

Review Article

ETHNOMEDICINAL, PHYTOCHEMICAL, AND PHARMACOLOGICAL ASPECTS OF GENUS ACANTHUS

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ABSTRACT

Acanthus (family Acanthaceae) is a genus of the major group angiosperms (flowering plants) comprising more than 29 species widely distributed in the tropical and subtropical region. The aim of this review is to offer thorough scientific information on ethnomedicinal uses, phytochemical, and pharmacological activities of the plant species belonging to the genus *Acanthus*. Numerous traditional uses of the genus have been supported in this article from the results, and executed by the extracts and/or pure compounds obtained from pharmacological studies will provide a single platform to help future researches on the genus *Acanthus*. Furthermore, ethnomedicinal evaluation using fractions or isolation of medicinal principles was extensively explored by databases like Google, Google Scholar, and Science Direct at the same time.

Keywords: *Acanthus*, Acanthaceae, Ethnomedicinal uses, Phytochemistry, Pharmacology, Medicinal principles

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INTRODUCTION

The word '*Acanthus*' is originated from the Greek word '*Acantha*' meaning thorn or thistle signifies sensitive leaves [1]. Most of the species are shrubs or perennial herbs with terminal or axillary, uninterrupted spikes; flower with lower lip only; calyx 4-lobed with larger posterior and anterior lobes; corolla tube short, horny; elongate 3-lobed lip and with 4 exerted stamens, inserted at top of

corolla tube [2]. The genus exhibits some mangrove species which are known to survive in the most antagonistic environment which makes this genus as inimitable taxa among all true mangrove genera that represent both terrestrial species and true mangrove. Thus, researchers grow attractive reason to assemble attention for the study of the genus and also to understand the origin and evolution of mangrove species. The distribution of the species of the genus *Acanthus* has been represented in the fig. 1.

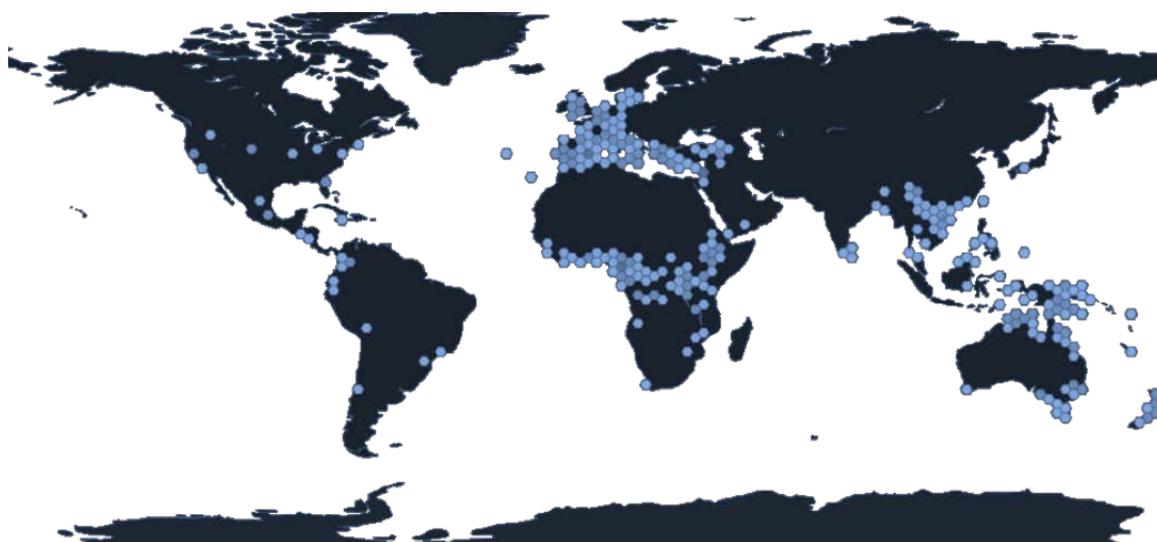


Fig. 1: The distribution of the species of the genus *Acanthus* (Maps are not to scale)

Description of the genus

The genus *Acanthus* L. is consist of about 29 representative species geographically distributed mostly in the tropical and subtropical region of the world [3]. Total 28 genera from 20 families represent c.

a. 70 true mangroves species among these the genus *Acanthus* represents five mangrove species e. g. *A. ebracteatus*, *A. illicifolius*, *A. volubilis*, *A. latisepalus* and *A. montanus* [4-5]. However, Tomlinson and Yang *et al.* reported only three mangrove species and c. a. 27 terrestrial species [6-7]. In India, only 6 species of the genus are

available; *A. ebracteatus* Vahl, *A. ilicifolius* L., *A. leucostachyus* Wall. ex Nees, *A. carduaceus* Griff., *A. mollis* L., *A. volubilis* Wall. Out of these 6 species *A. ilicifolius* and *A. leucostachyus* are extremely medicinal and *A. leucostachyus* Wall. ex Nees, *A. carduaceus* Griff., *A. mollis* L. are terrestrial species [8]. Asia and Australia represent the paramount variety and distribution of mangrove species [1]. Therefore, the genus is unique among all true mangrove genera were both true mangrove and terrestrial members are obtainable. The two sub species *A. ebracteatus* subsp. *ebracteatus* and *A. ebracteatus* subsp. *ebarbatus* of *A. ebracteatus* which are endemic to Australia [1]. Moreover, both subspecies are detached by few key morphological features *i.e.* leaf shape, stem spines, flower color and hairiness *etc.* [1]. In our previous study, the genus was reported with one known species; *A. leucostachyus* from North East India which was originally established by Wallich in his Numerical List of Dried Specimens (Cat. No. 2512) on the basis of the collection made by F. De Silva from Sylhet District of Bangladesh [8]. But in the worksheet of [9], higher plant diversity in Pakke Wildlife Sanctuary and Tiger Reserve in East Kameng District of Arunachal Pradesh revealed another member of the genus. *A. ilicifolius* L., a shrub was available in those areas, medicinal use still unknown and least concern at the international union for conservation of nature (IUCN) status [10]. While in the same checklist *A. leucostachyus* Wall. was mentioned as a herb. Ethnomedicinal uses in cut and wound and anti-inflammatory activity was also revealed and evaluated at IUCN status [10]. *A. leucostachyus* is a terrestrial species present in the rainforest at 600 to 1200 m above the sea level and bounds to South to Southeast Asia which has the same geographical distribution and same

environmental support as the analogous mangrove species. These unique features have made the species more eccentric which have the possibilities to exemplify the phylogenetic aspects of the true mangrove species of the fascinating genus *Acanthus* [7, 11]. Some of the important species of the genus have described below.

