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CARNIVOROUS MARVEL: AN IN-DEPTH STUDY OF THE INDIAN PITCHER PLANT

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ABSTRACT

Nepenthes khasiana is commonly referred as Indian pitcher plant. It is carnivorous species and only nepenthes species found in India. It is endemic in India and mainly found in Garo and khasi hills of Meghalaya. It found at an elevation between 500 to 1500 m above mean sea level. Due to numerous anthropogenic factors, population of *Nepenthes khasiana* is decreasing hence, it is categorized in Red Data Book by SSC-IUCN as Endangered species. Pitcher is present at the leaf of this plant due to leaf's tip modification and it attract prey by various way. Traditional Utilization of this plant by local communities showcase its cultural and ethno-medicinal values. In Meghalaya, N. khasiana is the medicinal plant that are mostly collected. Various indigenous communities of Meghalaya tradionally utilize it to treat different ailments. Many phyto-chemicals are present in different quantity which have pharmacological effects and used to cure various diseases through their individual, additive, or synergistic effect. Phyto-chemicals compound present in fluid of unopened pitcher of *Nepenthes khasiana* are detect and identify by GC-MS technique. Crude extract and the pure bioactive compound of *Nepenthes khasiana* show different pharmacological activities such as antifungal, antioxidant, anti-diabetic and hepatoprotective. This review assess its profile, taxonomy, distribution, morphology, phyto-chemicals present in it and pharmacological activities.

KEYWORDS: *Nepenthes khasiana*, Carnivourous plant, Pitcher plant, Nepenthes species, Phyto-chemicals, Ethno-medicinal.

INTRODUCTION

Another name for *Nepenthes kasiana* is Indian picture plant.

The pitcher plant *Nepenthes khasiana* is carnivorous in nature and endemic in India.[1] More than 810 species of carnivorous plants belonging to 13 families around the world, mostly species are member of Nepenthales and Lamiales family.[2,1] Blue fluorescence of this pitcher plant attract insects.[3] when insects become trapped inside the fluid-containing pitcher, then insects start dying and get digested by several hydrolytic enzymes present in the pitcher. Example of enzymes present in the pitcher are aspartic or cysteine proteinase, chitinase, ribonuclease, esterase, phosphatase, β-1, 3-glucanase and β-D-xylosidase.[4]

Pitcher plant population are decreasing in India and across the world as a result of number of threat factors like habitat destruction and over-exploitation.[5] Various anthropogenic factors are causing the plant population to decline hence, it is categorised as the Endangered species in Red Data Book by SSC-IUCN.[2] as appendix-1 category by CITES under the Negative List of Export by the Govt. of India.[6]

It is found in Meghalaya, India at an altitude varying from 500 to 1500 m above mean sea level.[2,1] They have just been found in the Dima Hasao of Assam.[7]

In their major centre of diversity i.e. Bomeo, Sumatra, and the Philippins mainly Nepenthes species are found in prehumid (high humid index), mountain region with warm days and cold and humid nights.[8,9,10]

Fig 1: The pitcher plant (*Nephenthes khasiana Hook.f.).*[1]

PLANT PROFILE

Botanical name: *Nepenthes khasiana hook.f.*[11]

Common name: Monkey cups, Pitcher plant

Vernacular name: Ksete-phare, Memang koksi, Tiew-rakot

Khasi people call it: Tiew-rakot (means demon flower or devouring flower)

Jaintias call it: Kset phare (which is roughly translated as lidded fly net)

Garo call it: Memang-koksi (means basket of the devil).[12,13]

Biate tribe of Assam call it: Jug-par (means jug flower) and loisul kola (means Pitcher-plant).[7]

In some older texts, the specific epithet khasiana is spelled khasyana.[14,15]

TAXONOMY.[11]

1.	Kingdom	Plantae
2.	Phylum	Tracheophyta (vascular plants)
3.	Class	Magnoliopsida (dicotyledons)
4.	Order	Caryophyllales
5.	Family	Nepenthaceae
6.	Genus	Nepenthes
7.	Species	*Nepenthes khasiana*

DISTRIBUTION

They cover an area of 250 km situated at an elevation ranging from 500 to 1500 m over mean level of sea in Meghalaya, India.[2,1] In meghalaya, these area are found in separate forest fragment: In Jaintia Hills : Jarain, Jowai, and Umtra regions In Garo Hills: Baghmara, Balpakram, Bandari, Chokpot, and Maheskhola regions.

