

# Ethnopharmacological survey on medicinal plants for the Dengue Hemolytic Infections in selected regions in Sri Lanka

## ABSTRACT

**Aims:** To conduct an Ethnopharmacological survey on medicinal plants used in the treatment of Dengue Hemolytic Infection (DHI) in Sri Lanka and, to make inventory of plant species used in the *Deshiya Chikithsa* (DC).

**Study design:** This was qualitative ethnopharmacological survey.

**Place and Duration of Study:** Eleven selected districts in Sri Lanka covering Western, Southern and Mountain hill ranges of the country, between December 2017 and December 2018.

**Methodology:** This ethnopharmacological survey was conducted using a semi-structured questionnaire. The study focused only on registered Traditional Medical Practitioners (TMPs). Plants were categorized based on plant part used and method of preparation. Quantitative Ethnopharmacological analysis were carried out to using Frequency index (*F*), Use Value ( $UV_{sp}$ ) for one species and the species UV index for one informant ( $UV_{IF}$ ) to claim and prove use of medicinal plants for DHI.

**Results:** The survey identified 181 plant species belongs to 76 families. Approximately 33.6% used as air dried flowers and 30.0% of plants are prepared by aqueous decoction. The most used plants in Sri Lanka were *Carica papaya L.* (43.9), *Coriandrum sativum L.* (37.0), *Mollugo cerviana* (34.1) and *Zingiber officinale* (31.2). As calculated by  $UV_{sp}$ , and  $UV_{IF}$  *Carica papaya L.*, *Coriandrum sativum L.* and *Mollugo cerviana*, were reported to be of the highest use value above 0.25. There were 5.5% plant species with above 0.20  $UV_{sp}$  and 6.1% plant species were above 0.20  $UV_{IF}$ .

**Conclusion:** According to the analysis, it can be concluded that medicinal plants identified in this study are reported here for the first time in relation to their use for DHI.

Therefore, this documented information on the medicinal plants used in DC system in Sri Lanka may be used as baseline data for future pharmacological and phytochemical studies.

**Keywords:** *Deshiya Chikithsa*, Frequency index, Dengue hemolytic infection, Medicinal plants

## 1. INTRODUCTION

The concepts an autochthonous medicine known as *Deshiya Chikithsa* (DC) in Sri Lanka are believed to be 3000 years old. It was handed down from generation to generation and in the course of time DC became fused with Ayurveda. Ayurveda was introduced to Sri Lanka by the King Vijaya in 6<sup>th</sup> century BC. As a believe the DC known to be originated and being practiced during the period of King Ravana “the legendary Great King of antient Sri Lanka” [1-3]. There is a large traditional knowledge was blend with this DC traditional system of medicine. The Sri Lankan community relies on this system for many treatments including for the treatment of eye diseases, fractures, and dislocations,

burns and scalds, boils and carbuncles and cancers. Some of these practitioners specializing in fractures and dislocations are of such high reputation that they are often the first choice for treatment even by sections of the community accustomed to allopathic (western) medicine. There is more traditional knowledge based on ola-leaf manuscripts and ancient books on this traditional system of medicine. Still these texts and the traditional knowledge are uncovered for public. It is well known concept in traditional system is “Deyyange leda” or “God’s diseases”, such as Measles and Variola infections, commonly referred to viral infectious diseases. Those infections were known to be effectively controlled using medicinal plants and remedies unique to DC system of medicine in the past. People of Sri Lanka was believed and practiced a strict self-lock-down concept as a curative measurement for so-called “God’s diseases”, which is an effective controlling method even today for the COVID 19 pandemic.

Dengue is a mosquito born viral infection which causes flu like illness and occasionally develops into a potentially lethal complication called Severe Dengue Hemorrhage (SDH). Dengue Hemolytic Infection (DHI) is a global burden which is about a half of the world population in tropical countries is now at risk [4]. Dengue or severe dengue has no specific treatment yet, only the early detection and proper medical care lowers fatal rate, but this is not always successful. The DHI is transmitted mainly by the female mosquitos belongs to species *Aedes aegypti* and, to a lesser extent by *Aedes albopictus*. There are four distinct, but closely related serotypes of dengue virus have been identified as, DEN-1, DEN-2, DEN-3 and DEN-4. Among these serotypes, DEN-2 and DEN-3 are considered as ‘Asian serotypes’ and are mainly associated with SDH accompanying secondary dengue infection. Incubation period of the disease is 4-10 days, where an infected mosquito can transmit the virus within this period [5-7].

Although with the current global COVID 19 pandemic situation hinders the prevalence and attention to DHI, the disease progressing in the topical regions of the world. According one recent estimate of WHO [4]; there are 390 million dengue infections per year all over the world whereas 96 million manifests clinically (with any severity of disease) and another study of the prevalence in dengue disease estimates that about 3.9 billion people in 128 countries are at risk of infection with dengue viruses [8]. In Sri Lanka, during the outbreaks, it has been identified that serotype 2 (DEN-2) as the circulating strain and, moreover DEN-2 is the most frequently detected serotype since 2009. However, during the period between 2019-2020, a total of 41043 dengue cases and 61 dengue deaths have been reported across the country. According to Epidemiology Unit of in Sri Lanka (EUSL) sources, the highest number of dengue cases, had been reported from the Colombo district (8856) followed by Gampaha district (5389). Jaffna district representing the northern part of the country reported 3815 cases [9].

Herbal materials, herbal preparations and finished herbal products that contain parts of plants, other plant materials or combinations in thereof as active ingredients are considered as the “Traditional and Complementary Medicinal Products”. Sri Lanka, being a country with rich plant diversity, the current survey was decided to focus a study on medicinal plants used in the treatment of DHI. There are about 3,771 species of flowering plants including 927 endemic species (24.6% of total number of flowering plants) and 1430 plant species, which is approximately 38.0% of total number of flowering plants can be considered as ‘medicinal plants’. While 174 (which is approximately 12.0% of total number of medicinal plants) are endemic to Sri Lanka [10]. The knowledge of Sri Lankan indigenous medicine and DC may be found to be more fruitful in future endeavor to fight against the DHI. Since this indigenous medicine knowledge is inherited to certain families among the population, it was assumed that there can be unique treatments strategies available with DC practitioners in Sri Lanka. However, DC has been blended with Ayurveda during past few decades of practice. Between these two systems, Ayurveda system is well documented while the DC is less documented, and the knowledge sharing is highly restricted. Obviously, the knowledge is scattered among certain generations and there is a threat of ceasing of generations with the knowledge on DC system of medicine [1, 3, 11].

