Asystasia gangetica, beyond its Widespread Distribution Recorded in Two Indonesian Herbaria Since 1863: A Nuisance or A Blessing?

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Abstract

In the world of botanical diversity, some plants manage to find their niche through adaptability and widespread distribution. *Asystasia gangetica*, one of those versatile species, has established itself in various ecosystems worldwide. Based on specimen collections of the Herbarium Bogoriense and the Herbarium Anda, we investigated the global distribution of this plant by highlighting its characteristics, ecological adaptability, significance, implications, and potential benefits. This study showed that *A. gangetica* had flourished in Malaysia in 1863, 30 years before it had in Indonesia, refuting the popular belief that it had been introduced to the country in 1876. Furthermore, given the two *A. gangetica* subspecies differ in phenotype and genotype, we propose that they should be considered distinct species. So, the subsp. *gangetica*, native to the Indian subcontinent and Southeast Asia and is synonymous with *Asystasia coromandeliana*, should be named *Asystasia gangetica*, while the subsp. *micrantha*, native to Africa and the Arabian Peninsula and is synonymous with *Asystasia intrusa*, should be named *Asystasia micrantha*. This study confirmed that *A. micrantha* is more invasive than *A. gangetica*. Both plants, however, exhibit advantageous qualities beneficial to humans. As a cover crop, it is useful for conservation efforts. As a food source, it is nutritious for humans and animals. As a bioactive compound source, it can be developed into novel drugs. Its beneficial properties imply that this plant is intended to benefit humans and animals, even though its invasiveness needs to be monitored and regulated. Thus, we believe its advantages outweigh its drawbacks.

1. Introduction

Asystasia gangetica (L.) T. Anderson is a flowering perennial herbaceous plant known for its delicate flowers and distinctively shaped leaves. This species belongs to the Acanthaceae family and consists of two subspecies, *Asystasia gangetica* subsp. *gangetica* and *Asystasia gangetica* subsp. *micrantha*. It is often referred to by various vernacular names, including Tropical Violet, Tropical Primrose, Coromandel (English), Herbe Piment, Mange-tout (French), Caracola (Spanish), Kaligharani (Gujarati), Talakushe, Burutula (Giriama), Fuchwe, Mtikini (Swahili), Ara Songsang (Malaysian), Kalaluda (Maranao), Terigis (Melayu), and Bungo Lado-Lado (Minang) (Adetula 2004; Lin et al. 2009; Stuart 2015).

This plant is recognized for its distinctive features characterized by trumpet-shaped flowers in purple, yellowish, or white shades. The subspecies *micrantha* has smaller white flowers marked with dark purple dots and lines on the lower lip. This plant typically grows as a creeping perennial herb with square stems that can reach a meter in height and has lush ovate to lanceolate heart-shaped opposite leaves, making it relatively easy to identify.

Asystasia gangetica is native to Asia, particularly the Indian subcontinent and Southeast Asia. However, with its ability to adapt to diverse environments outside its native range, this plant has spread far beyond its original place. Habitats where it thrives include tropical rainforests, forest edges, savannas, and grasslands, with moderate to high rainfall (Asiedu et al. 1978; Maundu et al. 1999; Setyawati et al. 2015). Asystasia seeds are believed to spread through wind, water, birds, or ballistics, which expel the seeds in a powerful and explosive process.

Over time, its great adaptability has led it to disperse across continents. This plant has been introduced to various parts of the world, where it has established itself as an invasive species. Its worldwide distribution, confirming its adaptability, is supported by rapid growth, prolific seed production, and tolerance to various soil types. This plant has thrived in various ecosystems, from temperate regions to arid landscapes, demonstrating its resilience and versatility.

The Herbarium Bogoriense is the most complete and oldest herbarium in Southeast Asia. During the Dutch colonial era, all herbarium materials for research purposes supported by the Dutch East Indies government had to be sent to the Leiden Museum before the construction of the Herbarium Bogoriense in 1844. Since then, this herbarium has been functioning as a research facility for the biodiversity of Indonesian tropical flora. It is listed as the third largest herbarium in the world after Leiden in the Netherlands and Kew in England.

The current herbarium building was constructed with grants from the Japanese community, where construction of research facilities and equipment began in April 2005 and was completed in June 2006. The Herbarium Bogoriense stores around 2 million dry, wet, microbial, fungal, and fossil specimens, which serve as references for botanical researchers. The dry herbaria reached 1.28 million specimens, while the wet herbaria are around 50,000 specimens (MAIS 2017).

The Herbarium Anda is managed by the Biology Department, Faculty of Mathematics and Natural Sciences at Andalas University. Prof. Dr. Meijer initiated this herbarium in 1954–1958, and Mr. Rusdi Tamin founded it as the first curator in 1980. It is the oldest herbarium in Sumatra and the second largest in Indonesia. It has around 60,000 specimen sheets and has been listed on the Index Herbarium of The New York Botanical Garden since October 2010. This herbarium stores documentation data on the flora of Sumatra, especially West Sumatra,

Jambi, and Riau Provinces, in the form of dry and wet specimens. Most specimens have been digitized into the Global Biodiversity Information Facility (GBIF) dataset (Unand 2017).

This study of the distribution of Asystasia has several objectives, including understanding the management of invasive species, ecological research, the impact of climate change and modernization on its distribution, and its use as a medicine in ethnobotany. Because this plant has become invasive in non-native areas, studying its distribution makes it possible to track its spread, assess potential ecological and economic impacts, and develop strategies for its control and management. Changes in the distribution of Asystasia species indicate ecological shifts in climate patterns or environmental conditions. Expansion, shrinkage, or shifts in plant ranges may indicate changes in temperature and rainfall patterns or simply the impact of modernization. Thus, by studying plant distribution, we can better understand how climate or environmental changes affect ecosystems, allowing us to contribute to adaptation and mitigation strategies. Moreover, Asystasia has traditionally been used for medicinal purposes and agricultural benefits in various cultures and ethnic groups. Studying its distribution can help identify regions where it has significant cultural value and is naturally abundant, thereby facilitating research into the potential applications of this plant in agriculture or health.

2. Materials and Methods

The data used in this study comes from the Asystasia collections stored in the Herbarium Anda of the Andalas University, Padang, West Sumatra, and the Herbarium Bogoriense in Bogor, West Java. There are 67 Asystasia specimens recorded in the Herbarium Anda (Table 1) and 51 specimens collected in the Herbarium Bogoriense (Table 2).