In East Khasi Hills: Lawboh and Mawlynnong region.[16,17,18,19,20,21] They are recently discovered in the Assam's Dima Hasao region.[7]

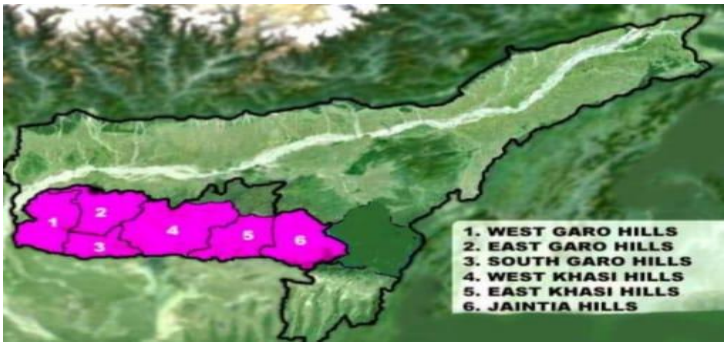

Fig 2: Distribution map of *Nepenthes khasiana* Hook. in Meghalaya state.[1]

MORPHOLOGY

N. Khasiana is a climbing plant under shrub for support and attain heght ranges from few centimeters to several meters f.

Two type of plant height are identified

Dwarf plant: It obtain only height of 10-15 cm and grows on rocky or sandy pockets.

Tall plant: It obtain height of 15-20 m and grows on a damp soil strata of significant depth or along hill streams. It straggle up with the help of tendrils on large shrub or small trees.

Root: it possesses superficial root system. It goes few centimeters deep only in the soil.

Stem: it possesses Cylindrical shape when young, colour of stem is green and in the older parts trurns into brown.

Leaf: Leafs have significant morphological importance as parts of leaf undergo various modification to perform different function.

Mid rib: Tip of the leaf's midrib extends and transforms into appealing pitcher to capture prey in order to stable the insufficient nutrients obtained from soil.[22]

Pitcher: leaf apex of the Plant possesses a pitcher.[9,23,24,25] and it is the modification of leaf's tip.[26,28]

Internal body of pitcher's consist of two zones: i. Wax zone ii. Digestive zone.[27]
wax zone refer to the top portion of the pitcher's opening (inner pitcher body) that is located directly beneath the lid to the digestive zone boundaries.[28]

Most nepenthes species produces pitcher of two type: lower and upper pitchers.[29]
Lower pitcher: It develops by sapling leaves or stems which are in rosettes form. lower pitchers are usually found close or connected to the surface. When stem are in rosette form during the stage of growth, the lower pitcher is present on the upper stem.

Upper pitcher: It develops from the leaves that are on mature stems or grown up stems. Picture is the modification of nepenthes leaves to attract, trap, and digest prey like insects to provide additional nutrients.[24,30,31,32,33,34]

Nepenthes attract (lure) prey by various way that are

i. Nepenthes attract visitor insects with nectar as source of food.[30,35,36]

ii. pitcher of Nepenthes emit certain scent to lure prey.[37,34]

iii nepenthes also employ color of the pitcher, pitcher's form and environmental factors to lure prey.[38,39]

Shape, size, and color of pitcher play important role for attracting prey.[37] Nepenthes variety are identified with the help of pitcher's form and color, moreover each pitcher produce pigment that lead to variation in the color of pitcher.[40]

Flower: Dioecious plant and separate plant bear male and female flowers.

Flowering season: June to October

Inflorescence: Raceme consist of 2-flowered cymes possesses length of about 25-60 cm.[41] Male inflorescence is double the length and denser than female inflorescence. In both male and female flowers, multicellular trichomes are occur on the abaxial surface of perianth lobes.[42]

Anthers: They are bisporangiate and archesporial initials are set in uniseriate rows of cells in it.[43]

Pollen grains: These grains are non-aperturate and possess thick spinuliferous sexine that are distributed in tetrads with sparsely echinate sculpture.
Size of the tetrads is 30.7 µm.[44]

Fruits: They are elongated capsules and length range between 20 to 25 mm.
Polyploid chromosomes number is high in this species.[44]

Optimum growth condition

Good humidity: 34-80%.[45]

Optimal humidity: 67-90%.[46]

Optimal pH: 5-7.5[47]

ETHNOMEDICINAL USES

N. khasiana is widely collected medicinal plant species in Meghalaya. in Meghalaya, the various indigenous communities traditionally use it to cure different diseases.[48]

Following are the traditional medical uses of *Nepenthes khasiana*

Leaves Methanolic extract: employed for strong liver protection.[49]

Fluid from unopened pitcher: i. Used in the treatment of cough and stomachache.[50]

ii. Employed to treat diabetes mellitus and painful urination.[20,51]

Iii. Used as an eye drop to treat redness, cataract, itching, night blindness.[41]

iv. Fluid is also used for female diseases.[52]

v. Employed as eardrop to cure ear troubles.[53]

vi. Pitcher's liquid is consumed as a digestive tonic in the morning

Grind powder of pitcher: Used to cure cholera.[54,53]

Fine paste of pitcher: Used to cure leprosy.[55]

Root of pitcher pant: Used to cure dysentery and stomachache.[56]