Though, ethnopharmacology has a relatively short history, but for centuries researchers have been discovered new chemical entities through the investigation of indigenous herbs and their biological activities. The scientific investigation of beliefs and knowledge of practice with natural products requires a critical and engaged discussion about the logical basis, the relevant methods, and the overall standards necessary for excellence [1, 3]. The current study was focused on the medicinal plants used in the treatment of DHI under the DC system of medicine in Sri Lanka, since there are extremely limited studies were reported. The aim of the study to gather and elaborate a comprehensive review on plant based systematic remedies for DHI. The study population was DC practitioners, who are registered under Department of Indigenous Medicine Sri Lanka, under Section-55 (1) (e) in Ayurvedic Medical Council (AMC). The study area was selected as respective districts declared by the AMC database [12].

## **2. MATERIAL AND METHODS**

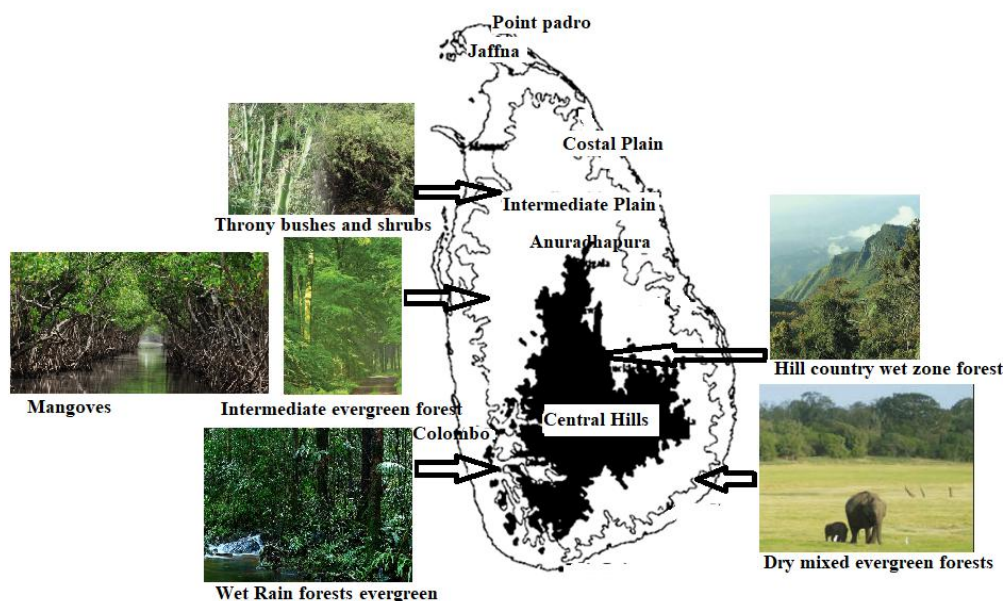
### **2.1 Description of the study area**

Sri Lanka formerly known as Ceylon, is an island with a beautiful landscape located in Indian Ocean. The island consists of three zones basis of relief, Coastal plain up to 30 m from the sea level, Intermediate plain from 30 m to 300 m and Central mountains over 300 m. Although Sri Lanka has a high humid and high temperature due to its location close to equator, the temperature decreases as it surrounded by the Indian Ocean. There are seven vegetation zones identified in Sri Lanka [13, 14]: Namely, Tropical wet forests, Dry mixed ever green forests, Intermediate ever green forests, Hill country wet zone forests, Hill country dry zone forests (Patanas), Thorny bushes and scrub lands and Mangroves . This in variation climate and diverse natural vegetation resources allowed a wide choice in medicinal plant selection in DC by TMPs (fig.1).

### **2.2 Population and ethnicity**

The ethnic structure of the population of Sri Lanka is heterogeneous. According to Census of Population and Housing 2001, the ethnic groups include: Sinhalese (82%), Sri Lanka Tamil (4.3%), Indian Tamil (5.1%), Sri Lanka Moor (7.9%), Burgher (0.2%), Malay (0.3%) and Others (0.2%). The main spoken languages are Sinhala and Tamil, even though, Sinhala, Tamil and English are official languages in Sri Lanka.

The Sri Lankan population belongs to three cultural diversities based on their customs and beliefs according to Buddhist, Hindu and Islamic cultures. Where the Ayurveda, Siddha and Unani system of medicine mainly focuses based on these cultures. But the DC practice is unique which is an autochthonous medicine system existing in Sri Lanka. However, uses of medicinal plants have slight variation among these four systems. In this study TMPs are regarded as the sample.



**Fig. 1. Map showing the natural vegetation of Sri Lanka**

### 2.3 The study population

According to the AMC data base a total number of 5,259 TMPs are registered under Section-55 (1) (e) in the Ayurvedic Council in Sri Lanka. Out of that, 3,549 TMPs are general practitioners, while others are snake bite practitioners. Therefore, sample size distribution within the 3,549 population was 347 TMPs, which can be consulted in fig.2. Most of the DC traditionally being practiced using the “Hela” the native Sri Lankan language, which is currently the more like Sinhala language. Hence, sample size selected was 175 TMPs, where majority of Sinhala speaking population lives.

