

Original Article

Herbal medicines for wound healing among tribal people in Southern India: Ethnobotanical and Scientific evidences

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Summary: Results of an ethnobotanical study of wound healing treatments among the tribal people of Tirunelveli hills in southern India are presented. A total of 46 plants belonging to 44 genera and 26 families have been documented for their therapeutic use against wounds and related injuries such as cuts, burns, bruises caused by external injury, boils, sores, abscess and wounds created during delivery. Leaves were the most frequently utilized plant part and most herbal remedies are prepared as paste and applied externally; in some cases medicinal preparations were also administered orally. Of the plants collected in the present study none of the plants have been reported to have such specific wound healing compounds except *Areca catechu* and *Scoparia dulcis*. The present study suggested that further clinical experimentation is needed to scientifically evaluate these widely used herbal remedies for possible bioactive effects.

Industrial Relevance: The study of ethnomedical systems and herbal medicines as therapeutic agents of a paramount importance in addressing health problems of traditional communities and third world countries as well as industrialized societies. Of the reported plants, *Acalypha indica*, *Anacardium occidentale*, *Areca catechu*, *Calotropis gigantea*, *Cissampelos pareira*, *Cleome viscosa*, *Eupatorium odoratum*, *Euphorbia hirta*, *Ficus racemosa*, *Ixora coccinia*, *Morinda pubescens*, *Opuntia dillenii*, *Pongamia pinnata*, *Scoparia dulcis* and *Vitex altissima* were studied in animal models for wound healing, analgesic and anti-inflammatory activity on the basis of their use in traditional medicine as wound healers and these plants can be used to formulate drugs in pharmaceutical companies.

Keywords: Medicinal plants; Traditional medicine; Tirunelveli hills; Wounds.

Introduction

Since time immemorial man has used various parts of plants in the treatment and prevention of many ailments (Chah et al., 2006). Historically all medicinal preparations were derived from plants, whether in the simple form of plant parts or in the more complex form of crude extracts, mixtures, etc. Today a substantial number of drugs are developed from plants (Fabricant and Farnsworth, 2001) which are active against a number of diseases. The majority of these involve the isolation of the active ingredient (chemical compound) found in a particular medicinal plant and its subsequent modification. In the developed countries 25 percent of the medical drugs are based on plants and their derivatives (Principe, 2005) and the use of medicinal plants is well known among the indigenous people in rural areas of many developing countries. In the past our ancestors made new

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discoveries of the healing power of plants through trial and error. Although some of the therapeutic properties attributed to plants have proven to be erroneous, medicinal plant therapy is based on the empirical findings of hundreds and thousands of years (Gurib-Fakim, 2006).

Wound infection is one of the most common diseases in developing countries because of poor hygienic conditions (Senthil Kumar et al., 2006). Wounds are the physical injuries that result in an opening or breaking of the skin and appropriate method for healing of wounds is essential for the restoration of disrupted anatomical continuity and disturbed functional status of the skin (Meenakshi et al., 2006). In other words wound is a break in the epithelial integrity of the skin and may be accompanied by disruption of the structure and function of underlying normal tissue and may also result from a contusion, haematoma, laceration or an abrasion (Enoch and John Leaper, 2005). Healing of wounds starts from the moment of injury and can continue for varying periods of time depending on the extent of wounding and the process can be broadly categorized into three stages; inflammatory phase, proliferate phase, and finally the remodeling phase which ultimately determines the strength and appearance of the healed tissue (Sumitra et al., 2005).

Wound healing process holds several steps which involve coagulation, inflammation, formation of granulation tissue, matrix formation, remodeling of connective tissue, collagenization and aquisition of wound strength (Suresh Reddy et al., 2002). Research on wound healing agents is one of the developing areas in modern biomedical sciences and many traditional practitioners across the world particularly in countries like India and China have valuable information of many lesser-known hitherto unknown wild plants for treating wounds and burns (Kumar et al., 2007). Traditional forms of medicine practiced for centuries in Africa and Asia are being scientifically investigated for their potential in the treatment of wounds related disorders (Krishnan, 2006).

According to Biswas and Mukherjee (2003), 70% of the wound healing Ayurvedic drugs are of plant origin, 20% of mineral origin, and the remaining 10% consisting of animal products and these drugs are stated to be effective in different conditions such as *Vrana* (wounds or ulcers), *Nadivrana* (sinuses), *Vidradhi* (abscess), *Visarpa* (erysipelas), *Upadamsha* (syphilitic ulcers), *Vranajakrimi* (maggots in wounds), *Dustavrana* (septic wounds), *Vranashotha* (inflammatory changes of wounds), *Vranavisha* (cellulitis), *Ugravrana* (purulative ulcer), *Netravrana* (hordeolum or stye sepsis), *Pramehapidaka* (diabetic carbuncle), and *Bhagandara* (fistula-in-ano). Sussman (2007) reported that, haemorrhologics, pentoxyfilline (*Trental*), other methyl xanthenes, retinoids, phenytoin, prostaglandins, Vitamin A and C, zinc and some growth factors are the drugs which are having the potential of improving the healing of wounds. Also, nitrofurazone ointment is used as a standard drug for comparing the wound healing potential of the extract in the animal studies. Some of the commonly available drugs used in the healing of wounds are, NSAIDs ibuprofen (non-steroidal anti-inflammatory drug), colchicine, corticosteroids, antiplatelets (aspirin), anticoagulants (heparin), warfarin and vasoconstrictors e.g., nicotine, cocaine and adrenaline (Grey and Harding, 2006).

Our preliminary survey among the Kani tribals in Tirunelveli hills (Ayyanar, 2008) demonstrated that wounds were one of the major problems among these tribals and they prepared herbal medicines with a number of plants to heal wounds. Although some ethnobotanical studies have been accomplished in and around Tirunelveli hills among the tribal people by some earlier researchers (Janaki Ammal and Nagendra Prasad, 1984; Nagendra Prasad et al., 1996; Ignacimuthu et al., 1998; Viswanathan et al., 2001; Ayyanar and Ignacimuthu, 2005a, b); no systematic ethnotherapeutic studies have been undertaken to assess the traditional management of wounds. The present study was performed with the aim of producing an inventory of the plants used by traditional healers in Tirunelveli hills to document the traditional therapies practiced for various wound and related injury conditions along with major active compounds and related pharmacological activities of each wound healing plant.