Places or localities whose names have changed over time are written with their original and current names. Old data that does not include information about the time the specimen was obtained is determined by tracing the curator, such as the specimen BO1280561 taken from Singapore by Sulpiz Kurz (JSTOR 2023)(JSTOR 2023).

Data without complete geographic positions are determined by estimating their location within the area where the specimen was most likely obtained, such as on the side of a road that existed at that time. Data without geographic coordinates but containing precise information on where the specimen was collected; its location is derived using references. For example, the position of specimen BO1278953 is determined using Chawari (2002)Chawari (2002). Determination of the geographical location and altitude of these data was carried out using the websites www.google.com/maps/place/ and https://www.mapcoordinates.net/en.

The Asystasia distribution map was created using the following steps: in the initial process, the datasets in the form of Excel tables from both herbaria were analysed, then the data was cleaned, especially the header section. Then, the two datasets were combined to facilitate visualization, and the application used was Tableau Public version 2023, Tableau Software, LLC, a free platform to explore, create, and publicly share data visualizations online.

Table 1
Collection of *Asystasia gangetica* from the Herbarium Anda of Andalas University

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
1	*Asystasia gangetica*	5/20/2011	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15544	Herbaceous, yellow flowers
2	*Asystasia gangetica*	5/4/2008	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15545	Frutescens, white flowers, quadrilateral stems
3	*Asystasia gangetica*	5/24/2008	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15546	Shrub, opposite leaves, yellow flowers, quadrilateral stems
4	*Asystasia gangetica*	5/24/2008	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15547	Herbaceous, white flowers
5	*Asystasia gangetica*	4/26/2008	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15548	Shrubs, alternate leaves, white flowers
6	*Asystasia gangetica*	4/26/2008	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15549	Shrubs, white flowers, odourless, gummy
7	*Asystasia gangetica*	4/26/2008	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15550	Shrub, odourless, not gummy, white flowers, purple corolla
8	*Asystasia gangetica*	4/26/2008	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15551	Shrubs, white flowers, quadrilateral stems, single leaves opposite, terminalis flowers

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
9	*Asystasia gangetica*	12/12/2004	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15552	
10	*Asystasia gangetica*	5/11/2006	Nagari Sungai Asam, 2x11 Enam Lingkung District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.59	100.28	74	ANDA15553	
11	*Asystasia gangetica*	7/5/2007	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15554	
12	*Asystasia gangetica*	4/26/2008	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15555	
13	*Asystasia gangetica*	4/29/2017	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15556	
14	*Asystasia gangetica*	4/24/2005	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15557	
15	*Asystasia gangetica*	4/6/2013	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15558	
16	*Asystasia gangetica*	5/25/2002	Lubuk Hitam, Cindakir, Bungus Teluk Kabung District, Padang City, West Sumatra Province, Indonesia	-1.03	100.4	6	ANDA15559	
17	*Asystasia gangetica*	4/5/2013	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15560	

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
18	*Asystasia gangetica*	N.A.	Lubuk Hitam, Cindakir, Teluk Kabung Utara Village, Bungus Teluk Kabung District, Padang City, West Sumatra Province, Indonesia	-1.03	100.4	6	ANDA15561	
19	*Asystasia gangetica*	5/20/2011	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15562	
20	*Asystasia gangetica*	4/6/2013	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15563	
21	*Asystasia gangetica*	12/17/2004	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15564	
22	*Asystasia gangetica*	12/17/2004	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15565	
23	*Asystasia gangetica*	12/17/2004	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15566	
24	*Asystasia gangetica*	12/17/2004	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15567	
25	*Asystasia gangetica*	5/25/2002	Lubuk Hitam, Cindakir, Bungus Teluk Kabung District, Padang City, West Sumatra Province, Indonesia	-1.03	100.4	6	ANDA15568	
26	*Asystasia gangetica*	5/25/2002	Lubuk Hitam, Cindakir, Bungus Teluk Kabung District, Padang City, West Sumatra Province, Indonesia	-1.03	100.4	6	ANDA15569	

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
27	*Asystasia gangetica*	5/26/2002	Lubuk Hitam, Cindakir, Bungus Teluk Kabung District, Padang City, West Sumatra Province, Indonesia	-1.03	100.4	6	ANDA15570	
28	*Asystasia gangetica*	5/25/2002	Lubuk Hitam, Cindakir, Bungus Teluk Kabung District, Padang City, West Sumatra Province, Indonesia	-1.03	100.4	6	ANDA15571	
29	*Asystasia gangetica*	12/18/2004	Dr. Muhammad Hatta Botanical Garden, Ladang Padi, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.9599	100.4521	135	ANDA15572	
30	*Asystasia gangetica*	6/5/2005	Education and Biological Research Forest, Andalas University Campus, Limau Manis, Pauh District, Padang City, West Sumatra Province, Indonesia	-0.8895	100.5206	1,525	ANDA15573	
31	*Asystasia gangetica*	12/18/2004	Lubuk Hitam, Cindakir, Bungus Teluk Kabung District, Padang City, West Sumatra Province, Indonesia	-1.03	100.4	6	ANDA15574	
32	*Asystasia gangetica*	6/8/2006	Nagari Kayu Tanam, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.55	100.33	146	ANDA15575	
33	*Asystasia gangetica*	6/9/2006	Nagari Kayu Tanam, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.55	100.33	146	ANDA15576	
34	*Asystasia gangetica*	5/14/2006	Nagari Kayu Tanam, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.55	100.33	146	ANDA15577	
35	*Asystasia gangetica*	11/13/1999	Nagari Kapalo Hilalang, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.517092	100.323587	274	ANDA15578	
36	*Asystasia gangetica*	6/12/2006	Nagari Kayu Tanam, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.55	100.33	146	ANDA15579	

