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PHYTOCHEMICAL PROFILING AND ANTIOXIDANT POTENTIAL OF FIVE MEDICINAL CONVOLVULACEAE SPECIES OF BANGLADESH

MD MUSHFIQUR RAHMAN, ARUP KARMOKAR, MD RIYADH AREFIN[1], AKM AZAD-UD-DOULA PRODHAN AND AKM GOLAM SARWAR*

Department of Crop Botany, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

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Abstract

Plants of the family Convolvulaceae are known for their medicinal properties and diverse phytochemical profiles. This study compared five native species of Bangladesh: *Evolvulus glomeratus* (Choisy) Nees and Mart., *Ipomoea batatas* (L.) Lam., *I. cairica* (L.) Sweet, *I. quamoclit* L., and *I. aquatica* Forssk. The analysis examined chlorophyll, carotenoids, anthocyanins, flavonoids, phenolics, tannins, proline contents, and antioxidant capacity. The results revealed significant variations among the species. *Evolvulus glomeratus* exhibited the highest levels of chlorophyll a (2.12 mg/g FW), total chlorophyll (2.65 mg/g FW), total phenolic (6.62 mg eq. GAE/100g FW), total flavonoid (6.41 mg eq. QUE/100g FW), tannin (4.63 mg/g FW), and antioxidant capacity (6.68 mg eq. AA/g FW). In contrast, *I. cairica* showed the lowest levels for chlorophyll a (0.47 mg/g FW), chlorophyll b (0.25 mg/g FW), total chlorophyll (0.72 mg/g FW), total carotenoids (0.94 mg/g FW), and total flavonoids (3.04 mg QE/g FW). This study emphasizes the phytochemical diversity of the Convolvulaceae family and its potential for nutraceutical and pharmaceutical applications, suggesting that future research should isolate specific compounds to assess their pharmaceutical potential.

Introduction

Phytochemicals are crucial plant constituents that enhance defense mechanisms and possess therapeutic potential. Phenolic compounds are known for their antioxidant properties, while flavonoids exhibit anti-inflammatory, antimicrobial, and anticancer effects, making them important in drug discovery and development (Mohanraj and Sivasankar 2014).

Convolvulaceae is one of the major families of flowering plants with approximately 2,000 species, classified into 60 genera and 12 tribes, and includes many plants of medicinal, nutritional, and ecological importance (Staples and Brummitt 2007). Members of this family are primarily found in the tropical and subtropical regions and have been used in traditional medicine to treat a range of ailments (Stefanović *et al.* 2003). The genera *Evolvulus* and *Ipomoea* are known for their diverse phytochemical profiles and pharmacological potentials. Plants of the family contain various organic compounds, including alkaloids, flavonoids, tannins, terpenoids, steroids, and carbohydrates, which are synthesized through metabolic pathways and exert distinct physiological effects on the human body (Edeoga *et al*. 2005, Sultana and Rahman 2016). Secondary metabolites are known for their structural diversity and a wide range of biological activities. They have applications in pharmaceuticals, agriculture, and research, and they exhibit antimicrobial efficacy *in vitro* across various chemical groups/classes (Cowan 1999, Vasu *et al.* 2009).

The rich biodiversity and longstanding tradition of herbal medicine in Bangladesh offer over 1,200 medicinal and aromatic plant (MAP) species used in folk and traditional practices (Sarwar 2020, Sarwar *et al*. 2025). However, comprehensive phytochemical, pharmacological, and toxicological studies remain lacking for many of these species (Ghani 2003, Yusuf *et al.* 2009). Recently, phytochemical analyses of several MAPs have been conducted and published (Sarwar

*Author for correspondence: <drsarwar@bau.edu.bd>. [1]Botany Division, Bangladesh Tea Research Institute, Sreemangal-3210, Bangladesh.

et al. 2023, Fakir *et al.* 2025, Islam *et al.* 2025). This study aims to explore and compare the phytochemical composition and antioxidant potential of *Evolvulus glomeratus*, *Ipomoea batatas*, *I. cairica*, *I. quamoclit*, and *I. aquatica*.