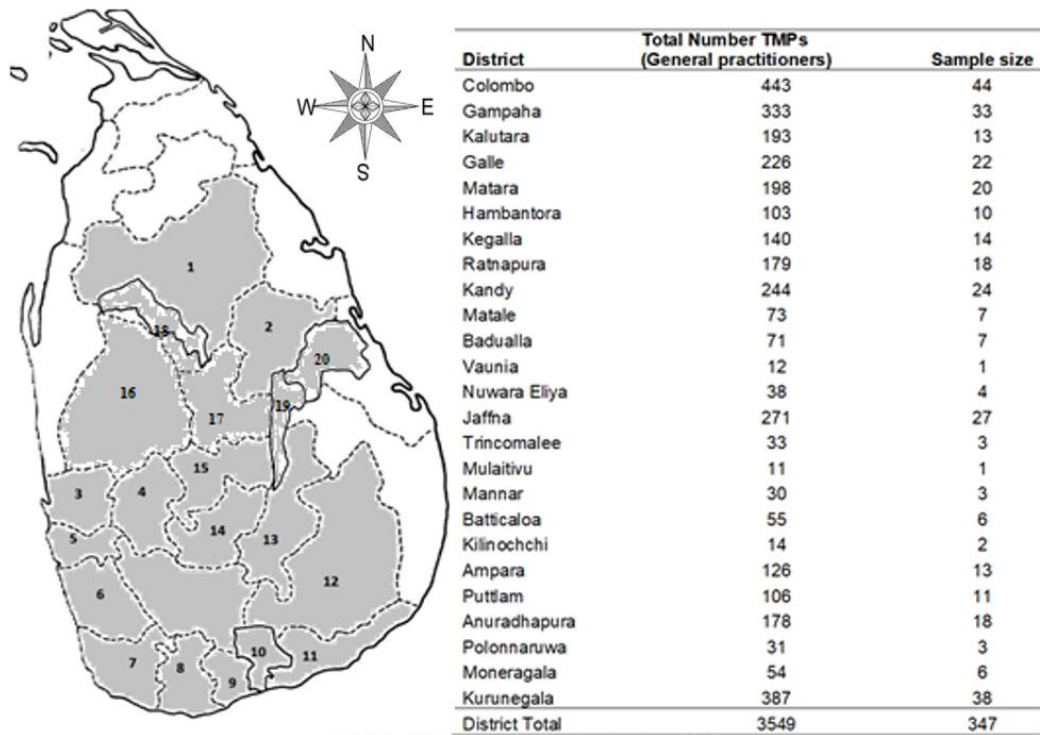
TMPs were randomly selected from eleven districts using the district-based lists of registered TMPs from AMC data to fulfil district wise sample size requirements. Data collection was carried out in 20 selected districts in the island Fig. 2, representing Western, Southern, North Central and South western provinces in Sri Lanka.

### 2.4 Ethnobotanical survey

The study was a descriptive, quantitative survey which was designed in order to collect the data on medicinal plants used in the treatment of DHI. A semi-structured questionnaire was used to gather information regarding,

- Specific medicinal plant(s) used in the treatment
- specific parts of plants utilized in the treatment
- the method and mode of administration
- recommended period of time to be used
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Medical clinics and residences of TMPs were selected as the study setting. Random selection of TMPs based on the practice from the selected districts in Sri Lanka were included in the study. TMPs who were registered under special category (sane bite) were excluded.



Ayurvedic Medical Council, Sri Lanka, data base 2019

**Fig. 2. Districts selected as study areas**

## 2.5 Sampling techniques and selection of respondents

The sample size was calculated based on 3,549 TMPs using Raosoft software online sample size calculator under 5% margin of error and 95% confidence level and, sample size of 175 TMPs was selected after consideration of the current practice, knowledge on medicinal plants and inclusion-exclusion criteria of the study.

The information collected through the questionnaire was covered the name, registration number, qualification and whether he/she was treating for dengue or not, whether he/she was aware of plants used in the treatment of dengue, whether there were plants specific to their medical tradition and, whether he/she was willing to declare such plants as personal information of TMPs.

## 2.6 Ethical consideration

Data collection was based on verbal and written consent from the TMPs and confidentiality of individual personal information was ensured. Ethical clearance was obtained from the Ethics Review Committee (ERC) of University of Sri Jayewardenepura under ERC Application No 88/17, with effective from 25/01/2018.

## 2.7 Quantitative ethnopharmacological analysis

All the plants mentioned by respondents in the study questionnaires were listed based on districts in Microsoft Excel 2010. The plant lists mentioned under section 2.5, were updated with the number of plants and the frequency index (FI), which was calculated for each plant using the following formula.

$$FI = \frac{N_C}{N_T} \times 100 \%$$

Where,  $N_C$  is the total number of use citations by all informants for a given plant species  $s$  and  $N_T$  is the total number of informants

The Use Value ( $UV_{sp}$ ) for one species was calculated by method described by Albuquerque et al. (2007) [15]. It is calculated as follows:

$$UV_{sp} = \frac{\sum N_C}{N_T}$$

Where,  $N_C$  is the sum of the total number of use citations by all informants for a given species, divided by the total number of informants  $N_T$ . This method evaluates the relative importance (RI) of each medicinal species based on its relative use among informants. This index is useful for the analysis of the use of a single species and to compare plants among the same sample [16].

The species UV index for one informant ( $UV_{IF}$ ) was used to calculate the number of uses mentioned for species by one informant in different events [17, 18].

$$UV_{IF} = \frac{\sum U_{is}}{N_{IF}}$$

Where,  $U_{is}$  is the number of uses mentioned for species by the informant and  $N_{IF}$  is the number of events in which the informant cites a use for species  $s$ .

The specific components of the plants used by TMPs were listed out and percentage of each component in relation to the total number of components were calculated. Administrative techniques or modes of administration used by TMPs were listed out and percentage of each administrative technique in relation to the total number of administrative techniques used was calculated.

Plants with high FI were selected. Undamaged healthy plants were collected at the field in the herbal gardens of TMPs and Botanical Garden of Hambantota with proper field notes. Specimens were authenticated at National Herbarium, Hanbantota, Sri Lanka and Bandaranayake Ayurvedic Research Institute, Navinna, Maharagama, Sri Lanka.

### 3. RESULTS AND DISCUSSION

#### 3.1 Survey on medicinal herbs used for Dengue Hemolytic Fever in *Deshiya Chikithsa* in Sri Lanka

Out of 25 districts in Sri Lanka, eleven selected districts have been covered in this survey. In all selected districts, the respondents reported the information on using a vast number of medicinal plants for treating DHI. Satisfactory rate of response was observed but most of the TMPs declared that they can share only a limited portion of their knowledge due to intellectual reasons. During the survey 173 TMPs were responded with 98.9% of respond rate. The results of the ethnobotanical research in the selected regions showed that 180 plant species are used in the treatment of the DF in Sri Lanka. Species were classified into 66 families. Families such as Fabaceae (8.4%), Euphorbiaceae (4.2%), Cucurbitaceae (4.2%), Lamiaceae/verbinaceae (4.2%), Meliaceae (4.2%), Rutaceae (4.2%), Malvaceae (4.2%), Apiaceae (3.0%), Apocynaceae (3.0%), Asclepiadaceae (3.0%), Moraceae (3.0%), Solanaceae (3.0%) and Acanthaceae (2.4%) had the widest representation (Table 1), with 39.8% of the recorded species that belong to these families.