A. leucostachyus Wall. Ex Nees

Common name: Mishisala (Barman); Mussali (Riang); Sam-sikal (Khasi), Sam-Khatchi (Meghalaya). *A. leucostachyus* is an unbranched herb height reach up to 90 cm, erect; stem brown, ca 4 mm in diam, hairy; abaxially glabrescent or brown pubescent along veins, petiole ~0.8-2.5 cm; leaf blade elliptic, secondary veins ~5-8 on each side of midvein and netted near margin, oblanceolate, or lanceolate, 9-23 × 2-4.5 cm, margin slightly spinose dentate occasionally unnoticeably dentate or irregularly entire, ovate-lanceolate, base rounded to subcordate, adaxially glabrous, tertiary veins inconspicuous, apex acute. Inflorescences fatal thorns, top severe to acuminate; bracteoles lanceolate to oblanceolate, abaxially pubescent, base rounded, palmately veined, apex rounded with a short tip; calyx ca 2 cm, pubescent; corolla white, ca 2.1 cm, villous; lobes orbicular, ca 5 × 5 mm, apex emarginated, margins apically spikey, ca 1-2 × ~0.2-0.4 cm, rachis grayish pubescent; base rounded, margin entire and ciliate. Staminal filaments ca ~8 mm, upper pair curved, glabrous. Ovary ca ~3 mm [8].

Distribution: The plant is distributed in India Bangladesh (Sylhet), China (Yunnan), Myanmar, Laos, Thailand, and Vietnam. Specimen examination, date, and place of collection of the plant in Bhutan and North East India has been enlisted in table 1.

Table 1: List showing the specimens of *Acanthus leucostachyus* examined in the Bhutan and North East India [8]

Specimen examined by	Date of collection	Place of collection
U. N. Kanjilal	01.10.1908	Nambor Reserve Forest, Assam
S. R. Sharma	07.03.1932	Nongkhaw Forest, West Khasi Hills, Meghalaya
N. L. Bor	01.01.1934	Aka Hills, Arunachal Pradesh
S. R. Sharma	23.03.1936	Umsaw, East Khasi Hills, Meghalaya
N. L. Bor	March, 1937	Sibsagar, Hollongpar, Assam
G. K. Deka	22.02.1938	Shella, East Khasi hills, Meghalaya
G. K. Deka	03.02.1939	Powai, Tinsukia, Assam
G. Panigrahi	25.05.1957	Garbhanga Reserve Forest, Kamrup, Assam.
R. S. Rao	01.09.1957	Katakhal Reserve Forest, Hailakandi, Assam
G. Panigrahi	22.10.1960	Doomdooma Reserve Forest, Tinsukia, Assam
G. Panigrahi	09.03.1962	Dullong Reserve Forest, Lakhimpur, Assam
D. B. Deb	23.01.1963	Kheitum, Lushai Hills Mizoram,
R. M. Dutta	12.07.1963	Vawmbuk to Thalthlang, Mizoram
N. P. Balakrishnan	14.03.1965	Jashigong to Yangtzi, Eastern Bhutan, Butan
J. Joseph	14.05.1965	Nongpoh, Meghalaya, and Noonmati-Barholng, Assam
D. M. Verma	22.05.1968	Chalohowa, Kananadi, North Lakhimpur, Assam
N. P. Balakrishnan	21.11.1969	Jaintia Hills, 16 km from Khleihriat on road to Sonapur, Meghalaya
A. K. Das	14.02.2002	Goawara forest, Assam
R. Bora and A. K. Das	05.02.2012	Loharbond, Cachar, Assam
J. Sarma and S. Baruah	04.03.2013	Gibbon Wildlife Sanctuary, Jorhat, Assam
J. Sarma and S. Baruah	12.04.2013	Lakhipathar Area of Upper Dihing Reserve Forest under Digboi Forest Division, Assam

Habitat and Ecology: Grow shady places association with other plants like *Thottea tomentosa* (Blume) Ding Hou and *Borreria hispida* (L.) K. Schm. *etc.* [8].

Phenology: March-September

Specimen examined: Specimens of *A. leucostachyus* Wallich examined in the Bhutan and North East India by various workers in different times [8, 12, 13].

Status: The plant was reported wrongly as endemic to Eastern Himalaya [13-14].

A. ilicifolius L

Common names: Holy leaved acanthus, holy mangrove, holy leaved acanthus and sea holy (Eng.), Harkukanta (Hind.), Harkucha kanta (Beng.), Holechudi (Kan.), Payinachulli (Mal.), Kaludaimulli (Tam.), Alasyakampa, Alchi (Tel.).

The plant is a shrub, height up to 3 m green, light green or purple, stem thick, branched, roots rarely above ground leaves simple, opposite, lanceolate to broadly lanceolate, leaf margin spiny/dentate, leaf tip acute, petiole low length ca 0.5-2 cm long, inflorescences terminal [15].

Distribution: *A. ilicifolius* true mangrove species distributed in tropical Asia and Africa, through Malaya to Polynesia grown in the many of the foreshore areas [1, 16]. The plant is also reported to grow in Bangladesh [17, 18]. In India, it is reported from the east (the large area of mangrove forest, the Sunderbans) and west seashore and Andamans and a northeastern state, Meghalaya [1, 17].

