Abrahamia
An International Journal of Plant Science
Vol. 8 (1)
5-14
2022
ISSN: 2395-4108

Review of the genus *Asystasia* Blume (Acanthaceae)

Deepa Lekshmi V.S. & Anil Kumar V.S.*
Plant systematics laboratory, Department of Botany, University College,
Thiruvananthapuram, Kerala, India - 695 034, India
*Corresponding author: vsanilbotany@gmail.com

Abstract

The genus *Asystasia* (Acanthaceae), commonly called Chinese violet is widely distributed in India and Africa. The word 'asystasia' means inconsistency in shape of corolla. The genus comprises of about 70 species, generally perennial herbs and subshrubs, having multi-potential applications such as medicinal,nutritional as well as ornamental. The present review focuses on phytochemical, pharmacological, taxonomical, ecological, cytological and molecular studies on the genus.

Keywords: Acanthaceae, *Asystasia*, Asystoside, Southern Western Ghats

INTRODUCTION

The family Acanthaceae consists of approximately 229 genera and 3450 species (Mabberley, 2008). The genus *Asystasia*, commonly called Chinese violet, was established by Blume in 1826. The genus generally comprises perennial herbs and subshrubs. It has about 70 species, distributed in the tropics of the Old World (Mabberely,1997; Mabberely, 2017), chiefly in India and Africa (Long, 1970). Karthikeyan *et al.,*(2009) included nine species and two varieties from India, of which six were reported from Kerala (Sasidharan, 2013).

The family Acanthaceae consists of many medicinal plants with biologically active phytoconstituents. Multi-potential applications have been reported for the taxon - the leaves are eaten as a vegetable because it contains high amounts of proteins, amino acids, minerals and fibres (Yeoh and Wong, 1993; Mepba *et al.,* 2007), used in traditional medicine (Akah *et al.,*2003) and also as an ornamental plant (Gopal *et al.,* 2013). While, few species are highly invasive and become noxious weeds because of their competitiveness for soil nutrients and physical interference with harvesting plantation crops (Roger *et al.,* 1999; Westaway *et al.,* 2016; Jordan, 2015). But *Asystasia* is highly palatable to ruminants and can be controlled by grazing (Chen and Chee, 1993).

TAXONOMIC STUDIES

'Asystasia 'means inconsistency and it relates to the fact that the corolla is more or less regular (Edwards and Getliffe Norris, 1993).

Asystasia gangetica (L) T. Anderson is a perennial herbaceous plant with dark green, oval-shaped

leaves with pentamerous flowers (Hooker 1885; Dassanayake 1998; Backer 1965; Edwards and Getliffe Norris,1993). It is synonymously known as *Justicia gangetica*, Linn. and *A. coromandeliana*, Nees. (Alston,1932). It exhibits flower colours like purple, yellow, white etc. Plants with pale purple, white, yellow and pink flowers are recorded in the literature (Hooker, 1885; Bailey and Bailey, 1946; Bailey, 1942). The study based on vegetative, floral and micromorphology of seed and pollen of different colour variants of *A. gangetica* and *A. gangetica* var. *krishnae* from various geographical regions of Kerala shows that the species show variability in colour of flower as well as leaf shape. The microspore sculpturing was uniform for all accessions except for *A. gangetica* var. *krishnae,* which shows slight variation (Deepa Lekshmi and Anil Kumar, 2022).

According to Westaway *et al.,* 2016, *A. gangetica* has two subspecies, subsp. *gangetica* and subsp. *micrantha*. The two subspecies are closely related but differ in floral morphology and ecology. *Asystasia gangetica* var. *krishnae* is a new variety from the southern Western Ghats of Kerala (Druvan*et al.,*2019). In this study, *Asystasia gangetica* var. *krishnae* is compared and characterised with *A. gangetica* var. *gangetica*, concerning shape of lamina, colour of bract and bracteole, size of corolla limb and colour of lower median lip as well as anther.

Asystasia gangetica subsp. micrantha (Nees) Ensermu was naturalized in southern Taiwan (Hsu *et al.,*2005). Moreover, it is the only species of *Asystasia* reported during the floristic study of Acanthaceae from the South Eastern United States (Dieter,1998). Also, it is noted as one of the seventeen sleeper weeds (Cunningham *et al.,* 2003). *A. retrocarpa* T.J.Edwards was a record from Southern African Lowveld. It shows similarity with *A. subbiflora* in features of pollen and apparent differences in habit and structure of pedicel (Edwards, 1991). *A. indica* (Chowdhery and Bhattacharjee, 2006) was reported from Indian Botanical Garden, Howrah during a plant survey. It is an erect hairy herb with white flowers having prominent purple-violet spots on the lower lip.

It is intermediate between *Asystasia gangetica* (L) T. Anderson and *Asystasia gangetica* subsp. micrantha (Nees) Ensermu. *Asystasia pinguifolia* is recorded from the eastern coast of Tanzania to northern Natal; earlier, it was confused with A. varia. But studies (Edwards and Getliffe Norris, 1987) revealed that *A. pinguifolia* is closely allied to the African form of *A. gangetica* and it refers to the unusual fleshy leaves. *Asystasia variabilis* (Nees) Trimen was considered as variety quadrangularis belonging to *Asystasia chelonoides* Nees (Karthikeyan *et al.,* 2009; Sasidharan, 2013; GBIF, 2016); is a semi scandent herb with pinkish violet corolla. The most recent studies consider *Asystasi avariabilis* (Nees) Trimenas accepted species. The south Indian variety quadrangularis and Sri Lankan *A. variabilis* were currently assigned to a single taxon, *Asystasia variabilis* (Nees) Trimen (Jose *et al.,* 2017). Clarke (1885) treated *A. mysorensis* as synonym of *A. lawiana*. But *A. lawiana* is not included in the studies of Karthikeyan *et al.,* (2009) on Indian *Asystasia*. However, *A. mysorensis* differs from *A. lawiana* in secund inflorescence; bracts obovate- acute, long and wider than sepals; corolla tube 1.5cm long and white with grey spotted throat. So *A. mysorensis* and *A. lawiana* are considered as two distinct species and *A. mysorensis*is reported as a new addition to Flora of Telangana state (Reddy and Paramesh, 2021).

