

Clerodendrum and Healthcare: An Overview

Neeta Shrivastava* • Tejas Patel

B. V. Patel Pharmaceutical Education and Research Development (PERD) Centre, S. G. Highway, Thaltej, Ahmedabad - 380054, Gujarat, India

Corresponding author: * neetashrivastava_perd@yahoo.co.in

ABSTRACT

The genus *Clerodendrum* L. (Family: Lamiaceae) is very widely distributed in tropical and subtropical regions of the world. More than five hundred species of the genus are identified till now, which includes small trees, shrubs and herbs. Ethno-medical importance of various species of *Clerodendrum* genus has been reported in various indigenous systems of medicines and as folk medicines. The genus is being used as medicines specifically in Indian, Chinese, Thai, Korean, Japanese systems of medicine for the treatment of various life-threatening diseases such as syphilis, typhoid, cancer, jaundice and hypertension. Few species of the genus like *Clerodendrum inerme*, *C. thomasonae*, *C. indicum*, and *C. speciosum* are ornamental and being cultivated for aesthetic purposes. The powder/paste form and the various extracts of root, stem and leaves are reported to be used as medicine for the treatment of asthma, pyreticosis, cataract, malaria, and diseases of blood, skin and lung. To prove these ethno-medical claims, some of these species are being extensively studied for their biological activities using various animal models. Along with biological studies, isolation and identification studies of chemical constituents and its correlation with the biological activities of the genus has also been studied. The major chemical components reported from the genus are phenolics, steroids, di- and triterpenes, flavonoids, volatile oils, etc. This review mainly covers the extent of work done on biological activities of various *Clerodendrum* species such as *C. trichotomum*, *C. bungei*, *C. chinense*, *C. colebrookianum*, *C. inerme*, *C. phlomidis*, *C. petasites*, *C. grayi*, *C. indicum*, *C. serratum*, *C. campbellii*, *C. calamitosum* and *C. cyrtophyllum* that can be used both in conventional therapy or as replacement therapies for the treatment of various diseases.

Keywords: ethnomedical, phytochemistry, anti-inflammatory, antimicrobial, antimalarial, antioxidant, antidiabetic, polyphyletic, paraphyletic

Abbreviations: AGC, apigenin-7-O-β-D-glucoside; GSH, glutathione; MDA, malondialdehyde; PGE2, prostaglandin E2; XO, xanthine oxidase

CONTENTS

INTRODUCTION.....	142
ETHNOMEDICAL USES.....	146
PHYTOCHEMISTRY.....	146
BIOLOGICAL ACTIVITIES.....	147
Anti-inflammatory activities.....	147
Antimicrobial activities.....	147
Antimalarial activities.....	148
Antioxidant activities.....	148
Other biological activities of <i>Clerodendrum</i> genus.....	148
SUMMARY.....	148
ACKNOWLEDGEMENT.....	149
REFERENCES.....	149

INTRODUCTION

The genus *Clerodendrum* L. [Family Lamiaceae (Verbenaceae)] is very widely distributed in tropical and subtropical regions of the world and is comprised of small trees, shrubs and herbs. The first description of the genus was given by Linnaeus in 1753, with identification of *C. infortunatum*. After a decade later in 1763 Adanson changed the Latin name "*Clerodendrum*" to its Greek form "*Clerodendron*"; in Greek *Klero* means chance and *dendron* means tree i.e. chance tree which means the tree which does not bring good luck like *Clerodendron infortunatum* or the tree which brings good luck like *C. fortunatum*. Later on after a span of about two centuries in 1942 Moldenke readopted the Latinized name '*Clerodendrum*', which is now commonly used by taxonomists for the classification and description of the genus and species (Moldenke 1985; Rueda 1993; Hsiao and Lin 1995; Steane *et al.* 1999). *Clerodendrum* is a very

large and diverse genus and till now five hundred and eighty species of the genus have been identified and are widely distributed in Asia, Australia, Africa and America (**Table 1**). A high degree of morphological and cytological variation (from 2n=24 to 2n=184) amongst the species, suggesting the paraphyletic or polyphyletic origin of the genus. Molecular systematic studies based on chloroplast and nuclear DNA also indicate polyphyletic origin of the genus (Steane *et al.* 1999). Owing to morphological variations like length of the corolla tube, size of leaves, and type of inflorescence some authors have classified the genus into two major subgenera, *Clerodendrum* and *Cyclonema* (Steane *et al.* 1999) while others have classified it into five subgenera and each subgenus is again subdivided into many sections (Moldenke 1985). Similarly many species of the genus have been described by more than one author and hence are denoted in the literature with the name of different authors e.g. *C. floribundum* Hort. and *C. floribundum* R.Br., *C. foetidum* Bunge

Table 1 List of various species from the genus *Clerodendrum*. * Species described by more than one author.

