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Species diversity of Asteraceae in Gayo Highlands, Bener Meriah District, Aceh Province, Indonesia

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Abstract. *Puspa VR, Zumaidar, Nurdin, Fitmawati. 2024. Species diversity of Asteraceae in Gayo Highlands, Bener Meriah District, Aceh Province, Indonesia. Biodiversitas 25: 2828-2837.* Asteraceae flourishes in the Gayo Highlands of the Bener Meriah District, Aceh Province, Indonesia despite being frequently overlooked due to its classification as a wild plant. There has been no comprehensive documentation of the non-cultivated Asteraceae species indigenous to this location. Thus, this study endeavored to elucidate the diversity of the Asteraceae species in the Gayo Highlands. Data on Asteraceae diversity were amassed using the quadrat method across eight sub-districts, encompassing abandoned land and roadside areas. The composition of species was scrutinized through the Important Value Index (IVI) and the diversity index was quantified utilizing the Shannon-Wiener index. The results revealed 13 species of Asteraceae comprising a total of 9,780 individual specimens, including *Ageratum conyzoides* L., *Bidens pilosa* L., *Acmella uliginosa* (Sw.) Cass., *Crassocephalum crepidioides* (Benth.) S. Moore., *Galinsoga parviflora* Cav., *Erigeron sumatrensis* Retz., *Sonchus oleraceus* L., *Synedrella nodiflora* (L.) Gaertn., *Gerbera jamesonii* Adlam., *Sphagneticola trilobata* (L.) Pruski., *Emilia sonchifolia* (L.), *Tridax procumbens* L., and *Youngia japonica* (L.) DC. *Ageratum conyzoides* registered the highest IVI at 143.91, whilst *S. oleraceus* had the lowest at 3.53. According to the Shannon-Wiener index, the diversity of the Asteraceae in the Gayo Highlands is denoted as low ($\hat{H}$=1.69). This exploration provides contemporary insights into the Asteraceae diversity within the Gayo Highlands, serving as a valuable reference for both researchers and interested stakeholders.

Keywords: Asteraceae, diversity index, Gayo Highlands, important value, quadrate methods

INTRODUCTION

Asteraceae is one of the families where most species have a herbaceous habitus, covering about 1,707 genera and 34,942 accepted species (POWO 2024). It is the kingdom Plantae's largest member and one of the most prominent flowering plant families (Commock et al. 2018; Hoveka et al. 2020). The family is divided into 12 subfamilies and 43 tribes, and some of the basal clades supported by molecular data are still poorly characterized from morphological characters. It has florets in centripetally forming heads surrounded by bracts, anthers fused in a ring with pollen pushed out by the style, and achenes (cypselas) with a pappus (Funk et al. 2009). The next distinctive feature is ribbon and tube flowers (Tjitrosoepomo 2010; Bahadur et al. 2023).

The family Asteraceae exhibits a global distribution (Bremer 1994; Minaeifar et al. 2015; Azizi et al. 2018; Zhang et al. 2021), inhabiting nearly all environmental niches under its adaptive proficiency in response to temperature variances, salinity levels, drought conditions, solar radiation, and intense wind occurrences (Asif et al. 2020; Abd El-Fatah et al. 2022). An impressive accumulation of 201 species spanning 93 genera has been documented in the Chihuahuan Desert of Mexico, with genera such as *Ageratum* and *Helianthus* figuring prominently (González-Zamora et al. 2020). A study by Abd El-Fatah et al. (2022) reported six species of Asteraceae in North Africa's Sharkia Province, notably dominated by *Sonchus oleraceus* and *Bidens pilosa*. Further east, in Rajshahi of Bangladesh and South Asia, fieldwork has indicated the prevalence of 36 species across 29 genera in the Asteraceae, principally *Ageratum conyzoides* and *Blumea lacera* (Rahman et al. 2008b). Kurniawan et al. (2022) presented 18 species from 16 genera within the family in Wonosobo, Central Java, Indonesia with *Ageratina riparia* being the most abundant species identified at the site. The pervasive presence of Asteraceae across diverse environments underscores its remarkable endurance and adaptability, warranting additional investigation to understand these survival mechanisms (Fonseca and Venticinque 2018).

Harahap et al. (2022) identified nine species of the Asteraceae in Deli Serdang, Indonesia. Crossing national borders, 27 species of the same family were recorded in the Mansehra District of Pakistan by Asif et al. (2020). The fecund lands of the Gayo Highlands, which support a thriving agricultural sector with commodities such as coffee, tomatoes, potatoes, chili, cabbage, and red onions, lack a comprehensive examination of the Asteraceae species diversity. It is imperative to conduct systematic research to elucidate the diversity index of wild Asteraceae species in the Bener Meriah District, Aceh Province, Indonesia.

Regarded as one of the planet's megadiverse countries, Indonesia is among the top three countries for exceptional biological diversity (von Rintelen et al. 2017). Indonesia's rich and varied flora calls for scholarly examination to catalog this vast natural inheritance fully. In the context of invasive species, Asteraceae is noted as an invasive alien plant in China, posing a substantial risk to endemic species diversity and ecosystem integrity (Yang et al. 2023). Similar concerns arise in North Sumatra, where the family predominantly manifests as invasive Alien Plant Species (IAP), notably with *A. conyzoides* and *Chromolaena odorata* among the most invasive (Huda et al. 2022).