Habitat and Ecology: Generally it is found on river banks or low marshland areas of mangrove forests and its surroundings above the high tide mark [1].

Phenology: February-May.

Specimen examined: India, Andaman and Nicobar Islands, South Andaman, Shoal Bay Creek (P. Ragavan, PBL 30965 and 30966) [15].

A. ebracteatus Vahl-Vahl

It is a shrub up to 2 m tall, branched, axial spines downward facing, stem thick, grey tint, roots rarely above ground, broadly elliptic to lanceolate, ~10-20 x 3-6 cm, leaves simple, opposite, leaf tip acute to obtuse with or without spiny; petiole length low ca ~0.5-1.5 cm. inflorescence terminal; ovary bilocular; style surrounded by stamens [15].

Distribution: India to tropical Australia, Southeast Asia, and the western Pacific islands. In Southeast Asia plant has found in Cambodia, Myanmar, the Philippines, Vietnam, Malaysia, Singapore, Indonesia and Papua New Guinea; in India, it has recorded in Kerala, Puducherry, and ANI [15].

Habitat and Ecology: Grow in landward ends of mangroves over the high tide mark and in inner mangroves.

Phenology: Throughout the year.

Specimen examined. India, Andaman and Nicobar Islands, South Andaman, Sippighat (P. Ragavan, PBL 30969 and 30970) [15].

Acanthus volubilis wall

Plant is a twisted shrub up to ~2-4 m tall; stem slim, soft, green, branched, axial spines lacking; roots rarely above ground/prop roots on lower parts of reclining stem; leaves simple, opposite, spines absent, juicy, elliptic/oblong-lanceolate, leaf tip acute to obtuse with spin, leaf margin spines lacking, petiole low length ca 0.5-2 cm long, green; inflorescence terminal; style surrounded by stamens; ovary bilocular [15].

Distribution: South to Southeast Asia i.e. Sri Lanka and the Andaman Islands, to Myanmar, Indonesia, Cambodia, Malaysia, Singapore, Thailand and Papua New Guinea. In India, the plant has found in Odisha, ANI, and Sundarbans [15].

Habitat and Ecology: Grown in landward edges of mangroves up to the high tide mark.

Phenology: March-June.

Specimen examined: India, Andaman and Nicobar Islands, South Andaman, Shoal Bay Creek (P. Ragavan, PBL 30969 and 30970) [15].

Acanthus mollis L.

Synonyms: *A. Hispanicus* Lou., *A. latifolius* E. Goetz., *A. longifolius* Poir., *A. lusitanicus* Auct., *A. niger* Mill., *A. platyphyllus* Murb., *A. spinosissimum* Host.

Traditional uses

A. ilicifolius also named as "Holy Mangrove" is used as an ethnomedicinal plant in many countries. In Malaysia the plant leaf used to heal rheumatism, neuralgia and poison arrow wounds; in Bangladesh, leaves are used in the treatment of cancer [18]; in Malaysia, seeds of this plant and *A. ebracteatus* Vahl. Consumed for curing urolithiasis; in India, the root is utilized to treat coughs and asthma; in Thailand, the fresh bark is applied as an antiseptic [19].

Moreover, the plant is also used in asthma, diabetes, dyspepsia, hepatitis, leprosy, paralysis, ringworm, rheumatism, skin problems, snakebite, leucorrhoea, leukemia etc. [19, 20], dropsy [21]; different plant parts, fruit, leaf, bark, and root are used in healing of asthma, diabetes, hepatitis, inflammation, and rheumatism [22-25]; leaves are applied in snake bite [26], consumed as blood purifier [19]; root used in leucorrhoea [27]; different plant parts useful to treat rheumatism, asthma, paralysis, psoriasis and leucorrhoea [28].

A. leucostachyus is another ethnomedicinal plant belongs to this genus. This plant has also been employed in treatment of various diseases like; the leaves of the plant used in fever and toothache [29]; leaf paste is applied externally in cuts and wounds; pest of leaves are prescribed to be applied externally on cancerous tumor

by different tribes of Cachar district of Assam [12, 30]; paste of leaves combined with the extract of tuber of *Allium* sp. and leaves of *Thunbergia* sp. is applied externally for swelling, fever, toothache [31]; seed, sap and leaves are used in treatment of allergy, headache, hair tonic, boil, eczema and worms [32]. This plant is also used as traditional medicine by Naga tribe of North East India [33]. Moreover, the plant is used by Derois tribe of India in preparation of Sujen, a rice beer along with other plants like *Alpinia malaccensis*, *Costus speciosus* etc. [34].

A. montanus (Nees.) T. Anders leaves are reported to be practiced in curing cough, pneumonia, and fever by Mount Cameroon region, Africa [35]. While, the fruit of *A. ebracteatus* utilized as a blood purifier, leaf paste is applied in a dressing of burns, roots in snakebite and also used in pain caused by wounds and the seeds are used as anthelmintic [36]. 170 genes of *A. ebracteatus* are recognized which are engrossed in response to salt stress [37].

Phytochemistry

Investigation phytochemical study of the genus *Acanthus* indicated that phytochemical study has been extensively done on the true mangrove species; *A. ilicifolius*, beside this work no phytochemical isolation has been performed on this genus.

Phytochemical screening

Phytochemical study of *A. ilicifolius* done by Raut and Khan [38] emphasized the presence of some important chemical constituents like triterpenoids, alkaloids, saponins glycosides, flavonoids, steroids etc. Ralf and Gerd [39] study also specify the presence of terpenoids, alkaloids, flavonoids, phenols, coumarins. Flower extracts disclose the occurrence of alkaloids, terpenoids, saponins, phenolics, flavonoids, tannins but the absence of steroids [40]. Other study reveals that the plant possesses alkaloids, steroids, tannins, flavonoids and reducing sugar but saponins and gums are absent in crude methanol extract [27].