Detailed morphological and anatomical studies have not been carried out in this genus. Very few studies regarding the structure and distribution of the foliar epidermal hairs and trichomes of certain species of *Asystasia* exist. *Asystasia dalzelliana* and *Asystasia chelonoides* have unicellular non-glandular hairs on the leaf surface (Ahmad, 1978.). *A. dalzelliana* var. *alba*, a variety new to the genus *Asystasia*, reported recently from the southern Western Ghats of Kerala, is different from *A. dalzeliliana* with respect to its whitish corolla and absence of black blue bands on anthers (Deepa Lekshmi and Anil Kumar, 2022). *A. gangetica* subsp. *micrantha* has a leaf with stellate-like layers on the abaxial surface and verrucate wax on adaxial surface. Radiating cuticular striations can be found on the epidermal cells adjacent to the guard cells. It possesses simple trichomes with echinate ornamentation (Nurul-Ainia*et al.,* 2014). The pollen grains of *A. gangetica* and *A. scandens* are prolate in shape, tricolpate aperture with six pseudocolpi anastomosing in pairs at the endings (Maeiotti, 1999; Anisa *et al.,* 2013). Detailed systematic studies of the genus from Kerala are now being carried out (DeepaLekshmi and Anil Kumar, in preparation).

PHYTOCHEMICAL STUDIES

Medicinal plants provide valuable therapeutic recipes in traditional healing systems for curing diseases. The medicinal values of plants lie in some non-nutritive chemical substances that have protective or disease preventive properties on the human body. Despite the significant advances achieved in traditional medicine, plants

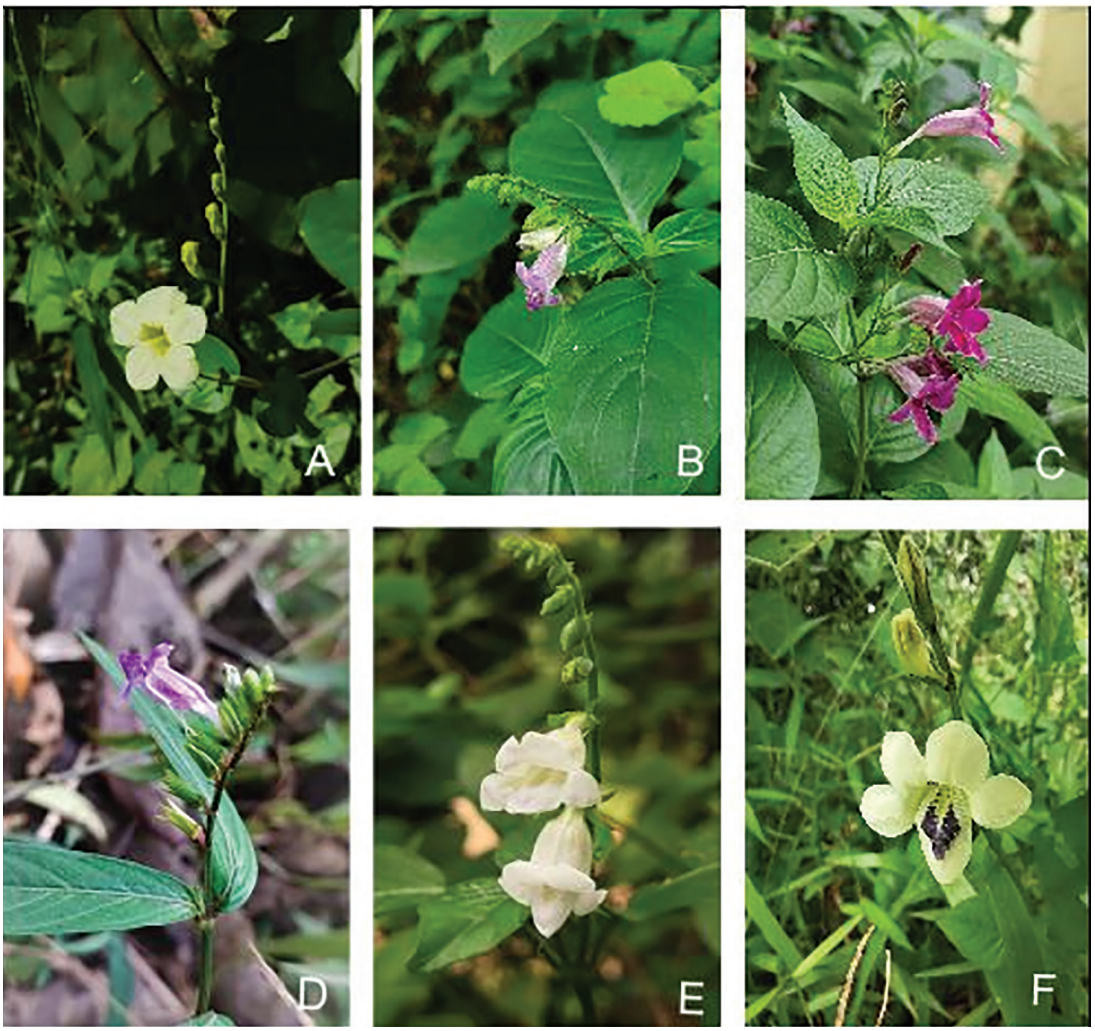

Figure 1. Inflorescence of *Asystasia* species found in Kerala: A-*A. gangetica* (Linn) T. Anderson; B- *A. dalzelliana*Santapau; C-*A. intrusa*(Forssk.) Blume; D-*A. variabilis* (Nees) Trimen; E-*A.dalzelliana*Santapauvar. *alba* V.S.A. Kumar &Deepalekshmi; E- *A. gangetica* var. *krishnae*Tandyekk.,Pandur. & N.Mohanan.

are still used as a source of potent drugs. The genus *Asystasia* has species with high nutritional value with various biologically active substances (Kirtikar and Basu, 1998; Kanchanapoom and Ruchirawat, 2007; Hamid *et al.,* 2011; Tilloo *et al.,* 2012). Members of this genus are reported to contain several types of compounds particularly, iridoid glycosides from *A.bella* (Harv.) Benth and Hook.f., *A. intrusa* Blumeand *A. gangetica* subsps. *micrantha* (Helle *et al.,*1989; Kanchanapoometal., 2004 ; Isna *et al.*,2020), megastigmane glycosides, aliphatic alcohol and phenolics from *A. intrusa* Blume and *A. gangetica* (Kanchanapoom *et al.*, 2004 and Hamid *et al.,* 2011) and flavonoides from *A. calyciana* Benth, *A. mysorensis* (Roth) T.*Anderson* and *A. travancorica* Bedd(Hamid and Aiyelaagbe,2012; Komalavalli *et al.,* 2014; Maina *etal.*, 2019).