PHYTO-CHEMICALS

Phyto-chemicals are also called as secondary metabolites and are present in different quantity in plants and their individual, additive, or synergistic effects are utilized to cure different diseases.[57, 58] Plants have been traditional source of effective medications, and this is still continuely explored for new noval lead chemicals compound present in plant.[59] Vital part of plant research is identification of the physiologically active compound found in plants that lead to additional biological and pharmacological studies.[60,1] Gas chromatography–mass spectrometry (GC–MS) is a combined analytical method that are employed to analyze and identify the phyto-chemicals present in the plant.[61] The phytochemical analysis of medicinal plants with physiologically active compounds relies on GC–MS.[62] because it is most effective, rapid, and accurate method for identifying various chemicals present in plant.[63]

The GC-MS study of methanolic extracts of *Nepenthes khasiana* fluid identify following phytochemicals are

Sr. no.	Compound identified	Class of compound	Molecular formula	Molecular weight	Area %	Chemical %	Refer-ence
1	Octane, 4-methyl	Hydrocarbon	C_9H_{20}	128	0.26	0.10	[64]
2	Decane	Hydrocarbon	$C_{10}H_{22}$	142	0.58	0.21	-
3	Undecane	Hydrocarbon	$C_{11}H_{24}$	156	1.5	0.56	[65]
4	Dodecane	Hydrocarbon	$C_{12}H_6$	170	5.62	2.08	-
5	Cetene	Hydrocarbon	$C_{16}H_{32}$	224	0.75	0.28	-
6	Quinoline, 1,2-dihydro-2,2,4-Trimethyl	Nitrogen compound /heterocyclic	$C_{12}H_{15}$	173	1.14	0.42	[66]

		compound					
7	2,4-Di-tert-butylphenol	Phenyl propane	$C_{14}H_{22}O$	206	5.85	2.17	[67, 68]
8	p-Cresol, TMS derivative	Phenol	$C_{10}H_{16}OSi$	180	0.49	0.18	[69]
9	Butylated Hydroxytoluene	Phenol	$C_{15}H_{24}O$	220	1.24	0.46	[70, 71]
10	2,4-Di-tert-Butylphenoxytrimethylsilane	Phenol	$C_{17}H_{30}OSi$	278	1.12	O.41	[72]
11	1,3,5-Benzetriol, 3TMS Derivative	Phenol	$C_{15}H_{30}O_3Si_3$	342	1.09	0.40	[73, 74]
12	Triethyl citrate	Ester	$C_{12}H_{20}O_7$	276	47.24	17.49	[72]
13	D-Fructose, 1,3,4,5,6-pentakis-O- rimethylsilyl)-, O-Methyloxime	Sugar	$C_{22}H_{55}NO_6Si_5$	569	1.25	0.46	[72]
14	β-D-Galactofuranose, 1,2,3,5,6-pentakis-O-(trimethylsilyl)	Sugar	$C_{21}H_{52}O_6Si_5$	540	2.1	0.78	[75]
15	D-Psicose, pentakis(trimethylsilyl) ether, methyloxime (syn)	Sugar	$C_{22}H_{55}NO_6Si_5$	569	1	0.37	[72]
16	Dodecanoic acid, TMS Derivative	Fatty acid	$C_{15}H_{32}O_2Si$	272	0.63	0.23	[72]
17	Myristic acid, TMS derivative	Fatty acid	$C_{17}H_{36}O_2Si$	300	3.19	1.18	[72]
18	Hexadecanoic acid, ethyl ester	Fatty acid	$C_{18}H_{36}O_2$	284	3.89	1.44	[76, 77]
19	Palmitic Acid, TMS derivative	Fatty acid	$C_{19}H_{40}O_2Si$	328	100	37.03	[72]
20	Heptadecanoic acid, TMS Derivative	Fatty acid	$C_{20}H_{42}O_2Si$	342	2.17	0.80	[72]
21	Octadecanoic acid, ethyl ester	Fatty acid	$C_{20}H_{40}O_2$	312	12.64	4.68	[78]
22	Stearic acid,TMS derivative	Fatty acid	$C_{21}H_{44}O_2Si$	356	76.31	28.26	[72]

PHARMACOLOGICAL ACTIVITIES

Phyto-chemicals present in the Indian pitcher plant exhibit certain pharmacological activities