UNDER PEER REVIEW

**Table 1. Extent of usage of plants used in the treatment of Dengue in selected districts of Sri Lanka**

Family	Scientific name	Vernacular name	Respondent	FI	UV	UV Inf
Acanthaceae	<i>Andrographis paniculata</i>	Heen bin kohomba/Kiratha	37	20.4	0.20	0.21
	<i>Barleria prionitis</i> L.	Ranwan katu/Ela katu karandu	1	0.6	0.01	0.01
	<i>Hygrophila schulli</i> (Buch. -Ham.)	Neeramulliya/Ikiriya	4	2.2	0.02	0.02
	<i>Jasticia adhatoda</i> L.	Adathoda/Pawatta/wanapala	36	19.9	0.20	0.21
Acoraceae	<i>Acorus calamus</i> L.	Wada kaha	3	1.7	0.02	0.02
Alangiaceae	<i>Alangium salviifolium</i>	Ruk aguna	1	0.6	0.01	0.01
Amaranthaceae	<i>Aerva javanica</i> L.	Pol pala	4	2.2	0.02	0.02
	<i>Cyathula prostrat</i>	Rath karal haba	2	1.1	0.01	0.01
Anacardiaceae	<i>Mangifera indica</i> L.	Amba	2	1.1	0.01	0.01
	<i>Pistacia terebinthus</i>	Terpentine	5	2.8	0.03	0.03
Apiaceae	<i>Centella asiatica</i> L.	Gotu kola	1	0.6	0.01	0.01
	<i>Coriandrum sativum</i> L.	Koththamalli	64	35.4	0.35	0.37
	<i>Cuminum Cyminum</i>	Sooduru/Korasami	1	0.6	0.01	0.01
	<i>Trachyspermum involucreatum</i>	Asamodagam	1	0.6	0.01	0.01
	<i>Anethum graveolens</i>	Walsathakuppa	1	0.6	0.01	0.01
Apocynaceae	<i>Alstonia scholaris</i> L.	Ruk aththana	22	12.2	0.12	0.13
	<i>Hemidesmus indicus</i> L.	Iramusu	11	6.1	0.06	0.06
	<i>Holarrhena antidysenterica</i>	Kelinda/ Kelinda Hal	3	1.7	0.02	0.02
	<i>Pagianta dichotoma</i> .	Divi kaduru	1	0.6	0.01	0.01
	<i>Wrightia antidysenterica</i>	Wana idda	1	0.6	0.01	0.01
Araceae	<i>Pothos scandens</i> L.	Pota wel	1	0.6	0.01	0.01
	<i>Xanthosoma sagittifolium</i>	Kiri ala	1	0.6	0.01	0.01
Arecaceae/Palmae	<i>Borassus flabellifer</i> L.	Thal bada	1	0.6	0.01	0.01
	<i>Cocos nucifera</i>	Thambili	1	0.6	0.01	0.01
Aristolochiaceae	<i>Aristolochia bracteolata</i>	Sathsanda	5	2.8	0.03	0.03
Asclepiadaceae	<i>Calotropis procera</i>	Akrapatta	1	0.6	0.01	0.01
	<i>Hoya ovalifolia</i>	Gonukaa wel	1	0.6	0.01	0.01



	<i>Marsdenia tenacissima</i>	Muruwa	3	1.7	0.02	0.02
	<i>Tylophora indica</i>	Keeta	1	0.6	0.01	0.01
	<i>Wattakaka volubilis</i>	Kiri anguna	1	0.6	0.01	0.01
Asparagaceae	<i>Asparagus racemosus Willd.</i>	Hathawariya	6	3.3	0.03	0.03
Asteraceae	<i>Blumea axillaris</i>	Kukula	2	1.1	0.01	0.01
	<i>Eclipta prostrata L.</i>	Keekirindiya	1	0.6	0.01	0.01
	<i>Tridax procumbens</i>	Thala	1	0.6	0.01	0.01
	<i>Vernonia cineria L.</i>	Monara kudummbiya/ Dutu sathutu	20	11.0	0.11	0.12
Athyriaceae	<i>Diplazium escolentos</i>	Miyana dalu	1	0.6	0.01	0.01
Bignoniaceae	<i>Oroxylum indicum L.</i>	Thotila	2	1.1	0.01	0.01
	<i>Stereospermum suaveolens DC.</i>	Palol	2	1.1	0.01	0.01
Burseraceae	<i>Commiphora mukul</i>	Shodhitha gugul	1	0.6	0.01	0.01
Cannabaceae	<i>Cannabis sativa L.</i>	Kansa	2	1.1	0.01	0.01
Cannaceae	<i>Canna indica</i>	Seeni ala	1	0.6	0.01	0.01
Capparaceae	<i>Cleomi gynandra</i>	Wela kola	1	0.6	0.01	0.01
Caprifoliaceae	<i>Crateva adansonii</i>	Lunuwarana	1	0.6	0.01	0.01
Caricaceae	<i>Carica papaya L.</i>	Papol/ gas labu	76	42.0	0.42	0.44
Celastraceae	<i>Gymnosporia emarginata</i>	Katupila	1	0.6	0.01	0.01
Cesalpinaceae	<i>Cassia auriculata L.</i>	Ranawara	2	1.1	0.01	0.01
Clusiaceae	<i>Mesua ferrea L.</i>	Namal Renu	1	0.6	0.01	0.01
Combretaceae	<i>Terminalia arjuna</i>	Arjuna/Kumbuk	2	1.1	0.01	0.01
	<i>Terminalia bellirica Roxb.</i>	Bulu	13	7.2	0.07	0.08
	<i>Terminalia catappa</i>	Suwanda kottan	3	1.7	0.02	0.02
	<i>Terminalia chebula Retz.</i>	Aralu	20	11.0	0.11	0.12
Conifereae	<i>Cedrus deodara R</i>	Dewaduru	1	0.6	0.01	0.01
	<i>Erythroxylu monogynum Roxb.</i>	Dewadaara	15	8.3	0.08	0.09
Convolvulaceae	<i>Ipomoea pes-caprae,</i>	Thamburu	3	1.7	0.02	0.02
	<i>Evolvulus alsinoides</i>	Vishnukranthi	18	9.9	0.10	0.10
	<i>Ipomoea batatus</i>	Bathala	8	4.4	0.04	0.05

