56]; protective effect of bark in rabbit heart against ischemic–reperfusion injury[57]; cardioprotective action of bark extract[58]; *in vitro* inhibition of platelet activation in healthy subjects and patients with coronary artery disease[59]; significant inotropic and hypotensive effcts exerted by bark as well as increased coronary artery flow and protection of myocardium against ischemic damage.[60]	Oleanane-type triterpene glycosides designated termiarjunoside I and termiarjunoside II in stem bark, which potently suppressed the release of nitric oxide and superoxide from macrophages as well as inhibited aggregation of platelets[61]; triterpenoid saponins—arjunolic acid and arjunic acid from bark with prominent antioxidant/free-radical scavenging,[62–64] and cytoprotective activities[65–68]; oleanane-based compound arjungenin and its glucoside with moderate free-radical scavenging activity[69]; (tetramethylhexadecyl) trihydroxybenzoate glucopyranoside from bark with prominent hypotensive activity[70]; naphthanol glycoside—arjunaphthanoloside[71], as well as terminoside A, an oleanane-type triterpene from stem bark[72] with potent antioxidant activities.

19	*Terminalia belerica* (Gaertn.) Roxb.		Gallic acid (hepatoprotective principle,[73] inhibitor of histamine release and proinflammatory cytokine production in mast cells,[74] and RBL-2H3 cells,[75] antiasthmatic[76]). Interestingly, methyl and ethyl gallates have been proposed to promote bronchodilatation in isolated guinea pig tracheal smooth muscle, possible through opening of some potassium channels.[77]
21	*Cuscuta reflexa* Roxb.		Alkaloidal fractions [7′-(3′,4′-dihydroxyphenyl)-*N*-[(4-methoxyphenyl)ethyl] propenamide; 7′-(4′-hydroxy, 3′-methoxyphenyl)-*N*-[(4-butylphenyl)ethyl] propenamide; 6,7-dimethoxy-2*H*-1-benzopyran-2-one 1,3-(3, 4-dihydroxyphenyl)-2-propen-1-ethanoate; 6,7,8-trimethoxy-2*H*-1-benzopyran-2-one; 3-(4-*O*-*β*-*d*-glucopyranoside-3,5-dimethoxyphenyl)-2-propen-1-ol; and 2-(3-hydroxy-4-methoxyphenyl)-3,5-dihydroxy-7-*O*-*β*-*d*-glucopyranoside-4*H*-1-benzopyrane-4-one] with strong α-glucosidase inhibitory activity.[78]
22	*Ipomoea fistulosa* Mart. ex Choisy		Hyperoside isolated from leaves[79] possessing significant antifungal,[80] mild topical antiinflammatory activity[81] but significant antiinflammatory activity *in vivo*,[82] antibacterial activity.[83]
23	*Kalanchoe pinnata* (Lam.) Pers.		Flavonoids like quercetin, quercitrin (and related compounds),[84–88] which have been reported to suppress the release of inflammatory and allergic mediators in relevant disease models.[85,89,90] Quercetin and related compounds have also been reported to have a relaxant effect on gastric smooth muscle[91,92] and counteract the inflammation and lipid peroxidation induced by *Helicobacter pylori* in gastric mucosa of guinea pig.[93]
28	*Cassia alata* L.	Used in the indigenous Nigerian medicinal system against dermatological diseases[94]; antimicrobial and antifungal activity.[95–99]	Flavonoidal glycosides, few of which have got kaempferol-based aglycones.[100,101] Kaempferol has been found to inhibit *Candida* infections.[102] Kaempferol-3-rutinoside has prominent antipruritic and antidermatitic activity.[103] Kaempferol-3-*O*-gentibioside isolated from the plant[100] has been shown to have significant antiinflammatory activity.[104] Aloe-emodin (belonging to the anthraquinone glycoside family) isolated from the plant[100] exhibited potent activity against several fungal strains.[105]
34	*Leucas aspera* (Willd.) Link	Antimicrobial activity in methanol extract of flowers and alkaloidal fractions.[106]	Lignans[107] and diterpenoids[108] isolated from the plant have been reported to have some effect on inflammatory mediators, notably prostaglandins.
35	*Ocimum gratissimum* L.	Used in Indian folk medicinal systems to treat bronchitis, bronchial asthma, and skin diseases[109]; antibacterial activity.[110]	

(*continued*)

Table 2. (Continued)