Methodology

Study area and ethnic people: The study was conducted during 2001–06 under the project “Survey of Medicinal plants of Western Ghats of Tamil Nadu”, an All India Coordinated Project funded by Indian Council of Medical Research to collect information on medicinal plants used by traditional healers in the southern Western Ghats of Tamil Nadu. Tirunelveli hills are situated in the southern tip of Western Ghats having rich vegetation and lie between the latitudes 8° 25' to 8° 53' N and longitudes 77° 10' to 77° 35' E¹⁰. The rich forests of these hills form the catchment area for more than 15 rivers and 10 dams; these form the back-bone of the irrigation network and provide drinking water for Tirunelveli, Tuticorin and Kanyakumari districts in south Tamil Nadu. The ethnomedicinal information was gathered from the indigenous people of the study area called Kani or Kanikaran, one of the oldest groups of the branch of ethnic people in South India. They reside in remote and inaccessible forest areas and practice indigenous phytotherapy to treat common ailments. During the course of exploration of ethnomedicinal plants the information has been gathered from the healers inhabiting the forest areas who have sound knowledge of herbal remedies. For many decades, the tribal community has a traditionally self managed system of folk medicine and primary healthcare mainly based on herbal remedies.

In Tirunelveli hills, they inhabited the villages of Agasthiyar nagar or Kani kudiiruppu, Periya Mayilar,

Chinna Mayilar, Inchikuzhi, Kannikatty and Servalar. The knowledge about medicinal plants is rather specialized and is limited to a few members in the community who are recognized as 'Vaidhyar' (also known as medicine men, informant and traditional healer). Traditional healers commonly begin their training as children or teenagers working as assistants to their mothers, fathers and to other relatives who are recognized healers. After having trained for a number of years, the apprentice will be ceremonially granted the authority to use a given treatment. This individual will be recognized by others in their culture as having mystical power to heal, as well as having the power to train others in the use of medicinal plants.

Data collection: The ethnomedicinal information was collected through general conversations with traditional healers and questionnaires were used to gather their knowledge. Details of medicinal plants used, mode of treatment, methods of preparation and types of administration were documented by interacting with them as well as through direct observations. The information got from the tribals was recorded in field notebooks and compared with the previously reported literatures (Jain, 1991 & Viswanathan, 2004). The collected plants were identified by the local people with their vernacular names, photographed and sample specimens were collected for the preparation of herbarium. The Flora of Presidency of Madras (Gamble, 1935) and The Flora of Tamil Nadu Carnatic (Matthew, 1983) were used to ascertain the nomenclature. The voucher specimens were deposited in the herbarium at Entomology Research Institute (ERIH), Loyola College, Chennai (India).

Results

Tirunelveli hills have a variety of medicinal plants which are used by the Kani tribals for their primary healthcare. The present study identified that Kani traditional healers used 46 species of ethnomedicinal plants (distributed in 44 genera belonging to 26 families) to treat wounds and related injuries such as cuts, burns, bruises caused by external injury, boils, sores, abscess, and wounds created during delivery. Of which, *Acalypha indica*, *Anacardium occidentale*, *Areca catechu*, *Calotropis gigantea*, *Cissampelos pareira*, *Cleome viscosa*, *Costus speciosus*, *Euphorbia antiquorum*, *Euphorbia hirta*, *Eupatorium odoratum*, *Ficus bengalensis*, *Ficus racemosa*, *Ixora coccinea*, *Jatropha gossypifolia*, *Madhuca longifolia*, *Morinda pubescens*, *Morus alba*, *Opuntia dillenii*, *Pongamia pinnata*, *Scoparia dulcis*, *Terminalia bellirica* and *Vitex altissima* are commonly used by the studied tribal people in the healing of wounds; medicinal properties and major chemical constituents of these plants have also been provided (table 1). Each plant used to treat wounds was cross referenced with the published literature.

Enumeration of Wound healing plants

The name of the botanical plant, vernacular name (Tamil), the family, the Voucher Specimen Number, parts and ingredients used, methods of preparation and dosage are summarized below.

Acalypha indica L. Kuppaimeni, Euphorbiaceae (ERIH 445): Leaf of this plant is ground into a paste and taken orally along with the leaf paste of *Mimosa pudica*, *Azadirachta indica* and flowers of *Albizia lebbek* to treat skin diseases (itching) and wounds. Dosage: Once a day for 3 days.

Anacardium occidentale L. Munthiri, Anacardiaceae (ERIH 53): Fruit of this plant, fruit of *Ananus comosus* and rhizome of *Withania somnifera* are ground with water and the juice thus obtained is taken orally to heal wounds. Dosage: 50 ml of juice is taken thrice a day after food for 2-5 days.

Areca catechu L. Kottai paakku, Arecaceae (ERIH 62): Dried fruits are powdered and heated with coconut oil and applied topically on burns until cure.

Aristida setacea Retz. Vaarip-pullu, Poaceae (ERIH 161): Whole plant parts are mixed with the stem bark of *Pongamia pinnata* and the mixture is made into a paste and applied topically on affected places to heal wounds.

Begonia fallox DC. Earan-kolli, Begoniaceae (ERIH 395): Leaf and stem are mixed and ground into a paste and applied topically on affected places to heal wounds.

Blepharis maderaspatensis (L.) B. Heyne ex Roth. Pappadak-kodi, Acanthaceae (ERIH 428): Juice extracted from the leaf is heated with gingelly oil and applied topically on affected places to heal wounds.

Calotropis gigantea (L.) R. Br. Erukku, Asclepiadaceae (ERIH 235): Few drops of the stem latex are used to treat wounds created by thorns in heels and to remove the thorns from heel (external application).