Crassulaceae	<i>Ipomoea pescaprae</i>	Ela bim thamburu	1	0.6	0.01	0.01	
	<i>Bryophyllum calycinum</i> Salisb.	Akkapana	1	0.6	0.01	0.01	
Cucurbitaceae	<i>Kalanchoe pinnata</i>	Katakataka threegn	1	0.6	0.01	0.01	
	<i>Benincasa hispida</i>	Puhul	1	0.6	0.01	0.01	
	<i>Cucurbita maxima</i>	Wattakka	3	1.7	0.02	0.02	
	<i>Momordica charantia</i> L.	Karawila/Batu karawila	5	2.8	0.03	0.03	
	<i>Mormodica dioica</i>	Thumba karawila	3	1.7	0.02	0.02	
	<i>Solena amplexicaulis</i> (Lam.)	Kawdu kekiri	1	0.6	0.01	0.01	
	<i>Tricosanthes cucumerina</i> L.	Dummalla	16	8.8	0.09	0.09	
Cyperaceae	<i>Lagenaria siceraria</i>	Diya labu	1	0.6	0.01	0.01	
	<i>Cyperus rotundus</i> L.	Kalanduru	14	7.7	0.08	0.08	
Ericaceae	<i>Vaccinium leschenaultii</i> L.	Boralu damana	1	0.6	0.01	0.01	
Euphorbiaceae	<i>Acalypha indica</i>	Kuppamenia	2	1.1	0.01	0.01	
	<i>Cleistanthus collinus</i>	Mal madatha	1	0.6	0.01	0.01	
	<i>Euphorbia hirta</i>	Dada keeriya/Kapum keeriya	3	1.7	0.02	0.02	
	<i>Phyllanthus debilis</i>	Pitawakka/ bim nelli	5	2.8	0.03	0.03	
	<i>Phyllanthus embelica</i> L.	Nelli	17	9.4	0.09	0.10	
	<i>Ricinus communis</i>	Thel Erandu	3	1.7	0.02	0.02	
	<i>Tragia hispida</i>	Kahambiliya/Wel kahambiliya	1	0.6	0.01	0.01	
	Fabaceae	<i>Abrus precatorius</i>	Olinda	1	0.6	0.01	0.01
		<i>Acasia caesia</i>	Hinguru	1	0.6	0.01	0.01
		<i>Aeschynomene indica</i>	Diya siyambala	1	0.6	0.01	0.01
<i>Alysicarpus vaginalis</i> L.		Aswanna	4	2.2	0.02	0.02	
<i>Caesalpinia bonduc</i>		Kumburu	2	1.1	0.01	0.01	
<i>Cassia tora</i>		Pethi thora	1	0.6	0.01	0.01	
<i>Glycyrrhiza glabra</i> L.		Valmee	3	1.7	0.02	0.02	
<i>Mimosa pudica</i>		Katu nidikumba	1	0.6	0.01	0.01	
<i>Phaseolus radiatus</i>		Mung bean	1	0.6	0.01	0.01	
<i>Pseudarthria viscida</i>		Gonika	1	0.6	0.01	0.01	

	<i>Pterocarpus santalinus</i>	Rath handun	2	1.1	0.01	0.01
	<i>Senna alata</i>	Ath thora	2	1.1	0.01	0.01
	<i>Sesbania grandiflora L.</i>	Katurumurunga	1	0.6	0.01	0.01
	<i>Tamarindus indica</i>	Siyambala	2	1.1	0.01	0.01
Graminae/Poaceae	<i>Cymbopogon confertiflorus</i>	Pangiri	5	2.8	0.03	0.03
	<i>Chrysopogon zizanioides</i>	Sawanna	4	2.2	0.02	0.02
Hippocrateaceae	<i>Salacia reticulata</i>	Kothala himbutu	1	0.6	0.01	0.01
Lamiaceae	<i>Leucas aspera</i>	Kiri thumba	2	1.1	0.01	0.01
	<i>Leucas biflora</i>	Wilanda/Vilanda wanna	2	1.1	0.01	0.01
	<i>Ocimum tenuiflorum L.</i>	Maduruthala/Thulsi	44	24.3	0.24	0.25
	<i>Premna obtusifolia</i>	Midi	3	1.7	0.02	0.02
Lamiaceae/Verbinaceae	<i>Leucas zeylanica</i>	Gata thumba	1	0.6	0.01	0.01
	<i>Plectranthus hadiensis</i>	Iriweriya	12	6.6	0.07	0.07
	<i>Allium sativum L.</i>	Sudu loonu	7	3.9	0.04	0.04
	<i>Gmelina asiatica</i>	Demata/Ath demata	5	2.8	0.03	0.03
	<i>Lantana camara</i>	Gandapana	1	0.6	0.01	0.01
	<i>Vitex negundo</i>	Nika	3	1.7	0.02	0.02
	<i>Clerodendrum serratum (L)M.</i>	Sirithaekku/Bhangi	4	2.2	0.02	0.02
Lauraceae	<i>Cinnamomum verum</i>	Kurundu	4	2.2	0.02	0.02
Lecythidaceae	<i>Careya arborea</i>	wisha kumba	1	0.6	0.01	0.01
Leguminosae	<i>Desmodium triflorum L.</i>	Heen Undupiyaliya	1	0.6	0.01	0.01
	<i>Erythrina indica</i>	Erabadu	1	0.6	0.01	0.01
Leguminosae/Fabaceae	<i>Abrus pulchellus</i>	Ela olinda	1	0.6	0.01	0.01
Loganiaceae	<i>Strychnos nux-vomica L.</i>	Goda kaduru/Koon thalan	2	1.1	0.01	0.01
	<i>Strychnos potatorum L.</i>	Inginu ata	1	0.6	0.01	0.01
Malastomataceae	<i>Osbeckia octandra</i>	Heen bowitiya	1	0.6	0.01	0.01
Malvaceae	<i>Abutilon indicum</i>	Beheth Anoda	1	0.6	0.01	0.01
	<i>Sida alnifolia</i>	Babila	3	1.7	0.02	0.02
	<i>Thespesia populnia</i>	Ran sooriya	1	0.6	0.01	0.01