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
37	*Asystasia gangetica*	12/27/2013	Kandang Ampek, Nagari Guguak, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.506512	100.374028	631	ANDA15580	
38	*Asystasia gangetica*	6/12/2004	Puncak Anai, Nagari Guguak, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.506512	100.374028	631	ANDA15581	
39	*Asystasia gangetica*	5/14/2006	Nagari Kayu Tanam, 2×11 Kayu Tanam District, Padang Pariaman Regency, West Sumatra Province, Indonesia	-0.55	100.33	146	ANDA15582	
40	*Asystasia gangetica*	11/22/2008	Air Sirah, Jorong Lubuk Selasih, Nagari Batang Barus, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.971055	100.604811	1047	ANDA15583	Herb, oblongus leaves, purple-in-white flowers
41	*Asystasia gangetica*	11/22/2008	Air Sirah, Jorong Lubuk Selasih, Nagari Batang Barus, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.971055	100.604811	1047	ANDA15584	Purple-white flowers
42	*Asystasia coromandeliana*	4/26/2003	Air Sirah, Jorong Lubuk Selasih, Nagari Batang Barus, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.971055	100.604811	1047	ANDA15585	Herb, yellow flowers
43	*Asystasia coromandeliana*	4/26/2003	Air Sirah, Jorong Lubuk Selasih, Nagari Batang Barus, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.971055	100.604811	1047	ANDA15586	Acuminatus lanceolatus integer leaves
44	*Asystasia gangetica*	11/23/2008	Air Sirah, Jorong Lubuk Selasih, Nagari Batang Barus, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.971055	100.604811	1,047	ANDA15587	White flowers
45	*Asystasia coromandeliana*	5/4/2001	Jorong Koto Baru - Koto Baririk, Nagari Kambang, Lengayang District, Pesisir Selatan Regency, West Sumatra Province, Indonesia.	-1.677343	100.764257	36	ANDA15588	

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
46	*Asystasia gangetica*	7/13/2008	Tingkalak Batang Climb - Lubuk Panjang Fall, Jorong Koto Pulai, Nagari Kambang, Lengayang District, Pesisir Selatan Regency, West Sumatra Province, Indonesia.	-1.6205	100.8369	206	ANDA15589	Herb, bright white flowers
47	*Asystasia coromandeliana*	5/4/2001	Jorong Koto Baru - Koto Baririk, Nagari Kambang, Lengayang District, Pesisir Selatan Regency, West Sumatra Province, Indonesia.	-1.677343	100.764257	36	ANDA15590	
48	*Asystasia coromandeliana*	5/4/2001	Jorong Koto Baru - Koto Baririk, Nagari Kambang, Lengayang District, Pesisir Selatan Regency, West Sumatra Province, Indonesia.	-1.677343	100.764257	36	ANDA15591	
49	*Asystasia coromandeliana*	5/4/2001	Jorong Koto Baru - Koto Baririk, Nagari Kambang, Lengayang District, Pesisir Selatan Regency, West Sumatra Province, Indonesia.	-1.677343	100.764257	36	ANDA15592	
50	*Asystasia coromandeliana*	5/4/2001	Jorong Koto Baru - Koto Baririk, Nagari Kambang, Lengayang District, Pesisir Selatan Regency, West Sumatra Province, Indonesia.	-1.677343	100.764257	36	ANDA15593	
51	*Asystasia gangetica*	4/25/2009	Jorong Bancah, Nagari Maninjau, Tanjung Raya District, Agam Regency, West Sumatra Province, Indonesia.	-0.320533	100.224562	467	ANDA15598	Herb, yellow flowers
52	*Asystasia gangetica*	4/25/2009	Jorong Bancah, Nagari Maninjau, Tanjung Raya District, Agam Regency, West Sumatra Province, Indonesia.	-0.320533	100.224562	467	ANDA15599	Herb, purple flowers, solitary
53	*Asystasia gangetica*	4/25/2009	Jorong Bancah, Nagari Maninjau, Tanjung Raya District, Agam Regency, West Sumatra Province, Indonesia.	-0.320533	100.224562	467	ANDA15600	Herb, pink and white flowers
54	*Asystasia coromandeliana*	6/16/2006	Nagari Koto Rantang, Palupuh District, Agam Regency, West Sumatra Province, Indonesia.	-0.240797	100.338886	850	ANDA15601	Herb, white flowers
55	*Asystasia coromandeliana*	4/19/2003	Bukik Bulek, Nagari Candung Koto Laweh, Candung District, Agam Regency, West Sumatra Province, Indonesia.	-0.336454	100.472637	1,450	ANDA15602	Herb

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
56	*Asystasia gangetica*	4/25/2009	Jorong Bancah, Nagari Maninjau, Tanjung Raya District, Agam Regency, West Sumatra Province, Indonesia.	-0.320533	100.224562	467	ANDA15603	Liana, white flowers
57	*Asystasia coromandeliana*	4/25/2009	Jorong Bancah, Nagari Maninjau, Tanjung Raya District, Agam Regency, West Sumatra Province, Indonesia.	-0.320533	100.224562	467	ANDA15604	Shrub
58	*Asystasia coromandeliana*	12/29/2012	Nagari Koto Malintang, Tanjung Raya District, Agam Regency, West Sumatra Province, Indonesia.	-0.288401	100.150627	480	ANDA15605	Liana
59	*Asystasia gangetica*	11/30/2007	Sarasah Bunta, Jorong Lubuk Limpato, Nagari Tarantang, Harau District, Lima Puluh Kota Regency, West Sumatra Province, Indonesia	-0.108935	100.676088	545	ANDA15606	Herb, quadrangular stem, purplish white flowers
60	*Asystasia gangetica*	1/2/2010	Sarasah Bunta, Jorong Lubuk Limpato, Nagari Tarantang, Harau District, Lima Puluh Kota Regency, West Sumatra Province, Indonesia	-0.108935	100.676088	545	ANDA15607	Herbaceous, purplish white flowers
61	*Asystasia gangetica*	11/30/2007	Sarasah Bunta, Jorong Lubuk Limpato, Nagari Tarantang, Harau District, Lima Puluh Kota Regency, West Sumatra Province, Indonesia	-0.108935	100.676088	545	ANDA15608	Shrub, white flowers
62	*Asystasia gangetica*	9/23/2022	Main road of Padang-Solok, Nagari Talang, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.887296	100.643865	581	N.A.	Creeping herb, bright violet flowers, green fruit. Used for traditional medicine. Bungo Lado-Lado
63	*Asystasia gangetica*	9/23/2022	Main road of Padang-Solok, Nagari Talang, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.887296	100.643865	581	N.A.	Creeping herb, bright violet flowers, green fruit. Used for traditional medicine. Bungo Lado-Lado

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
64	*Asystasia gangetica*	9/23/2022	Main road of Padang-Solok, Nagari Talang, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.887296	100.643865	581	N.A.	Creeping herb, bright yellowish flowers, green fruit. Used for traditional medicine. Bungo Lado-Lado
65	*Asystasia gangetica*	9/23/2022	Main road of Padang-Solok, Nagari Talang, Gunung Talang District, Solok Regency, West Sumatra Province, Indonesia	-0.887296	100.643865	581	N.A.	Creeping herb, bright yellowish flowers, green fruit. Used for traditional medicine. Bungo Lado-Lado
66	*Asystasia gangetica*	9/24/2022	Open area near the beach of Olo, West Padang District, Padang City, West Sumatra Province, Indonesia	-0.947172	100.351983	2	N.A.	Creeping herb, bright white flowers, green fruit. Wild plant used for traditional medicine.
67	*Asystasia gangetica*	9/24/2022	Open area near the beach of Olo, West Padang District, Padang City, West Sumatra Province, Indonesia	-0.947172	100.351983	2	N.A.	Creeping herb, bright white flowers, green fruit. Wild plant used for traditional medicine.