Sr. no.	Compound identified	Activity as per database	Reference
1	Octane, 4-methyl	Catechol-O-Methyl-transferase Inhibitor (Parkinson disease), lung cancer detection	[64]
2	Decane	No activity	-
3	Undecane	Anti-inflammatory	[65]
4	Dodecane	No activity	-
5	Cetene	No activity	-
6	Quinoline, 1,2-dihydro-2,2,4-Trimethyl	Antioxidant	[66]
7	2,4-Di-tert-butylphenol	Antioxidant, antidode, coronary dialator, diaphoretic, diuretic, disinfectant, uv stabilizer,	[67,68]
8	p-Cresol, TMS derivative	Algogenic, Anticancer, Antitumor, Asthama preventive, Cold preventive, Antioxidant, antiseptic and disinfectant	[69]
9	Butylated Hydroxytoluene	Antioxidant, antifungal	[70,71]
10	2,4-Di-tert-Butylphenoxytrimethylsilane	Antidode, disinfectant, diaphoretic, diuretic, coronary dialator	[72]
11	1,3,5-Benzetriol, 3TMS Derivative	Acceleration of labour, masculotropic anti-spasmodic, Safeguard skin against apoptosis, breast cancer	[73,74]
12	Triethyl citrate	Increases citrate excreation,inhibit citratelyase	[72]
13	D-Fructose, 1,3,4,5,6-pentakis- O-(trimethylsilyl)-, O-Methyloxime	Decrease glutamate oxaloacetate transaminase, Anticancer, Antineuritic optometry, Antitumor, Inhibit production of uric acid, smart drug	[72]
14	β-D-Galactofuranose, 1,2,3,5,6-pentakis-O-(trimethylsilyl)	Anticancer, antidote, antileukotriene, CNS depressant, coronary dialator, detoxicant, igestive, diuretic, antioxidant, urolithiasis	[75]
15	D-Psicose, pentakis(trimethylsilyl) ether, methyloxime (syn)	DNA-synthesis-inhibitor, Analgesic-synergist, Antioxidant synergist, Anticancer, Antileukotriene, Coronary dialator, Decongestant, Detoxicant, Diuretic	[72]
16	Dodecanoic acid, TMS Derivative	Acidifier, inhibit production of uric acid, urinary acidulant, urine-acidifier	[72]
17	Myristic acid, TMS derivative	Acidifier, inhibit production of uric	[72]

		acid, urinary acidulant, urine-acidifier	
18	Hexadecanoic acid, ethyl ester	Acidifier, inhibit production of uric acid, urinary acidulant, urine-acidifier, Antioxidant, antiproliferative, antimicrobial, antiinflammatory, muscle weakness, pulmonary edema, anemia, respiratory failure, drowsiness, diarrhea, hypocholisterolemic lubricant	[76,77]
19	Palmitic Acid, TMS derivative	Acidifier, inhibit production of uric acid, urinary acidulant, urine-acidifier	[72]
20	Heptadecanoic acid, TMS Derivative	Acidifier, inhibit production of uric acid, urinary acidulant, urine-acidifier	[72]
21	Octadecanoic acid, ethyl ester	Acidifier, inhibit production of uric acid, urinary acidulant, urine-acidifier, Antimicrobial	[78]
22	Stearic acid, TMS derivative	Acidifier, inhibit production of uric acid, urinary acidulant, urine-acidifier	[72]

MEDICINAL USES

Antioxidant

Methanolic extract of leaf of *N. khasiana* show strong antioxidant properties with half maximal inhibitory concentration (IC50) of 23.33±0.441, 62.75±0.713, and 38.38±0.425 µg/ml in 2,2-diphenyl-1-picrylhydrazyl (DPPH), superoxide anion, and hydroxyl radical scavenging activity, respectively.[78]

Anti-diabetic

In laboratory rats with insulin resistance and dexamethasone-induced hyperlipidemia, hypolipidemic and hypoglycemic activity of extract of N. khasiana Hook pitcher was investigated. At a dosage level of 250 and 500 mg/kg, methanolic extract of N. khasiana pitcher stop the rise in level of cholesterol, glucose, triglyceride, low density lipoprotein with progressively decreasing in high density lipoprotein, and body weight triggered by dexamethasone on tested rats.[79]

Anti-fungal

The liquid extract of N. khasiana pitcher contain droserone, 5-0-methyldroserone, and purified naphthoquinones which show antifungal activities when tested on Aspergillus sp.

and Candida sp.[80] MICs of 63, 125, 63, and 250 µg/ml were found for the antifungal activity of 3:1 droserone: medroserone mixture examined on C. albicans, Candida glabrata, Candida krusei, and Aspergillus fumigatus , respectively.[80]

Hepatoprotectve

In adult Wistar albino rats, N. khasiana show Hepatoprotective activity against alcoholic induced liver damage. Histopathological studies of the liver demonstrate that Administration of N. khasiana methanolic extract restored the damaging effect on liver caused by alcohol. As a result, N. khasiana show a potent hepatoprotective effect.[78]

Cytotoxicity

In rats at a 3000 mg/kg bw dose level, methanolic extract of N. khasiana leaf does not show any toxicity or mortality as demonstrated by acute cytotoxicity study.[81]