<i>C. acerbiana</i> Benth. & Hook.f.	<i>C. cemuum</i> Wall.ex Steud.	<i>C. foetidum</i> Bunge*	<i>C. kampoense</i> Dop
<i>C. aculeatum</i> (L.) Schlecht.*	<i>C. chamaeriphes</i> Wernham	<i>C. formicarum</i> Gurke	<i>C. kanichi</i> Wildem.
<i>C. acuminatum</i> Wall.	<i>C. citrinum</i> Ridley	<i>C. formosanum</i> Maxim.	<i>C. katangensis</i> Wildem.
<i>C. adenocalyx</i> Dop	<i>C. coccineum</i> D.Dietr.*	<i>C. fortunatum</i> Buch.-Ham.ex Wall.*	<i>C. kentrocaule</i> Baker
<i>C. adenophyllum</i> H.Hallier	<i>C. cochinchinense</i> Dop	<i>C. fortunei</i> Hemsl.	<i>C. kinabaluense</i> Stapf
<i>C. affine</i> Griff.	<i>C. colebrookianum</i> Walp.	<i>C. fragrans</i> Vent.*	<i>C. kirkii</i> Baker
<i>C. africanum</i> Moldenke	<i>C. commersonii</i> Spreng.	<i>C. francavilleanum</i> Buchinger ex Berthold Thomas	<i>C. kissakense</i> Guerke
<i>C. aggregatum</i> Gurke	<i>C. condensatum</i> Miq.	<i>C. friesii</i> K.Schum.	<i>C. klemmei</i> Elmer
<i>C. alatum</i> Gurke	<i>C. confusum</i> H.Hallier	<i>C. friesii</i> K.Schum.	<i>C. koshunense</i> Hayata
<i>C. albiflos</i> H.J.Lam	<i>C. congensense</i> Baker*	<i>C. f.rutectorum</i> S.Moore	<i>C. kwangtungense</i> Hand.-Mazz.
<i>C. amicum</i> Seem.	<i>C. congestum</i> Guerke	<i>C. fugitans</i> Wernham	<i>C. laciniatum</i> Balf.f.
<i>C. amplifolium</i> S.Moore	<i>C. conglobatum</i> Baker	<i>C. fuscum</i> Gurke.	<i>C. laevifolium</i> Blume
<i>C. amplius</i> Hance	<i>C. consors</i> S.Moore	<i>C. galeatum</i> Balf.f.	<i>C. lanceolatum</i> F.Muell.
<i>C. anafense</i> Britton & P.Wils.	<i>C. corbisieri</i> De Wild.	<i>C. garrettianum</i> Craib	<i>C. lanceolatum</i> Gurke.
<i>C. angolense</i> Guerke	<i>C. cordatum</i> D.Don	<i>C. gaudichaudii</i> Dop	<i>C. lanceoliferum</i> S.Moore
<i>C. angustifolium</i> Salisb.*	<i>C. cordifolium</i> A.Rich.	<i>C. geoffrayi</i> Dop	<i>C. lanessanii</i> Dop
<i>C. apayaoense</i> Quisumb.	<i>C. coriaceum</i> Poir.*	<i>C. giletii</i> Wildem. & Th.Dur.	<i>C. lankawiense</i> King & Gamble
<i>C. arenarium</i> Baker	<i>C. coromandelianum</i> Spreng.	<i>C. glaberrimum</i> Hayata	<i>C. lanuginosum</i> Blume
<i>C. arthur-gordoni</i> Horne ex Baker	<i>C. costaricensis</i> Standley	<i>C. glabratum</i> Guerke	<i>C. laciniatum</i> C.B.Clarke
<i>C. assurgens</i> K.Schum.	<i>C. costatum</i> R.Br.	<i>C. glabrum</i> E.Mey.	<i>C. laxicymosum</i> De Wild.
<i>C. attenuatum</i> De Wild.*	<i>C. costulatum</i> K.Schum.	<i>C. glandulosum</i> Colebr.ex Wall.	<i>C. laxiflorum</i> Baker
<i>C. auctubifolium</i> Hemsl.	<i>C. cruentum</i> Lindl.	<i>C. glandulosum</i> Lindl.	<i>C. lecomtei</i> Dop
<i>C. aurantiacum</i> Baker	<i>C. cubensis</i> Schau.	<i>C. glaucum</i> Wall.ex Steud.	<i>C. lehurii</i> Horne ex Baker
<i>C. aurantium</i> GDon	<i>C. culinare</i> Sesse & Moc.	<i>C. globuliflorum</i> Berthold Thomas	<i>C. lelyi</i> Hutchinson
<i>C. × speciosum</i> Teijsm. & Binn.	<i>C. cumingianum</i> Schau.	<i>C. godefroyi</i> Kuntze	<i>C. leucophloeum</i> Balf.f.
<i>C. bakeri</i> Gurke	<i>C. cuneatum</i> Guerke*	<i>C. goossensi</i> De Wild.	<i>C. leucosceptrum</i> D.Don
<i>C. balfourii</i> Hort.	<i>C. cuneifolium</i> Baker	<i>C. gordonii</i> Baker	<i>C. leveillei</i> Fedde ex Leveille
<i>C. barbafelis</i> H.Hallier	<i>C. cunninghamii</i> Benth.	<i>C. gossweileri</i> Exell	<i>C. ligustrinum</i>
<i>C. baronianum</i> Oliver	<i>C. curranii</i> Elmer	<i>C. grandicalyx</i> E.A.Bruce	<i>C. lindavianum</i> Lauterb.
<i>C. barteri</i> Baker	<i>C. curtisii</i> N.E.Br.	<i>C. grandiflorum</i> Schau.	<i>C. lindemuthianum</i> Vatke
<i>C. baumii</i> Guerke	<i>C. cuspidatum</i> Turcz.	<i>C. grandifolium</i> Gurke*	<i>C. lindianum</i> A.Eich.
<i>C. bequaerti</i> De Wild	<i>C. cyrtophyllum</i> Turcz	<i>C. gratum</i> Kurz*	<i>C. lindleyi</i> Decne.ex Planch.
<i>C. bernieri</i> Briq.	<i>C. darrisii</i> Leveille	<i>C. greyi</i> Baker	<i>C. linnaei</i> F.Muell.*
<i>C. bethuneanum</i> Low	<i>C. deflexum</i> Wall.	<i>C. griffithianum</i> C.B.Clarke	<i>C. lividum</i> Lindl.
<i>C. bingaense</i> S.Moore	<i>C. dekindtii</i> Guerke	<i>C. guerkii</i> Baker	<i>C. lloydianum</i> Craib
<i>C. bipindense</i> Guerke	<i>C. dembianense</i> Chiov.	<i>C. haematocalyx</i> Hance	<i>C. lobbii</i> C.B.Clarke
<i>C. blancoanum</i> Villar	<i>C. densiflorum</i> Griff.	<i>C. haematolasium</i> H.Hallier	<i>C. longicolle</i> G.F.W.Mey.
<i>C. blancoi</i> Naves ex Villar	<i>C. dentatum</i> Wall.	<i>C. hahnianum</i> Dop	<i>C. longiflorum</i> Decne.
<i>C. blumeanum</i> Schau.	<i>C. depauperatum</i> Wall.ex Steud.	<i>C. haxianense</i> Hand.-Mazz.	<i>C. longilimbum</i> P'ei
<i>C. bodinierii</i> Leveille	<i>C. dependens</i> Aug.DC.	<i>C. harmandianum</i> Dop	<i>C. longipetiolatum</i> Gurke*
<i>C. bolivianum</i> Rusby	<i>C. dicolor</i> Vatke	<i>C. harnierianum</i> Schweinf.	<i>C. longisepalum</i> Dop
<i>C. botryoides</i> Baker	<i>C. diepenhorstii</i> Miq.	<i>C. hastato-oblongum</i> C.B.Clarke	<i>C. longituba</i> Valetton
<i>C. botryoides</i> K.Schum.	<i>C. dinklagei</i> Gurke	<i>C. hastatum</i> Lindl.	<i>C. longitubum</i> Wildem. & Th.Dur.
<i>C. brachyanthum</i> Schau.	<i>C. discolor</i> Becc.	<i>C. helianthemifolium</i> Wall.ex Steud.	<i>C. luembense</i> De Wild.
<i>C. brachypus</i> Urb.	<i>C. disparifolium</i> Blume	<i>C. hemiderma</i> F.Muell.ex Benth.	<i>C. lujaei</i> Wildem. & Th.Dur.
<i>C. lerodendrum bracteatum</i> Wall.	<i>C. divar. catum</i> Jack*	<i>C. henryi</i> P'ei	<i>C. lupakense</i> S.Moore
<i>C. bracteosum</i> Kostel.	<i>C. diversifolium</i> Vahl	<i>C. herbaceum</i> Wall.	<i>C. luzoniense</i> Merrill
<i>C. brassii</i> Beer & H.J.Lam	<i>C. dubium</i> De Wild.	<i>C. heterophyllum</i>	<i>C. mabesae</i> Merrill
<i>C. brazzavillense</i> A.Cheval.	<i>C. duckei</i> Moldenke	<i>C. hettae</i> H.Hallier	<i>C. macradenium</i> Miq.
<i>C. breviflorum</i> Ridl.	<i>C. dumale</i> Baker	<i>C. hexagonum</i> De Wild	<i>C. macrocalycinum</i> Baker
<i>C. brookeanum</i> W.W.Smith	<i>C. dumale</i> K.Schum.	<i>C. hexangulatum</i> Berthold Thomas	<i>C. macrocalyx</i> De Wild.*
<i>C. brunfelsiiflorum</i> H.Hallier	<i>C. dusenii</i> Guerke	<i>C. hildebrandtii</i> Vatke	<i>C. macrophyllum</i> Blume*
<i>C. brunsvigioides</i> Baker	<i>C. eketense</i> Wernham	<i>C. hircinum</i> Schau.	<i>C. macrosiphon</i> Hook.f.*
<i>C. buechananii</i> Herb.Roxb.ex Wall.	<i>C. ekmani</i> Moldenke	<i>C. hirsutum</i> GDon*	<i>C. macrostachyum</i> Baker*
<i>C. buchholzii</i> Gurke	<i>C. elbertii</i> H.Hallier	<i>C. hispidum</i> M.R.Henderson	<i>C. macrostegium</i> Schau.
<i>C. buchneri</i> Gurke	<i>C. elegans</i> Manetti ex Lem.	<i>C. hockii</i> De Wild.	<i>C. madaeera</i> Voigt
<i>C. buetneri</i> Gurke	<i>C. ellipticum</i> Zipp.ex Span.	<i>C. holstii</i> Guerke ex Baker*	<i>C. magnificentum</i> Warb.
<i>C. bukobense</i> Gurke	<i>C. elliptifolium</i> Merrill	<i>C. holtzei</i> F.Muell.	<i>C. magnoliaefolium</i> Baker
<i>C. bungei</i> Steud.	<i>C. elmeri</i> Merrill	<i>C. horsfieldii</i> Miq.	<i>C. makanjanum</i> H.Winkler
<i>C. buruanum</i> Miq.	<i>C. emarginatum</i> Briq.	<i>C. huegelii</i> Hort.ex Regel	<i>C. mandarinorum</i> Diels
<i>C. buxifolium</i> Spreng.	<i>C. emirnense</i> Boj.ex Hook.	<i>C. humile</i> Chiov.	<i>C. manetti</i> Vis.
<i>C. cabrae</i> De Wild.	<i>C. epiphyticum</i> Standley	<i>C. hysteroanthum</i> Baker	<i>C. manni</i> Baker
<i>C. caeruleum</i> N.E.Br.	<i>C. erectum</i> De Wild.	<i>C. illustre</i> N.E.Br.	<i>C. margaritense</i> Moldenke
<i>C. caesium</i> Guerke	<i>C. eriophyllum</i> Gurke	<i>C. impensum</i> Berthold Thomas	<i>C. matudae</i> Standley
<i>C. calamistratum</i> Hort.Belg.ex Lem.	<i>C. eriosiphon</i> Schau.	<i>C. imperialis</i> Carr.	<i>C. medium</i> R.Br.
<i>C. calamitosum</i> Linn.	<i>C. esquirolii</i> Leveille*	<i>C. inaequipetiolatum</i> Good	<i>C. megasepalum</i> Baker
<i>C. calcicola</i> Britton	<i>C. eucalycinum</i> Oliver	<i>C. incisum</i> Klotzsch	<i>C. melanocrater</i> Gurke
<i>C. calycinum</i> Turcz.	<i>C. eupatorioides</i> Baker	<i>C. indeniense</i> A.Cheval.	<i>C. membranifolium</i> H.J.Lam
<i>C. camagueyense</i> Britton & P.Wils.	<i>C. euryphyllum</i> Mildbr.	<i>C. indicum</i> Druce*	<i>C. mexicanum</i> T.S.Brandegee
<i>C. canescens</i> Wall.	<i>C. excavatum</i> De Wild.	<i>C. inferne</i> Gaertn.*	<i>C. meyeri-johannis</i> Mildbraed
<i>C. canescens</i> Wall.	<i>C. fallax</i> Lindl.	<i>C. infortunatum</i> Dennst.*	<i>C. micans</i> Gurke
<i>C. capense</i> D.Don ex Steud.*	<i>C. fargesii</i> Dode	<i>C. ingratum</i> K.Schum. & Lauterb.	<i>C. microcalyx</i> Ridley
<i>C. capitatum</i> Hook.*	<i>C. farinosum</i> Wall.	<i>C. intermedium</i> Berthold Thomas*	<i>C. microphyllum</i> Berthold Thomas
<i>C. capsulare</i> Blanco	<i>C. fasciculatum</i> Berthold Thomas	<i>C. involucreatum</i> Vatke	<i>C. mildbraedii</i> Berthold Thomas
<i>C. cardiophyllum</i> F.Muell.	<i>C. fastigiatum</i> H.J.Lam	<i>C. ixoraeflorum</i> Hazsk.	<i>C. minahassae</i> Teijsm. & Binn.
<i>C. carnosulum</i> Baker	<i>C. ferrugineum</i> Turcz.	<i>C. jackianum</i> Wall.	<i>C. mindorense</i> Merrill
<i>C. castaneaefolium</i> Klotzsch	<i>C. finetii</i> Dop	<i>C. japonicum</i> Mak.*	<i>C. minutiflorum</i> Baker
<i>C. castaneifolium</i> Hook. & Arn.	<i>C. fischeri</i> Gurke ex Engl.	<i>C. javanicum</i> Spreng.*	<i>C. mirabile</i> Baker
<i>C. catalpifolium</i> H.Hallier	<i>C. fistulosum</i> Becc.*	<i>C. johnstoni</i> Oliver	<i>C. mite</i> Vatke
<i>C. caulambum</i> Exell	<i>C. flavum</i> Merrill	<i>C. kaempferi</i> Fisch.ex Morr.	<i>C. moldenkeanum</i> Standley
<i>C. cauliflorum</i> De Wild.*	<i>C. fleuryi</i> A.Chevalier	<i>C. kalaotoense</i> H.J.Lam	<i>C. molle</i> H.B. & K.*
<i>C. cavaleriei</i> Leveille	<i>C. floribundum</i> Hort.*	<i>C. kalbreyeri</i> Baker	<i>C. montanum</i> Berthold Thomas
<i>C. cephalanthum</i> Oliver			

Table 1 (cont.) * Species described by more than one author.