Chasalia curviflora Wall. ex Kurz. Mundanchedi, Rubiaceae (ERIH 355): Root is ground into a paste with water and applied topically on affected places to heal wounds and pimples. Dosage: Twice a day for 5-7 days before going to bed and early in the morning.

Cissampelos pareira L. Malaithangi, Menispermaceae (ERIH 363): Juice extracted from the leaf is taken orally along with rice flour to heal wounds soon. Dosage: 50 ml of juice is taken twice a day before food.

Cleome viscosa L. Naai kadugu, Cleomaceae (ERIH 78): Leaf is ground into a paste and heated with castor oil. The warm oil thus obtained is applied topically on affected places to treat wounds and swellings.

Commelina benghalensis L. Naara valli, Commelinaceae (ERIH 60): Juice extracted from the stem is mixed with the stem juice of *Canna indica* and fruits of *Areca catechu*. The mixture is applied topically on affected places to heal wounds.

Costus speciosus (Koenig.) J. E. Smith., Kostak-kilangu, Costaceae (ERIH 103): Leaf of this plant is mixed with the leaves of *Cynodon dactylon*, *Glycyrrhiza glabra*, *Canna indica* and stem bark of *Punica granatum*. The juice extracted from this mixture is applied topically on affected places to heal wounds.

Cyanotis villosa (Spreng.) Schultes & Schultes f., Thengaipul chedi, Commelinaceae (ERIH 117): Stem of this plant and stem juice of *Canna indica* are ground into a paste and applied externally to heal wounds.

Cyperus halpan L., Chappai korai, Cyperaceae (ERIH 64): Juice extracted from the whole plant is mixed with the leaf juice of *Leucas aspera* and *Abutilon indicum* and applied topically on affected places to heal wounds.

Dendrophthoe falcata (L.f) Etting., Ottunichedi / Pulluruvi, Loranthaceae (ERIH 297): Fresh leaf and stem are ground into a paste with water and applied topically on affected places to heal wounds.

Didymocarpus humboldtiana Gardn., Eanan-kolli, Gesneriaceae (ERIH 140): Whole parts of this plant, stem bark of *Pongamia pinnata* and leaf of *Abutilon indicum* are ground into a paste and applied topically on affected places to heal wounds.

Dimorphocalyx lawianus (Muell.- Arg.) Hook.f., Sirukottai maram, Euphorbiaceae (ERIH 142): Leaf of this plant, leaf of *Lawsonia inermis*, bulbs of *Aloe vera*, *Scilla indica*, fruit juice of *Citrus limon* and rhizome of *Curcuma longa* are ground into a paste and applied topically on affected places to treat felon (wound on nail). Dosage: Once a day for 3 days.

Diotacanthus albiflorus (Bedd.) Benth., Kodi urinji, Acanthaceae (ERIH 220): Leaf is ground into a paste and applied topically on affected places to heal wounds and heel cracks. Dosage: Once a day for a week before going to bed.

Dumasia villosa DC., Kaana chedi, Fabaceae (ERIH 242): Whole plant parts are boiled with water and decoction thus obtained is used to wash wounds thrice a day to heal soon.

Eupatorium odoratum DC., Aana vanthan, Asteraceae (ERIH 45): Leaf is ground into a paste and mixed with the oil of *Pongamia pinnata* and the mixture is applied topically on affected places to heal wounds.

Euphorbia antiquorum L., Sathura kalli, Euphorbiaceae (ERIH 406): Latex obtained from the stem is applied on spots with burn injury. The stem is heated on fire and the juice thus obtained is topically applied on affected places to heal wounds.

Euphorbia hirta L., Paal chedi, Euphorbiaceae (ERIH 104): Fresh latex is applied topically on affected places to heal wounds. Also leaf of this plant, *Acalypha indica*, *Commelina bengalensis*, *Cissampelos pareira* and *Begonia fallox* are mixed and ground into a paste and the mixture thus obtained is applied topically on affected places to heal wounds.

Ficus bengalensis L., Aalamaram, Moraceae (ERIH 130): Leaf powder is mixed with coconut oil and applied topically on affected places to treat wounds. Dosage: Once a day for 3 days.

Ficus racemosa L., Atthimaram, Moraceae (ERIH 407): Stem bark of this plant, stem barks of *Syzygium cumini* and *Punica granatum* are boiled in water and the decoction thus obtained is used to wash wounds twice or thrice a day to heal soon.

Ixora coccinia L., Idli poo, Rubiaceae (ERIH 415): Flowers of this plant are mixed with the leaves of *Coldenia procumbens*, *Centella asiatica* and stem bark of *Madhuca longifolia* and boiled with water. The decoction thus obtained is applied topically along with coconut oil on affected places to heal wounds.

Jatropha gossypifolia L., Adhalai, Euphorbiaceae (ERIH 416): Resin obtained from this plant is used for mouth wash and to heal wounds in lips and tongue. Dosage: Twice a day for a week.

Knoxia sumatrensis (Retz.) DC. var. *glaberrima* Bhat & Deb., Kaattu mavilai, Rubiaceae (ERIH 150): Leaf is ground into a paste and applied topically on affected places to heal wounds.