REFERENCES

1. Momin KC, Mehra TS, Dobhal S, et al. Status of Nephenthes khasiana Hook. f. (Pitcherplant) in Meghalaya: a review. J Pharmacogn Phytochem., 2018; 7(3): 353–358.
2. Ved, D., D. Saha, K. Haridasan and K. Ravikumar: Nepenthes khasiana. The IUCN Red List of Threatened Species, 2015; T48992883 A49009685.
3. Kurup, R., A.J. Johnson, S. Sankar, A. A. Hussain, C.S. Kumar & S. Baby Fluorescent prey traps in carnivorous plants. Plant Biology, 2013; 15(3): 611–615. doi:10.1111/j.1438-8677.2012.00709.x
4. Biteau F, Nisse E, Miguel S, Hannewald P, Bazile V, Gaume L, et al. A simple SDS-PAGE protein pattern from pitcher secretions as a new tool to distinguish Nepenthes species (Nepenthaceae). Am J Bot., 2013; 100: 2478–2484.
5. Rizqiani, S., N.S. Ariyanti and Sulistijorini: Diversity of Lowland Nepenthes (Pitcher Plants) in Bangka Belitung Islands. IOP Conf. Ser.: Earth Environ. Sci., 2018; 197: 012021.
6. Ziemer, B.: Exciting conservation news: The rare Nepenthes collection project! Carnivorous Plant Newsletter, 2010; 39: 67.
7. . Sajem Betlu, A.L. "Nepenthes khasiana Hook. f. (Nepenthaceae) from Assam". Current Science, 2016; 3(8).
8. Moran JA, Gray LK, Clarke C, Chin L. Capture mechanism in Palaeotropical pitcher plants (Nepenthaceae) is constrained by climate. Ann Bot., 2013; 112: 1279-1291. https://doi.org/10.1093/aob/mct195.

9. Clarke C, Moran JA. Climate, soils and vicariance-their roles in shaping the diversity and distribution of Nepenthes in Southeast Asia. Plant Soil, 2016; 403: 37-51. https://doi.org/10.1007/s11104-015-2696-x.
10. Gray LK, Clarke C, Wint GW, Moran JA. Potential effects of climate change on members of the Palaeotropical pitcher plant family Nepenthaceae. PloS One, 2017; 12: 0183132, https://doi.org/10.1371/journal.pone.0183132
11. Hooker, J. D. Ordo CLXXV bis. Nepenthaceæ. In: A. de Candolle Prodromus Systematis Naturalis Regni Vegetabilis, 1873; 17: 90–105.
12. Prasad, M.N.V. & S. Jeeva Coal mining and its leachate are potential threats to Nepenthes khasiana Hook. f. (Nepenthaceae) that preys on insects - an endemic plant in North Eastern India. Archived 2016-03-04 at the Wayback Machine Biological Diversity and Conservation, 2009; 2/3: 29-33.
13. Flora of Meghalaya Archived 2007-12-25 at the Way back Machine.
14. Moore, D. 1872. On the culture of Nepenthes at Glasnevin. The Gardeners' Chronicle and Agricultural Gazette, 1872; (11): 359–360.
15. Masters, M.T. 1872. The cultivated species of Nepenthes. The Gardeners' Chronicle and Agricultural Gazette, 1872; (16): 540–542.
16. Hooker, J.D.: The Flora of British India. Vol. 5, L. Reeve & Co., London, 1890; 759.
17. Jain, S. K. and A.R.K. Sastri: Threatened Plants of India: A State of Art Report. Botanical Survey of India, 1980; 48.
18. Joseph, J. and G. Mani: One new species and one new record from India in the genus Utricularia. Bulletin of Botanical Survey of India, Govt. of India, 1982; 24: 108-111.
19. Haridasan, K. and R.R. Rao: Forest flora of Meghalaya. 2 Vols. Bishen Singh Mahendrapal Singh, Dehra Dun, India, 1987; 937.
20. Choudhury, A.: Range extension of Nepenthes khasiana in the Jaintia Hills, Meghalaya. J. Bombay Nat. Hist. Soc., 2000; 97: 166–167.
21. Devi, R. and N. Venugopal: The status of insectivorous plants in North-East India: their uses and conservation. J. Swamy Bot. Club, 2006; 23: 75-80.
22. Kitching R & Schofield C, Every pitcher tells a story, New Scientist, 1986; 23: 48-51.
23. Dančák M, Majeský E, Čermák V, Golos MR, Płachno BJ, Tjiasmanto W. First record of functional underground traps in a pitcher plant: Nepenthes pudica (Nepenthaceae), a new species from North Kalimantan, Borneo. PhytoKeys, 2022; 201: 77-97. DOI:10.3897/phytokeys.201.82872.