Serial number (as in Table 1)	Scientific name	Relevant pharmacologic activity findings in medicinal plants used by the Tripuras	Relevant phytochemicals and their pharmacologic activities in medicinal plants used by the Tripuras
40	*Lygodium flexuosum* (L.) Sw.		Kaempferol,[111] isolated from this plant as well as others, has been reported to possess prominent sedative and anxiolytic activity.[112,113]
46	*Azadirachta indica* A. Juss.	Anthelmintic action against sheep gastrointestinal nematodes[114]; used by herdsmen of southern Punjab, Pakistan as anthelmintic for ruminants[115]; used in Nigerian folk medicine for dermatological disorders.[94]	Azadirachtins present in the plant reportedly possess anthelmintic/antiparasitic activity[116–118]; the plant is well known to have potential antifungal activity[119] and an antifungal terpenoid, azadiradione, is notable[120]; the plant has also been reported to have broad-spectrum antibacterial activity.[121–124]
48	*Ludwigia octovalvis* (Jacq.) Raven		Oleanane-type tripernoids[125,126] are present in the plant, notably oleanolic acid, which is known to have *in vivo* wound-healing properties.[127] Another triterpenoid present in the plant, namely, ursolic acid,[126] has been shown to have potential therapeutic effect in vascular injury.[128] Triterpenoids present in the plant including β-amyrin, oleanolic acid, and ursolic acid[125,126] are all well-known antiinflammatory agents.[129–131]
53	*Hedyotis* spp.	Although the *Hedyotis* species described here could not be identified, several *Hedyotis* species have been reported to possess significant antioxidant, radical scavenging, anti-inflammatory, and cytotoxic activities.[132] *Hedyotis lawsoniae* have been shown to possess significant nematicidal activity.[133]	Two anthraquinones, 2-hydroxy-3-methylanthraquinone and 1-methoxy-2-hydroxyanthraquinone, have been isolated from *Hedyotis diffusa* Willd., which showed inhibitory activity against protein tyrosine kinases v-src and pp60src and arrested the growth of SPC-1-A, Bcap37, and HepG2 cancer cells.[134]
55	*Scoparia dulcis* L.	Chloroform/methanol fractions of the plant were found to have prominent activity against different bacteria and fungi.[135]	Scopadulane-type diterpenoids known to be present in the plant[136] may contribute to the antibacterial activity. Scoparinol, a diterpene, isolated from the plant, showed significant antiinflammatory activity.[137] Momordin Ic, a saponin glycoside present in this plant, has been shown to inhibit gastric emptying.[138] Plant extract also contains both noradrenaline and adrenaline, which can offer bronchorelaxation through β2-adrenergic receptor stimulation.[139]
58	*Centella asiatica* (L.) Urb.	Protective action against ethanol-induced gastric mucosal lesions in rats[140]; protective action against acetic acid-induced gastric ulcers in rats.[141]	An active constituent of the plant, asiaticoside was found to exhibit significant antiinflammatory activity through modulation of inducible nitric oxide synthase (iNOS) during gastric ulcer healing in rats.[142] Asiaticoside was also found to promote healing effect in gastric ulcer and wounds.[141,143,144]
63	*Premna esculenta* Roxb.	Although any direct scientific studies on this plant are lacking, many species of the same genus have been reported to have analgesic and antiinflammatory activities.[145, 146]	
64	*Kaempferia galanga* L.	Crude leaf extract of this plant possesses antiinflammatory[147] and mild antiallergic activity.[148]	*p*-Coumaryl alcohol-γ-*O*-methyl ether isolated from this plant has been found to exert antiinflammatory activity through modulation of cytokine production.[149]

urination, and the gathering of ants around the ground where a person has urinated.

Discussion

Pharmacologic activity studies of plants used by the Tripura tribe and validation of traditional uses

A search of scientific databases demonstrated that a number of plants used by the Tripura healers are in traditional medicinal use in other parts of the world. Relevant pharmacologic activity studies on extracts of whole plant or plant parts as well as isolated relevant bioactive phytochemicals from plants also validate the use of some of the plants. The results are summarized in Table 2.[11–149]

Conclusions

The available scientific literature thus points out the fact that the use of at least 25 of the 64 medicinal plant species used by the Tripura healers is validated by scientific findings on pharmacologic activities of crude extracts or phytochemical constituents present in the plant species. Dozens more have not been studied until now. One can say with confidence that more plants will be validated in their uses once they have been studied by modern scientific methods. It would be interesting to prioritize plants for further research. Such prioritization can be based on two criteria: (1) plants that have not been scientifically studied thus far or not analyzed to any significant extent (e.g., *Colocasia nymphaeifolia*, *Combretum decandrum*, *Commelina nairobiensis*, *Laportea crenulata*, and *Premna esculenta*, to name only a few), and (2) plants that have already shown a great deal of promise in initial pharmacologic studies or having important bioactive phytochemicals and which are active against ailments that affect a substantial number of the world population (e.g., *Justicia adhatoda*, *Achyranthes aspera*, *Holarrhena antidysenterica*, *Mikania cordata*, and *T. arjuna*). For instance, the first group of the above-named plants can be further studied in bioactivity-guided assays (based on their indigenous use) for discovery of new phytochemicals to treat, respectively, decreased lactation in mothers following childbirth, skin disorders, eye diseases (such as conjunctivitis or stye disease), snake bites, and insect or animal bites; the phytochemicals obtained from the second group of the above-mentioned plants can be assessed in details for their efficacy of use in respiratory disorders, hepatic disorders, gastrointestinal disorders, internal or external bleeding, and cardiovascular disorders. The studies may further include research on adverse side-effects as well as mechanism of action, and if found promising may then go into preliminary clinical trials. *T. arjuna*, in particular, has shown exceptional promise as a candidate plant for discovery of newer drugs, which can be used against cardiovascular disorders—a leading cause of mortality throughout the world. A symbiotic relationship can occur; knowledge of scientific validation, when disseminated to the healers, can enable them to treat ailments more effectively, and at the same time knowledge of indigenous healers can enable scientists to more effectively evaluate any medicinal plant in the quest for newer and more effective drugs. At the same time, this knowledge can enable both the Tripura tribe as well as the country to take effective steps in the conservation of valuable medicinal plant species. It is noteworthy that the tribal people (including the Tripuras) mainly cultivate through the *jhum* method (i.e., slash-and-burn method). A piece of forest land is burned and then cultivated. This is repeated on fresh forest lands every 2–3 years. Thus, a whole gamut of important plant species is lost. Accumulation of ethnopharmacologic knowledge can contribute to stopping this destructive method of cultivation and thus save many endangered plant species. The Tripuras and also the population of rural areas can be encouraged to cultivate many medicinal plants in their homesteads or in fallow lands near their homes and cultivation fields.

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