A. gangetica is an ornamental plant used in traditional and folk medicine to treat several ailments and it is also used as food in times of food scarcity (Gopal *et al.,*2013). The rural peoples of Tamil Nadu, the southern part of India, use the whole plant juice and the paste of roots to treat rheumatism and skin allergies, respectively (Daffodil *et al.,* 2013). Phytochemical studies of *A.*

gangetica reveals the presence of carbohydrates, proteins, tannins, alkaloids, steroidal aglycans, saponins, flavonoids, triterpenoids and minerals like calcium, phosphorus, sodium, manganese, copper, zinc, magnesium, iron (Odhava *et al.,* 2007; Hamid *et al.,*2011;Mary, 2011) and the presence of Luteolin, Quercetin, Kaempferol, Isorhamnetin and 2 unknown compounds (Gopal *et al.,* 2013). The compound 5,11-epoxymegastigmane glucoside (asysgangoside) was isolated from the aerial parts of the plant (Kanchanapoom and Ruchirawat, 2007). In contrast, verbascoside, forsythiaside, and 4''-O-caffeoyl-6-O-rhamnopyranosyl catalpol are separated from the methanol extract of leaves (Isna *et al.,*2020).

Isosalipurposide (I), accompanied by luteolin 7-glucoside, has been identified as the yellow pigment in petals of *Asystasia gangetica* (Harborn, 1966). Janakiraman (2012) studied the phytochemical constituents of *A. gangetica* in petroleum ether, benzene, chloroform, ethanolic and aqueous extract and concluded that anthraquinones were absent in all the five different extracts and the phytochemical analysis done by Hamid *et al.* (2011) with hexane, ethyl acetate and methanolic extracts of the whole plant of *A. gangetica* revealed the presence of steroids, glycosides, flavonoids, anthraquinones, saponins, reducing sugars and absence of alkaloids and tannins. The volatile composition of the aerial, seed and root parts of *A. gangetica* was studied by Moronkola (2011) by hydrodistillation and evaluated using GC and GC-MS. The analysis showed the presence of fifty-four, twenty-one and fifteen compounds in aerial, seed and root, respectively. The *in vitro* callogenesis of *A. gangetica* using the leaf as explant in MS medium with different concentrations and combination of growth regulators show poor regeneration capacity (Tamilselvan and Rajeswari, 2014).

The preliminary phytochemical studies done by Hamid and Aiyelaagbe (2012) revealed the presence of saponins, tannins, steroids, glycosides, flavonoids, and anthraquinones in *A.calyciana* Benth.from North Central, Nigeria. *Asystasia intrusa* Blume. is an underutilized source of nitrogen for ruminant diets and it is reported to have crude protein concentrations of 21±26% (Ibrahim *et al.,* 1990; Sivaraj *et al.,* 1991; Tuen, 1994; Roger *et al.,*1999) while the aerial parts of the plant have the presence of asystoside, an aliphatic alcohol glycoside and iridoiddiglucoside (3'-O- β -D-glucopyranosyl-catalpol)(Kanchanapoom *et al.,*2004).

A. mysorensis (Roth) T. Anderson is a wild indigenous vegetable, makes considerable contributions to food among farmers in sub-Saharan Africa. The species is a dietary resource, it contains sufficient amount of proteins, carbohydrates, fats, minerals and other micronutrients. The presence of phenolic acids and flavonoids in this wild edible plant in varying amounts has enriched its nutraceutical properties and as a healthy diet (Maina *et al.,* 2019). The vitamin C content of *A. mysorensis* makes it compatible with starchy staples because they contain ascorbic acid, enhancing iron absorption (Maseko *et al.,* 2017). The efficiency of beta carotene obtained from *A. mysorensis* was studied for the fortification of sunflower oil and palm oil (Nderitu *et al.,* 2018).

The GC-MS analysis of the whole plant of *A. travancorica* Bedd.revealed the presence of ten bioactive compounds. Among the identified phytochemicals, stigmasterol and phytol are two primary compounds. Phytol was observed in the whole plant (Komalavalli *et al.,* 2014). Four iridoid glycosides are reported from *Asystasia gangetica* subsp. *micrantha* and *Asystasia salicifolia* (Prateep *et al.,* 2012*;* Isna *et al.,*2020*).*

PHARMACOLOGICAL STUDIES

The secondary metabolites obtained from the plants have a vital role in the ancient and modern medicinal system. These compounds act as a versatile source of drugs. Moreover, these compounds show antimicrobial, antifungal, cytotoxic, antiseptic, anti-asthmatic, antipyretic, antiarthritic, antidiabetic and analgesic activities.

Asystasia gangetica (L) T. Anderson is a weed taxon as well as a traditional folk medicinal plant with a rich source of natural bioactive compounds and possesses several therapeutic properties like antipyretic, anti-inflammatory, antipruritic, anthelmintic, antiarthritic, antidiabetic, analgesic, galactagogue, antimicrobial (Akah *et al.,* 2003; Suseela, 2005; Tilloo *et al.,* 2012; Mary, 2011; Janakiraman *et al.,* 2014) and used by Africans as well as Indians for traditional treatment of rheumatism, skin allergies, etc. (Senthilkumar, 2006; Devi Prasad *et al.,* 2013). It is used against mild hypoglycaemia and epidermoid carcinoma of the nasopharynx; in addition, *A. gangetica* has broad-spectrum antimicrobial activity, particularly against *Escherichia coli*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* (Sudhakar *et al.,* 2006).

The methanol extract of leaves of *Asystasia gangetica* has in-vitro antioxidant, α-glucosidase,

and α-amylase enzymes inhibitory activity (Reddy *et al.,*2010) while methanolic extract of the whole plant of *A. gangetica* exhibits inhibition of platelet aggregation and decrease in blood viscosity, due to the presence of flavonoid mixture, which was separated by column chromatography (Gopal *et al.,*2013). In *A. gangetica*, benzene extracts exhibited the broadest spectrum of activity with the maximum level of inhibition (12 mm) against *Bacillus subtilis* followed by 11mm in ethanolic quotes against *Salmonella typhi*. Aqueous extract of stem and leaf of the plant had analgesic and anti-inflammatory activities (Adeyemi *et al.,* 2011). Methanol extract of the plant showed the highest activity against *Salmonella paratyphi*, whereas petroleum ether extract has maximum action against *Salmonella paratyphi* and *Proteus vulgaris* (Daffodil *et al.,*2013). The green synthesized silver nanoparticles of leaf extract show a potential bactericidal activity against both Gram-positive and Gram-negative bacteria (Jose *et al.,* 2018). The ethanolic extracts of leaves of *A. gangetica* having a good hypoglycaemic and hypolipidemic effect and found to be as effective as glibenclamide in reducing the plasma lipid profiles in diabetic rats (Pradeep Kumar etal.,2010). The co-infusion of aqueous leaf extract of *A. gangetica* has inhibitory activity with either angiotensin I or angiotensin II significantly (Pierre Mugabo and Raji, 2013).