Material and Methods

Fresh leaves from mature plants were collected from the Botanical Garden of Bangladesh Agricultural University for analysis in June to July 2024. The experiment was carried out using a completely randomized design, with three replicates from each of three plants. Fresh samples were used to determine pigment content, whereas methanolic leaf extracts were used to assess phenol, flavonoid, antioxidant capacity, tannin, and proline levels. Fifty mg of leaf samples were placed in 10 ml of 80% ethanol and kept in the dark for seven days for pigment analysis. The concentrations of plant pigments (chlorophyll a, chlorophyll b, total chlorophyll, total carotenoids, and total anthocyanin) were expressed as mg/g of fresh weight (FW) and quantified by the equations provided by previous studies (Afify and Hassan 2016). Again, 50 mg of the fresh leaf sample was ground in 2.5 ml of methanol, and the mixture was centrifuged at 12,000 rpm for 5 minutes to obtain methanolic leaf extracts (Islam *et al*. 2025). Total phenolic compounds (TPC) and total flavonoid contents (TFC) were estimated by the Folin-Ciocalteu reagent (FCR) method (Singleton *et al.* 1999) and Aluminum Chloride ($AlCl_3$) colorimetric assay method (Arvouet-Grand *et al.* 1994), respectively. The phosphomolybdenum assay (Prieto *et al*. 1999), the FCR method (Mythili *et al.* 2014), and the ninhydrin colorimetric method (Bates *et al.* 1973, Hussain *et al.* 2025) were used to determine total antioxidant activity (TAC), total tannin content, and proline content in the collected species. Moreover, TPC, TFC, TAC, tannin, and proline contents were expressed as mg/g of gallic acid equivalent (mg GAE/g FW), mg/g of quercetin equivalent (mg QE/g FW), mg/g of ascorbic acid equivalent (mg AA/g FW), mg/g of gallic acid equivalent (mg GAE/g FW), and µg/g FW, respectively.

The analysis of variance (ANOVA) and pairwise comparison (Tukey's HSD) tests were conducted by ‘Statistix 10’ statistical software. All the graphs were prepared using ‘Microsoft Excel 2019’, and the two-way clustering heatmap with dendrogram was created using the ‘OriginPro 2025' software.

Results and Discussion

The analysis of variance (ANOVA) revealed highly significant variations among species for all traits (Table 1). The low error mean squares and low-to-moderate coefficient of variation (CV %) indicated that the current investigation was conducted with good precision. The given LSD values suggested effective discrimination among species means for all phytochemical parameters.

The total phenolic content (TPC) varied significantly among the tested species, ranging from 1.31 to 6.62 mg GAE/g FW. *Evolvulus glomeratus* exhibited the highest concentration (6.62 mg GAE/g FW), followed by *I. aquatica* (3.32 mg GAE/g FW), *I. batatas* (2.71 mg GAE/g FW), and *I. cairica* (2.26 mg GAE/g FW). The species *I. quamoclit* had the lowest TPC, 1.31 mg GAE/g FW (Fig. 1A). These differences highlight the influence of genetic diversity, species-specific metabolic pathways, and environmental adaptations on phenolic biosynthesis and accumulation. This observation is consistent with existing literature on various plant taxa (Rai and Kon 2013). The high phenolic content in *E. glomeratus* is associated with its strong antioxidant potential. Phenolics can donate hydrogen atoms or electrons to neutralise free radicals, thereby mitigating oxidative damage (Pistelli and Giorgi 2012, Arefin *et al.* 2025). In contrast, the lower phenolic content in *I. quamoclit* suggests a reduced antioxidant capacity, which may impact its ecological interactions and medicinal properties.

Table 1. Analysis of variance of phytochemical traits of *Evolvulus glomeratus* and *Ipomoea* species.