<i>C. morigono</i> Chiov.	<i>C. poggei</i> Gurke	<i>C. schultzei</i> Mildbr.	<i>C. thyrsoides</i> Baker*
<i>C. mossambicensis</i> Klotzsch	<i>C. polyanthum</i> Guerke	<i>C. schweinfurthii</i> Gurke	<i>C. tomentellum</i> Hutchinson & Dalziel
<i>C. moupinense</i> Franch.	<i>C. polycephalum</i> Baker	<i>C. scopiferum</i> Miq.	<i>C. tomentosum</i> R.Br.
<i>C. muenzneri</i> Berthold Thomas	<i>C. populneum</i> Beer & H.J.Lam	<i>C. semiserratatum</i> Wall.	<i>C. tonkinense</i> Dop
<i>C. multibracteatum</i> Merrill	<i>C. porphyrocalyx</i> K.Schum. & Lauterb.	<i>C. sereti</i> De Wild.	<i>C. toxicarium</i> Baker*
<i>C. multiflorum</i> G.Don	<i>C. powellii</i> Benth. & Hook.f.ex Drake	<i>C. sericeum</i> Wall.	<i>C. tracyanum</i> F.Muell.ex Benth
<i>C. myrianthum</i> Mildbr.	<i>C. preslii</i> Elmer	<i>C. serotinum</i> Carr.*	<i>C. transvaalense</i> Berthold Thomas
<i>C. myricoides</i> Gurke*	<i>C. preussii</i> Gurke.	<i>C. serratum</i> Moon*	<i>C. tricholobum</i> Guerke
<i>C. myrmecophila</i> Ridl.	<i>C. prittwitzii</i> Berthold Thomas	<i>C. sieboldii</i> Kuntze	<i>C. trichotomum</i> Thunb.*
<i>C. natalense</i> Gurke	<i>C. puberulum</i> Merrill	<i>C. silvaeanum</i> Henriques	<i>C. triflorum</i> Vis.
<i>C. navesianum</i> Vidal	<i>C. pubescens</i> Lindl.	<i>C. silvestre</i> Berthold Thomas	<i>C. trifoliatum</i> Steud.
<i>C. nereifolium</i> Wall.	<i>C. pubescens</i> Walp.	<i>C. silvicola</i> Guerke.	<i>C. triphyllum</i> H.H.W.Pearson
<i>C. neumayeri</i> Vatke	<i>C. pulchrum</i> Fawc.	<i>C. simile</i> H.H.W.Pearson*	<i>C. triplinerve</i> Rolfe
<i>C. nhatrangense</i> Dop	<i>C. pulverulentum</i> Engl.	<i>C. simplex</i> G.Don	<i>C. tuberculatum</i> A.Rich.
<i>C. nipense</i> Urb.	<i>C. pumilum</i> Ridley	<i>C. singalense</i> Miq.	<i>C. ubanghense</i> A.Chevalier
<i>C. noiroti</i> A.Chevalier	<i>C. pumilum</i> Spreng.	<i>C. singwanum</i> Berthold Thomas	<i>C. ugandense</i> Prain
<i>C. nutans</i> Jack*	<i>C. pusillum</i> Guerke	<i>C. sinuatum</i> Hook.	<i>C. ulei</i> Hayek
<i>C. nyctaginifolium</i> Good	<i>C. putre</i> Schau.	<i>C. siphonanthus</i>	<i>C. ulugurense</i> Guerke
<i>C. obanense</i> Wernham	<i>C. pygmaeum</i> Merrill	<i>C. somalense</i> Chiov.	<i>C. umbellatum</i> Poir.
<i>C. obovatum</i> Walp.	<i>C. pynaertii</i> De Wild.	<i>C. speciosissimum</i> Hort.Angl.ex Schau.	<i>C. umbratile</i> King & Gamble
<i>C. obtusidens</i> Miq.	<i>C. pyramidale</i> Andr.	<i>C. speciosum</i> Guerke*	<i>C. uncinatum</i> Schinz
<i>C. odoratum</i> D.Don	<i>C. quadrangulatum</i> Berthold Thomas	<i>C. spicatum</i> Thunb.	<i>C. urticifolium</i> Wall.
<i>C. ohwii</i> Kanehira & Hatusima	<i>C. quadriloculare</i> Merrill	<i>C. spinescens</i> Gurke	<i>C. utakwense</i> Wernham
<i>C. orbicularis</i> Baker	<i>C. ramosissimum</i> Baker	<i>C. spinosum</i> Spreng.	<i>C. validipes</i> S.Moore
<i>C. oreadam</i> S.Moore	<i>C. reflexum</i> H.H.W.Pearson	<i>C. splendens</i> A.Cheval.*	<i>C. vanoverberghii</i> Merrill
<i>C. ornatum</i> Wall.	<i>C. rehmannii</i> Guerke	<i>C. splendidum</i> Wall.	<i>C. vanprukii</i> Craib
<i>C. ovalis</i> Klotzsch	<i>C. rhytidophyllum</i> K.Schum.	<i>C. squamatum</i> Vahl	<i>C. var. um</i> Berthold Thomas
<i>C. ovalifolium</i> A.Gray*	<i>C. ridleyi</i> King & Gamble	<i>C. squiresii</i> Merrill	<i>C. velutinum</i> A.Chevalier
<i>C. ovatum</i> Poir.*	<i>C. riedelii</i> Oliver	<i>C. stenanthum</i> Klotzsch	<i>C. velutinum</i> Berthold Thomas*
<i>C. oxysepalum</i> Miq.	<i>C. ringoeti</i> De Wild.	<i>C. streptocaulon</i> Hutchinson & Dalziel	<i>C. venosum</i> Wall.
<i>C. palmatolobatum</i> Dop	<i>C. robecchii</i> Chiov.	<i>C. strictum</i> Baker	<i>C. verrucosum</i> Splitg.ex De Vriese
<i>C. paniculatum</i> Linn.	<i>C. robinsonii</i> Dop	<i>C. stuhlmannii</i> Gurke	<i>C. verticillatum</i> D.Don
<i>C. papuanum</i> Scheff.	<i>C. robustum</i> Klotzsch	<i>C. subpandurifolium</i> Kuntze	<i>C. vestitum</i> Wall.ex Steud.
<i>C. parvitubulatum</i> Berthold Thomas	<i>C. roseum</i> Poit.	<i>C. subpeltatum</i> Wernham	<i>C. villosum</i> Blume
<i>C. pearsoni</i> Moldenke	<i>C. rotundifolium</i> Oliver	<i>C. subreniforme</i> Guerke	<i>C. violaceum</i> Guerke*
<i>C. peekelii</i> Markgraf	<i>C. rubellum</i> Baker	<i>C. subscaposum</i> Hemsl.	<i>C. viscosum</i> Vent.
<i>C. penduliflorum</i> Wall.	<i>C. rumphianum</i> Bull	<i>C. suffruticosum</i> Guerke	<i>C. volubile</i> Beauv.
<i>C. pentagonum</i> Hance	<i>C. rumphianum</i> De Vriese	<i>C. swynnertonii</i> S.Moore	<i>C. weinlandii</i> K.Schum.ex H.J.Lam
<i>C. petasites</i> S.Moore	<i>C. rusbyi</i> Moldenke	<i>C. sylvaticum</i> Briq.	<i>C. welwitschii</i> Gurke
<i>C. petunioides</i> Baker	<i>C. sagittatum</i> Wall.	<i>C. syringae-folium</i> Baker	<i>C. wenzelii</i> Merrill
<i>C. philippinense</i> Elmer	<i>C. sagraei</i> Schau.	<i>C. talbotii</i> Wernham	<i>C. whittfieldii</i> Seem.*
<i>C. philippinum</i> Schau.	<i>C. sahelangii</i> Koord.ex Bakh.	<i>C. tanganyikense</i> Baker	<i>C. wildemanianum</i> Exell
<i>C. phlebodes</i> C.H.Wright	<i>C. sanguineum</i> K.Schum.	<i>C. tatomense</i> Dop	<i>C. williamsii</i> Elmer
<i>C. phlomoides</i> Hort.Ital.ex DC.*	<i>C. sansibarensis</i> Gurke	<i>C. teaguei</i> Hutchinson	<i>C. wilmsii</i> Guerke
<i>C. phyllomega</i> Steud.	<i>C. sarawakanum</i> H.J.Lam	<i>C. ternatum</i> Schinz	<i>C. yakusimense</i> Nakai
<i>C. picardae</i> Urb.	<i>C. savanorum</i> De Wild.	<i>C. ternifolium</i> Baker*	<i>C. yaundense</i> Guerke
<i>C. pierreanum</i> Dop	<i>C. scandens</i> Beauv.*	<i>C. tessmanni</i> Moldenke	<i>C. yunnanense</i> Hu
<i>C. pilosum</i> H.H.W.Pearson	<i>C. scheffleri</i> Guerke*	<i>C. thomasi</i> Moldenke	<i>C. zambesiaceum</i> Baker
<i>C. pithecobium</i> Standley & Steyerm.	<i>C. schlechteri</i> Guerke	<i>C. thonneri</i> Guerke	
<i>C. pittieri</i> Moldenke ex Standley	<i>C. schliebenii</i> Mildbr.		
<i>C. pleiosciadium</i> Gurke	<i>C. schmidtii</i> C.B.Clarke		

Table 2 A few species of the *Clerodendrum* genus described by many authors.

<i>C. aculeatum</i> (L.) Schlecht.	<i>C. floribundum</i> Hort.	<i>C. infortunatum</i> Dennst.	<i>C. ovalifolium</i> Bakh.
<i>C. aculeatum</i> Griseb.	<i>C. floribundum</i> R.Br.	<i>C. infortunatum</i> Gaertn.	<i>C. ovalifolium</i> Engl.
<i>C. angustifolium</i> Salisb.	<i>C. foetidum</i> Bunge	<i>C. infortunatum</i> Linn.	<i>C. ovatum</i> Poir.
<i>C. angustifolium</i> Spreng.	<i>C. foetidum</i> D.Don	<i>C. intermedium</i> Berthold Thomas	<i>C. ovatum</i> R.Br
<i>C. attenuatum</i> De Wild.	<i>C. foetidum</i> Hort.Par.ex Planch.	<i>C. intermedium</i> Cham.	<i>C. scandens</i> Beauv.
<i>C. attenuatum</i> R.Br.	<i>C. fortunatum</i> Buch.-Ham.ex Wall.	<i>C. japonicum</i> Mak.	<i>C. scandens</i> Druce
<i>C. capense</i> D.Don ex Steud.	<i>C. fortunatum</i> Linn.	<i>C. japonicum</i> Sweet	<i>C. scandens</i> Linn.ex Jackson
<i>C. capense</i> Eckl. & Zeyh.ex Schau.	<i>C. fragrans</i> Vent.	<i>C. javanicum</i> Spreng.	<i>C. scheffleri</i> Guerke
<i>C. capitatum</i> Hook.	<i>C. fragrans</i> Willd.	<i>C. javanicum</i> Walp.	<i>C. schiffieri</i> A.Cheval.
<i>C. capitatum</i> Schum & Thou.	<i>C. glandulosum</i> Colebr.ex Wall.	<i>C. linnaei</i> F.Muell.	<i>C. serratum</i> Moon
<i>C. cauliflorum</i> De Wild.	<i>C. glandulosum</i> Lindl.	<i>C. linnaei</i> Thw.	<i>C. serratum</i> Spreng.
<i>C. cauliflorum</i> Vatke	<i>C. grandiflorum</i> Schau.	<i>C. macrocalyx</i> De Wild.	<i>C. simile</i> H.H.W.Pearson
<i>C. coccineum</i> D.Dietr.	<i>C. grandifolium</i> Gurke	<i>C. macrocalyx</i> H.J.Lam	<i>C. simile</i> Merrill
<i>C. coccineum</i> H.J.Lam	<i>C. grandifolium</i> Salisb.	<i>C. macrophyllum</i> Blume	<i>C. ternifolium</i> D.Don
<i>C. congensis</i> Baker	<i>C. gratum</i> Kurz	<i>C. macrophyllum</i> Sims	<i>C. ternifolium</i> H.B. & K.
<i>C. congensis</i> Engl.	<i>C. gratum</i> Wall.	<i>C. molle</i> H.B. & K.	<i>C. thyrsoides</i> Baker
<i>C. coriaceum</i> Poir.	<i>C. hirsutum</i> G.Don	<i>C. molle</i> Jack	<i>C. thyrsoides</i> Guerke
<i>C. coriaceum</i> R.Br.	<i>C. hirsutum</i> H.H.W.Pearson	<i>C. myricoides</i> Gurke	<i>C. toxicarium</i> Baker
<i>C. divar. catum</i> Jack	<i>C. holstii</i> Guerke ex Baker	<i>C. myricoides</i> R.Br. & Vatke	<i>C. toxicarium</i> Baker ex Gurke
<i>C. divar. catum</i> Sieb. & Zucc.	<i>C. holstii</i> Gurke.	<i>C. nutans</i> Jack	<i>C. velutinum</i> A.Chevalier
<i>C. fistulosum</i> Becc.	<i>C. indicum</i> Druce	<i>C. nutans</i> Wall.	<i>C. velutinum</i> Berthold Thomas
<i>C. fistulosum</i> Bower	<i>C. indicum</i> Kuntze	<i>C. ovalifolium</i> A.Gray	<i>C. velutinum</i> Wall.