Asystasia dalzelliana, commonly known as violet *Asystasia* is a perennial branched herb used in Indian folk medicine (Satish Kumar *et al.,* 2011). Since the whole plant is medicinal, it is used as a natural fodder resource for domesticated animals (Subrahmanya and Raveendran, 2011). Its antioxidant activities, reducing powers, DPPH scavenging activities, amount of total flavonoid compounds and antimicrobial activities of methanol and hot water extracts were studied (Subrahmanya and Raveendran 2011; Satish Kumar *et al.,*2011). The methanolic and aqueous extracts of the leaves of *A. dalzelliana* have antimicrobial activity against Gram-positive and Gram-negative bacteria like *S. aureus* ATCC 25922, *B. subtilis* ATCC 6633, E. coli ATCC 25923, and *P. aeruginosa* ATCC 27853 and exhibited high anticandidal activity against a C. albicans ATCC 60192 (Satish Kumar *et al.,*2011). The antiarthritic activity of ethanolic extract of *Asystasia dalzelliana* leaves may be due to the presence of phytoconstituents such as alkaloids and flavonoids (Vishal Babushetty and Chandrashekhar, 2012).The species is exploited for therapeutic uses and its conservation demand has recently been evaluated (Deepa Lekshmi and Anil Kumar, in Press).

Asystasia vogeliana (Benth) is an herbaceous medicinal plant used locally to treat malaria, gastric disorders, and gonorrhoea. The infusion of *A. vogeliana* in combination with the leaves of *Cassia alata*, *Cymbopogon citratus* and fruit juice of *Citrus aurantifolia* recorded a higher fidelity level in the treatment of malaria, chronic fever, gonorrhoea and leprosy and suggested as a better alternative to *Moringa oleifera* and *Andrographis paniculata* (Popoola *et al.,*2017). In contrast, its extract is used for fish poisoning(Uno *et al.,*2018).

Bioactive molecules having antioxidant activity have an immense role in human health. Due to their ability as cardioprotective agents, they are used in the treatment of cancer. But the production of antioxidants in plants is less and it is affected by environmental fluctuations (Aysel and Sevan, 2014). So, *in vitro* methods like callus and suspension cultures are considered an alternative way to produce natural antioxidants. The in vitro antioxidant assays, including DPPH, FRAP, Phosphomolybdenum assay and reducing power assay reveal that the callus is an effective antioxidant (Umesh and Dilkalal, 2014; Abhirami *et al.,*2021).

Asystasia variabilis is known as "GadaPuruk," used to treat abscesses, wounds and ulcers in Sri Lankan traditional and folk medicines. The leaf extract had significant antibacterial activity against *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa* and *Escherichia coli* in a concentration dependent manner (Wijerathna, 2018).

Asystasia calycina Benth. is an erect or straggling herb, recorded from Guinea to South Nigeria and also found in East Cameroun. The plant parts are used in traditional medicine across West Africa to treat ailments like skin diseases, headache, impotency or erectile dysfunction, children's yaw, large craw-craw sores and the twig is said to be aphrodisiac. Leaves are eaten as vegetable in Gabon and also it possesses antibacterial and antifungal properties that made it an alternate traditional medicine for the treatment of bacterial diseases like gonorrhoea, syphilis, typhoid and in the treatment of fungal infections such as skin and mouth sores and craw-craw (Burkil, 1985;Hamid andAiyelaagbe, 2012).

Paste of leaves and flowers of *A. travancorica* Bedd. mixed with honey is used to treat rheumatism (Sutha *et al.,*2010). The whole plant extract of *A. travancorica* has biological activities such as anticancer and anti-inflammatory (Komalavalli *et al.,* 2014). It may be due to the higher content

of phenols and flavonoids *A.travancorica* whole plant extract showed concentration-dependent free radical scavenging activity and antioxidant effect; in addition, it has antifertility activity. Thus, it can be used in nutritional or pharmaceutical fields to prevent free radical related diseases (Mohan *et al.,* 2016; Paulpriya *et al.,* 2019).

MOLECULAR STUDIES

Molecular level information related to genus *Asystasia* is very limited. Danthanawanit *et al.,* (2015) studied the pattern of genetic diversity among a collection of *Asystasia gangetica* from Thailand using RAPD markers and UPGMA. Thirty plant samples of six colour variants were used for the analysis.The thirty samples were three clusters at a 55% similarity level.The study showed a high level of genetic diversity. However, genetic diversity studies have not been carried out so far focusing on the intraspecific or interspecific relationships in *Asystasia* and currently being carried out by the authors.

Table 1.RAPD analysis of 30 samples of *A. gangetica* (Linn) T. Anderson (Danthanawanit *et al.,* 2015)

Primer codes	5′ sequence 3′	No.of amplified bands
OPA-01	3′ CAGGCCCTTC 5′	10
OPA-12	3′ TCGGCGATAG 5′	9
OPA-16	3′ AGCCAGCGAA 5′	10
OPA-18	3′ AGGTGACCGT 5′	15
OPA-20	3′ GTTGCGATCC 5′	14
OPC-02	3′ GTGAGGCGTC 5′	12
OPC-05	3′ GATGACCGCC 5′	11
OPH-05	3′ AGTCGTCCCC 5′	10

CYTOLOGY

A. gangetica has been reported with varying chromosome numbers in their haploid and diploid condition (Thomas, 2000). The diploid number of chromosomes for *A gangetica* from nine regions was 2n= 26 (Narayanan, 1951; Grant, 1955; Ellis, 1962; Kaur, 1965; Valsala Devi and Mathew, 1982; Saggoo and Bir, 1983, 1986), (2n=26) for *A. gangetica* in Singapore (Pandit *et al.,* 2006) and the haploid number of chromosome have been reported as n=13 (Narayanan, 1951; Mangenot and Mangenot, 1957, 1962; Gadella, 1977; Ugborogho and Adetula, 1988 and Pandit *et al.,* 2006),n=14 (Subramanian and Govindarajan, 1980; Govindarajan and Subramanian, 1983), n=22 (Narayanan, 1951), 24 (Narayanan, 1951) and n=25 (De 1966; Sarkar *et al.,* 1978). The genus also exhibited polyploidy and presumed dysploidy as reported for *A. travancorica* Bedd. (Narayanan, 1951) and *A. mysorensis,*(Roth)T.Anders.(Kaur, 1965).