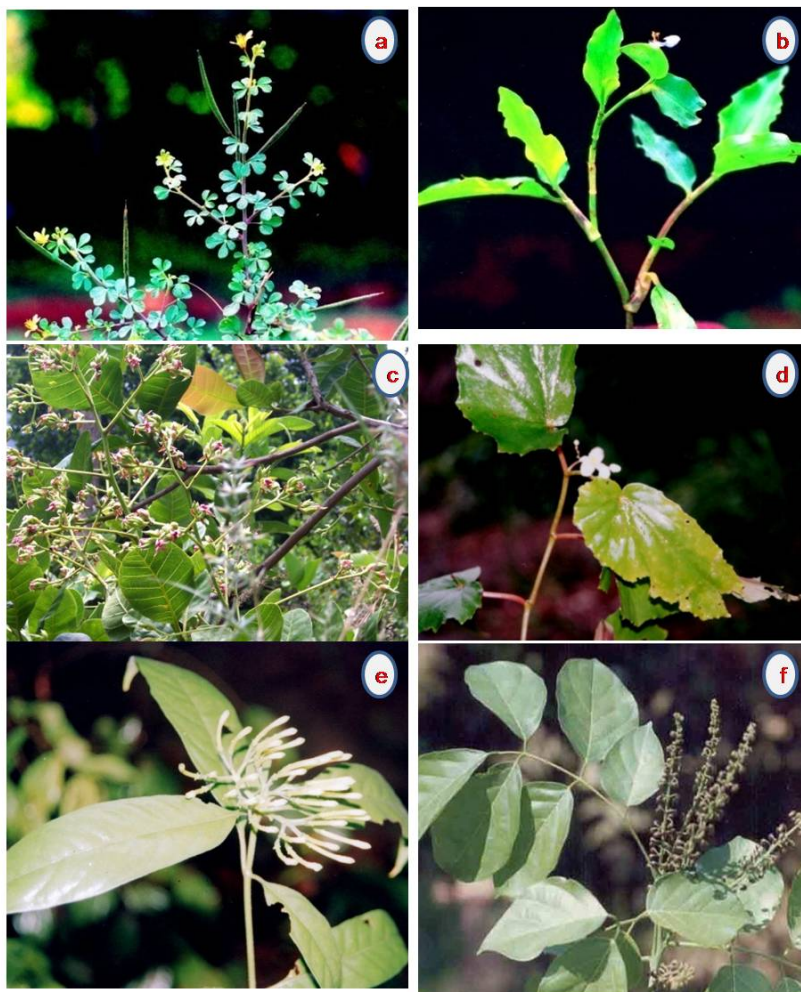


Figure 1A. Wound Healing Plants used by the studied tribal people . (a) *Cleome viscosa*, (b) *Commelina benghalensis*, (c) *Anacardium occidentale*, (d) *Begonia fallox*, (e) *Pavetta hispidula*, (f) *Pongamia pinnata*

Kyllinga melanosperma Nees in Wight., Kutthu korai, Cyperaceae (ERIH 85): Whole plant is crushed with the stem bark of *Cassia auriculata* and ground into a paste. This is applied topically on affected places to heal wounds.

Madhuca longifolia (J.) J. Macbr., Naattu iluppaii, Sapotaceae (ERIH 419): Stem bark of this plant, rhizomes of *Asparagus racemosus*, *Aristolochia indica*, leaves of *Ocimum basilicum* and *Elephantopus scaber* are mixed and boiled with water and the decoction thus obtained is taken orally to heal wounds. Dosage: 50 ml of decoction is taken twice a day after food for 2-3 days.

Morinda pubescens J.E. Smith., Manjanatthi / Nuna, Rubiaceae (ERIH 100): Leaf paste is applied topically on affected places to heal wounds.

Morus alba L., Moraceae (ERIH 425): Leaf of this plant is mixed with the leaves of *Eupatorium odoratum*, *Euphorbia hirta* and *Ficus benghalensis*. This mixture is ground into a paste and applied topically on affected places to heal wounds.

Ophiorrhiza mungos L., Keeripoondu, Rubiaceae (ERIH 431): Whole plant is ground into a paste with coconut oil and applied topically on affected places to heal wounds.

Opuntia dillenii (Ker-Gawl.)Haw., Sappathikalli, Cactaceae (ERIH 183): Inner fleshy part of stem is mixed with the leaf of *Aloe vera* and sugar. The mixture is ground into a paste and taken orally as well as applied topically on affected places to heal wounds. Dosage: 2 teaspoon of paste is taken once a day for 2-3 days early in the morning.

Pavetta hispidula Wight & Arn., Kaattu kitchili, Rubiaceae (ERIH 369): Root bark of this plant is mixed with the rhizomes of *Acorus calamus*, *Alpinia calcarata*, *Alpinia galanga* and seeds of *Piper hymenophyllum*.

The mixture is shade dried, powdered and taken orally with honey by children who are affected by wounds in tongue. Dosage: One teaspoon of mixture is taken thrice a day before food for 2-3 days.

Pongamia pinnata (L.) Pierre., Punga maram, Fabaceae (ERIH 25): Oil extracted from the seeds of this plant is applied topically on affected places to treat wounds.

Pothos scandens L., Parattan kodi, Araceae (ERIH 116): Leaf of this plant is mixed with the fruits of *Capsicum annum* and rhizome of *Allium sativum*. The mixture is ground into a paste with coconut oil and applied topically on affected places to heal wounds created during delivery.

Priva cordifolia (L.f.) Druce., Ottu urinji, Verbenaceae (ERIH 429): Root, stem, leaf and flowers are shade dried, powdered and mixed and made into a paste with coconut oil and applied topically on affected places to heal wounds. Dosage: Once a day for 2-3 days.

Psychotria flavida Talbot., Periya avalpori, Rubiaceae (ERIH 386): Root is dried, powdered and mixed with coconut oil and applied topically on affected places to treat wounds.

Rungia repens (L.) Nees., Siru kodiurinji, Acanthaceae (ERIH 440): Whole plant is ground into a paste and applied topically on affected places to heal wounds.

Scoparia dulcis L., Sarak-kothhini, Scrophulariaceae (ERIH 384): Leaf is ground into a paste and applied topically on affected places to heal wounds.

Smilax zeylanica L., Kuruvilanchi, Smilacaceae (ERIH 374): Rhizome of this plant, *Asparagus racemosus*, *Aristolochia indica*, leaves of *Ocimum basilicum* and *Elephantopus scaber* are shade dried and powdered. The fine powder thus obtained is taken orally along with water to heal wounds. Dosage: One teaspoon of mixture is taken once a day before breakfast for 3-5 days.

Spermacoce ocymoides Burm. f., Sirupeelai, Rubiaceae (ERIH 09): Leaf of this plant, leaf of *Garcinia pictoria* and stem bark of *Syzygium cumini* are mixed, ground into a paste and heated with gingelly oil. The mixture thus obtained is applied topically on affected places to heal wounds.