and *C. foetidum* D. Don, *C. lanceolatum* F. Muell. and *C. lanceolatum* Gurke, etc.; some more examples are cited in **Table 2** (Rueda 1993; Hsiao and Lin 1995; Steane *et al.* 1999). Conclusive remarks on the origin and classification

of the genus are still lacking and a thorough revision of the classification of this genus supported by molecular systematics has been suggested by some researchers (Steane *et al.* 1999, 2004).

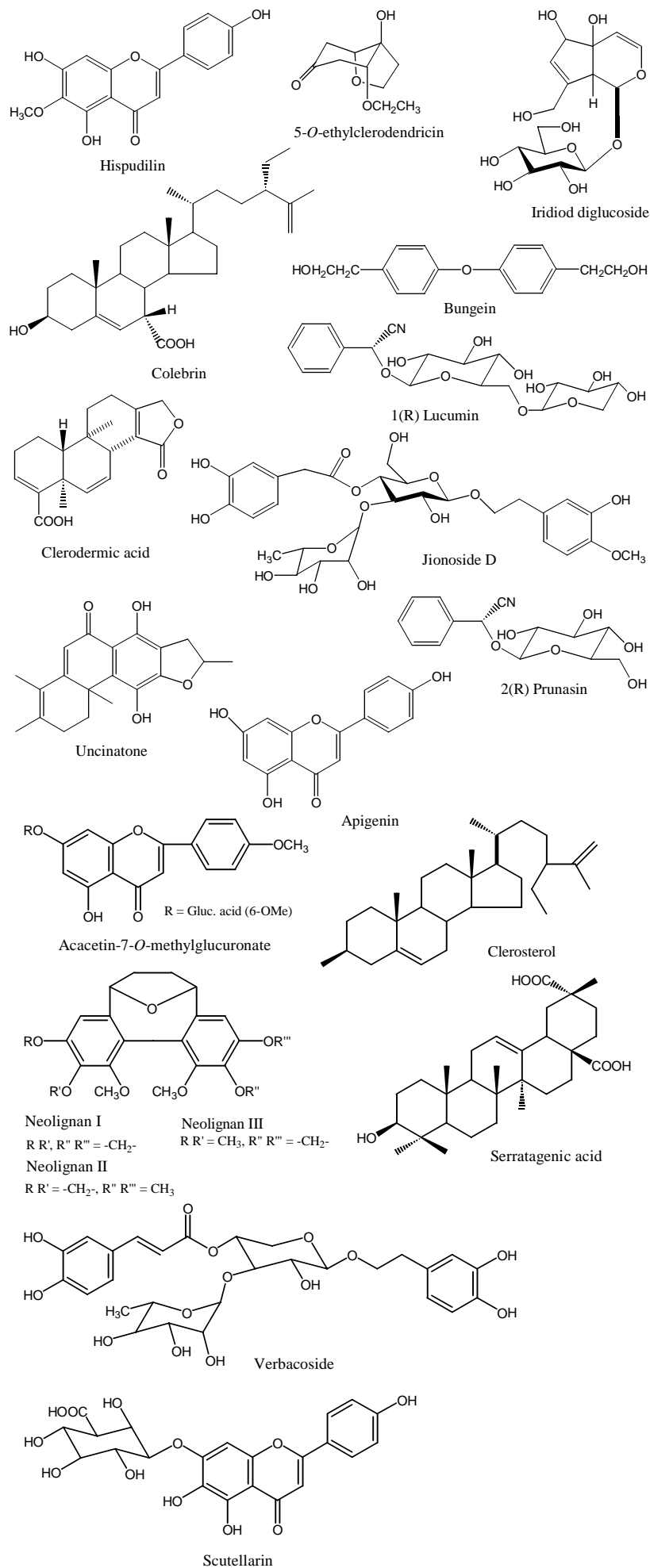


Fig. 1 Some of the major chemical constituents of *Clerodendrum* genus.

The genus is taxonomically characterized by its entire or toothed, oppositely arranged leaves, terete stems, terminally or axillary cymose inflorescence, hypogynous bisexual flowers, persistent calyx, cylindrical corolla tube with spreading 5-lobed at the top, exserted stamens, short bifid stigma, imperfectly 4-celled ovary, exalbuminous seeds and endocarp separating into 4 stony pyrenes (Kirtikar and Basu 1991; Hsiao *et al.* 1995; Steane *et al.* 1999). Resembling its taxonomic diversity, the genus exhibits a wide spectrum of folk and indigenous medicinal uses. Research is advancing towards scientific validation of classical therapeutic claims of the genus. In the present review we have focused on the medicinal and health care aspects of the genus. We have also included the work done on the phytochemical constituent responsible or believed to be responsible for the therapeutic properties of various species belong to the genus (**Fig. 1**).

ETHNOMEDICAL USES

A number of species from this genus were documented to be used as folk medicine by various tribes in Asian and African continents (**Table 3**). Many species of the genus have also been documented in traditional systems of medicine practiced in countries like India, China, Korea, Thailand and Japan.

Roots and leaf extracts of *C. indicum*, *C. phlomidis*, *C. serratum*, *C. trichotomum*, *C. chinense* and *C. petasites* have been used for the treatment of rheumatism, asthma and other inflammatory diseases (Anonymous 1992; Hazekamp *et al.* 2001; Kang *et al.* 2003; Panthong *et al.* 2003; Choi *et al.* 2004; Sungwook *et al.* 2004; Kanchanapoom *et al.* 2005). Plant species such as *C. indicum* and *C. inerme* were used to treat coughs, serofulous infection, buboes problem, venereal infections, skin diseases and as a vermifuge, febrifuge and also to treat Beriberi disease (Anonymous 1992; Rehman *et al.* 1997; Kanchanapoom *et al.* 2001). It was also reported that tribals use *C. inerme* as an antidote of poisoning from fish, crabs and toads (Rehman *et al.* 1997; Kanchanapoom *et al.* 2001; Pandey *et al.* 2003). *C. phlomidis*, *C. colebrookianum*, *C. calamitosum* and *C. trichotomum* have been reported to have antidiabetic, anti-hypertensive and sedative properties (Singh *et al.* 1980; Chaturvedi *et al.* 1984; Khan *et al.* 1996; Cheng *et al.* 2001; Kang *et al.* 2003; Chae *et al.* 2004; Choi *et al.* 2004). *C. cyrtophyllum* and *C. chinense* were used for the treatment of fever, jaundice, typhoid and syphilis (Cheng *et al.* 2001; Kanchanapoom *et al.* 2005). Roots, leaves and fresh juice of leaves of *C. infortunatum* were used in eliminating ascarids and tumors, and also as a laxative (Anonymous 1992). *C. phlomidis* has been used as an astringent and also in the treatment of gonorrhoea (Rani *et al.* 1999; Murugesan *et al.* 2001). The roots of *C. serratum* have been claimed to be used in dyspepsia, seeds in dropsy and leaves as a febrifuge and in cephalalgia and ophthalmia (Anonymous 1992). *C.*

calamitosum was used as a medicine for the treatment of kidney, gall and bladder stones. This plant is also reported to have diuretic and antibacterial properties (Cheng *et al.* 2001). In the Chinese system of medicine *C. bungei* is used for the treatment of headaches, dizziness, furuncles and hysteroptosis (Zhou *et al.* 1982; Yang *et al.* 2002). In India, fruits of *C. petasites* are used to produce sterility, while in China the plant is used as medicine for malaria (Hazekamp *et al.* 2001; Panthong *et al.* 2003). Leaves of *C. buchholzii* are reported in African pharmacopeia for treatment of furunculosis, echymosis and gastritis (Nyegue *et al.* 2005). Other than their therapeutic use, some of the species of the genus such as *C. inerme*, *C. thomsonae*, *C. indicum* and *C. speciosum* are also cultivated and used as ornamental plants.

PHYTOCHEMISTRY

As mentioned earlier the genus *Clerodendrum* is reported in various indigenous systems of medicine throughout the world for the treatment of various diseases. Efforts have been made by various researchers to isolate and identify biologically active principle and other major chemical constituents from various species of the genus. Research reports on the genus denote that the major class of chemical constituents present in the *Clerodendrum* genus are steroids such as β -sitosterol, γ -sitosterol octacosanol, clerosterol, bungein A, acteoside, betulinic acid, clerosterol 3-O- β -D-glucopyranoside, colebrin A-E, campesterol, 4 α -methylsterol, cholesta-5-22-25-trien-3- β -ol, 24- β -cholesta-5-22-25-triene, cholestanol, 24-methyl-22-dihydrocholestanol, 24- β -22-25-bis-dehydrocholesterol, 24- α -methyl-22-dehydrocholesterol, 24- β -methyl-22-dehydrocholesterol, 24-ethyl-22-dehydrocholesterol, 24-ethylcholesterol, 22-dehydroclerosterol, 24-methylathosterol, 24- β -ethyl-25-dehydro-lathosterol, (24S)-ethylcholesta-5-22-25-triene-3 β -ol have been isolated from various *Clerodendron* species such as *C. inerme*, *C. phlomidis*, *C. infortunatum*, *C. paniculatum*, *C. cyrtophyllum*, *C. fragrans*, *C. splendens*, *C. campbellii* and *C. splendens* (Bolger *et al.* 1970; Abdul-Alim 1971; Joshi *et al.* 1979; Sinha *et al.* 1980; Singh and Singhi 1981; Sinha *et al.* 1982; Hsu *et al.* 1983; Singh and Prakash 1983; Singh and Singhi 1983; Pinto and Nes 1985; Rempner and Hunkler 1986; Akihisa *et al.* 1989; Att-Ur-Rehman *et al.* 1997; Goswami *et al.* 1996; Yang *et al.* 2000; Kanchanapoom *et al.* 2001; Yang *et al.* 2002; Gao *et al.* 2003a, 2003b; Pandey *et al.* 2003; Kanchanapoom *et al.* 2005; Lee *et al.* 2006).