A thorough diversity analysis of the Asteraceae is crucial, as it equips local stakeholders with knowledge of prevalent species and their propagation. Such analyses aid in identifying species that exhibit resilience to certain environmental stressors alongside those necessitating control measures to mitigate adverse effects on agriculture and native species. Leveraging this knowledge can stimulate local development, potentially bolstering the economic vitality of the Gayo highlands and surrounding Aceh region while fostering biodiversity conservation. Undertaking this research is important, with the principal objective of ascertaining the Asteraceae diversity index and importance value index within the Gayo Highlands.

MATERIALS AND METHODS

Study area

The research was conducted in the Gayo Highlands of the Bener Meriah District, Aceh Province, Indonesia, encompassing eight subdistricts, namely Timang Gajah, Gajah Putih, Pintu Rime Gayo, Bukit, Wih Pesam, Bandar, Mesidah, and Permata (Figure 1 and Table 1). Sampling occurred across diverse ecological niches constituting two community types, i.e. abandoned lands are properties once occupied but now vacated, offering both exposed and shaded microhabitats; and roadsides are areas adjacent to thoroughfares, typically open to sunlight. Climatic conditions for the locale report an average annual temperature of 22°C and relative humidity at 92% (Central Bureau of Statistics of Bener Meriah 2023).

Procedures

Research design

This study entailed an exploratory survey to ascertain the Asteraceae's Important Value Index (IVI) and diversity index. Adopting a purposive sampling methodology, quadrats were strategically placed in locations where species of Asteraceae were present. To ensure that the vegetation samples were representative, it was imperative to establish a minimal plot area by applying the minimum area curve for each stratum of the plant community (Syafei 1993). The minimum area for a plot in this investigation was 1x1 m. Subsequently, the minimum plot number for each site was calculated utilizing a series of three repetitions. This method necessitates sampling cease at an observation station when the addition of plots does not yield new species (reaching a constant species count). The empirical outcome indicated a requirement of five quadrats per species, culminating in a minimum of 15 sampling quadrats per observation station. Accordingly, with eight subdistricts in the study area, a total of 120 quadrats was the minimum established. However, this investigation exceeded this minimum, implementing 160 quadrats in total (Table 1).

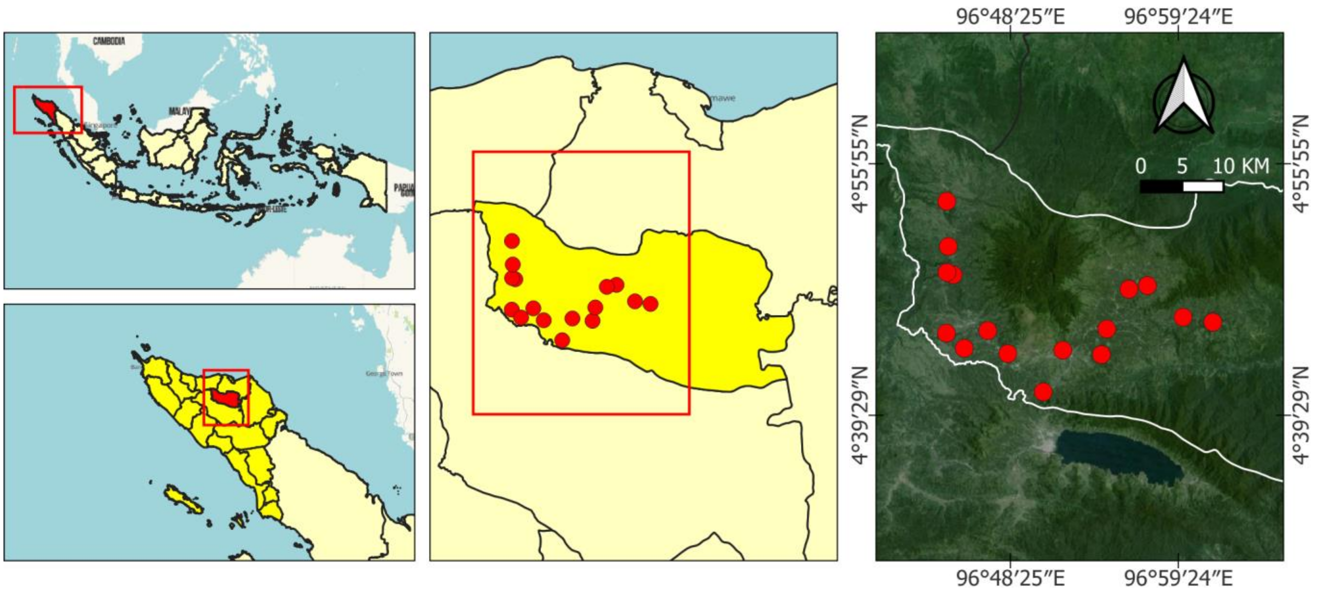

Figure 1. Research sites in Gayo Highland, Bener Meriah District, Aceh Province, Indonesia

Table 1. Detailed information on the research sites in Gayo highlands, Bener Meriah District, Aceh Province, Indonesia