	<i>Hibiscus micranthus</i>	Siri wadi babila	1	0.6	0.01	0.01
	<i>Azadirachta indica</i>	Kohomba	33	18.2	0.18	0.19
	<i>Munronia pinnata</i>	Bim kohomba	46	25.4	0.25	0.27
	<i>Xylocarpus rumphii</i>	Koo thalan/Goda kaduru	1	0.6	0.01	0.01
Menispermaceae	<i>Cissampelos pareira</i>	Diyamiththa	8	4.4	0.04	0.05
	<i>Cosciniium fenestratum</i>	Venivelgata	47	26.0	0.26	0.27
	<i>Tinospora cordifolia</i>	Rasakinda	35	19.3	0.19	0.20
Molluginaceae	<i>Mollugo cerviana</i>	Pathpadagam/Papiliya	59	32.6	0.33	0.34
Moraceae	<i>Artocarpus heterophyllus</i>	Polos	11	6.1	0.06	0.06
	<i>Artocarpus heterophyllus</i>	Waraka	1	0.6	0.01	0.01
	<i>Artocarpus heterophyllus</i>	kos	5	2.8	0.03	0.03
	<i>Ficus racemosa</i>	Aththikka	2	1.1	0.01	0.01
	<i>Ficus religiosa</i>	Bo	1	0.6	0.01	0.01
Moringaceae	<i>Moringa oleifera</i>	Murunga	3	1.7	0.02	0.02
Musaceae	<i>Musax paradisiaca</i>	Ambul banana	1	0.6	0.01	0.01
Myricaceae	<i>Myrica esculenta</i>	Katphala	1	0.6	0.01	0.01
Myristicaceae	<i>Myristica fragrans Houtt.</i>	Sadikka/wasa wasi	2	1.1	0.01	0.01
Myrtaceae	<i>Eugenia bracteata</i>	Thambiliya	1	0.6	0.01	0.01
	<i>Syzygium aromaticum</i>	Karabu nati	1	0.6	0.01	0.01
	<i>Syzygium cumini</i>	Ma dan	1	0.6	0.01	0.01
Nelumbonaceae	<i>Nelumbo nusifera</i>	Nelum	1	0.6	0.01	0.01
Nyctaginaceae	<i>Boerhavia diffusa</i>	Sarana	4	2.2	0.02	0.02
Oleaceae	<i>Nyctanthus arbor-tristis L.</i>	Sepalika	2	1.1	0.01	0.01
Piperaceae	<i>Piper betle L.</i>	Bulath	5	2.8	0.03	0.03
	<i>Piper longum L.</i>	Thippili	31	17.1	0.17	0.18
	<i>Piper nigrum</i>	Gammiris	5	2.8	0.03	0.03
Plumbaginaceae	<i>Plumbago indica L.</i>	Rath netul	1	0.6	0.01	0.01
Poaceae	<i>Bambusa vulgaris</i>	Una/Una kapuru	6	3.3	0.03	0.03
Polypodiaceae	<i>Drymoglossum piloselloides</i>	Panam pethi	1	0.6	0.01	0.01

Pteridaceae	<i>Adiantum capillus-veneris</i>	Walaa wenna	1	0.6	0.01	0.01	
Punicaceae	<i>Punica granatum L.</i>	Delum	5	2.8	0.03	0.03	
Ranunculaceae	<i>Aconitum heterophyllum</i>	Athiwidayam	3	1.7	0.02	0.02	
	<i>Nigella sativa</i>	Kalu duru	1	0.6	0.01	0.01	
Rosaceae	<i>Malus sp.</i>	Apple	2	1.1	0.01	0.01	
Rubiaceae	<i>Ixora coccinea</i>	Rath mal	1	0.6	0.01	0.01	
	<i>Mussaenda frondosa</i>	Mussanda	2	1.1	0.01	0.01	
	<i>Nauclea orientalis</i>	Bak mee	2	1.1	0.01	0.01	
Rutaceae	<i>Paederia foetida</i>	Prana Jeewa	2	1.1	0.01	0.01	
	<i>Aegle marmelos</i>	Beli	3	1.7	0.02	0.02	
	<i>Atlantia ceylanica</i>	Yaki naran	1	0.6	0.01	0.01	
	<i>Citrus aurantium</i>	Ambul dodam	1	0.6	0.01	0.01	
	<i>Citrus aurantium L.</i>	Dodam	1	0.6	0.01	0.01	
	<i>Citrus limon</i>	Dehi	2	1.1	0.01	0.01	
	<i>Citrus reticulata</i>	Heen naran	4	2.2	0.02	0.02	
	<i>Pamburus missionis</i>	Pamburu	1	0.6	0.01	0.01	
	Santalaceae	<i>Santalum album</i>	Sudu handun	8	4.4	0.04	0.05
	Sapindaceae	<i>Cardiospermum halicacabum</i>	Val penela	4	2.2	0.02	0.02
<i>Dimocarpus longan</i>		Mora	1	0.6	0.01	0.01	
Scrophulariaceae	<i>Bacopa monnieri</i>	Lunuwila	1	0.6	0.01	0.01	
	<i>Picrorhiza scrophulariiflora</i>	Ela katu karosana	1	0.6	0.01	0.01	
	<i>Picrorhiza scrophulariiflora</i>	Katu karosana	15	8.3	0.08	0.09	
Selaginellaceae	<i>Selaginella bryopteris</i>	Sanjeevani	1	0.6	0.01	0.01	
Solanaceae	<i>Capsicum annum</i>	Miris	1	0.6	0.01	0.01	
	<i>Solanum indicum L.</i>	Ela batu	12	6.6	0.07	0.07	
	<i>Solanum nigrum</i>	Kalukammeriya	2	1.1	0.01	0.01	
	<i>Solanum violaceum</i>	vel thibbatu	3	1.7	0.02	0.02	
	<i>Solanum virginianum</i>	Katuwel batu	36	19.9	0.20	0.21	
Urticaceae/Euphorbiaceae	<i>Boehmeria nivea/Tragia plukenetii</i>	Kahambiliya/Wel kahambiliya	2	1.1	0.01	0.01	