Table 2
Collection of *Asystasia gangetica* from the Herbarium Bogoriense

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
1	Asystasia gangetica (L.) T. Anderson	3/30/1941	Malabang Mountain, Liborio Ela Ebalo, Lanao del Sur Province, Mindanao, Philippines	7.591941	124.116465	169	BO1278933	Recumbent shrub; flowers white, Name in Maranao: Kalaluda
2	*Asystasia intrusa*	7/4/1932	Behind Residence Office, Pasuruan, East Java Province, Indonesia	-7.641183	112.908179	10	BO1278953	
3	*Asystasia coromandeliana* Nees	1914	Jember Regency, East Java Province, Indonesia	-8.168041	113.700283	90	BO1278954	
4	*Asystasia gangetica* (L.) T. Anderson	5/15/1933	Pasuruan, East Java Province, Indonesia	-7.641007	112.906553	5	BO1278955	Crossing post road
5	*Asystasia gangetica* (L.) T. Anderson	9/24/1916	Pasar, Kampoeng Baroe Polonia (now: Medan City, North Sumatra Province, Indonesia	3.550965	98.672907	36	BO1278956	White flowers, 70 cm tall. Native name: Pokok daun Terigis
6	*Asystasia coromandeliana* Nees	1902	Weltevreden (now: Sawah Besar District, Central Jakarta), Batavia, Java, Indonesia	-6.170067	106.836438	11	BO1278957	
7	*Asystasia coromandeliana* Nees	1902	Weltevreden (now: Sawah Besar District, Central Jakarta), Batavia, Java, Indonesia	-6.170067	106.836438	11	BO1278958	
8	*Asystasia coromandeliana*	2/22/1893	Calcutta (near Central National Herbarium), Botanical Garden, Shalimar, Howrah, West Bengal, India	22.556298	88.286417	13	BO1278959	
9	*Asystasia coromandeliana* Nees	9/18/1924	Port Swettenham (now: Port Klang), Klang District, Selangor, Malaysia	3.003267	101.396186	8	BO1278960	
10	*Asystasia coromandeliana* Nees	7/27/1898	Museum VII Afdeeling, Buitenzorg (now: Bogor), West Java Province, Indonesia	-6.603783	106.797130	271	BO1279015	Flower: light blue violet. Roadside weeds
11	*Asystasia gangetica* (L.) T. Anderson	6/23/1919	Batoe Hitam, Riouw Arch. (now: Kepulauan Riau), Bintan Island, Indonesia	0.909729	104.441083	15	BO1279018	Flowers: white and light violet. Roadside
12	*Asystasia gangetica* (L.) T. Anderson	4/11/1920	Batu Tulis Resid. Batavia (now: Bogor City), West Java Province, Indonesia	-6.62579	106.80976	250	BO1279410	Crown light yellow, lobes light violet, plant slightly climbing. Wilderness roadside

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
13	*Asystasia gangetica* (L.) T. Anderson	4/11/1920	Batu Tulis Resid. Batavia (now: Bogor City), West Java Province, Indonesia	-6.62579	106.80976	250	BO1279411	Flowers: light violet, brown-light yellow. Roadsides and jungle along the road opposite the station
14	*Asystasia coromandeliana* Nees	3/2/1893	Bidara Cina, Batavia (now: Jatinegara District, East Jakarta), Indonesia	-6.233789	106.867361	25	BO1279412	
15	*Asystasia coromandeliana* Nees	3/21/1893	Ciliwung River-Botanical Garden, Buitenzorg (Bogor City), West Java Province, Indonesia	-6.597548	106.799877	261	BO1279413	
16	*Asystasia coromandeliana* Nees	3/2/1893	Bidara Cina, Batavia (now: Jatinegara District, East Jakarta), Indonesia	-6.233789	106.867361	25	BO1279414	
17	*Asystasia coromandeliana*	4/24/1910	Bangkong, Semarang City, Central Java Province, Indonesia	-6.9942	110.4319	11	BO1279428	
18	*Asystasia gangetica* (L.) T. Anderson	1900	Kebumen (Residentie Bagelen), Central Java Province, Indonesia	-7.805073	109.799488	25	BO1279551	
19	*Asystasia coromandeliana* Nees	3/5/1893	Besuki District, Situbondo Regency, East Java Province, Indonesia	-7.734982	113.690268	9	BO1279552	
20	*Asystasia gangetica* (L.) T. Anderson	1863	Singapore, Malay Archipelago (now: side of Keppel Road),	1.272646	103.836626	17	BO1280561	
21	*Asystasia coromandeliana*	3/20/1915	Pagantenan Village, Pagantenan District, Pamekasan Regency, Madura Island, East Java Province, Indonesia	-7.1568	113.4746	300	BO1280900	Roadside Kawedanan
22	*Asystasia gangetica* (L.) T. Anderson	Jul-Nov 1913	Amboina (now: Ambon), Maluku Province, Indonesia	-3.69336	128.18117	9	BO1280902	
23	*Asystasia gangetica* (L.) T. Anderson	1918	Pangkal Pinang, Bangka Island, Indonesia	-2.120612	106.112389	9	BO1280903	
24	*Asystasia gangetica* (L.) T. Anderson	1938	Karo Batak Plateau (now: Berastagi District), Karo Regency, North Sumatra Province, Indonesia	3.190522	98.508857	1393	BO1280904	