Terminalia bellirica (Gaertn.) Roxb., Thandrimaram, Combretaceae (ERIH 231): Fruit of this plant, stem barks of *Pongamia pinnata*, *Toddalia asiatica* and *Pterocarpus marsupium* are boiled with water and the decoction thus obtained is used to wash the affected places to heal wounds soon. Dosage: about 25 ml of juice is used to wash thrice a day for 2 days.

Themeda triandra Forssk., Perumanip-pullu, Poaceae (ERIH 80): Powder of whole plant parts is ground with the leaves of *Toddalia asiatica* and *Pongamia pinnata*. The mixture thus obtained is mixed with coconut oil and applied topically on affected places to treat wounds.

Trichodesma zeylanicum (Burm. f.) R. Br., Mulluthumbai chedi, Boraginaceae (ERIH 447): Leaf of this plant, rhizome of *Glycyrrhiza glabra*, stem of *Canna indica* and stem bark of *Punica granatum* are mixed and ground into a paste and applied topically on affected places to heal wounds.

Vitex altissima L. Mayilai maram, Verbenaceae (ERIH 603): Leaf of this plant and leaf of *Wrightia tinctoria* are shade dried, powdered and boiled with water. The decoction thus obtained is taken orally to remove the scar created by wounds. Dosage: About 50 ml of decoction is taken twice a day for a week.

With regard to the families with wound healing plants, Rubiaceae is represented by highest number of species (6 species) followed by Euphorbiaceae (5), Moraceae and Acanthaceae (3) Fabaceae (2), Verbenaceae (2), Poaceae (2), Cyperaceae (2) and Commelinaceae (2). 17 families had one species each. 21 species of plants are herbs, 8 species are shrubs, 8 species are trees, 5 species are small trees and 3 species are climbers respectively. Leaves were found to be the most frequently used plant parts accounting for 21 preparations followed by whole plant parts (9), stem (4), fruit and latex (3), root (2) and others such as flower, stem bark, root bark, resin, seed oil and rhizome. Most of the ethnobotanical studies confirmed that leaves are the major portion of the plant used for the treatment of diseases. The reason why leaves are used mostly is that they are easily accessible and are active in photosynthesis and production of metabolites (Ghorbani, 2005). The methods of preparation fall into four categories, viz.: plant parts applied as a paste, juice extracted from the various fresh parts of the plant, plant parts used to prepare decoction in the combination of water and powder made from fresh or dried material. Majority of the remedies reported in the present study for wound healing were applied externally. The most important modes were the direct application of the paste or ointment (with oil); some of the preparations were taken internally.

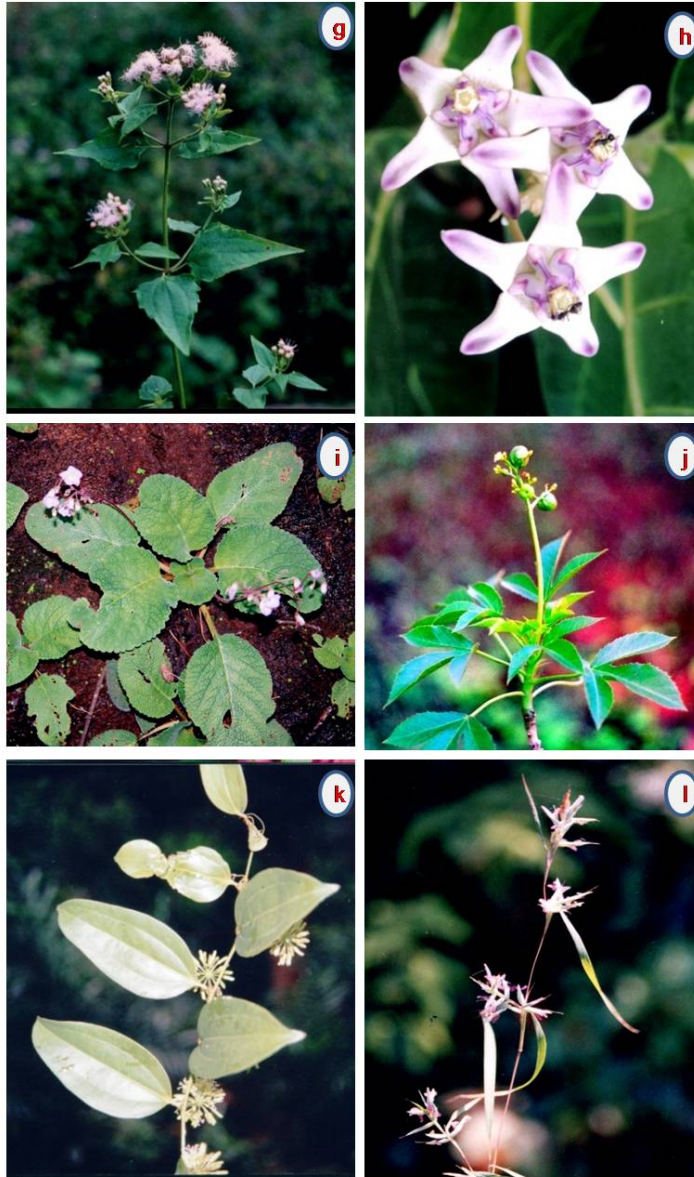


Figure 1B. Wound Healing Plants used by the studied tribal people . (g) *Eupatorium odoratum*, (h) *Calotropis gigantea*, (i) *Didymocarpus humboldtiana*, (j) *Jatropha gossypifolia*, (k) *Smilax zeylanica*, (l) *Themeda triandra*