Subdistrict	Altitude (m asl)	Villages	Coordinates	Total plot
Timang Gajah	1,219	Bandar Lampahan	4°45'0.047"N 96°46'56.72"E	10
	945	Timang Rasa	4°44'50.36'N 96°44'14.53"E	10
Gajah Putih	916	Pante Karya	4°48'39.43"N 96°44'40.90"E	10
	861	Reronga	4°48'48.39"N 96°44'16.64"E	10
Pintu Rime Gayo	766	Alur Cincin	4°53'27.84"N 96°44'15.88"E	10
	911	Blang Ara	4°50'30.17"N 96°44'21.93"E	10
Bukit	1,431	Babussalam	4°43'43.59"N 96°51'51.51"E	10
	1,282	Blang Tampu	4°41'0.05"N 96°50'34.63"E	10
Wih Pesam	1,231	Pante Raya	4°43'30.11"N 96°48'15.44'E	10
	1,023	Suka Makmur	4°43'50.78"N 96°45'24.51"E	10
Bandar	1,339	Bukit Wih Ilang	4°43'26.22"N 96°54'23.13"E	10
	1,413	Mutiara	4°45'6.68"N 96°54'44.26"E	10
Mesidah	1,202	Buntul Gayo	4°45'33.32"N 97°1'40.43"E	10
	1,263	Cemparam Jaya	4°45'52.83"N 96°59'43.37"E	10
Permata	1,402	Ayu Ara	4°47'57.11"N 96°57'23.84"E	10
	1,416	Darul Aman	4°47'42.35"N 96°56'10.83"E	10

Table 2. The important value index and diversity index category

Category	Important Value Index (IVI)	Diversity Index (Ĥ)
High	110.58<IVI≤143.91	3<Ĥ≤4
Moderate	73.72<IVI≤110.58	2<Ĥ≤3
Low	36.86<IVI≤73.72	1<Ĥ≤2
Deficient	IVI≤36.86	Ĥ≤1

Data collection

Data of Frequency (F), Density (D), and Dominance (B) were recorded using the quadrat method for quantitative analysis. Twenty quadrats measuring 2x2 m for the herbaceous layer were installed in each subdistrict. Plots were placed subjectively, targeting areas that faithfully represented Asteraceae's habitat, resulting in 160 plots and an observational area of 640 m^2 (Odum 1971).

Plant species were identified by examining morphological features such as roots, stems, leaves, and flowers. Identification references included Flora of Java Volume II (Backer and van den Brink 1965), the PlantNet application (available in the Play Store and App Store), and several botany websites, including https://powo.science.kew.org, https://www.inaturalist.org, https://www.plant.id, and https://plantamor.com.

Data analysis

The compositional structure of species is assessed by employing the Importance Value Index (IVI). At the same time, diversity is quantified by utilizing the Shannon-Wiener diversity index (Ĥ) (Ludwig and Reynolds 1988). The IVI for individual species is ascertained using the equation: IVI = relative frequency + relative density + relative dominance (Mueller-Dombois and Ellenberg 1974). In further analyses, the IVI contributes to the calculation of the species diversity index through an interpretative formula that incorporates the Highest Important Value Index (HIVI) and the Lowest Important Value Index (LIVI), with the sum divided by four to establish an IV category relevant to the vegetation analysis at the specified research location. The categorical criteria are delineated in Table 2.

Species diversity is an evaluative parameter that facilitates the comparative analysis of disparate biological communities, principally undertaken to ascertain community stability. According to Odum (1971), the measurement of community species diversity is operationalized by employing the Shannon-Wiener Species Diversity Index (Ĥ). The derived Shannon-Wiener index values yield interpretable data that provide significant ecological understanding. Interpretive guidelines are accordingly established and presented in Table 2.

$$\hat{H} = -\sum p_i \ln p_i$$

Where: Ĥ = Shannon diversity index; *pi* = ni/N; ni = number of individual to-i; N = the sum of important values of the whole species; In = natural logaritma

RESULTS AND DISCUSSION

Important Value Index (IVI)

Within the Gayo Highlands of Bener Meriah District, Aceh Province, Indonesia, 13 species of Asteraceae have been identified. This encompasses species such as *A. conyzoides*, *B. pilosa*, and *A. uliginosa*, among others, as depicted in Figure 2 and Table 3. Taxonomic analysis reveals these species are distributed among several subfamilies, namely Asteroideae with 10 species, Cichorioidae with 2 species, and Mutisioidae with a single species. The research categorizes the importance value index into four distinct classifications: high, moderate, low, and deficient, according to the outcomes of the IVI assessment. Notably, *A. conyzoides* exhibits the highest IVI of 143.91 in Timang Gajah, contrasted with *S. oleraceus*, which possesses the lowest IVI of 3.53 in Pintu Rime Gayo (Table 3). The dominance of *A. conyzoides* is attributed to its substantial representation in individual count and frequency across the surveyed locales, substantiating its elevated IVI. An examination at the subdistrict level reveals that Bandar harbors the preponderance of species classified as deficient in IVI at 78%, closely followed by Timang Gajah at 75%. The calculated IVI of species within a community offers insight into their ecological roles and relative importance within the community structure.

Species exhibiting a low IVI are characterized by minimal dominance, which may correspond to reduced adaptability and tolerance within their ecological niches. Such limited resilience can precipitate adverse impacts on species persistence, particularly under challenging environmental pressures that surpass their adaptive capacities, thereby risking species loss within the community. For instance, *Sonchus oleraceus* within the Pintu Rime Gayo Subdistrict manifests a minimal IVI of 3.53, warranting focused conservation efforts. Research areas typified by a significant proportion of species with deficient IVI figures must receive increased scrutiny to preclude potential species extirpation.

Species diversity of Asteraceae were systematically gathered from fallow tracts of land featuring both open and partially shaded locales and roadsides subject to direct solar exposure (Table 3). The heterogeneous light conditions of these sites may bear relevance to the observed IVI values and warrant further ecological investigation.