24. Rizqiani S, Ariyanti N, Sulistijorini. Anatomical characters used for defining five species of Nepenthes from Bangka Belitung Islands, Indonesia. J Trop Life Sci., 2018; 8(3): 311-322. DOI: 10.11594/jtls.08.03.14.
25. Robinson AS, Golos MR, Barer M, Sano Y, Forgie JJ, Garrido D, Gorman CN, Luick AO, McIntosh NWR, McPherson SR, Palena GJ, Pančo I, Quinn B. D, Shea J. Revisions in nepenthes following explorations of the kemul massif and the surrounding region in north-central Kalimantan, Borneo. Phytotaxa., 2019; 392(2): 97-126. DOI: 10.11646/phytotaxa.392.2.1.
26. Gilbert KJ, Nitta JH, Talavera G, Pierce NE. Keeping an eye on coloration: Ecological correlates of the evolution of pitcher traits in the genus Nepenthes (Caryophyllales). Biol J Linn Soc., 2018; 123(2). DOI: 10.1093/biolinnean/blx142.
27. Wang L, Zhou Q. Nepenthes pitchers: Surface structure, physical property, anti-attachment function and potential application in mechanical controlling plague locust. Chin Sci Bull., 2014; 59(21): 2513-2523. DOI: 10.1007/s11434-014-0383-6.
28. Schwallier R, van Wely V, Baak M, Vos R, van Heuven BJ, Smets E, van Vugt RR, Gravendeel B. Ontogeny and anatomy of the dimorphic pitchers of Nepenthes rafflesiana jack. Plants, 2020; 9(11): 1-16. DOI: 10.3390/plants9111603
29. Bauer U, Di Giusto B, Skepper J, Grafe TU, Federle W. With a flick of the lid: a novel trapping mechanism in Nepenthes gracilis pitcher plants. PLoS One, 2012; 7(6): 1-7. DOI: 10.1371/journal.pone.0038951.
30. Bauer U, Rembold K, Grafe TU. Carnivorous Nepenthes pitcher plants are a rich food source for a diverse vertebrate community. J Nat Hist., 2015; 50(7-8): 483-495. DOI: 10.1080/00222933.2015.1059963.
31. Bazile V, Moguédec GLe, Marshall DJ, Gaume L. Fluid physico-chemical properties influence capture and diet in Nepenthes pitcher plants. Ann Bot., 2015; 115(4): 705-716. DOI: 10.1093/aob/mcu266.
32. Buch F, Kaman WE, Bikker FJ, Yilamujiang A, Mithöfer A. Nepenthesin protease activity indicates digestive fluid dynamics in carnivorous Nepenthes plants. PLoS One, 2015; 10(3): 1-15. DOI: 10.1371/journal.pone.0118853.
33. Pavlovič A, Saganová M. A novel insight into the cost-benefit model for the evolution of botanical carnivory. Ann Bot., 2015; 5(7): 1075-1092. DOI: 10.1093/aob/mcv050.
34. Tarigan MRM, Corebima AD, Zubaidah S, Rohman F. Arthropods discovered in lower and upper pitchers of Nepenthes at Rampa-Sitahuis hill, North Sumatra, Indonesia. Biodiversitas, 2021; 22(12): 5358-5366. DOI: 10.13057/biodiv/d221217.

35. Farré G, Filella I, Llusià J, Peñuelas J. Relationships among floral VOC emissions, floral rewards and visits of pollinators in five plant species of a Mediterranean shrubland. Plant Ecol Evol., 2015; 148(1): 90-99. DOI: 10.5091/plecevo.2015.963.
36. Kocáb O, Bačovčinová M, Bokor B, Šebela M, Lenobel R, Schöner CR, Schöner MG, Pavlovič A. Enzyme activities in two sister-species of carnivorous pitcher plants (Nepenthes) with contrasting nutrient sequestration strategies. Plant Physiol. Biochem., 2021; 161: 113-121. DOI: 10.1016/j.plaphy.2021.01.049.
37. Gaume L, Bazile V, Huguin M, Bonhomme V. Different pitcher shapes and trapping syndromes explain resource partitioning in Nepenthes species. Ecol Evol., 2016; 6(5): 1378-1392. DOI: 10.1002/ece3.1920.
38. Baby S, Johnson, AJ, Zachariah EJ, Hussain AA. Nepenthespitchers are CO2-enriched cavities, emit CO2 to attract preys. Sci Rep., 2017; 7(1): 1-10. DOI: 10.1038/s41598-017-11414-7.
39. Vong V, Ali A, Onsanit S, Thitithanakul S, Noon-Anant N, Pengsakul T. Larval mosquito (Diptera: Culicidae) abundance in relation with environmental conditions of pitcher plants Nepenthes mirabilis var. mirabilis in Songkhla province, Thailand. Songklanakarin J Sci Technol., 2021; 43(2): 431-438.
40. Handayani T, Hadiah JT. Pitcher morphology and pitcher coloring of Nepenthes mirabilis druce. From east Kalimantan, Indonesia. Biodiversitas, 2019; 20(10): 2824-2832. DOI: 10.13057/biodiv/d201007.
41. Joseph J & Joseph KM Insectivorous plants of Khasi and Jaintia Hills, Meghalaya, India: a preliminary survey, (Botanical Survey of India, Calcutta, India), 1986.
42. Subramanyam K & Narayana LL, A contribution to the floral anatomy of Nepenthes khasiana Hook F, Proc Ind Acad Sc., 1971; 73: 124-131.
43. Venugopal N & Devi NR, Development of the anther in Nepenthes khasiana Hook.f. (Nepenthaceae), an endemic and endangered insectivorous plant of North East India, Feddes Repert, 2003; 114: 69-73.
44. Basumatry SK, Tripathy S, Bera SK & Kumar S, Pollen morphology of Nepenthes khasiana Hook. f. (Nepenthaceae), an endemic insectivorous plant from India, Palynol., 2014; 38: 324-333.
45. Handayani T. Flower morphology, floral development and insect visitors to flowers of Nepenthes mirabilis. Biodiversitas, 2017; 18(4): 1624-1631. DOI: 10.13057/biodiv/d180442