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
25	*Asystasia gangetica* (L.) T. Anderson	11/4/1961	Mont Le Niole (roadside bank), Mahé Island, Seychelles	-4.626848	55.425307	200	BO1280905	Mange tout, weakly scrambling woody herb rooting at nodes, flowers white with purple markings on the lower lip
26	*Asystasia coromandeliana* Nees	4/28/1941	Melentang Coconut Estate, Bagan Datoh, Perak District, Malaysia	3.884127	100.933317	9	BO1281948	Flowers white fading purplish
27	*Asystasia coromandeliana* Nees	12/1/1932	Hoeta Padang (near Continental Plantation Company concession), Bandar Pasir Mandoge District, Asahan Regency, North Sumatra Province, Indonesia	2.784878	99.257487	251	BO1281949	Open places
28	*Asystasia gangetica* (L.) T. Anderson	11/11/1917	Pangkal Pinang, Bangka Island, Indonesia	-2.222071	106.070788	80	BO1284797	White flowers and weeds along the road
29	*Asystasia gangetica* (L.) T. Anderson	1899	Bangkok, Siam (now: Charoen Krung Road, Talat Noi Subdistrict, Samphanthawong District, Bangkok, Thailand	13.733235	100.514408	12	BO1285694	
30	*Asystasia gangetica* (L.) T. Anderson	1899	Bangkok, Siam (now: Charoen Krung Road, Talat Noi Subdistrict, Samphanthawong District, Bangkok, Thailand	13.733235	100.514408	12	BO1285695	
31	*Asystasia gangetica* (L.) T. Anderson	11/1/1939	Nearshore of Pago Pago Harbour, Tutuila Island, Samoa	-14.274438	-170.696039	16	BO1285702	Flowers: White
32	*Asystasia gangetica* (L.) T. Anderson	4/2/1998	Dalehi Village, Kefamenanu City, Timor Tengah Utara Regency, Nusa Tenggara Timur Province, Indonesia	-9.477778	124.480833	373	BO1397676	Upright perennial herb with white to blue flowers, growing up to 1 m tall. Locally abundant.
33	*Asystasia coromandeliana* Nees	4/1/1903	Weltevreden (now: Sawah Besar District, Central Jakarta), Batavia, Java, Indonesia	-6.170067	106.836438	11	BO1466329	
34	*Asystasia coromandeliana* Nees	4/1/1903	Pegangsaan (now: Menteng District, Central Jakarta), Batavia, Java, Indonesia	-6.203041	106.847197	16	BO1466330	

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
35	*Asystasia coromandeliana* Nees	5/1/1903	Mangga Besar (now: Taman Sari District, West Jakarta), Batavia, Java, Indonesia	-6.1468	106.82215	7	BO1466331	
36	*Asystasia gangetica* (L.) T. Anderson	5/1/1914	Kraton District, Pasuruan Regency, East Java Province, Indonesia	-7.61802	112.85158	5	BO1466333	Grassy road edges
37	*Asystasia gangetica* (L.) T. Anderson	3/20/1968	Purwokerto, Central Java Province, Indonesia	-7.424038	109.224046	70	BO1466335	Blue flowers, darker in shade, 1 m high
38	*Asystasia coromandeliana* Nees	7/16/1922	Depok Resid. Batavia (now: Depok City), West Java Province, Indonesia	-6.406535	106.818829	90	BO1466336	Flowers: quite small and white
39	*Asystasia intrusa*	4/30/1979	Sopu Valley, Sigi Regency (forest above the river), Central Sulawesi Province, Indonesia	-1.199825	120.105715	1000	BO1478120	Woody herb. Flowers zygomorphic white with violet stripes
40	*Asystasia intrusa*	1/14/1975	Roadside near Fatumnasi District, Timor Tengah Selatan Regency, Timor Island, Nusa Tenggara Timur Province, Indonesia	-9.652644	124.221618	1500	BO1478121	Grassland
41	*Asystasia gangetica* (L.) T. Anderson	5/29/2004	Jl. Selayo-Padang, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.951667	100.495	331	BO1841783	Perennial herb 1 m, white petal
42	*Asystasia gangetica* (L.) T. Anderson	5/29/2004	Jl. Selayo-Padang, Indarung, Lubuk Kilangan District, Padang City, West Sumatra Province, Indonesia	-0.951667	100.495	331	BO1843300	Perennial herb 1 m, white petal
43	*Asystasia gangetica* (L.) T. Anderson	8/23/2008	Bukit Barisan Selatan National Park, Way Canguk, Bengkunat Belimbing District, West Lampung Regency, Lampung Province, Indonesia	-5.6555	104.419917	60	BO1896367	Herb 20 cm. White flowers
44	*Asystasia gangetica* (L.) T. Anderson	4/2/2016	Road side, Bukit Tabuan, Mt. Seraya Forest, Karangasem Regency, Bali Province, Indonesia	-8.403889	115.651889	480	BO1946393	Herb 50–60 cm tall. Calyx pale green, corolla tube white, corolla pale purple. Root pale green.
45	*Asystasia gangetica* (L.) T. Anderson	4/2/2016	Road side, Bukit Tabuan, Mt. Seraya Forest, Karangasem Regency, Bali Province, Indonesia	-8.403889	115.651889	480	BO1946394	Herb 50–60 cm tall. Calyx pale green, corolla tube white, corolla pale purple. Root pale green.

No	Species	Date	Location	Latitude	Longitude	Altitude (m)	Reference Number	Annotation
46	*Asystasia gangetica* (L.) T. Anderson	4/2/2016	Road side, Bukit Tabuan, Mt. Seraya Forest, Karangasem Regency, Bali Province, Indonesia	-8.403889	115.651889	480	BO1946395	Herb 50–60 cm tall. Calyx pale green, corolla tube white, corolla pale purple. Root pale green.
47	*Asystasia gangetica* (L.) T. Anderson	2/24/2013	Palm Oil Plantation, Lubuk Kepayang, Air Hitam District, Sarolangun Regency, Jambi Province, Indonesia	-2.070889	102.791833	71	BO1946580	
48	*Asystasia gangetica* (L.) T. Anderson	4/28/2018	Goa Ngobaran, Menoreh Mountains, Kulon Progo Regency, Yogyakarta Province, Indonesia	-7.594166	110.131192	740	BO1960331	Herb 30 cm, purple flowers
49	*Asystasia gangetica* (L.) T. Anderson	2/5/2010	Beach of Moti Kota Village, Moti District, Ternate City, Moti Island, Maluku Utara Province, Indonesia	0.4727	127.421128	13	BO1983501	Flowers purple
50	*Asystasia gangetica* (L.) T. Anderson	6/6/2021	Palm Oil Plantation, Tanjung Api-Api, Sungsang IV, Banyuasin II, Banyu Asin Regency, South Sumatra Province, Indonesia	-2.399446	104.836344	4	BO1986531	Herb, green leaves, purplish-white flowers, green sepals
51	*Asystasia gangetica* (L.) T. Anderson	6/6/2021	Palm Oil Plantation, Tanjung Api-Api, Sungsang IV, Banyuasin II, Banyu Asin Regency, South Sumatra Province, Indonesia	-2.399446	104.836344	4	BO1986532	Herb, green leaves, purplish-white flowers, green sepals