Diversity index

Species diversity indices for Asteraceae within eight subdistricts are delineated in Table 4. Across the observational stations, the diversity of this family is demarcated as being in a low category, with species counts oscillating between 5 and 9. The mean index value for species diversity is also low, with an average of Ĥ=1.69. Within these subdistricts, the Gajah Putih area demonstrates the greatest species diversity, reflected by an index value of Ĥ=1.98, whereas the Bukit subdistrict registers the least diversity, with an index of Ĥ=1.44, where merely five species of Asteraceae have been documented, namely *A. conyzoides*, *B. pilosa*, *C. crepidioides*, *G. parviflora*, and *E. sumatrensis*.

Regarding species abundance, *A. conyzoides* was reported with the highest individual count at 3,343, while *Y. japonica* was observed minimally, with only two individuals noted. The presence of three species, *A. conyzoides*, *B. pilosa*, and *C. crepidioides* is conspicuous across all subdistricts, underlining their remarkable adaptational strategies. Specifically, *B. pilosa* and *C. crepidioides* exhibit a distributional consistency, with individual counts registering at 2,719 and 939, respectively, indicating their pervasive presence in the sampled locations.

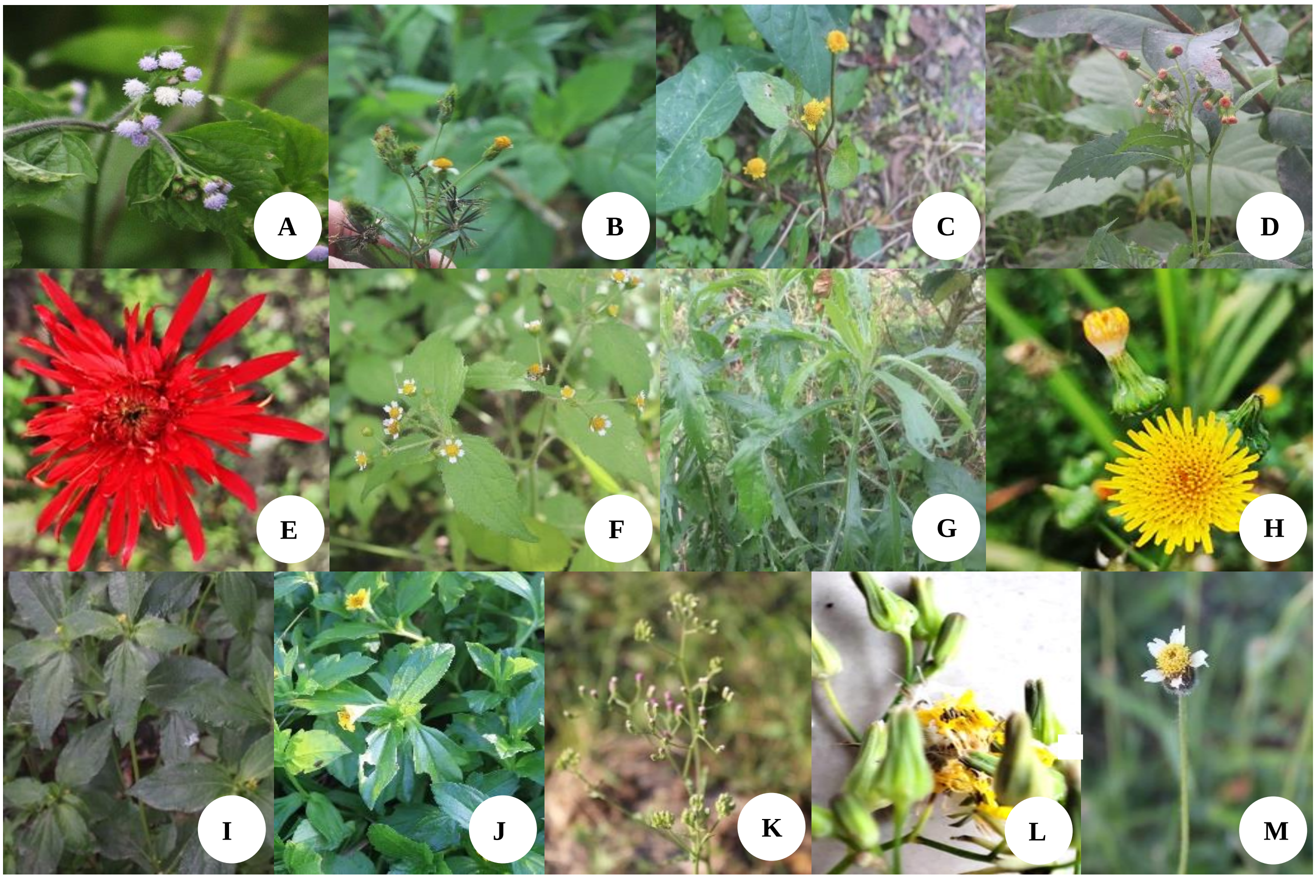

Figure 2. Species diversity of Asteraceae in Gayo Higlands, Bener Meriah District, Aceh Province, Indonesia: A. *Ageratum conyzoides*, B. *Bidens pilosa*, C. *Acmella uliginosa*, D. *Crassocephalum crepidioides*, E. *Galinsoga parviflora*, F. *Erigeron sumatranensis*¸G. *Sonchus oleraceus*, H. *Synedrella nodiflora*, I. *Gerbera jamesonii*, J. *Sphagneticola trilobata*, K. *Emilia sonchifolia*, L. *Youngia japonica*, M. *Tridax procumbens*