Govindasamy and Arulpriya [41] also showed that plant leaves contain with alkaloids, phenol, steroids, protein, resins, steroids, tannins, terpenoids, cardiac glycosides, carbohydrates, saponins, glycosides, sugars, and catechol.

Compound isolation

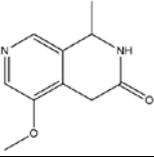
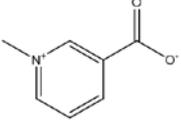
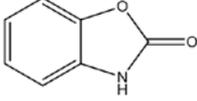
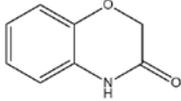
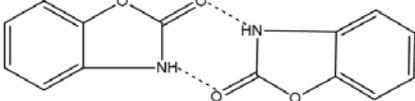
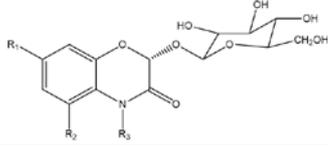
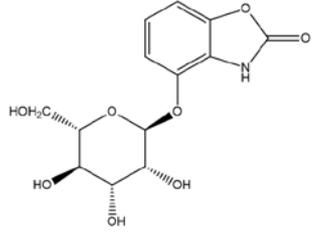
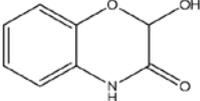
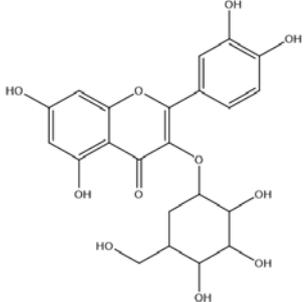
Wu et al. [42-43] obtained two aliphatic glycosides, ilicifolioside B and ilicifolioside C. Some lignan glycosides, (+)-syringaresinol-*O*- β -D-glucopyranoside, (+)-lyoniresinol 3 α -*O*- β -D-glucopyranoside, (+)-lyoniresinol 2 α -*O*- α -D-galactopyranosyl-3 α -*O*- β -D-glucopyranoside, (+)-lyoniresinol 3 α -*O*- α -D-galactopyranosyl-(1-6)- β -D-glucopyranoside, (-)-lyoniresinol 3 α -*O*- β -D-glucopyranoside [51, 43, 57]; fatty acid derivatives, β -sitosterol octadecanoate, octadecanoic acid, octacosanol, palmitic acid, stigmaterol octadecanoate, tetracosanol [48]; triterpenoids, lupeol and oleanolic acid and ursolic acid [44-45] were reported from the same species.

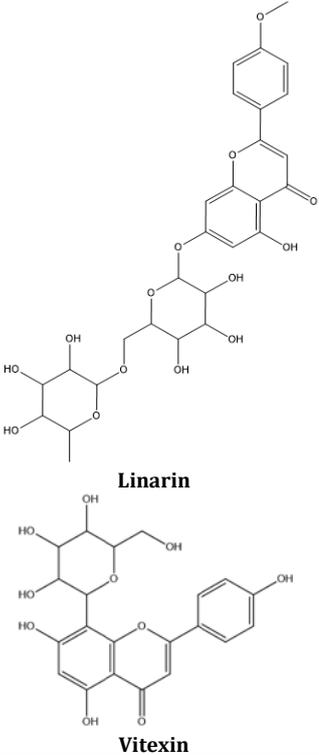
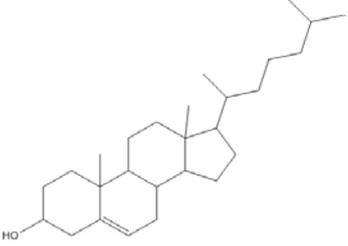
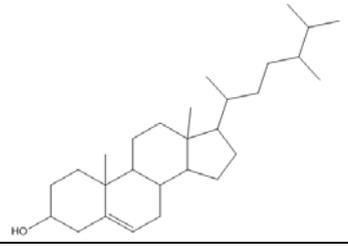
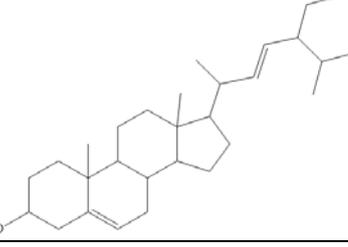
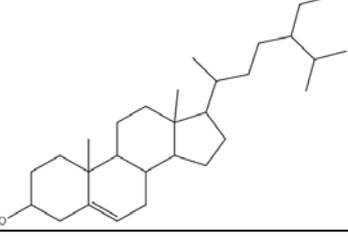
Besides these diverse classes of phytochemicals such as alkaloids, fatty acids, glycosides, lignans, triterpenoid, coumaric acid etc. various derivatives have been isolated and characterized from different extracts like Hexane, chloroform, ethanol, methanol of *A. ilicifolius*, illustrated in table 2 with their structures, pubchem ID's and relevant citations.

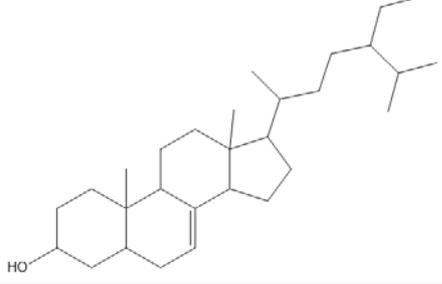
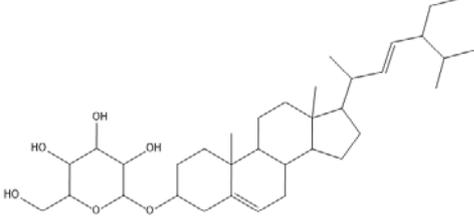
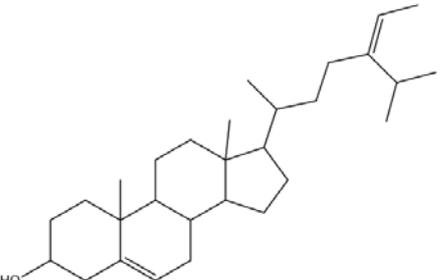
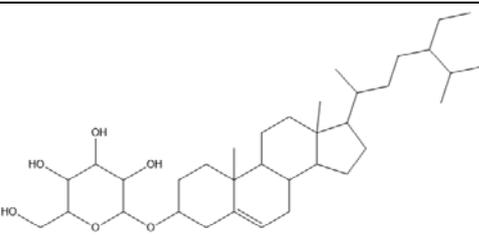
Pharmacology