ECOLOGY

A. gangetica can be used as cover crops in oil palm plantations due to its ability to increase soil water availability in the dry season (Ariyanti, 2017). In addition, it contains several nutrients such as N, P, K, Ca, Mg, Fe and Zn in the plant tissues and maintain nutrient balance in oil palm plantations (Odharva, 2007; Asbur, 2017). The decomposition rate of *A. gangetica* litter is faster in immature oil palm plantations with higher sunlight intensity than mature oil palm plantations with lower sunlight intensity, and the rate of litter decomposition increases with an increase in decomposition period (Yenni and Yayuk, 2018). *Asystasia gangetica* subsp. *micrantha* (Nees) Ensermu is a perennial herb that can grow as a mat and potentially affect agriculture or reduce biodiversity by competing with other plant species, especially for nutrients (Ismail and Shukor, 1998; Westaway *et al.,* 2016).

CONCLUSION

The present study provides an overview of the genus *Asystasia*. The study emphasizes the importance and potentials of the genus as a source of new compounds having biological activities. Data related to genetic diversity, intraspecific and interspecific variations and molecular aspects are very limited. So, further studies are highly warranted and are being carried out with species from Kerala as part of the research program by the authors.

REFERENCES

Abhirami, Dilkalal., Annapurna, A.S., Umesh, T.G.(2021) *In vitro* regeneration, antioxidant potential, and genetic fidelity analysis of *Asystasia gangetica (L.*) T. Anderson. *In Vitro Cellular and Developmental Biology-Plant,* 57(3).

Adeyemi, O., Aigbe, F.R.,Uyaiabasi, N.G. (2011) Analgesic and anti-inflammatory activities of the aqueous stem and leaf extract of *Asystasia gangetica*(Linn) T.Anderson.*Nig Q J Hosp Med* 21(2):129-134.

Ahmad Khwaja, J**. (**1978) Epidermal hairs of Acanthaceae. *Blumea*24 :101-117.

Akah, P.A., Ezike, A.C., Nwafor, S.V., Okoli, C.O., Enwerem, N.M. (2003) Evaluation of theantiasthmatic property of *Asystasia gangetica* leaf extracts. *J. Ethnopharmacol* 89(1):25-36.

Alston, A. H. G. (1932) *In Trimen, H. Handbook to the flora of Ceylon*, Vol. 6, 350.

Anderson, T. (1867–1869) List of Acanthaceae, cultivated in the Royal Botanical Gardens, Calcutta. *J AgrHortSoc*3: 265-289

Anisa Al-Hakimi., HajaMaideen., Latiff A. (2013) Palynological study of the genera *Ruellia*, *Ecbolium, Asystasia, Blepharis* and *Dicliptera* (Acanthaceae) of Yemen. AIP *Conference Proceedings* 1571, 389 (2013).

Ariyanti, Y., Mubarok, M., Asbur, S. (2017) Study of *Asystasia gangetica* (L.) T. Anderson as cover crop against soil water content in Mature Oil Palm Plantation. *J. Agron*16(4):154–159.

Asbur., Yenni. (2018) The roles of *Asystasia gangetica* (L.) T. Anderson and ridge terrace in reducing soil erosion and nutrient losses in oil palm plantation in South Lampung, Indonesia. *J. Penelit. KelapaSawit* 23(2): 53–60.

AVB, Reddy and L, Paramesh. (2021) *A.mysorensis* (Acanthaceae) : an addition to the flora of Telangana State India. *JETB* 44 (1-4).

Aysel, S., Sevan, D. (2014) Evaluation of seasonal antioxidant activity and total phenolic compounds in stems and leaves of some almond (*Prunus amygdalus* L.) varieties. *J Biol Res*.47-26.

Backer, C. A., Van Den Brink, R. C. B. (1965) *Flora of java*. (Vol. 2).

Bailey, H. (1942) *Standard cyclopedia of horticulture*.The MacMillan Co.,NewYork.1:1200.

Bailey, H., Bailey, E.Z. (1946) *Hortus.Second*.The MacMillan Co.,NewYork.778pp.

Blume, C.L. (1826) *Bijdragen tot de flora van Nederlandsch Indie. Bijdragen*. Part14:796. Batavia

Burkill, H.M**.** (1985) *The useful plants of West Tropical Africa*.2nd Ed. Vol.1. Families, AD. Royal Botanic Gardens, Kew, Richmond, United Kingdom. Pp. 960

Chen, C.P., Chee, Y.K. (1993) Ecology of forages under rubber and oil palm. In: Sivaraj, S., Agamuthu, P., Mukherjee, T.K. (Eds.), Advances in Sustainable Small Ruminant Tree Cropping Integrated Systems. *IDRC* 9-18.

Chowdhery, H.J., Av.Bhattacharjee. (2006) A new species of the genus *Asystasia* (Acanthaceae) Blume from West Bengal,India. *Indian J. For* 29(2):211-215.

Clarke, C.B. (1885) Acanthaceae. In: J.D. Hooker (ed.), The Flora of British India 4: 387–558. L. Reeve, London.

Cunningham, DC.,Woldendorp, G., Burges, M.B., Barry, S.C. (2003) Prioritising sleeper weeds for eradication: Selection of species based on potential impacts on agriculture and feasibility of eradication. Bureau of Rural Sciences Report, Canberra.

Daffodil, E.D., PackiaLincy, M., PonEsakki, D., Mohan, V.R. (2013) Pharmacochemical characterization and antibacterial activity of *Asystasia gangetica* (l.) T. And. *Jour. Harmo. Res. Pharm* 2(2): 112-120.

Danthanawanit, C., SupattraPoeaim., AnurugPoeaim. (2015) Evidence of molecular marker for genetic relationship of *Asystasia gangetica*(Linn) T. Anderson. *J. AgricTechnol*11(2): 287-296.

Dassanayake M.D., Fosberg F.R. (1998) *Flora of Ceylon* (Vol. 12). Published for the Smithsonian Institution, and the National Science Foundation, New Delhi.