Table 3. Important Value Index (IVI) and occurence of species in two communities of Asteraceae in Gayo Highlands, Bener Meriah District, Aceh Province, Indonesia

Species	Subfamilies	Local names	Sampling Location								Occurrence	
			TG	GP	PRG	BK	WP	BN	MS	PR	Exposed	Shaded
Ageratum conyzoides L.	Asteroideae	*Bandotan*	143.91	73.98	94.50	119.50	92.78	26.17	126.19	49.50	+	+
Bidens pilosa L.	Asteroideae	*Ketulan*	52.57	46.83	67.54	60.49	74.22	123.33	84.99	80.89	+	+
Acmella uliginosa (Sw.) Cass.	Asteroideae	*Jotang kecil*	15.94	11.85	42.31	-	15.54	31.30	22.85	8.95	+	+
Crassocephalum crepidioides (Benth.) S. Moore	Asteroideae	*Sintrong*	33.78	27.15	47.51	67.22	37.06	29.44	25.73	46.26	+	+
Galinsoga parviflora Cav.	Asteroideae	*Bribil*	-	30.63	39.47	34.40	34.06	56.54	24.67	66.35	+	+
Erigeron sumatrensis Retz.	Asteroideae	*Jelantir*	29.78	13.47	-	18.38	17.87	5.67	-	15.31	+	+
Sonchus oleraceus L.	Cichorioideae	*Tempuyung*	-	12.79	3.53	-	5.44	16.25	-	27.82	+	-
Synedrella nodiflora (L.) Gaertn.	Asteroideae	*Geletangan*	16.41	38.32	5.14	-	18.64	6.57	11.98	3.92	-	+
Gerbera jamesonii Adlam	Mutisioideae	*Herbras*	3.87	-	-	-	-	-	-	-	-	+
Sphagneticola trilobata (L.) Pruski	Asteroideae	*Widelia*	-	-	-	-	4.39	4.73	-	-	+	+
Emilia sonchifolia (L.) DC.	Asteroideae	*Tempuh wiyung*	-	3.88	-	-	-	-	-	-	+	+
Tridax procumbens L.	Asteroideae	*Gletang*	3.75	-	-	-	-	-	-	-	+	-
Youngia japonica (L.) DC.	Cichorioideae	*Jukut kamanilan*	-	-	-	-	-	-	3.59	-	+	+
Total			300	300	300	300	300	300	300	300		

Note: TG: Timang Gajah; GP: Gajah Putih; PRG: Pintu Rime Gayo; BK: Bukit; WP: Wih Pesam; BN: Bandar; MS: Mesidah; PR: Permata; (-) Not detected

Table 4. Species diversity index of Asteraceae in Gayo Highlands, Bener Meriah District, Aceh Province, Indonesia

Species	**Sampling location**							
	TG	**GP**	**PRG**	**BK**	**WP**	**BN**	**MS**	**PR**
Ageratum conyzoides L.	0.35	0.35	0.36	0.37	0.36	0.21	0.36	0.30
Bidens pilosa L.	0.31	0.29	0.34	0.32	0.35	0.37	0.36	0.35
Acmella uliginosa (Sw.) Cass.	0.16	0.13	0.28	-	0.15	0.24	0.20	0.10
Crassocephalum crepidioides (Benth.) S. Moore	0.25	0.22	0.29	0.34	0.26	0.23	0.21	0.29
Galinsoga parviflora Cav.	-	0.23	0.27	0.25	0.25	0.31	0.21	0.33
Erigeron sumatrensis Retz.	0.23	0.14	-	0.17	0.17	0.08	-	0.15
Sonchus oleraceus L.	-	0.13	0.05	-	0.07	0.16	-	0.22
Synedrella nodiflora (L.) Gaertn.	0.16	0.26	0.07	-	0.17	0.08	0.13	0.06
Gerbera jamesonii Adlam	0.06	-	-	-	-	-	-	-
Sphagneticola trilobata (L.) Pruski	-	-	-	-	0.06	0.07	-	-
Emilia sonchifolia (L.) DC.	-	0.06	-	-	-	-	-	-
Tridax procumbens L.	0.05	-	-	-	-	-	-	-
Youngia japonica (L.) DC.	-	-	-	-	-	-	0.05	-
Total	1.56	1.98	1.66	1.44	1.84	1.74	1.52	1.81

Note: TG: Timang Gajah, GP: Gajah Putih, PRG: Pintu Rime Gayo, BK: Bukit, WP: Wih Pesam, BN: Bandar, MS: Mesidah, PR: Permata, (-) Not detected

Discussion

The study conducted by Ridwan et al. (2022) identifies four species of Asteraceae prevalent in Kedah Rainforest Lodges in Aceh, namely *Gynura procumbens*, *A. uliginosa*, *C. crepidioides,* and *A. conyzoides*. Aligning with findings from Aceh Tengah district, three species *A. uliginosa*, *C. crepidioides,* and *A. conyzoides* exhibit a high frequency of occurrence in the Bener Meriah district relative to other species. It is notable, however, that *G. procumbens* was not detected in the current study. The absence of *G. procumbens* stems from dissimilar methodologies and disparate field locations between this and previous research efforts. Where prior investigations may have employed interview techniques to discern species used in traditional medicine, the present study incorporated a quadrat sampling approach in the field.