The pharmacological study has been extensively performed on *A. ilicifolius* among the species of this genus. This study revealed that *A. ilicifolius* has significant bioactivities like, antioxidant and cytotoxic activity [26, 55], antinociceptive activity [56], anti-inflammatory activity [23, 26], anti-osteoporotic activity [57], hepatoprotective activity [26, 58], chemopreventive activity [21]; leishmanicidal, tumour reducing and anticancer activities [26, 58, 59, 60]; antileishmanial, antiulcer, antimicrobial, and osteoblastic, activities [26]. Moreover, Firdaus et al. found in their study that flower extract of the plant also has good cytotoxic effects [40]; Smitha et al. showed the anticancer activity of ethyl acetate extract of on two cell lines PA-1 and MCF-7 [61].

Table 2: Compounds isolated from *Acanthus ilicifolius*

Class of Phytochemicals	Name of the Phytoconstituents	Compound structure	PubChem ID	References
Alkaloids	Acanthicifoline		442503	[46]
	Trigonellin		5570	[44]
	2-benzoxazolinone		6043	[47, 48]
	Benzoxazin-3-one		72757	[49]
	5,5'-bis-benzoxazolin-2,2'-dione		NF	[50]
	Benzoxazinoid glucosides		NF	[51]
	4-O-b-D-glucopyranosyl-benzoxazolin-2(3H)-one		NF	[52]
2-hydroxy-4H-1,4-benzoxazin-3-one		322636	[48]	
Flavonoids	Quercetin		5280343	[44]
	Quercetin-3-O-beta-D-glucopyranoside		15959354	[44]

	acacetin 7-O- α -L-rhamnopyranosyl-(1 ^{'''} 6 ^{''})-O- β -D-glucopyranoside (Linarin) and vitexin	 <p>Linarin</p> <p>Vitexin</p>	5317025 & 5280441	[53]
Steroids	Cholesterol		5997	[49]
	campesterol		173183	
	stigmasterol		5280794	
	β -sitosterol		222284	[44]

stigmast-7-en-3- β -ol,		441837	[49]
stigmasteryl β -D-glucopyranoside		70699355	[48,49]
28-isofucosterol		5281328	[54]
octacosyl alcohol		68406	[49]
β -sitosterol-3-O- β -D-glucopyranoside		70699351	[48]

NF: Not Found

Antioxidant activity

Firdaus *et al.*, [40] have scrutinized the antioxidant properties of *A. ilicifolius* by the DPPH scavenging assay. The assay was conducted on total five extracts (acetone, methanol, acetone 70%, methanol 80% and water) of flowers and found that methanol extract showed highest antiradical efficiency (141.30%), while water extract of showed lowest (0.0037%) among the extracts. Dey *et al.* [27] confirmed the antioxidant effects of the methanol extract of the plant. DPPH assay has been adopted for evaluation of the free radical scavenging activity of the extract by preparing ten different concentrations starting from 500 $\mu\text{g/ml}$ to 0.98 $\mu\text{g/ml}$ using serial dilution technique where IC_{50} was recorded to be 5.1 $\mu\text{g/ml}$. Moreover, the antioxidant activity of the fractions and isolated compounds of the plant has also been reported [58-60].

Polysaccharides isolated from the plant also showed significant radical scavenging activity [62]; Flavonoids and phenolic compounds of *A. ilicifolius* displayed their good antioxidant activity on the animal model [63].

Cytotoxic activity

Firdaus *et al.*, [40] analyzed the cytotoxic of the flower extracts of *A. ilicifolius* on the brine shrimp lethality. The results exhibited methanol extract has lowest LC_{50} value (22 $\mu\text{g/ml}$) while water

extract showed the highest value at 10 $\mu\text{g/ml}$ among the extracts. Dey *et al.* [27] have tested the cytotoxic activity of a methanolic crude extract of the plant where it has found that the extract exhibited a significant cytotoxic activity with the LC_{50} value at 60 $\mu\text{g/ml}$ and LC_{90} value at 120 $\mu\text{g/ml}$.

Antimicrobial activity

Antimicrobial activity of alcohol, butanol and chloroform extract (10 mg/ml) of both leaves and roots of the plant exhibited significant activity against all microbes, *B. subtilis*, *P. vulgaris*, *P. aeruginosa*, *S. aureus*, *C. albicans*, *A. niger*, and *A. fumigatus*. The experiment was followed by agar cup plate method that unveils the leaves were more active than that of roots where ampicillin used as a standard for bacteria and clotrimazole for fungi. Chloroform extract of leaf showed the highest zone of inhibition that was measured ~26 mm against the fungus *C. albicans*. But butanol extract of leaf extract displayed lowest ~08 mm against the bacterium *S. aureus* [64].

Govindasamy and Arulpriya [41] studied antimicrobial activity of against seven skin infection causing microbes, methicillin resistance *S. aureus* (MRSA), *L. plantarum*, *S. pyogenes*, *S. epidermis*, *C. albicans*, *P. aeruginosa*, and *T. rubrum*. In this test four extract of the leaf has been examined where chloroform extract showed the highest activity against all microbes (except *S. epidermis* and *L. plantarum*).