Another class of constituents are terpenes which include: monoterpenes, diterpenes, triterpenes, iridoids and sesquiterpenes. Terpenes such as α -amyrin, β -amyrin, caryoptin, 3-epicaryoptin, 16-hydroxy epicaryoptin, clerodendrin A, B and C, clerodrin, clerodermic acid, cleroinermin, friedelin, gramisterol, iridoids (inerminoside A, B, C and D, melittoside, monomelittoside, sammangaoside, ugandoside, 8-O-acetylmiosporoside), obtusifoliol, oleanolic acid, royleanone, dehydroroyleanone, sesquiterpene (sammangaoside A,

Table 3 A few species of *Clerodendrum* genus and their distribution in the world.

Scientific Name	Synonym	Distribution
<i>C. inerme</i> Gaertn.		India, Sri Lanka, South East Asian countries, Australia, Pacific Islands
<i>C. phlomidis</i> Linn. f.	<i>C. multiforum</i> Burm. f.	India
<i>C. serratum</i> Spreng.		India
<i>C. infortunatum</i> Linn.		The Philippines
<i>C. siphonanthus</i> R. Br.	<i>C. indicum</i> (Linn) Kuntze	India
<i>C. commersonii</i> Spreng.		China
<i>C. glabrum</i> E. Mey.		Southern Africa
<i>C. triphyllum</i> R. Br.		Southern Africa
<i>C. trichotomum</i>		China, Korea, Japan
<i>C. bungei</i> Stued.		China
<i>C. calamitosum</i> L.		Indonesia, Taiwan
<i>C. cyrtophyllum</i> Turcz.		Taiwan
<i>C. chinense</i> (Osborn) Mabblerley	<i>C. fragrans</i> (Vent.) Willd.	Tropical regions of Asia
<i>C. colebrookianum</i>		India, South Asian countries
<i>C. myricoides</i>		South Africa
<i>C. petasites</i> S. Moore		India, Malaysia, Sri Lanka, Vietnam, Southern China
<i>C. philippinum</i> Schauer		Queensland, Australia
<i>C. heterophyllum</i> R. Br. & Thb.		Southern Africa

B) clerodendrin A, uncinatone, Mi saponins-A, friedelanone, lupeol, betulinic acid, royleanone and dehydroroyleanone, and betulin have till now been isolated from various *Clerodendron* species such as *C. inerme*, *C. phlomidis*, *C. paniculatum*, *C. colebrookianum*, *C. wildii*, *C. uncinatum*, *C. mandarinorum*, *C. thomsonae*, *C. fragrans*, *C. ugandense*, *C. chinense* (Joshi *et al.* 1979; Sharma and Singh 1979; Singh *et al.* 1981; Sinha *et al.* 1981; Seth *et al.* 1982; Singh and Prakash 1983; Achari *et al.* 1990; Raha *et al.* 1991; Achari *et al.* 1992; Rao *et al.* 1993; Calis *et al.* 1994; El-Shamy *et al.* 1996; Kawai *et al.* 1998; Hazekamp 2001; Kanchanapoom *et al.* 2001; Yang *et al.* 2002; Kumari *et al.* 2003; Chae *et al.* 2004; Dorsaz *et al.* 2004; Nishida *et al.* 2004; Min *et al.* 2005).

Flavonoids are another class of compounds which are mainly present in *Clerodendron* species and they are also responsible for few biological activities. The major flavonoids present are cynaroside, 5-hydroxy-4'-7-dimethoxy methyl flavone, kaempferol, salvigenin, 4-methyl scutellarein, 5,7,4 O-trihydroxyflavone, apigenin, luteolin, acacetin-7-O-glucuronide, hispidulin, 2'-4'-4'-trihydroxy-6'-methyl chalcone, 7-hydroxy flavone, luteolin, naringin-4'-O- α -glucopyranoside, pectolinarigenin, cirsimaritin, cirsimaritin-4'-glucoside, quercetin-3-methyl ether which were isolated from *C. inerme*, *C. phlomidis*, *C. petasites*, *C. trichotomum*, *C. mandarinorum*, and *C. infortunatum* (Vendatham *et al.* 1977; Seth *et al.* 1982; Raha *et al.* 1989; Achari *et al.* 1990; Raha *et al.* 1991; Roy and Pandey 1994, 1995; Roy *et al.* 1995; El-Shamy *et al.* 1996; Anam 1997, 1999).

There are also other chemical constituents present which include volatile constituents such as 5-O-ethylclerodindin D, linalool, benzyl acetate and benzyl benzoate, which have been isolated from *C. canescens*, *C. cyrtophyllum*, *C. inerme* and *C. philippinum* (Yang *et al.* 2002; Nye-gue *et al.* 2004; Wong and Tan 2005).

Other chemical constituent includes cyanogenic glycosides such as lucumin and prunasin which were isolated from *C. grayi* (Miller *et al.* 2006). Phenolic compounds like β -benzyl alcohol, β -benzyl alcohol-D-glucoside, neolignan, darendoside-B, phenyl propanoids like (isovarbasoside, verbascoside, leucosceptoside), vanillic acid, anisic acid, para-hydroxy benzoic acid, gallic acid have been reported in *C. inerme*, *C. bungei* and *C. dauricum* (Liu and Fu 1980; Gabriele and Rimpler 1981; Zhou *et al.* 1982; Gabriele *et al.* 1983; Sakurai and Kato 1983; Calis *et al.* 1994); D-mannitol from *C. serratum* (Garg and Verma 2006). Carbohydrates like glucose, fructose, sucrose are been reported in *C. mandarinorum* and *C. inerme*. Other constituents such as ribosome-inactivating protein, salidroside, jinoside-D, acetoside have been isolated from *C. inerme* (Olivieri *et al.* 1996), while trichotomoside, cytotoxic pheophorbides and cleromyrin-I have been isolated from *C. trichotomum*, *C. calamitosum* and *C. cyrtophyllum* (Bashwira *et al.* 1989; Cheng *et al.* 2001; Chae *et al.* 2006).

BIOLOGICAL ACTIVITIES

The genus *Clerodendron* contains many plant species that are being used in various health care systems for the treatment of various disorders including life-threatening diseases. To validate traditional claims associated with the genus many studies are being carried out using various animal models and *in vitro* assays. These studies showed that the different species of the genus possess potent anti-inflammatory, antidiabetic, antimalarial, antiviral, antihypertensive, hypolipidemic and antioxidant activities and have potential to be developed as potent remedial agents from natural resources. Some major activities are described below.

Anti-inflammatory activities

Inflammation is a very complex pathophysiological process involving a variety of biomolecules responsible for causing it such as leucocytes, macrophages, mast cells, platelets and lymphocytes by releasing eicosanoids and nitric oxide. Pro-

inflammatory cytokines such as TNF- α and IL-1 β are also responsible for various inflammatory conditions. Many species of the genus *Clerodendron* showed potent anti-inflammatory activity. *C. phlomidis* was reported for significantly decreasing paw oedemas induced by carrageenan in rats at a dose of 1g/kg (Surendrakumar 1988). Similarly *C. petasites* was reported to show moderate anti-inflammatory activity in the acute phase of inflammation in rats. The ED₅₀ values of the experiment were reported to be 2.34 mg/ear and 420.41 mg/kg in rats (Panthong *et al.* 2003), it has been suggested by the authors that the anti-inflammatory activity of the plant extract could be due to the inhibition of prostaglandin synthesis by the extract.

The anti-inflammatory activity of *C. trichotomum* leaves were checked in rat, mice and Raw 264.7 macrophage cells using experimental models with 1 mg/kg solution of 30% and 60% methanolic extracts of leaves. Experimental results concluded that inhibition by methanolic extract was comparable to that of the positive control in an acute inflammation model, while in the chronic model the extract showed 10% higher activity than the positive control. It also suppressed the levels of prostaglandin E2 (PGE2) in RAW 264.7 macrophage cells (Choi *et al.* 2004). A phenyl propanoid glycoside 'acetoside' isolated from *C. trichotomum* also showed anti-inflammatory activity by inhibiting the release of histamine, arachidonic acid and prostaglandin E2 in RBL 2H3 cells. The mechanism identified for the inhibition of histamine release was related to calcium concentration (Lee *et al.* 2006).

Xanthine oxidase (XO) is the enzyme responsible for the formation of uric acid from the purines hypoxanthine and xanthine, and is responsible for the medical condition, gout. Gout is caused by the deposition of uric acid in the joints leading to painful inflammation. Purified hydroalcoholic extracts of leaves and branches of *C. floribundum* showed 84% inhibition of XO activity (Sweeney *et al.* 2001). Results of the experiment indicate the potential of the plant species to be developed as a remedy for XO-induced diseases.

Flavonoid glycosides of *C. inerme* showed modulation in calcium transport in isolated inflamed rat liver and thereby showed reduction in inflammation. The results obtained in the experiment were comparable with indomethacine used as a positive control (Somasundram and Sadique 1986). The alcoholic extract of roots of *C. serratum* showed a significant anti-inflammatory activity in carrageenan and also in the cotton pellet model in experimental mice, rats and rabbits (Narayanan *et al.* 1999).

Antimicrobial activities

Anti-infective compounds from natural resources are of great interest as the existing drugs are getting less effective due to increased tolerance of microorganisms. A number of species from the genus *Clerodendron* were documented in ancient texts for their antimicrobial action. To validate these claims, research work was carried out with various Gram positive and Gram negative bacterial strains and also with fungal and viral pathogens. Dried, aerial parts of *C. inerme* showed potent antiviral activity against Hepatitis B virus with an ED₅₀ value of 16 μ g/ml (Mehdi *et al.* 1997). Essential oil obtained from leaves of the plant showed antifungal activity against variety of fungal species such as *Alternaria* species, *Aspergillus* species, *Cladosporium herbarum*, *Cunninghamella echinulata*, *Helminthosporium saccharii*, *Microsporum gypseum*, *Mucor mucedo*, *Penicillium digitatum*, *Rhizopus nigricans*, *Trichophyton rubrum* and *Trichothecium roseum* (Sharma and Singh 1979). Alcoholic extracts of leaves and flowers of *C. inerme* also exhibited antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* (George and Pandalai 1949). Pectolinarigenin and chalcone glucoside isolated from leaf of *C. phlomidis* showed antifungal activity (Roy *et al.* 1995).