The distribution and establishment of plant species within a particular region, such as the Gayo Highlands, are contingent upon an array of ecological and environmental variables. These determinants encompass climate conditions, soil composition, altitudinal stratification, the availability of pollinating agents, interspecific competitive interactions, anthropogenic land use history, and extant human activities. *G. procumbens* requires an assemblage of conditions favorable to its propagation and sustained survival. An absence of *G. procumbens* within the Gayo highlands may be attributed to one or more vital ecological prerequisites not being fulfilled. Beyond immediate abiotic and biotic factors, the historical patterns of seed dispersal and enacted agricultural policies, as well as existing conservation measures, collectively play a crucial role in shaping the biogeographical patterns of plant species, including that of *G. procumbens.*

The existence of a species in a particular area implies that it is adaptable to its circumstances and has a high tolerance for environmental conditions. The higher a species' IVI, the greater its dominance over the community, and in reverse order. The existence of a species in a particular area demonstrates its ability to adapt to the habitat and its considerable tolerance for its natural surroundings (Yuliantoro and Frianto 2019). Species with relatively high IVI have a good level of mastery in a community if they get a large proportion of the available resources against other species (Asigbaase et al. 2019; Chhetri and Shrestha 2019).

This research funding *A. conyzoides* exhibits the highest IVI of 143.91 in Timang Gajah. According to Thapa et al. (2018), *A. conyzoides* has been denoted as an invasive alien plant in Nepal and India. Projections indicate that this species has the potential for extensive horizontal and vertical range expansion under various future climatic conditions, potentially colonizing habitats like secondary scrubland and subtropical coniferous woodlands. The possibility of *A. conyzoides* evolving into an IAP within the Gayo Highlands necessitates enhanced vigilance. It is imperative to develop and actualize strategic interventions to preserve the native biodiversity against the anticipated risks associated with expanding *A. conyzoides* in the Gayo Highlands ecosystem. Subsequent investigations are requisite to ascertain the invasive potential of *A. conyzoides*, thereby facilitating preemptive measures to avert biodiversity decrease in the Gayo Highlands.

According to Handayani et al. (2021), the family Asteraceae was identified as possessing the greatest quantity of IAP species within the forest zones of Gunung Gede Pangrango National Park, encompassing 23 distinct species. The research elucidates strategies for managing Naturalized Alien Plant Species (NAPS), advocating for their utilization across various domains such as culinary, medicinal, horticultural, aromatherapy, livestock fodder, fuel, and natural dye production. Such applications aim to harmonize NAPS into local ecosystems, mitigating their potential transition into invasive species within the region.

Conversely, *S. oleraceus* is delineated as possessing the lowest IVI of 3.53 in Pintu Rime Gayo (Table 3). This species reported as an IAP in Gunung Gede Pangrango National Park, suggests that the findings of this current study could provide supplementary insights for ecosystem management. Such information is critical to inform strategies to prevent the establishment of *S. oleraceus* as an

IAP in the Gayo highlands. Vecchia et al. (2022) have documented that *S. oleraceus* exhibits potential antioxidative and anti-inflammatory properties, particularly concerning gastric health. Hence, the therapeutic utilization of said species could be a tactical approach to avert its invasive proliferation, particularly within the Gayo Highlands.

The species richness across the Wih Pesam, Bandar, and Gajah Putih Subdistricts exhibits uniformity, however, the diversity indices display variability. Djufri et al. (2016) reported that the species diversity index is predominantly influenced by the discrepancies in importance values attributed to individual species at the respective sampling localities. To maintain elevated diversity within communities, periodic and stochastic disturbances are essential in otherwise stable ecosystems that exhibit regional expansion. These ecosystems characteristically have lower species diversity than those that are dynamically disturbed or present a mosaic pattern. Disturbance agents, such as fire, wind events, flooding, pathogenic outbreaks, and anthropogenic interventions, are crucial modulators of ecosystem dynamics. Post-disturbance scenarios generally witness a transient surge in species diversity before it stabilizes or declines, leading toward competitive exclusion and potential dominance by a few species. Consequently, conservation efforts are of paramount importance for protecting species at risk of extinction.

Barbour et al. (1999) highlighted complexities in sample estimation due to compositional variability, with richer species presence suggesting higher diversity indices. For instance, areas such as Bukit, with fewer species, exhibit lower diversity ($\hat{H}$=1.44). The interplay of environmental factors in habitats influences plant life directly and indirectly, ranging from photosynthesis in varied light conditions to changes in growth and structure. The responsiveness of species to these factors varies, with some reacting directly to primary factors like light, water, and temperature, while others are influenced indirectly. Weaver and Clements (1978) classify these as direct, indirect, and remote factors affecting plant activities and overall habitat structure. Despite similar altitudes, locations like Bukit, Wih Pesam, and Bandar display low diversity indices, suggesting that factors beyond altitude influence species diversity (Table 1).

This study yielded a significant discovery: the consistent detection of *A. conyzoides*, *B. pilosa*, and *C. crepidioides* across all surveyed stations. These species were recorded in illuminated and shaded environments (Table 3). Their prevalence and robust biomass production indicate supportive abiotic environmental factors that facilitate their dominance and growth, in coherence with the understandings presented by Odum (1971). Additionally, nine species that were exclusive to shaded regions or open areas were identified. This pattern is substantiated by Junaedi et al. (2019), which also documented that species, including *A. conyzoides* and *B. pilosa* were adaptable to both shaded and sunny habitats. *G. jamesonii* and *S. nodiflora* in shaded areas only, and *S. oleraceus* and *T. procumbens* in open habitats exclusively. Azzaroiha et al. (2022) reported Asteraceae species demonstrate notable resilience and habitat compatibility in sunlight-exposed areas with existing canopy cover.