Three extracts, ethanol, methanol and aqueous of leaf, stem, and root of the plant has used for the activity. The cub-plate method used to detect the efficiency of the plant against the eleven bacterial strains *Escherichia coli*, *Bacillus megaterium*, *Lactobacillus plantarum*, *Salmonella paratyphi B*, *Shigella dysenteriae*, *Streptococcus mutans*, *Klebsiella pneumoniae*, *Aspergillus flavus*, *Staphylococcus albus*, and *Lactobacillus acidophilus* and one fungus *C. albicans*. Ethanol and methanol extract showed more or less same activity and methanol extract indicated significantly more effective than the aqueous extract. Maximum zone of inhibition noticed on aqueous extract of root and methanol extract of the leaf as 17 mm against the same bacterium, *S. albus* [26].

Rao et al. [65] examined the antimicrobial activity of methanol, ethanol, and ethyl acetate extracts of flower, seed, leaf, and root of the plant by the well-diffusion method. Microbes like *Vibrio harveyi*,

Aeromonas hydrophila, and *E. coli* were taken for the test, results direct the highest activity observed on ethyl acetate seed extract against *V. harveyi*. Dey et al. [27] observed the antibacterial activity of a methanolic crude extract of the plant by ten gram-negative and six-gram positive bacteria, unfortunately, no activity was witnessed for the crude methanol extract.

Anticancer activity

Smitha et al. [61] studied the anticancer activity of ethyl acetate extract of leaf and root extract of the plant on two cell lines, MCF-7 and PA-1. The plant is more effective on PA-1 and the result has recommended that at 50 µg/ml ratio is adequate to inhibit the cancer cells. Moreover, the result has also unveiled that the extract is slightly cytotoxic to both of the cell lines. The antimicrobial and antioxidant activity of *A. ilicifolius* is depicted in table 3.

Table 3: Antimicrobial and antioxidant activity of *Acanthus ilicifolius*

Plant parts	Solvent used for extraction/isolated compound	Activity against	Reference
Leaf and root	Hexane, chloroform, and methanol	Antibacterial, antifungal	[66]
Leaf and root	Benzoate and phenylethanoid derivatives	Antimicrobial	[67]
Leaf and root	2-Benzoxazolinone 4 and benzoxazinium derivatives	Antimicrobial, antifungal and insecticidal	[22, 43,68]
Leaf and root	Methanol	Antibacterial DPPH	[27]
Flower	Acetone and methanol	DPPH	[55]

CONCLUSION

The plants from the genus *Acanthus* are broadly scattered in the tropical and subtropical regions of the world. The systematic pharmacological studies on the genus have given remarkable recognition to their ethnomedicinal uses in health care management. The phytochemical studies of the genus *Acanthus* revealed, isolation of a total of 21 bioactive compounds from *A. ilicifolius* and were identified with their structures and their respective PubChem ID's were mentioned in this review. Hence, the existence of these bioactive compounds may be explored from other sister species and their different pharmacological properties may also be compared. Numerous pharmacological studies using different types of extracts or pure phytochemicals of *Acanthus* species well justified their practice as an ethnomedicine; for example, antioxidant, antimicrobial, cytotoxic and anticancer activities besides its well-known antinociceptive, hepatoprotective, leishmanicidal and osteoblastic properties. Furthermore, scanty and limited toxicity reports on the animal model are presently available, which suggests that detailed toxicological evaluation is needed for different extracts from the various species. Correspondingly, the biological effectiveness should be carried out for the isolated secondary phytochemicals as well, which would definitely authenticate the medicinal claims of the *Acanthus* genus.

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CONFLICTS OF INTERESTS

All authors have no conflicts of interest to declare.

REFERENCES

- Saranya A, Ramanathan T, Kesavanarayanan KS, Adam. Traditional medicinal uses, chemical constituents and biological activities of a mangrove plant, *Acanthus ilicifolius* Linn.: a brief review. *Am Eur J Agric Environ Sci* 2015;15:243-50.
- Jiaqi H, Yunfei D, Wood JRI, Daniel TF. *Acanthaceae*. In: Al-Shehbaz. eds. *Flora of China*. Science Press, Beijing, and Missouri Botanical Garden Press: St. Louis, U. S. A; 2002;19:369-477.
- Mabberley DJ. *Mabberley's Plant-Book: A portable dictionary of plants, their classification and uses*. 3rd Edition. Cambridge University Press: Cambridge; 2008.
- Duke N, Ball M, Ellison J. Factors influencing biodiversity and distributional gradients in mangroves. *Glob Ecol Biogeogr Lett* 1998;7:27-47.
- Duke NC. *Australia's mangroves: the authoritative guide to Australia's Mangrove Plants*, University of Queensland; 2006.
- Tomlinson P. *The botany of mangroves*. Cambridge tropical biology series. Cambridge, New York, USA: Cambridge University Press; 1986.
- Yang Y, Yang S, Li J, Deng Y, Zhang Z, Xu S, et al. Transcriptome analysis of the holly mangrove *acanthus ilicifolius* and its terrestrial relative, *acanthus leucostachyus*, provides insights into adaptation to intertidal zones. *BMC Genomics* 2015;16:1-12.
- Bora R, Das AK, Sharma GD. Ecology and taxonomic study *Acanthus leucostachyus* Wall. ex Nees: a promising ethnomedicinal plant from Assam. *J Non-Timber Forest Prod* 2013;20:95-8.
- Tag H, Jeri L, Mingki T, Tsering J, Das AK. Higher plant diversity in pakke wildlife sanctuary and tiger reserve in east kameng district of arunachal pradesh: checklist-I. *Pleione* 2012;6:149-62.
- IUCN. *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 7 (August 2008). Prepared by the Standards and Petitions Working group of the IUCN-SSC Biodiversity Assessments Subcommittee, Huntingdon Road, Cambridge, UK; 2008. p. 1-70.
- Hu J, Deng YF, Wood JRI, Daniel TF. *Acanthaceae*. *Flora of China* 2011;19:369-477.
- Das AK, Dutta BK, Sharma GD, Hajra PK. Medicinal plants of southern Assam, deep publication, New Delhi-110063; 2010.
- Baruah S, Sarma J, Roy H, Borthakur SK. Notes on two interesting angiosperms from Assam, India. *Pleione* 2013;7:401-5.
- Barik SK, Haridasan K, Lakadong NJ. Medicinal plant resources of Meghalaya: Endemic threat status and consumption pattern. *Envis Forestry Bull* 2007;7:17-26.
- Ragavan P, Saxena A, Mohan PM, Jayaraj RSC, Ravichandra K. Taxonomy and distribution of species of the genus *Acanthus* (*Acanthaceae*) in mangroves of the Andaman and Nicobar Islands, India. *Boidversitas* 2015;16:225-36.
- Wang Y, Zhu H, Tam NFY. Polyphenols, tannins and antioxidant activities of eight true mangrove plant species in South China. *Plant Soil* 2014;374:549-63.
- Amirul I, Saifuzzaman M, Ahmed F, Mustafizur R, Nazneen AS, Naher K. Antinociceptive activity of methanolic extract of *Acanthus ilicifolius* Linn. leaves. *Turk J Pharm Sci* 2012;9:51-60.
- Nur KA, Mizanur R, Biswas S, Nasir A. Appraisals of bangladeshi medicinal plants used by folk medicine practitioners in the prevention and management of malignant neoplastic diseases. *Int Scholarly Res Notices* 2016;1-12. Doi:10.1155/2016/7832120.
- Supriya B, Vijayakumar K, Subramanian N, Kumar D. Medicinal values of *Putranjiva roxburghii*-a review. *Int J Curr Pharm Res* 2017;9:1-4.