De Anima. (1966) Cytological, anatomical and palynological studies as an aid in tracing affinity and phylogeny in the family Acanthaceae. *Cytological Studies*. Transactions of the Bose Research Institute, Calcutta. 29: 139-175.

Deepa Lekshmi V S., Anil Kumar. (2022) Assessment of variability in *Asystasia gangetica*(L.) T Anderson from the Western Ghats of Kerala, India. *Plant Science Today.*

Devi Prasad, A.G., Shyma, T.B., Raghavendra, M.P. (2013) Plants used by the tribes for the treatment of digestive system disorders in Wayanad district, Kerala. *J App Pharm Sci* 3(8):171-5.

DhruvanTandyekkal., Pandurangan, A.G., N. Mohanan. (2019) *Asystasia gangetica* var. *krishnae* (Acanthaceae): A new variety from Kerala, India. *Rheedea* 29(2): 174–177.

Dieter c. WasshausenJun. (1998). Acanthaceae of the Southeastern United States. *Castanea* 63(2): 99-116.

Edwards, T.J. (1991) A new species of *Asystasia* from southern Africa, with notes on its alliances.*SAfr J Bot* 57(6): 305 - 309.

Edwards, T.J.,Getliffe Norris, F.M. (1987) Taxonomic studies in the Acanthaceae-A new species of *Asystasia. S.AfrJ.Bot*. 53(3): 231-233.

Edwards, T.J., Getliffe Norris, F.M. (1993) *Asystasia gangetica.The Flowering Plants of Africa* 52: 2076.

Ellis J. L. (1962) Chromosome numbers in some members of Acanthaceae. *Sci Cult* 28: 191-192.

Ensermu, K. (1989) A New Species of *Asystasia* (Acanthaceae) from Ethiopia. *Nationale Plantentuin van Belgie* 59(3): 413-418.

Gadella, T. W. J. (1977) In IOPB chromosome number reports LVI. *Taxon* 26: 259-26.

Global Biodiversity Information Facility .2016. GBIF secretariat, Denmark, Digital resource at www.gbif.org.

Gopal, T.K., Megha, G., Chamundeeswari, D., Umamaheswara Reddy C. (2013) Phytochemical and pharmacological studies on whole plant of *Asystasia gangetica*. *IJRPB* 1(3): 365.

Govindarajan, T.D., Subramanian, D**.** (1983) Karyomorphological studies in South Indian Acanthaceae. *Cytologia* 48: 491-504.

Grant, W. F. 1955. A cytogenetic study in the Acanthaceae. *Brittonia* 8: 121-150.

Hamid, A.A., Aiyelaagbe, O. O., Ahmed, R.N., Usman, L.A., Adebayo, S. A**.** (2011) Preliminary phytochemistry, antibacterial and antifungal properties of extracts of *A. gangetica* Linn T. Anderson grow in Nigeria. *AdvApplSci Res*2: 219-226.

Hamid, A.A., Aiyelaagbe, O.O. (2012) Pharmacological investigation of *Asystasia calyciana* for its antibacterial and antifungal properties. *IJCBS*. 1: 99-104.

Harborn, J.B. (1966) Comparative biochemistry of flavonoids-i. distribution of chalcone and aurone pigments in plants. *Phytochemistry* 5: 111 - 115.

Helle, Demuth., SbrenRosendal., Bent Juhl Nielsen. (1989) Iridoid glycosides from *Asystasia bella*. *Phytochemistry* 28: 3361-3364.

Hooker, J. D. (1885) *Flora of British India*. (Vol. IV).

Hsu T.W., Chiang, T.Y. (2005) *Asystasia gangetica* (L.) T. Anderson subsp. *micrantha* (Nees) Ensermu (Acanthaceae), a newly naturalized plant in Taiwan. *Taiwania,* 50: 117–122.

Ibrahim, T., Sanchez, M.D., Darussamin, A., Pond, K.R. (1990) Evaluation of selected and introduced forage species in North Sumatra. SR-CRSP Annual Research Report1989-1990. Sungai Putih, Indonesia. pp. 82-87.

Ismail, B. S., ShukorJuraimi, A. (1998) Effects of water stress, shading and development of *Asystasia gangetica*. *Plant Protection Quarterly,* 13(3)

IsnaAthirah Othman., NorizanAhmat., AmjadAyadQatran Al-Khdhairawi. (2020) Iridoid glycosides and phenylpropanoids from *Asystasia gangetica* (l.) T. Andersonvar. *micrantha* (Acanthaceae). *Malaysian J. Anal Sci* 24(4): 530 – 537.

Janakiraman, N., JasminJansi, J., Johnson, M., Jeeva, S., Renisheya Joy Jeba Malar. (2012) Phytochemical analysis on *Asystasia gangetica* (l.) T. Anderson.*Res. Pharm* 1(1): 19-32.

Janakiraman, N., JasmineJasi Jonson. M., ZahirHussain,M. I., Jeeva, S. (2014) Antibacterial Efficacy of *Abrusprecatorius* L. and *Asystasia gangetica* (L.) T. Anderson. *Anti-infective agents*, 12 (2): 165-170.

Jordan, Skinner. (2015) The invasive weed Chinese violet ('*Asystasia gangetica*' subspecies *'micrantha'*) now threatens northern Australia. Plant Protection Quarterly 30 (4): 126-132.

Jose, A., Abirami, T., Kavitha, V., Sellakilli, R., Karthikeyan, J. (2018) Green synthesis of silver nanoparticles using *Asystasia gangetica* leaf extract and its antibacterial activity against gram-positive and gram-negative bacteria. *J.PharmacognPhytochem* 7(1): 2453-2457.

Jose, Mathew., Regy, Yohannan., Salim, P.M., George, K.V. (2017) Novelties in the family Acanthaceae from South Western Ghats. *Ind. Annal. Plant Sci*6(1): 1499-1503.

Kanchanapoom, T., Ruchirawat, S. (2007) Megastigmaneglucoside from *Asystasia gangetica* (L.) T. Anderson*J. Nat. Med*61: 430–433.

Kanchanapoom, T., Ruchirawat, S., Kasai, R., Otsuka, H. (2004) Aliphatic alcohol and iridoid glycosides from *Asystasia intrusa*. *Chem. Pharm Bull*52(8): 980-982.

Karthikeyan, S., Sanjappa, M., Moorthy, S. (2009) Flowering Plants of India. Volume 1. Dicotyledons (Acanthaceae-Avicenniaceae). *BSI* Kolkata. pp. 4–5.