Table 1. Commonly used wound healing plants in the study area

Botanical Name	Medicinal properties*	Major chemical compounds**
<i>Acalypha indica</i> L.	Anthelmintic, anodyne, bronchitis, cathartic, diuretic, emetic, expectorant, hypnotic and purgative	Acalyphin, acalyphamide, acalyphal acetate, aurantiamide, succinimide and flindersin
<i>Anacardium occidentale</i> L.	Anthelmintic, astringent, irritant, purgative, rubefacient and vesicant	Cardol, anacardic acid, anacardein, occidentoside, campesterol, β -sitosterol and stigmasterol
<i>Areca catechu</i> L.	Anthelmintic, aphrodisiac, astringent, cooling, digestive, diuretic and luxative	Arecoline*** , choline, arecaine, aricaidine, catechu, guvacin and α -catechin
<i>Calotropis gigantea</i> (L.) R. Br.	Anthelmintic, astringent, depurative, diaphoretic, digestive, emetic, expectorant, febrifuge, luxative, stomachic and tonic	Calotropin, akundarin, uscharin, calotoxin, calactin, α , β calotropeol, β -amyryn, giganteol and isogiganteol
<i>Cissampelos pareira</i> L.	Antilithic, astringent, diuretic, sedative, stomachic and tonic	Cissampeloflavone bebeerines, cycleanin, hyatin, hyatinin, cissampeline, cissampareine, pareirubrines A & B, quercitol, & d-tubocurarine
<i>Cleome viscosa</i> L.	Acrid, anthelmintic, antiscorbutic, carminative, febrifuge, stimulant, rubefacient, sudorific, vermifuge and vesicant	Viscous acid, viscosin, cleomiscosin A, B, C & D, cleosandrin and cleomeolide
<i>Costus speciosus</i> (Koenig.) J. E. Smith	Astringent, acrid, cooling, aphrodisiac, anthelmintic, depurative, digestive, febrifuge, expectorant, stimulant and tonic	Diosgenin, para-coumaric acid, prosapogenin B of dioscin, diosgenone, cycloartanol, cyclolaudenol and tocopherol
<i>Euphorbia antiquorum</i> L.	Acrid, anodyne, digestive, emetic, pungent, purgative, rubefaciant, stomachic, thermogenic and vesicant	Euphorbin, euphol, isohelianol and camelliol C
<i>Euphorbia hirta</i> L.	Colic and bronchitis	Euphorbia A & B, rutin, gallic acid, quercitrin, l-inositol, kaempferol, and xanthorhamin
<i>Ficus bengalensis</i> L.	Astringent, acrid, anodyne, antiemetic, cooling, diaphoretic, depurative, refrigerant, sweet and tonic	Bengalenoside, leucocyandin, perlargonidin, leucopelargonin, leucodelphinidin derivatives, caoutchouc and tannins
<i>Ficus racemosa</i> L.	Astringent, aphrodisiac, antidiabetic, carminative, coling, refrigerant, stomachic and vermicide	Racemosic acid, gluanol acetate, caoutchouc, tannins, β -sitosterol, stigmasterol, friedelin and hentriacontane
<i>Ixora coccinea</i> L.	Astringent, acrid, antiseptic, bronchitis, digestive, carminative, febrifuge and sedative	Lupeol, fatty ester, ursolic, oleanolic, stearic, oleic, linoleic acids and sitosterol
<i>Jatropha gossypifolia</i> L.	Emmenogogue and purgative	Jatropheneone, hydroxyjatrophone A, B, C, gadain, prasanthaline, isogadain, cyclogossine A, coumarino-lignoid and ricinoleic acid
<i>Madhuca longifolia</i> (J.) J. Macbr.	Astringent, anthelmintic, aphrodisiac, diuretic, emollient, bitter, bronchitis, refrigerant and luxative	Mowrin (a sapo-glucoside), mimusopside A, Mi-saponins A, B, and C, 3-O-beta-D-glucopyranosyl protobassic acid and arabinose
<i>Morinda pubescens</i> J.E. Smith	Astringent, alexeteric, carminative, digestive, febrifuge, stomachic, styptic and tonic,	Morindin, morindone, rubiadin and anthraquinones
<i>Morus alba</i> L.	Astringent, anthelmintic, aphrodisiac, diuretic, diaphoretic, emollient, luxative and purgative	Mulberroside A, moron A, mulberrifurans B,M,P & Q, kuwanol B, kuwanons D,E,F,Q,R & V, moracenin A,B,C & D, cis-mulberroside A, quercetin, isoquercitrin, astragaline, scopolin, skimming and roseoside II,
<i>Pongamia pinnata</i> (L.) Pierre.	Anthelmintic, alexeteric, acrid, carminative, depurative, digestive, haematinic, luxative and styptic	Pongamol, karanjin, glabrin, pongal, pongarotene, pongapinnol, pongapinone A, pongapinone B, conrauinones A & B, pongaflavone, pongol, pongaflabol, isopongachromene, kanjone and karanjachromene
<i>Scoparia dulcis</i> L.	Emetic	Amellin (antidiabetic), scoparic acid A, B & C, scopadulic acid A & B, scopadulin, scoparinol*** , friedelin and glutinol
<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Astringent, antipyretic, bitter, expectorant, luxative, purgative and tonic	Gallo-tannic acids, termilignan, thannilignan, triterpenes, sterols and phenolics

* - Nadkarni, 1976 & Warriar et al., 1994; **Nadkarni, 1976; Rastogi and Mehrotra, 1974-1994, Vol I-V & Yohanarasimhan, 2000; *** - Wound healing compounds

Discussion

The study of ethnomedical systems and herbal medicines as therapeutic agents of a paramount importance in addressing health problems of traditional communities and third world countries as well as industrialized societies (Cano and Volpato, 2004). Previous reports on the ethnobotany of Tirunelveli hills and adjoining areas are an evidence for the presence of numerous ethnomedicinal plants used by the Kani tribals (Janaki Ammal and Nagendra Prasad, 1984; Nagendra Prasad et al., 1996; Ignacimuthu et al., 1998; Viswanathan et al., 2001; Ayyanar and Ignacimuthu, 2005a, b). Our study observed that, wounds are one of the major problems among the Kani people, due to their life in the forest. While entering into the forests they get injured. The traditional healers residing among them treat such wounds. In Indian traditional medicine, the species of the following genera are commonly used to treat wound and related injuries; *Abutilon*, *Achyranthes*, *Acorus*, *Aegle*, *Aerva*, *Aloe*, *Azadirachta*, *Bambusa*, *Bidens*, *Boerhaavia*, *Butea*, *Caesalpinia*, *Calotropis*, *Carissa*, *Cassia*, *Cucumis*, *Curcuma*, *Cynodon*, *Datura*, *Dodonaea*, *Eclipta*, *Euphorbia*, *Ficus*, *Hyptis*, *Lantana*, *Leucas*, *Morinda*, *Ocimum*, *Opuntia*, *Pavetta*, *Pergularia*, *Plumbago*, *Pongamia*, *Sida*, *Smilax*, *Terminalia*, *Tridax*, *Vitex* and *Zizyphus* (Jain, 1991).