20. Bandaranayake WM. Bioactivities, bioactive compounds and chemical constituents of mangrove plants. *Wetlands Ecol Manag* 2002;10:421-52.
21. Chakraborty T, Bhuniya D, Chatterjee M, Rahaman M, Singha D, Chatterjee BN, et al. *Acanthus ilicifolius* plant extract prevents DNA alterations in a transplantable Ehrlich ascites carcinoma-bearing murine model. *World J Gastroenterol* 2007;13:6538-48.
22. Bandaranayake WM. Traditional and medicinal uses of mangroves. *Mangroves Salt Marshes* 1998;2:133-48.
23. Kumar KT, Gorain B, Roy DK, Samanta SK, Pal M, Biswas P, et al. Anti-inflammatory activity of *Acanthus ilicifolius*. *J Ethnopharmacol* 2008;120:7-12.
24. Sundaram R, Ganesan R, Murugesan G. *In vitro* antiplasmodial activity of spiro benzofuran compound from mangrove plant of Southern India. *Asian Pac J Trop Med* 2011;5:358-61.
25. Govindasamy C, Kannan R. Pharmacognosy of mangrove plants in the system of unani medicine. *Asian Pac J Trop Dis* 2012;2(Suppl 1):S38-S41.
26. Ganesh S, Vennila JJ. Screening for antimicrobial activity in *Acanthus ilicifolius*. *Arch Appl Sci Res* 2010;2:311-31.
27. Dey A, Raihan SM, Sariful Islam HM, Hamiduzzaman M, Monjur-Al-Hossain ASM. Phytochemical screening and the evaluation of the antioxidant, cytotoxic and antimicrobial properties of *Acanthus ilicifolius* (Family: Acanthaceae). *Int Res J Pharm* 2012;3:153-6.
28. Kirtikar KR, Basu BD. Indian medicinal plants. Vol. 8. 1st ed. Dehradun: International Book Distributors; 2001.
29. Jeeva S, Mishra BP, Venugopal N, Kharlukhi L, Laloo RC. Traditional knowledge and biodiversity conservation in the sacred groves of Meghalaya. *Indian J Traditional Knowledge* 2006;5:563-8.
30. Das AK, Dutta BK, Sharma GD. Medicinal plants used by different tribes of Cachar district, Assam. *Indian J Traditional Knowledge* 2008;7:446-54.
31. Singh OP, Tiwari BK, Lynser MB, Bharali S. Environmental accounting of natural resources of meghalaya: phase i-land and forest resources (Technical Report). the central statistical organization, the government of India, New Delhi; 2008.
32. Manikandaselvi S, Vadivel V, Brindha P. Review on ethnobotanical studies of nutraceutical plant: *Capparis spinosa* L. (Caper). *Asian J Pharm Clin Res* 2016;9:21-4.
33. Pfoze NL, Kehie M, Kayang H, Mao AA. Estimation of ethnobotanical plants of the Naga of North East India. *J Med Plants Stud* 2014;2:92-104.
34. Ahuja U, Ahuja SC. Alcoholic rice beverages. In: *Encyclopaedia of the history of science, technology, and medicine in non-western cultures*. Springer Netherlands, Dordrecht; 2014. p. 1-7.
35. Fongod AGN, Modjenpa NB, Veranso MC. Ethnobotany of acanthaceae in the mount cameroon region. *J Med Plants Res* 2013;7:2707-13.
36. Pradhan SD, Palei CN, Rath PB, Swain KK, Kar S. A new addition of mangrove species *Acanthus ebracteatus* Vahl. (Acanthaceae) to the mangrove flora of Bhitarkanika National Park, Odisha, India. *Int J Innov Appl Res* 2016;4:28-31.
37. Nguyen PD, Ho CL, Harikrishna JA, Wong MC, Rahim RA. Generation and analysis of expressed sequence tags from the mangrove plant, *Acanthus ebracteatus* Vahl. *Tree Genet Genomes* 2006;2:196-201.
38. Raut S, Khan S. Phytochemical fingerprinting of *Acanthus ilicifolius* L. *Adv Plant Sci* 2012;25:749-53.
39. Ralf W, Gerd L. Chemical composition of the mangrove holly *Acanthus ilicifolius* (Acanthaceae)-review and additional data. *Frankfurt Main* 2008;38:31-7.
40. Firdaus M, Prihanto AA, Nurdiani R, Widodo N. Antioxidant and cytotoxic activity of *Acanthus ilicifolius* flower. *Asian Pacific J Trop Biomed* 2013;3:17-21.
41. Govindasamy C, Arulpriya M. Antimicrobial activity of *Acanthus ilicifolius*: skin infection pathogens. *Asian Pac J Trop Dis* 2013;3:180-3.
42. Wu J, Zhang S, Huang J, Xiao Q, Li Q, Long L, et al. New aliphatic alcohol and (Z)-4-coumaric acid glycosides from *Acanthus ilicifolius*. *Chem Pharm Bull* 2003;51:1201-3.
43. Wu J, Zhang S, Xiao Q, Li Q, Huang J, Long L, et al. Phenylethanoid and aliphatic alcohol glycosides from *Acanthus ilicifolius*. *Phytochemistry* 2003;63:491-5.