Kaur, J**. (**1965) Chromosome numbers in Acanthaceae-II. *Sci and Cult,* 31: 531-532.

Kirtikar, K.R., Basu, B. D. (1998) *Medicinal plants in India*. Pullaiah Regency publication. Vol.1.

Komalavalli, T., Nithya, P.V., Muthukumarasamy, S., Mohan, V. R. (2014) Determination of Bioactive Components of *Asystasia travancorica* Bedd (Acanthaceae) by GC-MS Analysis.*IJPCR* 6(2): 155-158.

Komalavalli, T., Nithya, P.V., Muthukumarasamy, S., Mohan, V. R. (2014) Antinflammatory activity of whole plant of *Asystasia travancorica* Bedd.*Int. J.Biomed. Adv. res*. 5: 155-156.

Komalavalli, T., PackiaLincy, M., Muthukumarasamy, S., Mohan, V. R. (2014) Anticancer activity of ethanol extract of *Asystasia travancorica* Bedd. (Acanthaeae) whole plant against Dalton Ascites Lymphoma.*JAdv. PharmaceuEdu Res,* 4: 240-246.

Lekshmi, V S D., Arya S., Kumar, V S A. (2022) *Asystasia dalzelliana* var. *alba* (Acanthaceae), a new variety from southern Western Ghats of Kerala, India. *Plant Science Today* 9(sp1): 43-45

Long, R. W. (1970) The genera of Acanthaceae in the southeastern united states. *J. Arnold Arbor*, 51: 257-309.

Mabberley, D. J. (1997) *The plant book*: a portable dictionary of the vascular plants. Cambridge University Press. Cambridge.

Mabberley, D.J. (2008) *Mabberley's Plant Book*: A portable dictionary of plants, their classification and uses. Cambridge University Press.3:1-1021.

Mabberley, D.J**.** (2017) *Mabberley'sPlant*-Book: A portable dictionary of plants, their classifications and uses. (4th edition). Cambridge University Press, Cambridge.

Maeiotti Lippi, M., Ross Punt, W. (1999) Pollen morphology of some Acanthaceae from West Africa. *Biosystems* 133 (1): 73-82.

Maina, E.G.,Edwin, S. Madivoli., Josephine, A., Ouma Joel, K. Ogilo., Jackson M. Kenya. (2019) Evaluation of nutritional value of *Asystasia mysorensis* and *Sesamum angustifolia* and their potential contribution to human health. *Food Sci Nutr* 7(6): 2176–2185.

Mangenot, S., Mangenot, G. (1957) Nombreschromosomiques nouveaux chez divers Dicotyledones et Monocotyledonesd'Afriqueoccidentale. *Bulletin du JardinBotanique de l'Etat* 27: 639-654.

Mary Kensa,V**. (**2011) Studies on phytochemical profile and antimicrobial activity of *Asystasia gangetica* (L.) T. Anderson. *PSF*1 (7): 112-117.

Maseko, I., Mabhaudhi, T., Tesfay, S., Araya, H. T., Fezzehazion, M., Plooy,C. P. (2017) African leafy vegetables: A review of status, production and utilization in South Africa. *Sustainability* 10(1): 1–16.

Mepba, H. D., Eboh, L., Banigo, D.E.B. (2007) Effects of processing treatments on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables. *African J. Food, Agric. NutrDev*7(1):1-18.

Mohan, V.R., Paulpriya, K., Tresina, P.S. (2016) Evaluation of antioxidant activity of *Asystasia travancorica* Bedd (Acanthaceae). *Asian J. BiolLife Sci.*

Moronkola D. Olufunke. (2011) Essential Oils from Aerial,Seed and Root of Nigerian *Asystasia gangetica* (L.). *JEssent Oil Bearing Plants* 14 (5): 582-589.

Narayanan, C.R**.** (1951) Somatic chromosomes in the Acanthaceae. *J. of the Madras University*, 21: 220-231.

Nderitu, S. M., Nawiri, M. P., Nyambaka, H. N. (2018) Fortification of sunflower and palm oils using beta carotene extracted from *Asystasia mysorensis* and *Solanum nigrum*. *Food Research* 2(5): 437 – 442.

Nurul-Ainia, C.A.C., Norainia, T., Latiffa, A., Amirul-Aimana, A.J., Ruzia, A.R., Idrisa, S. (2014) Taxonomic Significance of Leaf Micromorphology in Some

Selected Taxa of Acanthaceae (Peninsular Malaysia). *AIP Conference Proceedings,* 1614: 727.

Odharva, B. H., Beekrum, S., Kuala, U. (2007) Preliminary assessment of nutritional leafy vegetables in Kwa Zulu-Natal. *J. Food Compos. Anal*., 20: 430–435.

Odhava, B., Beekrumb, S., Akulaa, U., Baijnathc, H. (2007) Preliminary assessment of nutritional leafy vegetables in Kwasulu – Natal, South Africa. *Journal of Food Compost Anal* 20: 430-435.

Pandit, M.K., Tan, H.T.W., Bisht, M.S. (2006) Polyploidy in invasive plant species of Singapore. *Bot. J. Linn* 151(3): 395-403.

Paulpriya, K., Tresina, T.S., Swarnalekshmi, V., Mohanan, V.R. (2019) Antifertility activity of ethanol extract of *A. travancorica* Bedd (Acanthaceae) and *Sonerilatinnevelliensis* Fischer (Melastomacea). *Ethnomedical plants with therapeutic properties*. 325-343.

Pierre, Mugabo., Ismaila A, Raji. (2013) Aqueous leaf extract of *Asystasia gangetica* on the blood pressure and heart rate in male hypertensive wistar rat. *Complement Altern* 13:283.

Popoola, J.O., Adebayo, H. A., Taiwo O. S., Ayepola O.O., OkosodoEhi, F. (2017) Studies on Local Knowledge and In vitro Cytotoxicity of *Moringa oleifera* L., *Andrographis paniculata* N. and *Asystasia vogeliana* B. Extracts. *Res. J. ApplSci*12 (2):180-190.

Pradeep Kumar, R., Sujatha, D., Mohamed Saleem T.S., MadhusudhanaChetty, C., Ranganayakulu, D. (2010) Potential hypoglycemicandhypolipidemic effect of *MorusIndica* and *Asystasia gangetica* in alloxan induced diabetes mellitus. *Int. J. Res. Pharm. Sci*. 1(1):51-56.