Vitaceae	<i>Cissus quadrangularis</i>	Heerassa	1	0.6	0.01	0.01
Xanthorrhoeaceae	<i>Aloe vera</i>	Komarika	1	0.6	0.01	0.01
Xyridaceae	<i>Xyris indica L.</i>	Ran manissan	1	0.6	0.01	0.01
Zingiberaceae	<i>Alpinia calcarata</i>	Heen araththa	10	5.5	0.06	0.06
	<i>Curcuma longa</i>	Kaha	1	0.6	0.01	0.01
	<i>Elettaria cardamomum</i>	Enasal/Karanda mungu	2	1.1	0.01	0.01
	<i>Zingiber officinale</i>	Inguru	54	29.8	0.30	0.31
Zygophyllaceae	<i>Tribulus terrestris</i>	Heen gokatu /Heen nerenchi	5	2.8	0.03	0.03

(overall response rate: 98.9%)

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### 3.2 Predominant medicinal herbs for Dengue Hemolytic Infection

In the present study the most cited 15 medicinal plants in Sri Lanka were *Carica papaya* L. (43.9), *Coriandrum sativum* L. (37.0), *Mollugo cerviana* (34.1), *Zingiber officinale* (31.2), *Coscinium fenestratum* (27.0), *Munronia pinnata* (26.6), *Ocimum tenuiflorum* L. (25.4), *Andrographis paniculata* (21.4), *Solanum virginianum* (20.8), *Jasticia adhatoda* (20.8), *Tinospora cordifolia* (20.2), *Azadirachta indica* (19.1), *Piper longum* L. (17.9), *Alstonia scholaris* L. (12.7) and *Vernonia cinerea* L. (11.6).

*Carica papaya* leaf extract as the most widely used plant in the treatment of Dengue in Sri Lanka. *C. papaya* leaves have been used traditionally to cure Dengue Fever [19]. Leaf extract of *C. papaya* has significantly increased the platelet count in patients with thrombocytopenia, WBC and Neutrophils associated with dengue with fewer side effects and good tolerability within 24 hours of treatment [20-22]. *Coriandrum sativum* L cited as an anti-dengue medicinal plant in the current survey, but there was no specific literature for *C. sativum* L. referring to Dengue. However, the plant based insecticidal activity was proven that the plant extracts have LC<sub>50</sub> value of 363.7 ppm. The immunomodulatory activity of the plant also proven [23, 24]. *Mollugo cerviana* found in most of the south Asian countries. It is useful herb in Ayurveda medicine which is used as antimicrobial, antioxidant, hepatoprotective and photo-protective agent. However antiviral and activity against DHI were reported for a polyherbal extract containing *Vetiveria zizanioides*, *Trichosanthes cucumerina*, and *M. cerviana* [25, 26]. The TMPs might have declared these two plants due to traditionally accepted anti-pyretic and anti-inflammatory properties. The most of the TMPs recommended using *Andrographis paniculata* as an alternative for *Munronia pinnata* in their formulations because of the scarcity and expensiveness of *M. pinnata*. Due to certain phytochemical properties and antioxidant capacity of these two plants justifies the use of *A. paniculata* as a substitute for *M. pinnata* in DC systems of medicine in Sri Lanka [25, 27, 28]. Major bioactive phytoconstituent of *A. paniculata* has been identified with number of vital clinical properties such as antioxidant, anti-inflammatory, anticancer, antimicrobial, antiparasitic, hepatoprotective, antihyperglycemic, and anti-hypoglycemic [29]. The methanolic extracts of *A. paniculata* and *Ocimum tenuiflorum* L have shown the ability of inhibiting the DENV-1 serotype in vitro.

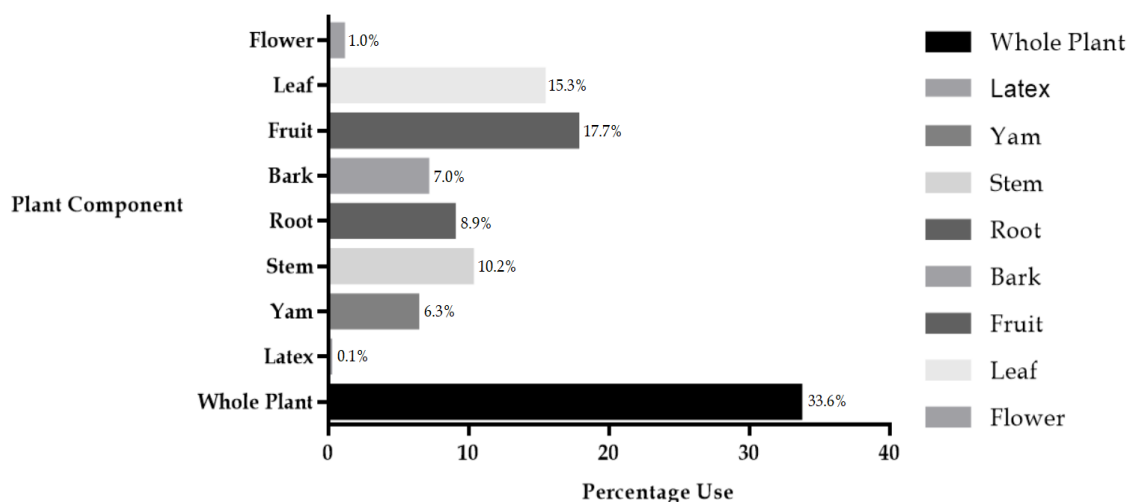
The plant is effective against upper respiratory tract infections, common cold, cardiovascular disease (due to anti-thrombotic activity), cancer and HIV [11, 30]. *A. paniculata* whole plant is being used by traditional healers in various districts of Bihar in India, in the management of Dengue fever [11].