46. Nainggolan L, Gultom T, Silitonga M. Inventory of pitcher plant (Nepenthes sp.) and its existence in North Sumatra Indonesia. J Phys Conf Ser., 2020; 1485(1). DOI: 10.1088/1742-6596/1485/1/012013.
47. Rizki M, Wardhana VWW, Mawardin M, Sunariyati S. Diversity of semar pockets (Nepenthes sp.) at Palangka Raya University. Bioeduscience, 2021; 5(2): 159-165. DOI: 10.22236/j.bes/526495.
48. Bordoloi RPM, The pitcher plant Nepenthes khasiana, (Sreeguru press, Guwahati, Assam), 1977; 2-10.
49. Uriah M, Patil B & Kumar S, In vitro antioxidant and hepatoprotective potential Nepenthes khasiana hook. f against ethanol-induced liver injury in rats, J Pharm Res., 2015; 149(4): 81-89.
50. Setiawan H, Hakim L, Batoro J. Ethnobotany of Nepenthes spp. In dayak Seberuang people, west Kalimantan, Indonesia. J Biodivers Environ Sci., 2015; 7(6): 275-84.
51. Sanusi SB, Bakar MFA, Mohamed M, Sabran SF & Mainasara MM, Ethnobotanical, phytochemical, and pharmacological properties of nepenthes.
52. Rao TA, Shanware PG & Tribedi GN, A note on the pitcher plant habitat in Assam, Ind For, 1969; 95: 611-613.
53. Jaiswal V, Culture and ethnobotany of Jaintia tribal community of Meghalaya, Northeast India - A mini review, Indian J Tradit Knowle, 2010; 9(1): 38-44.
54. Dolui AK, Sharm HK, Marein TB & Lalhriatpuii T, Folk herbal remedies from Meghalaya, Indian J Tradit Knowle., 2004; 39(4): 358-364.
55. Kharkongar P & Joseph J, Folklore medico botany of rural Khasi and Jantia tribes in Meghalaya, In: Glimpses of Indian ethnobotany, edited by Jain SK, (Oxford IBH Publishing Co, New Delhi), 1981; 124-136.
56. Schwallier R, de Boer HJ, Visser N, van Vugt RR, Gravendeel B. Traps as treats: A traditional sticky rice snack persisting in rapidly changing Asian kitchens. J Ethnobiol Ethnomed., 2015; 11: 24.
57. Mahomoodally MF. Traditional medicines in Africa: an appraisal of ten potent African medicinal plants. Evid Based Complementary Altern Med., 2013; 617459. https://doi.org/10.1155/2013/617459.
58. Patel DK. Plant as a source of medicine. Med Aromatic Plants, 2015; 3: 1. https://doi.org/10.4172/2167-0412.S3-e001.

59. Atanasov AG, Waltenberger B, Pferschy-Wenzig EM, et al. Discovery and resupply of pharmacologically active plant-derived natural products: a review. Biotechnol Adv., 2015; 33(8): 1582–1614. https://doi.org/10.1016/j.biotechadv.2015.08.001.
60. Farid MM, Hussein SR, Ibrahim LF, et al. Cytotoxic activity and phytochemicalanalysis of Arum palaestinum Boiss. Asian Pac J Trop Biomed., 2015; 5(11): 944–947. https://doi.org/10.1016/j.apjtb.2015.07.019
61. Uma G, Balasubramaniam V. GC-MS analysis of Nothapodytes nimmoniana, Mabberlyleaves. J Chem Pharm., 2012; 4(9): 4417–4419.
62. Hethelyi E, Tetenyi P, Dabi E, et al. The role of mass spectrometry in medicinal plantresearch. Biomed Environ Mass Spectrom., 1987; 14(11): 627–632. https://doi.org/10.1002/bms.1200141110.
63. Razack S, Kumar KH, Nallamuthu I, et al. Antioxidant, biomolecule oxidationprotective activities of Nardostachys jatamansi DC and its phytochemical analysis by RP-HPLC and GC-MS. Antioxidants, 2015; 4(1): 185–203. https://doi.org/10.3390/antiox4010185.
64. Gasparri R, Capuano R, Guaglio A, et al. Volatolomic urinary profile analysis for diagnosis of the early stage of lung cancer. J Breath Res., 2022; 16(4): 046008. https://doi.org/10.1088/1752-7163/ac88ec.
65. Choi D, Kang W, Park T. Anti-allergic and anti-inflammatory effects of undecane on mast cells and keratinocytes. Molecules, 2020; 25(7): 1554. https://doi.org/10.3390/molecules25071554.
66. Ibrahim B, Wiranata A, Malik A. The effect of addition of antioxidant 1, 2-dihydro- 2, 2, 4-trimethyl-quinoline on characteristics of Crepe Rubber modified asphalt in short term aging and long term aging conditions. Appl Sci., 2020; 10: 7236. https://doi.org/10.3390/app10207236.
67. Choi SJ, Kim JK, Kim HK, et al. 2, 4-Di-tert-butylphenol from sweet potato protects against oxidative stress in PC12 cells and in mice. J Med Food, 2013; 16: 977–983.
68. Varsha KK, Devendra L, Shilpa G, et al. 2, 4-Di-tert-butyl phenol as the antifungal, antioxidant bioactive purified from a newly isolated Lactococcus sp. Int J Food Microbiol., 2015; 211: 44–50. https://doi.org/10.1016/j.ijfoodmicro.2015.06.025.
69. Kadoma Y, Murakami Y, Ogiwara T, et al. Radical-scavenging activity and cytotoxicity of p-Methoxyphenol and p-Cresol Dimers. Molecules., 2010; 15: 1103–1112. https://doi.org/10.3390/molecules15031103.