3. Results

The collections of Asystasia species in the Herbarium Anda and the Herbarium Bogoriense are recorded under the names *Asystasia gangetica* (L.) T. Anderson, *Asystasia coromandeliana* Nees, and *Asystasia intrusa*. In the earliest records of the Herbarium Bogoriense until the year 1941, Asystasia specimens showing characteristics as roadside weeds with white, light blue-violet, or white fading purplish flowers were referred to as *Asystasia coromandeliana* but were later determined as *Asystasia gangetica*. At the same time, the records of the Herbarium Anda dated from 2001 to 2012 show that the specimens identified as *Asystasia coromandeliana* are characterized as liana (shrubs) with white or yellow flowers, while the specimens recorded as *Asystasia gangetica* have white, yellow, pink or purple flowers. In addition, two specimens identified as *Asystasia gangetica* (ANDA15583 and ANDA15584) have purple-in-white and purple-white flowers.

According to Alston (1931) and Adetula (2004), *Asystasia coromandeliana* Nees is also known synonymously as *Asystasia gangetica* (L.) T. Anderson or *Justicia gangetica* Linn. Therefore, the specimens recorded in the two herbaria under the names *Asystasia gangetica* and *Asystasia coromandeliana* are the same species, while specimens ANDA15583 and ANDA15584 are thought to be *Asystasia intrusa*. In this article, we suggest that *Asystasia gangetica* subsp. *gangetica*, the synonym of *Asystasia coromandeliana*, is named *Asystasia gangetica*, while *Asystasia gangetica* subsp. *micrantha*, also called synonymously as *Asystasia intrusa* based on the description of specimen BO1478120 collected in Central Sulawesi Province, Indonesia, is named *Asystasia micrantha*.

Figure 1 shows the distribution of Asystasia from Calcutta (India) in the north to Timor Island in the south and from Mahé Island (Seychelles) in the west to Tutuila Island (Samoa) in the east, most of which come from the Herbarium Bogoriense collection. Meanwhile, most of the Herbarium Anda collection originates from West Sumatra (Fig. 2).

The newest collection of the Asystasia specimens was obtained on September 24, 2022, from Padang, West Sumatra (Table 1), while the oldest was collected by Sulpiz Kurz in 1863 (JSTOR 2023) from Singapore (Table 2). The specimen collected from the Mont Le Niole of Mahé Island in the Seychelles is confirmed to be *Asystasia intrusa* (*Asystasia micrantha*) from the characteristics of the flowers recorded in the herbarium.

The herbarium records show that Asystasia specimens were acquired from the coastal area at 2 m above sea level to the highlands at an altitude of 1,525 m. This extensive altitude range indicates that this plant thrives everywhere, from the coastline, in the disturbed wastelands along the beach, at the roadside near the port, in the plantation areas, in cities, villages, and forests to the high mountain plateaus at an altitude above 1500 m. The ability of this plant to thrive in highly diverse climatic conditions with very distinct environments, such as the coast and the highlands, demonstrates its excellent adaptability and resilience.

4. Discussion

In Thwaites (1860), Anderson stated that the extensive distribution of *Asystasia gangetica* over tropical Asia and Africa renders the specific name *Asystasia coromandeliana* (Wallich 1832) adopted by Nees von Esenbeck inappropriate, so he revived the original name given by Linnaeus. However, apart from *A. coromandeliana*, another synonym mentioned in Thwaites (1860) was *A. intrusa* (synonym of *A. micrantha*). This information demonstrates that Anderson did not distinguish between the two subspecies and even referred to them by the same name, *Asystasia gangetica*. As a result, subsequent authors referred to *Asystasia gangetica* as a plant native to tropical Asia and Africa, even though Linnaeus (1756) only mentioned India as the habitat of this plant, which was identified as *Justicia gangetica* at that time. Therefore, we confirm that *Asystasia gangetica* (*A. coromandeliana*) is not native to Africa. POWO (2023a) supports our claim, stating that the native range of this plant is the Indian subcontinent and northern Southeast Asia. Furthermore, we believe that the name *Asystasia coromandeliana*, adopted by Nees von Esenbeck, is appropriate because coromandeliana means liana of Coromandel, which refers to the territory located on the east coast of Madras Presidency and northern Ceylon (Thurston 1913).

Asystasia gangetica enumerated by Anderson (1867) in the Malay Peninsula and *A. gangetica* collected by Kurz in Singapore (BO1280561, Table 2) while traveling from Buitenzorg (now: Bogor) to Calcutta (JSTOR 2023) indicate that this species already existed in Malaysia since 1863 or, more accurately, in Singapore, which at the time was still a part of Malaysia. This finding refutes Ridley's statement (Ridley 1923) quoted by Kiew & Vollesen (1997), which claimed that *A. gangetica* was introduced from India to Malaysia as an ornamental plant in 1876. This finding also confirms that *A. gangetica* had flourished in Malaysia in 1863, which means 30 years earlier than in Java (Indonesia), based on the first records of its existence dating back to 1893 in Batavia (now: Jakarta), Buitenzorg (now: Bogor) and Besuki in East Java (Table 2).

The oldest specimen of *Asystasia intrusa* recorded in the Herbarium Bogoriense (BO1278953) comes from a collection in 1932 (Table 2). However, Blume (1825) has documented *Asystasia intrusa* found around Buitenzorg with the synonymous name *Ruellia intrusa* Forsk, which he described as having pointed oval-ovate leaves dotted with tiny hairs. The characteristics of *Ruellia intrusa* given by Forskal (1775) support our assertion that *A. intrusa* is synonymous with *Asystasia gangetica* subsp. *micrantha* (*A. micrantha*). According to POWO (2023b), the native range of this species is tropical and South Africa to the Arabian Peninsula, Comoros, and Madagascar. Thus, *A. intrusa* is thought to have entered Java (Indonesia) via the Indian Ocean with the help of wind gusts and human activities almost 70 years earlier than *A. gangetica* subsp. *gangetica* (*A. gangetica*). This method of dispersal across the Indian Ocean is supported by specimen BO1280905 (Table 2) obtained from Mahé Island of Seychelles.