Ageratum conyzoides is a herbaceous plant characterized by upright-stemmed morphology and spherical monopodial branching with a green, coarse, hairy surface (Backer and van den Brink 1965). The species has the highest IVI, number of individuals, and attendance percentage. Its ecological potential causes research related to the use of *A. conyzoides* to be carried out. It is assumed that *A. conyzoides* has the suitability of his life factors with the environment so that his presence is dominant among others. In line with several other reported studies, *A. conyzoides* is the most commonly found species (Rahman et al. 2008a; González-Zamora et al. 2020; Huda et al. 2022). The substantial natural occurrence of this resource signifies a positive environmental potential, coupled with its notable adaptability, which renders it a viable candidate for cultivation as a medicinal raw material.

Bidens pilosa was found at all observation sites. It is a herbaceous plant with morphological characteristics of erect stems with forked branching, rectangular stem shape, and smoked surface with a slightly hairy reddish-green color (Backer and van den Brink 1965). This species is recognized as an invasive alien species due to its propensity to diminish biodiversity within native plant communities. Zhong et al. (2022) identified that *B. pilosa* exhibits a comparatively higher degradation rate than other IAP. The investigation of IAP is crucial owing to their substantial threats to environmental and ecological integrity, capable of disrupting global biodiversity, forestry sectors, livelihoods, and public health. Nonetheless, environmental and socioeconomic research to guide restoration efforts remains insufficient for numerous species, including *B. pilosa* (Rai et al. 2023). This particular species was examined in the peripheral regions of the Himalayas in Kangra, Himachal Pradesh, India, revealing that *B. pilosa* is a catalyst for species turnover (Sharma et al. 2023). Given these findings, it is imperative to explore the current impacts of *B. pilosa* to safeguard species diversity within the Gayo Highlands. The dissemination of invasive species is influenced by climatic factors, with precipitation and temperature fluctuations playing a pivotal role (Yang et al. 2023). Despite being classified as invasive, *B. pilosa* harbors potential benefits; for instance, its visually striking flower coloration suggests its utility as an ornamental plant, capitalizing on its aesthetic appeal (Megawati et al. 2017). In Wih Pesam, local agricultural practices involve the removal of this species as part of land preparation for chili cultivation. Conversely, the tenacity of *B. pilosa* seeds, which readily adhere to garments and present difficulties in removal, leads to its perception as a pest. It is important to evaluate plants traditionally categorized as weeds due to their adaptability, which may provide opportunities for intentional cultivation.

Crassocephalum crepidioides has erect, soft, green, and juicy stems with scattered leaves. The leaf blades are inverted and pointed-pointed, 8-20x3-10 cm, the leaf bones are pinnate, and the edges are jagged. Hump compound flowers with green color and orange-brown to brick-red tips, petals close and become erect after turning into fruit.

The blooming flowers will spread in a circle with fine feathers and fibrous white roots (Backer and van den Brink 1965). In ethnobotanical practices, *C. crepidioides* has garnered recognition for its therapeutic application in remedying gastric ulcers, dyspepsia, cutaneous wounds, burns, and additional dermatological afflictions. This species is under active cultivation and commerce in certain regions, reflecting its medicinal and economic value. Pharmacological investigations have substantiated a spectrum of bioactive properties inherent to *C. crepidioides*, including antioxidative, antibacterial, lipid-regulating, antidiabetic, antimalarial, and anticarcinogenic effects. Incorporating *C. crepidioides* in traditional medicinal and culinary applications underscores its potential utility as a nutraceutical agent (Silalahi 2021).

A restricted distribution pattern was observed for four species within the family Asteraceae family, such as *G. jamesonii*, *E. sonchifolia*, *T. procumbens*, and *Y. japonica*, with each species confined to a single subdistrict. The ornamental cultivation of *G. jamesonii* may account for its limited distribution, a hypothesis supported by the research methodology, which entailed surveying primarily abandoned lands and roadside areas. *E. sonchifolia* was found solely in the Gajah Putih Subdistrict, suggesting a possible correlation with localized climatic conditions. This is corroborated by a study indicating optimal growth of *E. sonchifolia* in environments presenting an air temperature of 24.90°C and soil temperature of 26.90°C (Yuskianti et al. 2019). *T. procumbens* was exclusively reported in Timang Gajah, aligning with literature asserting that temperature ranges of 25 to 35°C are favorable for the species' seed germination and root development (Gyuimarães et al. 2000). Central Bureau of Statistics of Bener Meriah (2023) reported an average temperature of approximately 22°C for the region, leading to the inference that the relatively cool climate of the Gayo highlands may be constricting the dispersal of both *E. sonchifolia* and *T. procumbens*. Similarly, *Y. japonica* was only detected in Mesidah, resonating with research demonstrating its occurrence in areas with air temperatures between 18.02 to 21.97°C (Nasution and Junaedi 2017). The parallel between these reported temperatures and the regional climate conditions suggests that the limited presence of *Y. japonica* in the Gayo highlands can be attributed to the comparably cooler temperature spectrum prevalent in this locality.