Kumar et al. (2007) and Biswas and Mukherjee (2003) reported that about 163 species of plants were used as wound healing plants in Indian systems of medicine such as Ayurveda, Siddha, Unani and folk medicine. Of these, *Aloe vera*, *Azadirachta indica*, *Berberis aristata*, *Carica papaya*, *Celosia argentea*, *Centella asiatica*, *Cinnamomum zeylanicum*, *Curcuma longa*, *Cynodon dactylon*, *Euphorbia nerifolia*, *Ficus bengalensis*, *Ficus racemosa*, *Glycyrrhiza glabra*, *Nelumbo nucifera*, *Ocimum sanctum*, *Phyllanthus emblica*, *Plumbago zeylanica*, *Pterocarpus santalinus*, *Rubia cordifolia*, *Symplocos racemosa*, *Terminalia arjuna* and *Terminalia chebula* were widely used by most of the tribal communities in India. Kani tribal people in Tirunelveli hills are also frequently using the leaves of *Ficus bengalensis* and stem of *Ficus racemosa* in the treatment of wounds.

According to various traditional medicinal practices throughout the world, wounds have been treated mostly topically with different medicinal herbs or with their extracts solely or in combination with some other plant parts. Kani tribals also prepare medicines in a combination of several plant parts and they believe that combination of different plant parts cures diseases rapidly. Faced with increasing burden on health care, wound healers are examining all possible resources for solutions.

The plants such as *Tridax procumbens*, *Trigonella foenum-graecum*, *Leucas lavandulaefolia*, *Aloe vera* and *Calotropis procera* (Rasik et al., 1999), *Heliotropium indicum*, *Plumbago zeylanica* and *Acalypha indica* (Suresh Reddy et al., 2002), *Cassia fistula* (Senthil Kumar et al., 2006), *Hypericum japonicum*, *Hypericum perforatum*, *Hypericum lydiu*m, *Hypericum papuanum*, and *Hypericum perforatum* (Ozturk et al., 2007), *Cissus quadrangularis*, *Guiera senegalensis* and *Butyrospermum parkii* (Inngjerdingen et al., 2004), *Napoleona imperialis*, *Ocimum gratissimum* and *Ageratum conyzoides* (Chah et al., 2006) have long been used both orally and topically for healing of wounds and burns in the folk medicine by the tribal communities of various countries. In Thailand *Aloe vera* gel was included in the Thai Herbal Fundamental Public Health Drug List as burn and wound therapy and several studies suggested that *Aloe vera*, or one or more of its constituents promote wound healing in various animal models (Maenthaisong, 2007).

Table 2. Scientific evidences for the studied wound healing plants

Botanical Name	Wound & related therapies practiced in folk medicine	Plant part, extracts and animal models used	Studied wound healing / related activity
<i>Acalypha indica</i> L.	Skin diseases	Alcoholic extract of whole plant in excision and incision rat models.	Wound healing activity (Reddy et al., 2002)
<i>Anacardium occidentale</i> L.	Arthritis, aches, pains, fever, wounds and inflammations	Methanolic extract of stem bark in Lipopolysaccharide (LPS) induced septic shock & microvascular permeability in mice.	Anti-inflammatory activity (Olajide et al., 2004)
	Skin ulcers	Ethanol extract of the leaves in wounded rats.	Antiulcerogenic activity and acute toxicity (Andre Konan et al., 2007)
<i>Areca catechu</i> L.	Wounds and skin diseases	Nut extract in excision, incision and dead space animal models.	Wound healing activity (Padmaja et al., 1994)
<i>Calotropis gigantea</i> (L.) R. Br.	Earache, toothache and headache, sprain, stiff joints and pains	Ethanol extract of the flowers in acetic acid induced writhing and hot plate test in mice.	Analgesic activity (Pathak and Argal, 2007)
<i>Cissampelos pareira</i> L.	Skin diseases, abdominal pain and gastric disorders	Ethanol extract of the roots in acetic acid induced writhing and hot plate test in mice.	Anti-inflammatory & antinociceptive effects (Amresh et al., 2007)
<i>Cleome viscosa</i> L.	Fever, inflammation, wounds and joint pains	Methanol extract of the whole plant in acetic acid induced writhing and the tail flick, tail clip, tail immersion methods in mice.	Analgesic activity (Parimaladevi et al., 2003)
<i>Eupatorium odoratum</i> L.	Wounds and inflammation	Aqueous extract of whole plant in carrageenan-induced oedema, cotton pellet granuloma and formalin-induced oedema methods in rats.	Anti-inflammatory activity (Owoyele et al., 2005)
	Wounds	Aqueous extract of the leaves in wounded rat models.	Wound healing activity (Phan et al., 1998)
<i>Euphorbia hirta</i> L.	Gastro-intestinal and respiratory disorders	Ethanol extract of the aerial parts in Wistar rat models.	Anti-histaminic and anti-inflammatory effects (Youssof et al., 2007)
<i>Ficus racemosa</i> L.	Inflammations and bone fracture	Petroleum ether extracts of the leaves in carrageenin, serotonin, histamine and dextran-induced rat hind paw oedema models.	Anti-inflammatory (Subhash et al., 2000).
	Inflammation of skin wounds, lymphadenitis, sprains and fibrositis	Extract of aerial parts in Fe-NTA-induced renal oxidative stress, hyperproliferative response and renal carcinogenesis in rats.	Chemopreventive effects (Khan and Sultana, 2005)
<i>Ixora coccinea</i> L.	Ulcers and inflammations	Alcoholic extracts of flowers in dead space wounded rat models.	Wound healing activity (Nayak et al., 1999)
<i>Morinda pubescens</i> J.E. Smith	Wounds	Fruit extracts in wounded rat models.	Wound healing activity (Mathivanan et al., 2006)
<i>Opuntia dillenii</i> (Ker-Gawl.)Haw.	Gastrointestinal & liver disturbances and inflamed wounds	Aqueous extract of fruits in writhing and hot plate test in rats and mice.	Analgesic activity (Loro et al., 1999)
		Aqueous extract of fruits in carrageenan- induced edema test in rats and mice.	Anti-inflammatory activity (Loro et al., 1999)
<i>Pongamia pinnata</i> (L.) Pierre.	Wounds, inflammations, piles, ulcers and rheumatism	Ethanol extract of leaves in acute, subacute and chronic models of inflammation in rats.	Anti-inflammatory and ulcerogenic effect (Srinivasan et al., 2001)
<i>Scoparia dulcis</i> L.	Bronchitis, gastric disorders, insect bites and skin wounds	Aqueous and ethanol extract of whole plant in Glutinol (a triterpene) induced rats and mice.	Analgesic and anti-inflammatory activity (Freire et al., 1991)
		Ethanol extract of the whole plant in mucosal and skin wounded rats.	Analgesic and anti-inflammatory (Freire et al., 1996)
	-	Scoparinol (a triterpene)	Analgesic and anti-inflammatory activity (Ahmed et al., 2001)