The assertion that *A. gangetica* subsp. *micrantha* should be a separate species from *A. gangetica* subsp. *gangetica* is strongly supported by Westaway et al. (2016), which confirmed that the two subspecies have different numbers of chromosomes, with subsp. *micrantha* being diploid and subsp. *gangetica* being tetraploid. Therefore, the two subspecies are reproductively isolated from each other, and any hybridization will result in the development of sterile triploid plants. This study proposes to use the nomenclature *A. intrusa* or *A. micrantha* instead of *Asystasia gangetica* subsp. *micrantha* because this plant has nothing to do with the Ganges River, from which the name gangetica comes. This plant, native to Africa and Arabia, is phenotypically and genotypically different from *A. gangetica* subsp. *gangetica*, as shown in Table 3 and Figs. 3 and 4, where the much smaller flower of the subsp. *micrantha* can be seen among the larger light purple flowers of the subsp *gangetica*.

Table 3
Differences between the two subspecies of *Asystasia gangetica*

Characteristics	subsp. *gangetica*	subsp. *micrantha*
Corolla colour	white, pale cream, light yellow, rosy, pale, or dark purple	white with purple blotches on the lowest petal lobe
Stem	glabrous, rigid, hard	downy, weak
Leaves	glabrous, deep green	downy, dull green

4.1. Ecological impacts

The two subspecies of *Asystasia gangetica* mentioned in various publications are generally considered weeds that negatively impact the environment. Their ability to produce vast amounts of small and lightweight seeds contributes to their extensive spread facilitated by wind, water, birds, or human activities, thus allowing the colonization of new territories. Once established, the plants form dense mats that compete with native vegetation and disrupt local ecosystems. The journey from their native regions to various parts of the world demonstrates their resilience and the importance of human interaction in determining plant dispersions.

In Africa, the native habitat of the subsp. *micrantha*, this plant has spread throughout most of tropical Africa, including Nigeria, Ethiopia, Malawi, and Kenya, as well as some Indian Ocean islands (Hyde et al. 2023; Idu and Onyibe 2007; Maundu et al. 1999). In America, it is thought that this plant entered the continent through the transatlantic slave trade, in which it was most likely carried on ships sailing from Africa. The plant has been documented in the Caribbean and North and Central America. Both subspecies of *Asystasia gangetica* are found in cultivation or as escape plants in Panama and much of tropical America (Tropicos 2023), as well as in the United States, such as in the states of Florida and Hawaii (Kamemoto and Storey, 1955; IFAS 2023). *A. gangetica* also succeeded in thriving in the islands of Oceania, such as Fiji, American Samoa, Palau, Niue, and Nauru (PIER 2013), where the plant was believed to have been introduced through trade networks and human migration.

The global distribution of this plant points out that natural factors and human activities have influenced its dispersal far beyond its native ranges. It also presents a paradoxical situation. Although its resilience makes it an exciting subject of study with potential exploitation, its invasive nature raises concerns regarding ecological balance. In regions where *Asystasia micrantha* has become invasive, such as Australia, this plant can form dense layers covering other plants, thereby disrupting local ecosystems. As an environmental weed, it outcompetes and displaces native plants, which reduces the availability of habitat for native plants and animals and, as a result, decreases biodiversity. *A. micrantha* is on the National Environmental Alert List and must not be sold anywhere in NSW Australia (DPI 2022).

In Peninsular Malaysia, both subspecies are common weeds in rubber, oil palm, coffee, and other crops; however, *A. micrantha* is particularly troublesome in oil palm plantations (Sahid and Juraimi 1998). On the other hand, *A. gangetica* is less invasive and is widely grown in Australia, where it has become naturalized throughout parts of northern Australia in Queensland and the Northern Territory (Weed CRC 2003). Furthermore, we specifically observed *A. micrantha* in Bogor Regency, West Java, and Padang Pariaman Regency, West Sumatra. This species grows everywhere, including on roadsides and vacant fields, in contrast to *A. gangetica*, which is limited to specific locations near streams or wet areas. Therefore, it is confirmed that *A. micrantha* is more invasive than *A. gangetica*.

The most remarkable aspect of the subsp. *micrantha* or *Asystasia intrusa* is its extraordinary resilience and adaptability to thrive in a variety of environments across the globe. This versatility has led to its classification as a highly invasive species. Nevertheless, this plant plays a role in supporting local ecosystems. Its nectar-rich flowers attract bees and butterflies, contributing to the intricate interactions that sustain biodiversity. In addition, its ability to flourish in different conditions can aid in erosion control and soil stabilization, making it a valuable asset in conservation efforts. Applying Asystasia as a cover crop in mature oil palm plantations effectively reduces soil erosion and loss of most organic C, N, P, and K contents (Asbur et al. 2016). It even adds N, P, and K nutrients to the soil, enhancing its chemical properties by recycling the nutrients it absorbs (Asbur et al. 2018).

Invasiveness has been considered the prominent trait of Asystasia, whereas it is only a negative aspect of this plant due to its high adaptability and resilience to almost any environmental conditions. It has many positive qualities that benefit humans but have escaped human attention. The upright nature of this plant, its ability to thrive in shade, its aroma and palatability, and its thornless physical characteristics all contribute to its attractiveness to grazing animals, and it is therefore used as forage for cattle, goats, and sheep in Africa and Southeast Asia (Adetula 2004; Asiedu et al. 1978). The crude protein content of this plant, which is similar to that of cassava leaves, is significantly higher than that of common grasses, while its mineral content indicates that Asystasia is a good source of Ca, P, Mn, Zn, and Cu for cattle (Khalil 2016). This plant has also become a favourite diet for cultivated gourami fish (*Osphronemus gourami*) in the Pariaman district of West Sumatra (personal communication). Therefore, grazing animals can be employed as natural controls for this weed.

4.2. Nutritious local specialties

Asystasia gangetica has traditionally been used in various African and Asian culinary practices. It has been incorporated into dishes as a leafy vegetable added to soups, stews, and salads. It is an essential vegetable among the Mijikenda people in Kenya, who eat the boiled or stir-fried tender leaves and stems of Asystasia (Lin et al. 2009) or combine it with other green vegetables such as pumpkin or cassava leaves (Maundu et al. 1999). The Paliyar tribe of Madurai district in Tamil Nadu, India, also consumes *A. gangetica* leaves as a vegetable (Ignacimuthu et al. 2006). The leaves and young shoots are boiled and stir-fried in China (Xu et al. 2020).