70. Nieva-Echevarria B, Manzanos MJ, Goicoechea E, et al. 2, 6-Di-Tert-Butyl-Hydroxytoluene and its metabolites in foods. Compr Rev Food Sci Food Saf., 2015; 14: 67–80. https://doi.org/10.1111/1541-4337.12121.
71. Tortosa V, Pietropaolo V, Brandi V, et al. Computational methods for the identification of molecular targets of toxic food additives. Butylated Hydroxytoluene as a case study. Molecules, 2020; 25(9): 2229. https://doi.org/10.3390/molecules25092229.
72. U. S. Department of Agriculture, Agricultural Research Service. (1992–2016). Dr. Duke's Phytochemical and Ethnobotanical Databases.
73. Piao MJ, Ahn MJ, Kang KA, et al. Phloroglucinol inhibits ultraviolet B radiation-induced oxidative stress in the mouse skin. Int J Radiat Biol., 2014; 90(10): 928–935. https://doi.org/10.3109/09553002.2014.911990.
74. Wu F, Chen Y, Zheng C. Efficacy of phloroglucinol for acceleration of labour: a systematic review and meta-analysis. Arch Gynecol Obstet., 2021; 304(2): 421–428. https://doi.org/10.1007/s00404-021-06043-5.
75. El Oumari FE, Mammate N, Imtara H, et al. Chemical composition, antioxidant potentials, and calcium oxalate Anticrystallization activity of polyphenol and saponinfractions from Argania spinosa L. Press Cake. Plants (Basel), 2022; 11(14): 1852. https://doi.org/10.3390/plants11141852.
76. Selvamangai G, Bhaskar A. GC-MS analysis of phytocomponents in the methanolic extract of Eupatorium triplinerve. Asian Pac J Trop Biomed., 2012: 1329–1332. https://doi.org/10.1016/S2221-1691(12)60410-9.
77. Vijayabaskar G, Elango V. Determination of phytocompounds in Withania somnifera and Smilax china using GC-MS technique. J Pharmacogn Phytochem., 2018; 7(6): 554–557.
78. Abubakar MN, Majinda RRT. GC-MS analysis and preliminary antimicrobial activityof Albizia adianthifolia (Schumach) and Pterocarpus angolensis (DC). Medicines (Basel), 2016; 3(1): 3. https://doi.org/10.3390/medicines3010003.
79. Tiewlasubon U, Mrityunjaya BP, Sivaiah K. In vitro antioxidant and hepatoprotective potential of Nepenthes Khasiana Hook. F against ethanol-induced. J Pharm Res., 2015; 14(4): 81-9.
80. Shil D, Mohanty JP, Das T, Bhuyan NR, Uriah T, Mohamed-Saleem TS. Protective role of pitcher of Nepenthes khasiana Hook against dexamethazone induced hyperlipidemia and insulin resistance in rat. Int J Res Pharm Sci., 2010; 1(2): 195-8.

81. Eilenberg H, Pnini-Cohen S, Rahamim Y, Sionov E, Segal E, Carmeli S, et al. Induced production of antifungal naphthoquinones in the pitchers of the carnivorous plant Nepenthes khasiana. J Exp Bot., 2010; 61(3): 911-22.
82. Shil D, Mohanty JP, Saleem TS, Debnath J, Uriah T. Anti-diabetic activity of leaf extract of Nepenthes khasiana hook on dexamethasone induced diabetic rats. J Pharm Chem Biol Sci., 2014; 1(1): 6-11.