The aqueous extract of *Zingiber officinale* rhizome contributes to regulation of plasma leakage in dengue infection and decrease the chances of severe dengue complications [31]. Methanolic extracts of *Solanum virginianum* (*Solanum xanthocarpum*) has been exhibited strong antibacterial effects in a laboratory study due to phenolic compounds and flavonoids. It has been also shown to have antioxidant properties. The extracts have terpenoids, tannins, steroids, and phenols as phytoconstituents. It was suggested that the anti-inflammatory activities of the tested plants by them are at least partially linked with their antioxidant properties [32, 33]. Hence it can be assumed that this plant may have been recommended by TMPs to prevent inflammation associated with DHI [31]. Aqueous extracts of *Azadirachta indica* leaves has shown anti-dengue activity by suppressing the replication of Dengue virus type-2 in both in vitro as well as in vivo systems [34, 35]. In the present survey none of the Sri Lankan TMPs stated *Psidium guajava* as a plant used in Dengue treatment. However, *P. guajava* fruits are used to increase platelet counts, therefore helping to avoid bleeding in dengue hemorrhage [36].

### 3.3 Quantitative ethnopharmacological study

Quantitative data analysis was performed to identify the most promising medicinal plants used in the treatment of DHI. As calculated by UV<sub>sp</sub>, *Carica papaya* L., *Coriandrum*

*sativum L.*, *Mollugo cerviana*, *Zingiber officinale*, *Coscinium fenestratum* and *Munronia pinnata* were reported to be of the highest use value above 0.25. *Carica papaya L.*, is used as the treatment of DHI, with a UV up to 0.42. While both *Coriandrum sativum L.* and *Mollugo cerviana*, used with a UV up to 0.35 and 0.33 respectively. The  $UV_{IF}$  for *Carica papaya L.*, *Coriandrum sativum L.* and *Mollugo cerviana* were 0.44, 0.37 and 0.34 respectively. There were 5.5% plant species with above 0.20  $UV_{sp}$  and 6.1% plant species were above 0.20  $UV_{IF}$ .



**Fig. 3. Assessment of specific plant components used by TMPs in the treatment of Dengue (overall response rate 98.9%)**

The analysis of the growth forms of the medicinal plants used in the research area revealed that the majority are trees (51.1%), followed by shrubs (42.8%), herbaceous plants (4.4%) and ferns (1.7%). Those plant parts or products used for making plant preparations are whole plant, fruits, leaves and stem (fig. 3), which contributes 33.3% from all plant parts used by TMPs in the treatment of DHI.

**Table 2: Assessment of administrative techniques used by TMPs in the treatment of Dengue**

Dosage form	Total Number	Percentage
Decoction (aqueous-warm but not boiled)	126	29.6
Alcoholic extract	31	7.3
Pills prepared usually in combination	51	12
Fermented form	22	5.2
Dry powder	58	13.6
Paste	45	10.6
Dried form	2	0.5
Extract (natural herbal extract)	42	9.9
Extract with boiled in coconut milk	28	6.6
Boiled with water	6	1.4
External applications	3	0.7
Concentrated form of decoction in sugar/ alcohol	1	0.2
Panchakarma* (five procedures eliminate toxin)	1	0.2



Tablet	1	0.2
Oral liquid	2	0.5
Oil	2	0.5
Enema remove toxins from anus	1	0.2
Soup	1	0.2

\***Panchakarma** is a combination of five procedures of purification of the body including, emesis, purgation, decoction enema, instillation of medicine through nostrils, and anal oil enema. These procedures aim at plucking away the deep-rooted imbalances in the body

Table 2 showed the most frequently mentioned plants the respondents used in the form of decoctions, powders and pills prepared usually in combination.

**Table 3: Assessment of administrative techniques used by TMPs in the treatment of Dengue in plants used in herbarium**

Scientific name	English name	Administrative technique
<i>Carica papaya L.</i>	Papaya/pawpaw	DC, FM, PD, EX, LT
<i>Coriandrum sativum L.</i>	Coriander	DC, AL, PL, FM, PD, PS
<i>Mollugo cerviana</i>	Thread stem carpetweed	DC, AL, PL, FM, PD, PS
<i>Zingiber officinale</i>	Ginger	DC, AL, PL, FM, PD, PS
<i>Coscinium fenestratum</i>	Yellow vine bark	DC
<i>Munronia pinnata</i>	Ground neem/king bitter	DC, FM, PD
<i>Ocimum tenuiflorum L.</i>	Holy basil/Thulsi	DC, AL, PL, FM, PD, PS
<i>Andrographis paniculata</i>	Green chiryta Yellow fruit nightshede/yellow-berried	DC, AL, PL, FM, PD, PS, BL
<i>Solanum virginianum</i>	nightshade	DC, PD
<i>Tinospora cordifolia</i>	Heart-leaved moonseed	DC, BL
<i>Justicia adhatoda L.</i> ( <i>Pavetta indica</i> )	Malabar nut	DC, AL, PL, FM, PD
<i>Azadirachta indica</i>	Neem	DC, FM, PD
<i>Piper longum L.</i>	Long pepper/Indian long pepper	DC, FM, PD
<i>Alstonia scholaris L.</i>	Blackboard tree/devils' tree	DC, PD
<i>Vernonia cinerea L.</i>	Little ironweed	DC, AL, PL, FM, PD, PS

AL-alcoholic extract, BL- boiled (aqueous extract), DC- decoction (aqueous extract), EX-extract by expression FM- fermented, PD-powder, PL- pill, PS- paste, LT- latex

#### 4. CONCLUSION

The local population of Sri Lanka still relies strongly on *Deshiya Chikithsa* and the use of medicinal plants as curative remedies for diseases. These medicinal plants are used as a preventative form of treatment, even though, the country has professionally managed government funded western medical system. DC practitioners transfer this knowledge to the descendants. The recipes for the preparation and use of medicinal plants are generously not shared with anyone interested in the use. A further pharmaceutical research is recommended in order to provide additional knowledge about the positive and negative effects of medicinal plants, thus justifying the need for screening and detailed studies intended to isolate and characterize compounds active against DHI.

## ETHICAL APPROVAL

All TMPs gave prior written informed consent before they were interviewed, and confidentiality of individual personal information was ensured. Ethical clearance was obtained from the Ethics Review Committee (ERC) of University of Sri Jayewardenepura under ERC Application No 88/17, with effective from 25/01/2018.

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