Edible portions of Asystasia are an excellent source of protein, carbohydrates, dietary fibre, β-carotene, vitamin C, iron, calcium, phosphorus, and magnesium (Odhav et al. 2007; Agea et al. 2014; Xu et al. 2020). The leaves of *A. micrantha* have an extremely high content of β-carotene and high content in iron, vitamin C, and vitamin E, while its protein content is around 4% (Lin et al. 2009; Shackleton et al. 2009).

Mineral concentrations in *A. gangetica* exceed 1% of plant dry weight and are significantly higher than average mineral concentrations in conventional edible green vegetables. These minerals are calcium, phosphorus, sodium, and magnesium (Odhav et al. 2007). Thus, commercial cultivation of this plant is advised so that this simple plant can be found on more plates worldwide, adding to culinary diversity and human health.

4.3. Traditional and future medicines

Despite its negative aspects, Asystasia has significance in some cultures and traditional practices, where the plant is used for its medicinal properties. In Africa, an infusion of the plant is employed to relieve pain during childbirth, and the sap is applied to sores, wounds, and piles. Powdered roots are analgesic and are used to treat stomach aches and snakebites. A leaf decoction is employed as an analgesic to treat epilepsy and urethral discharge (Adetula 2004). In Nigeria, the leaf extract of *A. micrantha* is used to treat asthma, as an anti-inflammatory and analgesic drug (Akah et al. 2003; Shackleton et al. 2009), as antipruritic, astringent, and vermifuge (Idu and Onyibe 2007). In West Africa and Guinea-Bissau, Asystasia is useful to treat neurological disorders, such as epilepsy (Romeiras et al. 2012). In the Moluccas of Indonesia, the plant juice, combined with lime and onion juice, is recommended for dry coughs accompanied by throat irritation and chest discomfort. In the Philippines, the leaves and flowers are used as an intestinal astringent. In India, the sap is used to cure rheumatism and as a vermifuge (Adetula 2004; Shanmugam et al. 2012).

Many studies have been and are being conducted to investigate the properties of Asystasia. For example, Ezike et al. (2008) suggested that the efficacy of *Asystasia micrantha* in treating asthma may be due to the bronchospasmolytic effect of terpenoid compounds found in the leaves. The antibacterial and antifungal activity of *A. micrantha* extract at high concentrations against human pathogenic bacteria and fungi (Hamid et al. 2011)d *gangetica* extract at a concentration of 100 mg/ml as an effective anthelmintic drug (Jiju et al. 2013) demonstrate that a large amount of biomass is required to produce the active extracts. The leaf extract of *A. gangetica* has been shown to reduce blood pressure and heart rate in hypertensive rats, which is thought to be due to its action on the angiotensin I-converting enzyme, the human angiotensin II receptor, and heart rate (Mugabo and Raji 2013). *A. gangetica* leaves also exhibit strong antivenom properties, making them helpful in treating snakebites (Enenebeaku et al. 2018).

Research on the phytochemical composition of Asystasia extract has asserted the presence of bioactive compounds such as alkaloids, tannins, steroidal aglycone, saponins, reducing sugar, steroids, glycosides, flavonoids, anthraquinones, terpenes, terpenoids including triterpenoids, coumarins, phenols, glycosides, phytosterols (Akah et al. 2003; Kumar et al. 2010; Hamid et al. 2011; Enenebeaku et al. 2018; Jose et al. 2018; Eriamiatoe et al. 2020). Many terpenoids have been shown to inhibit various human cancer cells. Thus, they are employed as anticancer drugs (Perveen 2018).

Many studies have been conducted on the effectiveness of Asystasia as a medicine, but these studies did not specify which plant subspecies were investigated. The name of the subspecies should have been given to avoid misinformation about the efficacy of Asystasia as a medicine. Therefore, it would be preferable for the taxonomy of this plant to be reconsidered because, in addition to the reasons mentioned above, the two subspecies cannot replace each other as a medicine to cure the same disease. For example, the subsp. *micrantha* effectively treats asthma, which the subsp. *gangetica* cannot replace. Likewise, the subsp. *gangetica*, which we have proved (unpublished data) effective in treating some human cancers, cannot be replaced by the subsp. *micrantha*.

As interest in natural treatments and herbal medicine increases, the bioactive compounds of Asystasia offer promising prospects for research and development. Incorporating this plant into modern medicine will lead to the development of new drugs, dietary supplements, or topical therapies. Additionally, in-depth scientific studies are required to fully understand the mechanisms of action, potential side effects, and correct dosage of these bioactive compounds to assess their efficacy and safety.

5. Conclusion

The global distribution of *Asystasia gangetica* is a story of ecological adaptability and successful colonization. However, its spread must be controlled to protect native plants and biodiversity. This plant is more than just an ornamental plant. It is a repository of potentially beneficial nutrients and bioactive compounds. These beneficial properties, combined with the plant's genetic makeup, which produces small and lightweight seeds, high adaptability and resilience, high nutritional content, and bioactive compounds, indicate that this plant has been intended to thrive almost anywhere on the planet, providing benefits to many humans and animals. Although traditional uses have hinted at its medicinal potential, current research highlights its multiple contributions to human health.

Declarations

Author Contribution

LRT carried out conceptualization, data curation, methodology, writing (preparation of the original draft), reviewing, and editing.NN carried out data curation and writing-review.WZ assisted in data curation.All authors reviewed the manuscript.

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Figures

Figure 1. Distribution of Asystasia species according to Herbarium Bogoriense (red dots ●) and Herbarium Anda (green dots ●) collections from Calcutta to Timor Island and Seychelles to Samoa. (https://public.tableau.com/app/profile/kepustakaan.bandung/viz/CollectionofAsystasiagangetica/Sheet1)

Figure 1

See image above for figure legend

Figure 2. Distribution of Asystasia species according to the Herbarium Anda collection (green dots ●) covering the West Sumatra region, while the Asystasia collection from the Herbarium Bogoriense is spread out over a larger region (red dots ●)

Figure 2

See image above for figure legend

Figure 3

Colour gradations of the subsp. *gangetica* flowers range from white, cream, and light purple to dark purple.

Figure 4

Flowers, leaves, and axillary and terminal racemes of the subsp. *micrantha*.