The natural regeneration of the family Asteraceae encompasses a sequence of distinct phases, commencing with seed dispersal. Seeds of Asteraceae taxa are commonly endowed with specialized morphological structures, notably the pappus, a modified calyx fashioned to facilitate aeolian dissemination over extended distances. After dispersal, a period of seed dormancy typically ensues until appropriate environmental stimuli, such as fluctuations in thermal conditions or physical perturbances, precipitate its cessation. The termination of dormancy, in concert with optimal ambient conditions, leads to the initiation of seed germination. The seedlings that emerge enter a phase of competitive establishment, wherein their survival is contingent upon success in securing critical resources, including luminosity, aqueous substrates, and nutrients. Both biotic interactions and abiotic elements within their environments influence their developmental trajectories during this phase. Upon successful establishment, seedlings undergo vegetative expansion, transitioning into mature specimens through the elaboration of roots, shoots, and foliar organ structures imperative to photosynthesis and the continuation of growth. The maturity phase culminates in the reproductive stage, where floral development concludes with pollination and subsequent seed set, thereby perpetuating the species' natural regeneration cycle within the Asteraceae (Klimeš et al. 1997; Bond and Midgley 2001; Grime 2001).

The IVI of *A. conyzoides* within the Gayo Highlands presents congruence with findings delineated by Komara et al. (2016), wherein high dominion of the species was likewise recorded. Abiotic environmental variables, such as edaphic parameters, hydric availability, and photic intensity, influence the IVI metrics of Asteraceae taxa. Furthermore, biotic interactions, including interspecific competition and symbiotic relationships, are instrumental in shaping these dynamics. The exertion of ecological pressure, including herbivory and anthropogenic disruptions, for instance, agricultural practices and urban expansion, contributes significantly to the patterns of distribution and dominance among species of Asteraceae. This botanical family is integral to the fabric of vegetative community structures, augmenting ecosystem resilience via nutrient recycling processes and providing habitats to diverse biotic entities. Moreover, certain Asteraceae members are pivotal in sustaining pollinators and herbivores, reinforcing the integrity of local food webs.

This investigation accentuates the necessity for conservation attention directed toward species of Asteraceae with lower IVI, such as *S. oleaceous*, which may be susceptible to environmental fluctuations or human activities. The preservation of such taxa is imperative for the sustenance of both biodiversity and ecosystem functionality. Conservation strategies advocated include implementing habitat management practices that adhere to sustainability principles and initiatives purposed for ecosystem restoration, to bolster populations of at-risk species. In summation, the research elucidates the critical ecological role of Asteraceae species as reflected by their IVI calculations. Dominant species, exemplified by *A. conyzoides*, have exhibited robust adaptability to the local environmental milieu. Future studies must persist in monitoring IVI variances temporally and further elucidate additional determinants influencing Asteraceae species distribution and dominance.

The comparative analysis of the Asteraceae's species diversity within the Gayo Highlands, as set against diverse ecological systems, reveals a marked homogeneity. The Shannon-Wiener index points to a moderate diversity level within the Asteraceae population, analogous to the figures reported in North Denpasar (Bali) by Azzaroiha et al. (2022). A confluence of environmental determinants, encompassing resource distribution, pedological attributes, climatic factors, and ecological disturbances, modulates species variegation. Altitudinal gradients are pivotal in biodiversity, particularly at elevated locales where temperature dynamics significantly impact the Asteraceae's species assortment. Moreover, biotic factors, including competitive and predatory interactions, i.e. goats and cows, intrinsically shape constructs.

The Asteraceae's diverseness is instrumental to ecological steadfastness and systemic functionalities. Species of minor prevalence often fulfill specialized ecological niches, such as unique pollination mechanisms or creating habitats conducive to other life forms. The intrinsic high diversity fosters ecological resilience against environmental perturbations and transformations. Consequently, conservation strategies should be tailored to uplift species diversity, particularly species of lesser abundance, through protective measures, rehabilitative ecological endeavors, and mitigation of human-induced stressors, such as deforestation and urban sprawl. The findings from the Gayo Highlands suggest that the species diversification of Asteraceae aligns with a temperate bracket. This classification not only denotes a balance between species number and the proportional abundance of individuals but also intimates broader implications on the stability and well-being of the ecosystem. Such equilibrium indicates an ecosystem's capacity to accommodate an array of species, each playing a dynamic ecological role, supporting equilibrated biotic exchanges, and manifesting resilience in environmental shifts. The variegated array of environmental conditions and life interactions are the principal drivers of species diversity within the Asteraceae. The conservational ramifications underscore the necessity for tailored habitat stewardship and effective management practices to perpetuate biodiversity and preserve ecosystem services. Further scholarly inquiry into the long-term dynamics of species diversity under various environmental conditions is essential for an enriched comprehension of these intricate biological networks.

In conclusion, Asteraceae in Gayo Highland, Bener Meriah District has been identified 13 species, namely *Ageratum conyzoides*, *Bidens pilosa*, *Acmella uliginosa*, *Crassocephalum crepidioides*, *Galinsoga parviflora*, *Erigeron sumatrensis*, *Sonchus oleraceus*, *Synedrella nodiflora*, *Gerbera jamesonii*, *Sphagneticola trilobata*, *Emilia sonchifolia*, *Tridax procumbens*, and *Youngia japonica*. The species with the highest importance value index (IVI) is *A. conyzoides* (IVI=143.91) in Timang Gajah, and the lowest is *S. oleraceus* (IVI=3.53) in Pintu Rime Gayo. Asteraceae's average species diversity index at the study site was in the low category ($\hat{H}$=1.69). The highest diversity index was found in Gajah Putih ($\hat{H}$=1.98) and the lowest in Bukit ($\hat{H}$=1.44).

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