44. Minocha PK, Tiwari KP. Chemical constituents of *Acanthus ilicifolius* Linn. *Pol J Chem* 1980;54:2089-90.
45. Minocha PK, Tiwari KP. A triterpenoid saponin from roots of *Acanthus ilicifolius*. *Phytochemistry* 1981;20:135-7.
46. Tiwari KP, Minocha PK, Masood M. Acanthilicifoline-a new alkaloid from *Acanthus ilicifolius*. *Pol J Chem* 1980;54:857-8.
47. Murty MSR, Solimabi Kamat SY. Isolation of 2-benzoxazolinone from *Acanthus ilicifolius*. *Indian J Pharm Sci* 1984;46:218-9.
48. Zhong LJ, Huang MY, Zhang JG, Li GW, Zhang YH. Study on the chemical constituents from *Acanthus ilicifolius* Linn. var. *xiamenensis*. *Chin J Marine Drugs* 2012;31:23-8.
49. Kokpol U, Chittawong V, Miles DH. Chemical constituents of the roots of *Acanthus ilicifolius*. *J Nat Prod* 1986;49:354.
50. D'Souza L, Wahidulla S, Mishra PD. Bisoxazolinone from the mangrove *Acanthus ilicifolius*. *Indian J Chem Sect B* 1997;36B:1079-81.
51. Kanchanapoom T, Kamel MS, Kasai R, Picheansoonthon C, Hiraga Y, Yamasaki K. Benzoxazinoid glucosides from *Acanthus ilicifolius*. *Phytochemistry* 2001;58:637-40.
52. Huo C, An D, Wang B, Zhao Y, Lin W. Structure elucidation and complete NMR spectral assignments of a new benzoxazolinone glucoside from *Acanthus ilicifolius*. *Magn Reson Chem* 2005;43:343-5.
53. Wu J, Zhang S, Xiao Q, Li Q, Huang J, Long L, et al. Megastigmane and flavone glycosides from *Acanthus ilicifolius*. *Pharmazie* 2003;58:363-4.
54. Clarke A, Gleeson P, Jermyn M, Knox R. Characterization and localization of lectins in lower and higher plants. *Funct Plant Biol* 1978;5:707-22.
55. Muhamad F, Prihanto AA, Nurdiani R. Antioxidant and cytotoxic activity of *Acanthus ilicifolius* flower. *Asian Pac J Trop Biomed* 2013;3:17-21.
56. Islam MA, Saifuzzaman M, Ahmed F, Rahman MM, Sultana NA, Naher K. Antinociceptive activity of Methanolic extract of *Acanthus ilicifolius* L. leaves. *Turk J Pharm Sci* 2012;9:51-60.
57. Van Kiem P, Quang TH, Huong TT, Nhung TH, Cuong NX, Van MC, et al. Chemical constituents of *Acanthus ilicifolius* L. and effect on osteoblastic MC3T3E1 cells. *Arch Pharm Res* 2008;31:823-9.
58. Babu BH, Shylesh BS, Padikkala J. Antioxidant and hepatoprotective effect of *Acanthus ilicifolius*. *Fitoterapia* 2001;72:272-7.
59. De Carvalho, PB Ferreira EI. Leishmaniasis phytotherapy. Nature's leadership against an ancient disease. *Fitoterapia* 2001;72:599-618.
60. Babu BH, Shylesh BS, Padikkala J. Tumour reducing an anticarcinogenic activity of *Acanthus ilicifolius*. *J Ethnopharmacol* 2002;79:27-33.
61. Smitha RB, Madhusoodanan PV, Prakashkumar R. Anticancer activity of *Acanthus ilicifolius* Linn. from chettuva mangroves, Kerala, India. *Int J Bioassays* 2014;3:3452-5.
62. Zhang T, Tian Y, Jiang B, Miao M, Mu W. Purification, preliminary structural characterization and *in vitro* antioxidant activity of polysaccharides from *Acanthus ilicifolius*. *LWT-Food Sci Technol* 2014;56:9-14.
63. Asha KK, Mathew S, Lakshmanan PT. Flavonoids and phenolic compounds in two mangrove species and their antioxidant property. *Indian J Mar Sci* 2012;41:259-64.
64. Bose S, Bose A. Antimicrobial activity of *Acanthus ilicifolius* (L.). *Indian J Pharm Sci* 2008;70:821-3.
65. Rao SM, Teja G, Sirisha IR, Rao PY. Screening of antimicrobial activity of mangrove plant *Acanthus ilicifolius* on shrimp and fish pathogens. *Asian J Plant Sci Res* 2015;5:1-3.
66. Pradeep V, Khajure, Rathod JL. Antimicrobial activity of extracts of *Acanthus ilicifolius* extracted from the mangroves of from the mangroves of Karwar coast karnataka. *Recent Res Sci Technol* 2010;2:98-9.
67. Ravikummar S, Raja M, Gnanadesigan M. Antibacterial potential of benzoate and phenylethanoid derivatives isolated from *Acanthus ilicifolius* L. leaf extracts. *Nat Prod Res* 2012;26:2270-3.
68. Das A, Ahmed AB. Natural permeation enhancer for transdermal drug delivery system and permeation evaluation: a review. *Asian J Pharm Clin Res* 2017;10:7-11.