Two phenyl propanoid glycosides (acteoside and acteoside isomer) isolated from *C. trichotomum* showed potent

inhibition of HIV-1 integrase with IC₅₀ values of 7.8 ± 3.6 and 13.7 ± 6.0 µM (Kim *et al.* 2001). A new hydroquinone diterpenoid was isolated from *C. uncinatum* and was strongly fungi toxic to the spores of *Cladosporium cucumerinum* (Dorsaz *et al.* 2004). Hexane extracts of *C. colebrookianum* at concentrations of 1000 and 2000 ppm showed strong antibacterial activities against various Gram positive and Gram negative pathogens such as *S. aureus*, *Staphylococcus haemolyticus*, *E. coli*, *Pseudomonas aeruginosa* (Misra *et al.* 1995).

Two flavonoids from roots of *C. infortunatum*, cabruvin and quercetin, showed strong antifungal activity. The former showed activity against *Alternaria carthami* and *Helminthosporium oryzae*, the latter against *Alternaria alternata* and *Fusarium lini* at concentrations of 200, 500 and 1000 mg/ml (Roy *et al.* 1996). Mi-saponin-A, a triterpenoid saponin isolated from the roots of *C. wildii*, showed potent antifungal activity against *Cladosporium cucumerinum* (Toyoto *et al.* 1990).

Antimalarial activities

In various ancient literatures related to healthcare *Clerodendron* have been reported for its antimalarial activities because of the presence of a bitter principle. Studies with different parasites support these ancient claims. The alcoholic extract of *C. phlomidis* showed antimalarial activity against *Plasmodium falciparum* with an IC₅₀ value of 48 µg/ml (Simonsen *et al.* 2001). Another Indian species, *C. inerme* also inhibited the growth of larvae of *Aedes aegypti*, *Culex quinquefasciatus* and *Culex pipiens* at 80 and 100 ppm concentration of petroleum ether and ether extracts (Gayar and Shazll 1968; Kalyanasundaram and Das 1985). *C. myricoides* a species from Southern Africa was also tested positive for its antimalarial activity against both sensitive and resistant strains of *P. falciparum* with IC₅₀ < 30 µg/ml (Muregi *et al.* 2004), it also showed 31.7% suppression in parasitaemia against chloroquine tolerant strain of *Plasmodium berghei* NK65 (Muregi *et al.* 2007). These plants may be useful as a source for novel anti-plasmodial drugs/compounds from natural origin.

Antioxidant activities

Antioxidant compounds are responsible for scavenging free radicals, which are produced during normal metabolism or during adverse conditions that can be harmful to biological systems and leading to death of an organism. Species like *C. inerme* have been used as antioxidant drugs in various indigenous systems of medicines (Masuda *et al.* 1999). Organic and aqueous extracts of *C. colebrookianum* showed significant inhibition of lipid peroxidation *in vitro* and *in vivo* induced by FeSO₄-ascorbate in rats. Aqueous extracts showed strongest inhibitory activity over organic extracts. This lends scientific support to the therapeutic use of the plant leaves claimed in tribal medicine (Rajlakshmi *et al.* 2003). Isoacteoside, trichotomoside and jionoside D, three compounds isolated from *C. trichotomum*, when tested showed significant scavenging activity of intracellular reactive oxygen species produced by hydrogen peroxide suggesting their antioxidant properties (Chae *et al.* 2004, 2005, 2006). Apigenin-7-O-β-D-glucuronopyranoside (AGC), isolated from *C. trichotomum* leaves decreased the volume of gastric juice and increased the gastric pH in a dose-dependent manner, decreasing the number of gastric lesions. A malondialdehyde (MDA) level, which is the end product of lipid peroxidation, was also decreased by AGC (i.d. 3 mg/kg), which increased significantly after the induction of reflux oesophagitis. The MDA levels did not decrease when either apigenin or omeprazole were used as a control suggesting that AGC has an antioxidative mechanism to reduce gastric lesions. Apigenin glucuronopyranoside also decreased mucosal glutathione (GSH) levels significantly suggesting that AGC possesses free radical scavenging activity. So it can be concluded that AGC is more potent in inhibit-

ing reflux oesophagitis and gastritis and may therefore be a promising drug for their treatment (Min *et al.* 2005). In present lifestyles where stress has taken an unwanted important position leading to excess production of free radicals these natural remedies will prove a support to our biological system to balance metabolism.

Other biological activities of *Clerodendron* genus

Other major biological activities reported for this genus are antihypertensive, antitumor, antidiabetic, antihyperlipidemic, larvicidal, antidiarrhoeal activities. Organic extracts of *C. inerme* showed strong uterine stimulant activity when tested in female rats and rabbits (Sharaf *et al.* 1969), and also showed strong antihemolytic activity in human adults at 0.02-2.0 mg/ml, with inhibition of phospholipase at 0.05-1.5 mg/ml (Somasundaram and Sidique 1986). The methanolic extract of *C. multiflorum* leaves showed antidiarrhoeal activity against castor oil-induced diarrhoea, PGE₂-induced enteropooling and caused reduction in gastrointestinal motility in rats (Rani *et al.* 1999), while leaf juice at 0.1% showed anthelmintic activity against *Ascaris lumbricoides*, *Phreittima posthuma* and *Taenia solium* (Garg and Sidique 1992). Two compounds, isoacteoside and jionoside D isolated from *C. trichotomum* also reduced the levels of apoptotic cells induced by the action of hydrogen peroxide (Chae *et al.* 2004, 2005). *C. bungei* showed antitumor activity in hepatic cells of mice at a dose of 100 g/kg (Shi *et al.* 1993). CNS-related activities were also observed in *C. phlomidis* showing tranquillizing, CNS depressant, muscle relaxant and psychopharmacological effects in experimental mice and rats (Murugesan *et al.* 2001). *C. mandarinorum* root extracts showed strong binding with opiate, adenosine-1, α-2-adrenergic, 5HT-1, 5HT-2, dopamine-2, histamine-1, GABA (A), and GABA (B) receptors. Isolated compounds of these plants showed weak binding with these receptors suggesting its synergistic effect (Zhu *et al.* 1996). *C. inerme* extracts showed hypotensive effects in dogs at 50 mg/kg (Bhakuni *et al.* 1969).

A decoction of the entire *C. phlomidis* plant has been reported to have antidiabetic activity. A dose of 1 g/kg showed antidiabetic effects in epinephrine and alloxan induced hyperglycemia in rats and it also showed antihyperglycemic activity in human adults at a dose of 15-30 g/day (Chaturvedi *et al.* 1984). Organic and crude extracts of *C. colebrookianum* significantly lowered the serum lipid profile in rats suggesting that it has cardioprotective potential (Devi and Sharma 2004). The methanolic extract of *C. phlomidis* and leaf extracts of *C. inerme* showed antispasmodic activity in mouse (200 mg/kg; Murugesan *et al.* 2001) and guinea pigs (2 mg/ml; Cox *et al.* 1989). Ethanolic extract (2.25-9.0 mg/ml) of *C. petasites* evaluated for spasmolytic activity in guinea-pigs showed spasmolysis on tracheal smooth muscles; it also relaxed the smooth muscle which was contracted by exposure to histamine. The activity of smooth muscle relaxation was attributed to hispidulin (flavonoid) with an EC₅₀ (3.0 ± 0.8 * 10⁻⁵ M) suggesting hispidulin has anti-inflammatory activity (Hazeekamp 2001). Dichloromethane leaf extracts of *C. myricoides* indicated antimutagenic properties against *Salmonella typhimurium* TA98 and TA100 bacterial strains (Reid *et al.* 2006).

No adverse effects of the genus have been reported in the literature until now. Various species of the genus like *C. infortunatum*, *C. serratum*, *C. phlomidis* have been reported to be safe in the prescribed dosage in traditional system of medicines (Anonymous 1; Sharma PV 2001).

SUMMARY

The genus *Clerodendron* has been cited in many indigenous systems of health care for the treatment of variety of disorders. A few species extensively used as folk medicines for years have been investigated for their chemical constituents and biological activity to confirm these traditional claims. The genus is reported to have activities against a wide spec-

trum of disorders which includes many life-threatening diseases like HIV. Still there are many species of the genus having a potential towards many disorders in their unexplored fold.

ACKNOWLEDGEMENT

The authors wish to thank Mr. H. Srinivasa for his help in preparing the manuscript.