Prateep,Worawittayanon.,Juriratana, Ruadreo., Wannaporn, Disadee., Poolsak, Sahakitpichan.,Somkidsitthimonchai., Tripetch, Kanchanapoom. (2012) Iridoid and flavone glycosides from *Asystasia gangetica* subsp. micrantha and *Asystasia salicifolia* and their antioxidant activities.Biochem. Syst. Ecol: 38-42.

Reddy, S., Sneha, N. V. L., Anarthe, J., Raghavendra, N. M. (2010) In Vitro Antioxidant and Antidiabetic activity of *Asystasia gangetica* (Chinese Violet) Linn. (Acanthaceae). *Int J Res. Pharm BiomedSci*1 (2).

Roger C. Merkela., Kevin R. Pondb., Joseph C. Burnsc., Dwight S. Fisher. (1999) Intake, digestibility and nitrogen utilization of three tropical tree legumes I. As sole feeds compared to *Asystasia intrusa* and *Brachiaria brizantha*. *Animal Feed Sci Tech* 82: 91-106.

Saggoo, M. I. S., Bir, S. S. (1983) Cytopalynological studies on Indian members of Acanthaceae and Labiatae. *J. of Palynology,*19: 243-277.

Sarkar, A. K., Chakraverty, M., Saha, N. C., Das, S. K., Hazra, D. (1978) In IOPB chromosome number reports LXII. *Taxon,* 27: 521.

Sasidharan, N. (2013) Flowering plants of Kerala: CD-ROM. Version 2.0. Kerala Forest Research Institute, Peechi, Kerala, India.

Satish Kumar., Vivek Kumar., Shashidhara S., Chandrashekhar, M.S. (2011) Antioxidant and Antimicrobial activities of *Asystasia dalzelliana*: A novel plant. *J. Pharm Res* 4(1): 186-188.

Senthilkumar, M., Gurumurthi, P., Janardhanan, K**. (**2006) Some medicinal plants used by Irular, the tribal people of Marudhamalai hills, Coimbatore, Tamil Nadu. *Nat Prod Radiance* 382-388.

Sivaraj, S., Agamuthu, P., Adam, A., Hamzah, I., Mukherjee, T.K. (1991) Comparative performance of sheep and goats in oil palm (Elaeisquineensis) plantations: preliminary report. In: Saithanoo, S., Norton, B.W. (Eds)Goat Production in the Asian Humid Tropics. Prince of Songkla University and the University of Queensland, 176-181.

Subrahmanya Prasad K., Raveendran, K. (2011) Fodder resources of Kasaragod district, Kerala, India. *Int J of Plant Sci*1(6): 95-102.

Subramanian, D., Govindarajan, T. (1980) Cytotaxonomy of some species of Acanthaceae. *J Cytol Genet* 15: 90-92.

Sudhakar,M., Ch.V.Rao., Rao,P. M., Raju, D. B., Venkateswarlu,Y. (2006) Antimicrobial activity of *Caesalpinia pulcherrima*, *Euphorbia hirta* and *Asystasia gangeticum. Fitoterapia,* 5(77): 378-380.

Suseela, L. (2005) Pharmacognostic studies on *Asystasia gangetica* (Acanthaceae). *J Pltytol. Rtes,* 18(2): l9l -198.

Sutha, S., Mohan, V.R., Kumaresan, S., Murugan, C., Athiperumalsami, T. (2010) Ethnomedicinal plants used by the tribals of Kalakad-Mundanthurai Tiger Reserve (KMTR) Western Ghats, TamilNadu for the treatment of rheumatism.*Indian J. TraditKnowl*9: 502-509.

Tamilselvan, V., Rajeswari, M. (2014) Impact of growth regulators on callus production of *Asystasia gangetica* (L) T. Anderson. *Adv. Appl. Sci. Res.,* 5(2): 328-333.

Thomas, F. Daniel. (2000) Additional chromosome numbers of American Acanthaceae.*Systematic Botany* 25(1):15-25.

Tilloo, S.K., Pandae, V.B., Rasala, T.M., Kale, V.V**.** (2012) *Asystasia gangetica*: review on multipotential application *J. Pharm Res* 3(4):18.

Tuen, A.A. (1994) Chemical composition and rumen degradability of forages and browse for goats and sheep in Sarawak. In: Djajanegara, A., Sukmawati, A. (Eds.), Sustainable Animal Production and the Environment. In: Proc. 7th AAAP Animal Science Congress,2: 503-504.

Ugborogho, R. E., Adetula, O. A. (1988) The biology of the *Asystasia gangetica* complex (Acanthaceae) in Lagos State, Nigeria. *Feddes Repertorium* 99: 507-517.

Umesh, T.G., Dilkalal,A. (2014) Evaluation of antioxidant potential and reducing power of callus induced from leaves of *Asystasia gangetica* (L.) T. Anderson. *Int J Pharm Sci,* 6: 532-8.

Uno,U. U., Ekpo, P. B., Onwudiwe, C. F.,Agu, R. C**.** (2018) Comparative Acute Toxicity of Ichthyotoxic Plants (*Tephrosiavogelii, Adenia cissampeloides and Asystasia vogeliana*) on Farmed African Catfish (Clariasgariepinus).Asian J Biol 1-7.

Valsaladevi G., Mathew, P. M. (1982) In IOPB chromosome number reports LXXVII. *Taxon,* 31: 773.

Vishal Babushetty., Chandrashekhar, M. (2012) Evaluation of Anti-Arthritic Activity of *Asystasia dalzelliana* Leaves. *Int.J.Pharm.Biol.Arch* ,3.

Westaway John O., Lesley Alford., Greg Chandler., Michael Schmid. (2016) *Asystasia gangetica* subsp.

micrantha, a new record of an exotic plant in the Northern Territory.*NorthernTerrit Nat* 27: 29–35.

Wijerathna, R., Asanthi, N.A.V., Ratnasooriya, W.D., Pathirana, R.N., Nelumdeniya, N.R.M. (2018) Evaluation of in vitro antibacterial activity and phytochemical profile of aqueous leaf extract of *Asystasia variabilis*. *J Pharm Phyt*7(3): 639-642.

YenniAsbur and YayukPurwaningrum. (2018) Decomposition and release rate of *Asystasia gangetica*(L.) T. Anderson litter nutrient using litterbag method. *IntJlEngTechnol* 7: 116-119.

Yeoh, H.H., Wong, P.F.M. (1993) Food value of lesser utilized tropical plants. *Food Chem* 46: 239 – 241.

Received: 22 January 2022
Revised & Accepted: 15 February 2023