<i>Vitex altissima</i> L.	Wounds and skin diseases	Leaf extracts in excision, incision and dead space wounded rat models.	Wound healing activity (Manjunatha et al., 2007)
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Of the 46 plant species reported by Kani tribals for wound healing, the plants such as *Acalypha indica*, *Anacardium occidentale*, *Areca catechu*, *Calotropis gigantea*, *Cissampelos pareira*, *Cleome viscosa*, *Eupatorium odoratum*, *Euphorbia hirta*, *Ficus racemosa*, *Ixora coccinea*, *Morinda pubescens*, *Opuntia dillenii*, *Pongamia pinnata*, *Scoparia dulcis* and *Vitex altissima* were investigated experimentally by various researchers in wounded animals. These studies showed significant wound healing activity and these plants were selected for wound healing study based on their use in traditional medicine (table 2).

Role of plant compounds in Wound healing

The process of wound healing is promoted by several natural products which are composed of active principles like triterpenes, alkaloids, flavonoids and biomolecules (Sumitra et al., 2005). Asiaticoside from *Centella asiatica* (Shukla et al., 1999), β -sitosterol (Krishnan, 2006) and glycoprotein (Choi et al., 2001) from the gel of *Aloe vera*, oleanolic acid from *Anredra diffusa* (Letts et al., 2006), quercetin, isorhamnetin and kaempferol from *Hippophae rhamnoides* (Fu et al., 2005), curcumin from *Curcuma longa* (Jagetia and Rajanikant, 2004), proanthocyanidins and resveratrol from *Vitis vinifera* (Khanna et al., 2002), acylated iridoid glycosides from *Scrophularia nodosa* (Stevenson et al., 2002), phenolic acids from *Chromolaena odorata* (Phan et al., 2001), (+)-epi- α -bisabolol from *Peperomia galioides* (Villegas et al., 2001), fukinolic acid and cimicifugic acids from *Cimicifuga* spp. (Kusano et al., 2001) and Xyloglucan from *Tamarindus indicus* (Burgalassi et al., 2000) are some of the important plant derived wound healing compounds which were tested in animal models.

Diallo et al. (2002) stated that polysaccharides are also partly responsible for the process of wound healing; for example, arabinogalactans from the root of *Angelica acutiloba*, acidic heteroglycans from the leaves of *Panax ginseng*, acemannan from the gel of *Aloe vera* and general polysaccharides from the leaves of *Plantago major* are reported to have wound healing activity. Besides these, aromatic plants have a long history of use for treating wounds; especially essential oils obtained from the various parts of the plants are very effective in treating small to medium wounds, skin abrasions, excoriations, skin infections and other topical health problems provided an appropriate concentration of essential oil is used (Kerr, 2002). Many traditional remedies are based on systematic observations and methodologies and have been time-tested but for many of them, scientific evidence is lacking and there are only few prospective randomized controlled trials that have proved the clinical efficacy of these traditional wound healing agents (Khalil et al., 2007). Kumar et al. (2007) stated that the major problem with pharmacological validation of the wound healing plants was that the exact mechanism of the healing process of wound was not clearly understood; hence most of the researchers restricted the screening of plants to simple healing of wounds and did not go into details. The validation by scientific method of the usefulness of various plant species could form the basis for their use as alternative treatments or when conventional therapy by Western medicine is unavailable (Hutt and Houghton, 1998).

Conclusion

The present study revealed that traditional medicines are still in common use by the kani tribal communities. Thus the study ascertains the value of a great number of plants used in tribal medicine especially in wound healing which could be of considerable interest in the development of new drugs. There is obviously much still unknown information about plants to treat various ailments including wounds. So far, very few studies have been carried out on a particular compound which confers the wound healing activity such as, arecholine from *Areca catechu* and scoparinol from *Scoparia dulcis*. *Ficus racemosa* has also been seems to the possibility of such active compounds, hence chemopreventive effect of the plant is supposed to the presence of its active constituents, lupeol, quercetin and β -sitosterol but the extract has not been elucidated exactly. These studies were done on the basis of their use in traditional medicine. Comprehensive evaluation on the plants with wound healing activity on the basis of traditional medicine may possibly give new compounds that could be used as prominent drugs in wound healing therapy. This study evidently point out that, instead of trying to identify the active components of herbs through massive collection of plants from natural sources, it is better to start investigating the efficacy of the natural product from the traditional use.

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