REFERENCES

- Abdul-Alim MA (1971) A chemical study of the leaves of *Clerodendron inerme*. *Planta Medica* **19**, 318-321
- Achari B, Chaudhuri C, Saha CR, Dutta PK, Pakrashi SC (1990) A clerodane diterpene and other constituents of *Clerodendron inerme*. *Phytochemistry* **29**, 3671-3673
- Achari B, Giri C, Saha CR, Dutta PK, Pakrashi SC (1992) A neo-clerodane diterpene from *Clerodendron inerme*. *Phytochemistry* **31**, 338-340
- Akihisa T, Ghosh P, Thakur S, Nagata H, Tamura T, Matsumoto T (1990) 24,24-dimethyl-25-dehydrolophenol, a 4- α -methylsterol from *Clerodendron inerme*. *Phytochemistry* **29**, 1639-1641
- Akihisa T, Matsubara Y, Ghosh P, Thakur S, Tamura T, Matsumoto T (1989) Sterols of some *Clerodendron* species (Verbenaceae) occurring of the 24- α and 24- β epimers of 24-ethylsterols lacking a Δ^{25} -bond. *Steroids* **53**, 625-638
- Anam EM (1997) Novel flavone and chalcone glycosides from *Clerodendron phlomidis* (Verbenaceae). *Indian Journal of Chemistry* **36B**, 897-900
- Anam EM (1999) Novel flavonone and chalcone glycosides from *Clerodendron phlomidis* (Verbenaceae). *Indian Journal of Chemistry* **38B**, 1307-1310
- Anonymous (1992) *The Useful Plants of India*, Publication and Information Directorate, CSIR, New Delhi, 132 pp
- Anonymous I (2005) *Quality Standards of Indian Medicinal Plants* (Vol 3) Indian Council of Medical Research, New Delhi, 167 pp
- Atta-Ur-Rehman, Begum S, Saied S, Choudhary MI, Farzana A (1997) A steroidal glycoside from *Clerodendron inerme*. *Phytochemistry* **45**, 1721-1722
- Bashwira S, Hootel  C, Tourw  D, Pepermans H, Laus G, van Binst G (1989) Cleromyrine I, a new cyclohexapeptide from *Clerodendron myricoides*. *Tetrahedron* **18**, 5845-5852
- Bhakuni OS, Dhar ML, Dhar MM, Dhavan BN, Mehrotra BN (1969) Screening of Indian plants for biological activities Part II. *Indian Journal of Experimental Biology* **7**, 250-262
- Bolger LM, Rees HH, Ghisalberti EL, Goad LJ, Goodwin TW (1970) Isolation of two new sterols from *Clerodendron campbellii*. *Tetrahedron Letters* **11**, 3043-3046
- Bolger LM, Rees HH, Ghisalberti EL, Goad LJ, Goodwin TW (1970) Biosynthesis of 24-ethylcholesta-5, 22, 25-trien-3 β -ol, a new sterol from *Clerodendron campbellii*. *Biochemistry Journal* **118**, 197-200
- Calis I, Hosny M, Yuruker A (1994) Inerminosides A1, C and D three iridoid glycosides from *Clerodendron inerme*. *Phytochemistry* **37**, 1083-1085
- Calis I, Hosny M, Yuruker A, Wright AD, Sticher O (1994) Inerminosides A and B two novel complex iridoid glycosides from *Clerodendron inerme*. *Journal of Natural Products* **57**, 494-500
- Chae S, Kang KA, Kim JS, Hyun JW, Kang SS (2006) Trichotomoside: A new antioxidative phenylpropanoid glycoside from *Clerodendron trichotomum*. *Chemistry and Biodiversity* **3**, 41-48
- Chae S, Kim JS, Kang KA, Bu HD, Lee Y, Hyun JW, Kang SS (2004) Antioxidant activity of jionoside D from *Clerodendron trichotomum*. *Biological and Pharmaceutical Bulletin* **27**, 1504-1508
- Chae S, Kim JS, Kang KA, Bu HD, Lee Y, Seo YR, Hyun JW, Kang SS (2005) Antioxidant activity of isoacteoside from *Clerodendron trichotomum*. *Journal of Toxicology and Environmental Health A* **68**, 389-400
- Chaturvedi GN, Subramaniam PN, Tiwari SK, Singh KP (1984) Experimental and clinical studies of diabetes mellitus evaluating the efficacy of an indigenous oral hypoglycemic drug – arani. *Ancient Science Life* **3**, 216-224
- Cheng H-H, Wang H-K, Ito J, Bastow KF, Tachibana Y, Nakanishi Y, Xu Z, Luo T-Y, Lee K-H (2001) Cytotoxic pheophorbide-related compounds from *Clerodendron calamitosum* and *C. cyrtophyllum*. *Journal of Natural Products* **64**, 915-919
- Choi J-H, Wang W-K, Kim H-J (2004) Studies on the anti-inflammatory effects of *Clerodendron trichotomum* thunberg leaves. *Archives of Pharmacological Research* **27**, 189-193
- Cox PA, Sperry LB, Tuominen M, Bohlin L (1989) Pharmacological activity of the Samoan Ethnopharmacopoeia. *Economic Botany* **43**, 487-497
- Devi R, Sharma DK (2004) Hypolipidemic effect of different extracts of *Clerodendron colebrookianum* Walp in normal and high-fat diet fed rats. *Journal of Ethnopharmacology* **90**, 63-68
- Dorsaz A-C, Marston A, Stoeckli-Evans H, Msonthi JD, Hostettmann K (2004) Uncinatone, a new antifungal hydroquinone diterpenoid from *Clerodendrum uncinatum* Schinz. *Helvetica Chimica Acta* **68**, 1605-1610
- El-Shamy AM, El-Shabrawy ARO, El-Fiki N (1996) Phytochemical study of *clerodendron inerme* L. growing in Egypt. *Zagazig Journal of Pharmaceutical Science* **5**, 49-53
- Gabriele L, Rimpler H (1981) Iridoids in *Clerodendrum thomsonae* Balf. F., Verbanaceae. *Zeitschrift fur Naturforschung C: A Journal of Biosciences* **36C**, 708-713
- Gabriele L, Rimpler H (1983) Distribution of iridoid glycosides in *Clerodendrum* species. *Phytochemistry* **22**, 1729-1734
- Gao LM, Wei XM, He YQ (2003a) Studies on chemical constituents in leaf of *Clerodendron fragrans*. *Zhongguo Zhong Yao Za Zhi* **28**, 948-951
- Gao LM, Wei XM, He YQ (2003b) Studies on chemical constituents of *Clerodendron bungei*. *Zhongguo Zhong Yao Za Zhi* **28**, 1042-1044
- Garg SC, Siddiqui N (1992) Anthelmintic activity of *Vernonia teres* L., and *Clerodendrum phlomidis* L. *Journal of Research Education in Indian Medicine* **11**, 1-3
- Garg VP, Verma SCL (2006) Chemical examination of *Clerodendron serratum*: Isolation and characterization of D-mannitol. *Journal of Pharmaceutical Sciences* **56**, 639-640
- Gayar R, Shazli A (1968) Toxicity of certain plants to *Culex pipiens* larvae. *Bulletin of the Society of Entomology, Egypt* **52**, 467
- George M, Pandalai KM (1949) Investigations on plant antibiotics, Part IV. Further search for antibiotic substances in Indian medicinal Plants. *Indian Journal of Medical Research* **37**, 169-181
- Goswami P, Kotoky J, Chen Z-N, Lu Y (1996) A sterol glycoside from leaves of *Clerodendron colebrookianum*. *Phytochemistry* **41**, 279-281
- Hazekamp A, Verpoorte R, Panthong A (2001) Isolation of a bronchodilator flavonoid from the Thai medicinal plant *Clerodendrum petasites*. *Journal of Ethnopharmacology* **78**, 45-49
- Hsiao JY, Lin ML (1995) A Chemotaxonomic study of essential oils from the leaves of genus *Clerodendrum* (Verbenaceae) native to Taiwan. *Botany Bulletin Academia Sinica* **36**, 247-251
- Hsu YC, Chen C, Yuh P, Hsu HY (1983) Constituents of *Clerodendron paniculatum* Linn var. *albiflorum* Hemsl. *Chung-kuo Nung Yeh Hua Hsueh Hui Chih* **21**, 26
- Joshi KC, Singh P, Mehra A (1979) Chemical investigation of the roots of different *Clerodendron* species. *Planta Medica* **37**, 64-66
- Kalyanasundaram M, Das PK (1985) Larvicidal and synergistic activity of plant extracts for mosquito control. *Indian Journal of Medical Research* **82**, 19-23
- Kanchanapoom T, Chumsri P, Kasai R, Otsuka H, Yamasaki K (2005) A new iridoid diglycoside from *Clerodendrum chinense*. *Journal of Asian Natural Products Research* **7**, 269-272
- Kanchanapoom T, Kasaia R, Chumsric P, Hiragad Y, Yamasaki K (2001) Megastigmane and iridoid glucosides from *Clerodendron inerme*. *Phytochemistry* **58**, 333-336
- Kang DG, Lee YS, Kim HJ, Lee YM, Lee HS (2003) Angiotensin converting enzyme inhibitory phenylpropanoid glycosides from *Clerodendron trichotomum*. *Journal of Ethnopharmacology* **89**, 151-154
- Kawai K, Amano T, Nishida R, Kuwahara Y, Fukami H (1998) Clerodendrin from *Clerodendron trichotomum* and their feeding stimulant activity for the turnip sawfly. *Phytochemistry* **49**, 1975-1980
- Khan MA, Singh VK (1996) A folklore survey of some plants of Bhopal district forest Madhya Pradesh India described as antidiabetics. *Fitoterapia* **67**, 416-421
- Kim HJ, Woo ER, Shin CG, Hwang DJ, Park H, Lee YS (2001) HIV-I integrase inhibitory phenyl propanoid glycosides from *C. trichotomum*. *Archives in Pharmacological Research* **24**, 286-291
- Kirtikar KR, Basu BD (1991) *Indian Medicinal Plants* (2nd Edn, Vol III) Bishen Singh Mahendra Pal Sing Publication, 1945 pp
- Kumar D, Verma HN, Tuteja N, Tewari KK (1997) Cloning and characterization of a gene encoding an antiviral protein from *Clerodendrum aculeatum* L. *Plant Molecular Biology* **33**, 745-751
- Kumari GNK, Balachandran J, Aravind S, Ganesh MR (2003) Antifeedant and growth inhibitory effects of some neo-clerodane diterpenoids isolated from *Clerodendron* species (Verbanaceae) on *Earias viella* and *Spodoptera litura*. *Journal of Agriculture and Food Chemistry* **51**, 1555-1559
- Lee JH, Lee JY, Kang HS, Jeong CH, Moon H, Whang WK, Kim CJ, Sim SS (2006) The effect of acteoside on histamine release and arachidonic acid release in RBL-2H3 mast cells. *Archives in Pharmacological Research* **29**, 508-513
- Lu Y-L, Fu F-Y (1980) Studies on the chemical constituents of *Clerodendron dauricum* L. Part IV. Identification of carboxylic acids. *Ts'ao Yao* **11**, 152-153
- Masuda T, Yonemori S, Oyama Y, Takeda Y, Tanaka T, Andoh T, Shinohara A, Nakata M (1999) Evaluation of the antioxidant activity of environmental plants: activity of the leaf extracts from seashore plants. *Journal of Agriculture and Food Chemistry* **47**, 1749-1754
- Mehdi H, Tan GT, Pezzuto JM, Fong HHS, Farnsworth NR, EL-Ferally FS (1997) Cell culture assay system for the evaluation of natural product mediated anti-hepatitis B virus activity. *Phytomedicine* **3**, 369-377
- Miller RE, McConville MJ, Woodrow IE (2006) Cyanogenic glycosides from the rare Australian endemic rainforest tree *Clerodendrum grayi* (Lamiaceae). *Phytochemistry* **67**, 43-51
- Min YS, Yim SH, Bai KL, Choi HJ, Jeong JH, Song HJ, Park SY, Ham I, Whang WK, Sohn UD (2005) The effects of apigenin-7-O- β -D-glucuro-

- nopyranoside on reflux oesophagitis and gastritis in rats. *Autonomic and Autacoid Pharmacology* **25**, 85-91
- Misra TN, Singh SR, Pandey HS, Kohli YP (1995) Antibacterial and antifungal activity of three volatile hexane eluates extracted from the leaves of *C. colebrookianum*. *International Seminar on Recent Trends in Pharmaceutical Sciences*, Ootacamund, Abstract No 29
- Moldenke HN (1985) Notes on the genus *Clerodendrum* (Verbenaceae). IV. *Phytologia* **57**, 334-365
- Muregi FW, Chhabra SC, Njagi EN, Lang'at-Thoruwa CC, Njue WM, Orago AS, Omar SA, Ndiege IO (2004) Anti-plasmodial activity of some Kenyan medicinal plant extracts singly and in combination with chloroquine. *Phytotherapy Research* **18**, 379-384
- Muregi FW, Ishih A, Miyase T, Suzuki T, Kino H, Amano T, Mkoji GM, Terada M (2007) Antimalarial activity of methanolic extracts from plants used in Kenyan ethnomedicine and their interactions with chloroquine (CQ) against a CQ-tolerant rodent parasite, in mice. *Journal of Ethnopharmacology* **111**, 190-195
- Murugesan T, Saravanan KS Lakshmi S, Ramya G, Thenmozhi K (2001) Evaluation of psychopharmacological effects of *Clerodendrum phlomidis* Linn. extract. *Phytotherapy Research* **8**, 472-476
- Narayanan N, Thirugnanasambantham P, Viswanathan S, Vijayasekaran V, Sukumar E (1999) Antinociceptive, anti-inflammatory and antipyretic effects of ethanol extract of *Clerodendron serratum* roots in experimental animals. *Journal of Ethnopharmacology* **65**, 237-241
- Nishida R, Kawai K, Amano T, Kuwahara Y (2004) Pharmacophagous feeding stimulant activity of neo-clerodane diterpenoids for the turnip sawfly, *Athalia rosae fuficornis*. *Biochemistry and Systematic Ecology* **32**, 15-25
- Nyegue MA, Belinga-Ndoye CF, Amvam Zollo PH, Agnaniet H, Menut C, Bessière JM (2005) Aromatic plants of tropical central Africa, Part L. Volatile components of *Clerodendrum buchholzii* Gürke from Cameroon. *Flavour and Fragrance Journal* **20**, 321-323
- Olivieri F, Prasad V, Valbonesi P, Srivastava S, Ghosal-Chowdhury P, Barbieri L, Bolognesi A, Stirpe F (1996) A systemic antiviral resistance-inducing protein isolated from *Clerodendrum inerme* Gaertn. is a polynucleotide adenosine glycosidase (ribosome-inactivating protein). *FEBS Letters* **396**, 132-134
- Pandey R, Verma RK, Singh SC, Gupta MM (2003) 4 α -methyl-24 β -ethyl-5 α -cholesta-14,25-dien-3 β -ol and 24 β -ethylcholesta-5, 9(11), 22e-trien-3 β -ol, sterols from *Clerodendrum inerme*. *Phytochemistry* **63**, 415-420
- Panthong D, Kanjanapothi T, Taesotikul T, Wongcomea V (2003) Anti-inflammatory and antipyretic properties of *Clerodendrum petasites* S. Moorea. *Journal of Ethnopharmacology* **85**, 151-156
- Pinto WJ, Nes WR (1985) 24 β -ethylsterols, *n*-alkanes and *n*-alkanols of *Clerodendrum splendens*. *Phytochemistry* **24**, 1095-1097
- Raha P, Banerjee H, Das AK (1989) Occurrence of three 5-hydroxyflavones in *Clerodendron scandens* and *Clerodendrum inerme* Linn. *Indian Journal of Chemistry* **28B**, 874
- Raha P, Das AK, Adityachaudhuri N, Majumdar PI (1991) Cleroinermin A neo-clerodane diterpenoid from *Clerodendrum inerme*. *Phytochemistry* **38**, 3812-3814
- Rajlakshmi D, Banerjee SK, Sood S, Maulik SK (2003) *In-vitro* and *in-vivo* antioxidant activity of different extracts of the leaves of *Clerodendron colebrookianum* Walp in the rat. *Journal of Pharmacy and Pharmacology* **55**, 1681-1686
- Rani S, Ahamed N, Rajaram S, Saluja R, Thenmozhi S, Murugesan T (1999) Anti-diarrhoeal evaluation of *Clerodendrum phlomidis* Linn, leaf extract in rats. *Journal of Ethnopharmacology* **68**, 315-319
- Rao LJM, Pereira J, Gurudutt KN (1993) Neo-clerodane diterpenes from *Clerodendrum inerme*. *Phytochemistry* **34**, 572-574
- Reid KA, Maesa J, Maesa A, van Staden J, Kimpec ND, Mulholland DA, Verschaev L (2006) Evaluation of the mutagenic and antimutagenic effects of South African plants. *Journal of Ethnopharmacology* **106**, 44-50
- Roy R, Pandey VB (1995) Flavonoids of *Clerodendrum phlomidis*. *Indian Journal of Natural Products* **11**, 13-14
- Roy R, Pandey VB (1994) A chalcone glycoside from *Clerodendrum phlomidis*. *Phytochemistry* **37**, 1775- 1776
- Roy R, Pandey VB, Singh UP, Prithiviraj B (1996) Antifungal activity of the flavonoids from *C. infortunatum* roots. *Fitoterapia* **67**, 473-74
- Roy R, Singh UP, Pandey VB (1995) Antifungal activity of some naturally occurring flavonoids. *Oriental Journal of Chemistry* **11**, 145-148
- Rueda RM (1993) The genus *Clerodendrum* (Verbenaceae) in Mesoamerica. *Annals of the Missouri Botanical Garden* **80**, 870-890
- Seth KK, Pandey VB, Dasgupta B (1982) Flavanoids of *Clerodendrum phlomidis* flowers. *Pharmazie* **37**, 74-75
- Sharaf A, Aboulezz AF, Abdul-Alim MA, Goman N (1969) Pharmacological studies on the leaves of *C. inerme*. *Quality Plant Material Vegetation* **17**, 293
- Sharma PV (2001) *Dravyaguna-Vijnana* (Vol II, Vegetable Drugs), Chaukhanbha Bharati Academy, Varanasi, pp 221, 298, 300, 523
- Sharma SK, Singh VP (1979) The antifungal activity of some essential oils. *Indian Drugs Pharmaceutical Industry* **14**, 3-6
- Shi XF, Du DJ, Xie DC, Ran CQ (1993) Studies on the antitumor effect of *Clerodendrum bungei* Steud or *C. foetidum* Bge. *Zhongguo Zhong Yao Za Zhi* **18**, 687-690, 704
- Simonsen HT, Nordskjold JB, Smitt UW, Nyman W, Palpu P, Joshi P, Varughese G (2001) *In vitro* screening of Indian medicinal plants for anti-plasmodial activity. *Journal of Ethnopharmacology* **74**, 195-204
- Singh P, Singhi CL (1981) Chemical investigation of *Clerodendrum fragrans*. *Journal of the Indian Chemical Society* **58**, 626-627
- Singh R, Prakash L (1983) Chemical examination of stems of *Clerodendrum inerme* (L) Gaertn. (Verbenaceae). *Pharmazie* **38**, 565
- Singh VP, Sharma SK, Khan VS (1980) Medicinal plants from Ujain district Madhya Pradesh part II. *Indian Drugs and Pharmaceutical Industry* **5**, 7-12
- Sinha NK, Pandey VB, Dasgupta B, Higuchi R, Kawasaki T (1982) Acteoside from the flowers of *Clerodendrum infortunatum*. *Indian Journal of Chemistry* **22B**, 97-98
- Sinha NK, Pandey VB, Shah AH, Dasgupta B (1980) Chemical constituents of the flowers of *Clerodendrum infortunatum*. *Indian Journal of Pharmaceutical Science* **42**, 21
- Sinha NK, Seth KK, Pandey VB, Dasgupta B, Shah AH (1981) Flavonoids from the flowers of *Clerodendrum infortunatum*. *Planta Medica* **42**, 296-298
- Somasundaram S, Sadique J (1986) The role of mitochondrial calcium transport during inflammation and the effect of anti-inflammatory drugs. *Biochemical Medicine and Metabolic Biology* **36**, 220-230
- Somasundram S, Sadique J (1986) Anti-hemolytic effect of flavonoidal glycosides of *C. inerme*: An *in vitro* study. *Fitoterapia* **57**, 103-110
- Steane DA, Scotland RW, Mabblerley DJ, Olmstead RG (1999) Molecular systematics of *Clerodendrum* (Lamiaceae): its sequences and total evidence. *American Journal of Botany* **86**, 98-107
- Steane DA, De Kok RPJ, Olmstead RG (2004) Phylogenetic relationships between *Clerodendrum* (Lamiaceae) and other Ajugoid genera inferred from nuclear and chloroplast DNA sequence data. *Molecular Phylogenetics and Evolution* **32**, 39-45
- Stenzel E, Rimpler H, Hunkler D (1986) Iridoid glucosides from *Clerodendrum incisum*. *Phytochemistry* **25**, 2557-2561
- Surendrakumar P (1988) Anti-inflammatory activity of *Lippia nodiflora*, *Clerodendrum phlomidis* and *Delonix elata*. *Journal of Research Education Indian Medicine* **7**, 19-20
- Sweeney AP, Wyllie SG, Shalliker RA, Markham JL (2001) Xanthine oxidase inhibitory activity of selected Australian native plants. *Journal of Ethnopharmacology* **75**, 273-277
- Toyota M, Msonthi JD, Hostettmann K (1990) A molluscicidal and antifungal triterpenoid saponin from the roots of *Clerodendrum wildii*. *Phytochemistry* **29**, 2849-2851
- Vendatham TNC, Subramanian SS, Harborne JB (1977) 4'-methylscutellarein and pectolinarigenin from *Clerodendrum inerme*. *Phytochemistry* **16**, 294
- Wong KC, Tan CH (2005) Volatile constituents of the flowers of *Clerodendrum fragrans* (Vent.) R. Br. *Flavour and Fragrance Journal* **20**, 429-430
- Yang H, Hou A-J, Mei S-X, Sun H-D, Che C-T (2002) Constituents of *Clerodendrum bungei*. *Journal of Asian Natural Products Research* **4**, 165-169
- Yang H, Jiang B, Hou A-J, Lin Z-W, Sun H-D (2000) Colebroside A, a new diglucoside of fatty acid ester of glycerin from *Clerodendrum colebrookianum*. *Journal of Asian Natural Product Research* **2**, 177-185
- Yang H, Wang J, Hou A-J, Guo Y-P, Lin Z-W, Sun H-D (2000) New steroids from *Clerodendrum colebrookianum*. *Fitoterapia* **71**, 641-648
- Zhou P, Pang Z, Hso HQ (1982) Studies on chemical constituents of *Clerodendron bungei*. *Zhiwu Xaobao* **24**, 564-567
- Zhu M, Phillipson JD, Greengrass PM, Bowery NG (1996) Chemical and biological investigation of the root bark of *Clerodendrum mandarinorum*. *Planta Medica* **62**, 393-396