Phytochemical parameters	df (Var/ Error)	MS (Variety)	MS (Error)	F-value	CV (%)	LSD (5%)
Chlorophyll a	4 / 8	1.30479	0.00205	638.04	2.87	0.1273
Chlorophyll b	4 / 8	0.05061	0.00063	79.70	5.23	0.0710
Total chlorophyll	4 / 8	1.83201	0.00774	236.85	4.27	0.2476
Total carotenoids	4 / 8	3.81300	0.01200	317.62	4.07	0.3085
Total anthocyanin	4 / 8	0.06306	0.00020	323.38	10.12	0.0393
Total phenolic compound	4 / 8	12.2977	0.0567	159.61	7.34	0.6704
Total flavonoid content	4 / 8	6.25974	0.03922	216.97	4.18	0.5576
Total antioxidant capacity	4 / 8	9.24411	0.03221	287.04	4.65	0.5053
Total Tannin	4 / 8	5.92107	0.00337	1756.12	2.62	0.1635
Proline	4 / 8	19546.4	10.6	1844.92	4.01	9.1652

df: degrees of freedom, MS: mean square, F-value: ratio of variance among species to variance within species (error), CV (%): coefficient of variation, LSD: least significant difference at 5% significance level.

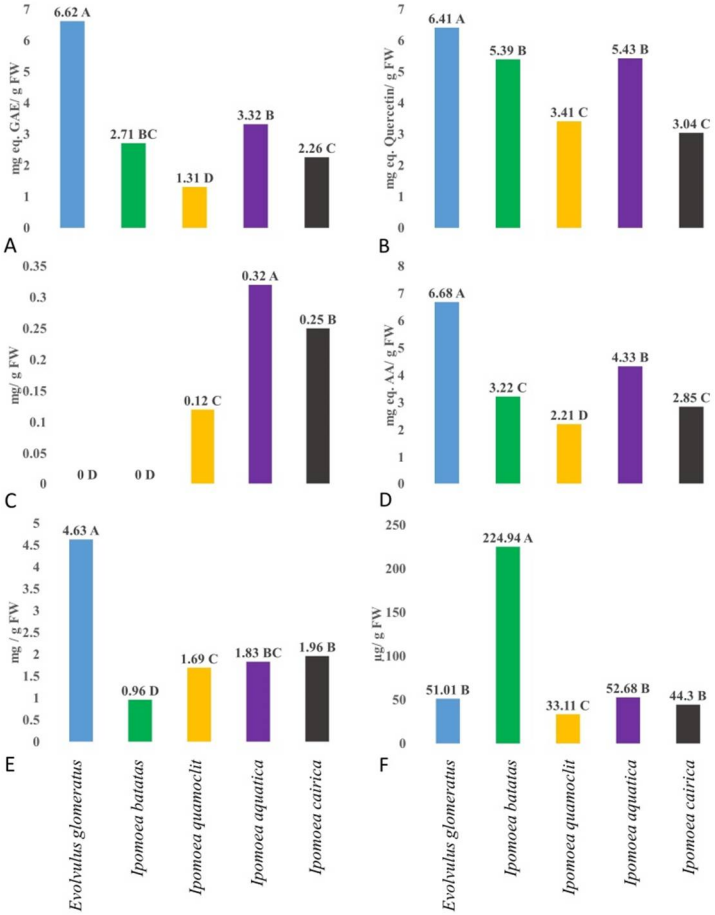

Fig. 1. Phytochemical profile of *Evolvulus glomeratus* and *Ipomoea* species: (A) total soluble phenolic content, (B) total soluble flavonoid content, (C) total anthocyanin content, (D) total antioxidant capacity, E: Total tannin content and, (F) total proline content. Bars sharing different letters are significantly different from each other at $P \leq 0.05$.

Evolvulus glomeratus has the highest flavonoid content, averaging 6.41 mg QUE/g FW, surpassing other species and suggesting its potential as a valuable source of bioactive flavonoids (Fig. 1B). Lower concentrations were found in *I. quamoclit* (3.41 mg QUE/g FW) and *I. cairica* (3.04 mg QUE/g FW). This aligns with previous studies that highlight variability in flavonoid levels across species and plant parts, driven by factors such as genetic diversity, ecological conditions, and developmental stages (Ma *et al*. 2024). The high levels of flavonoids in *E. glomeratus* may further support its traditional medicinal uses, given their antioxidant and anti-inflammatory properties. Additionally, differences in total flavonoid content correlate with variations in related phytochemicals, including chlorophylls, carotenoids, and anthocyanins. These phytochemicals collectively impact the plants' antioxidant potential and health benefits. Notably, *E. glomeratus* has the highest levels of chlorophyll a and total chlorophyll, which may be linked to enhanced flavonoid biosynthesis pathways (Fig. 2A, C).

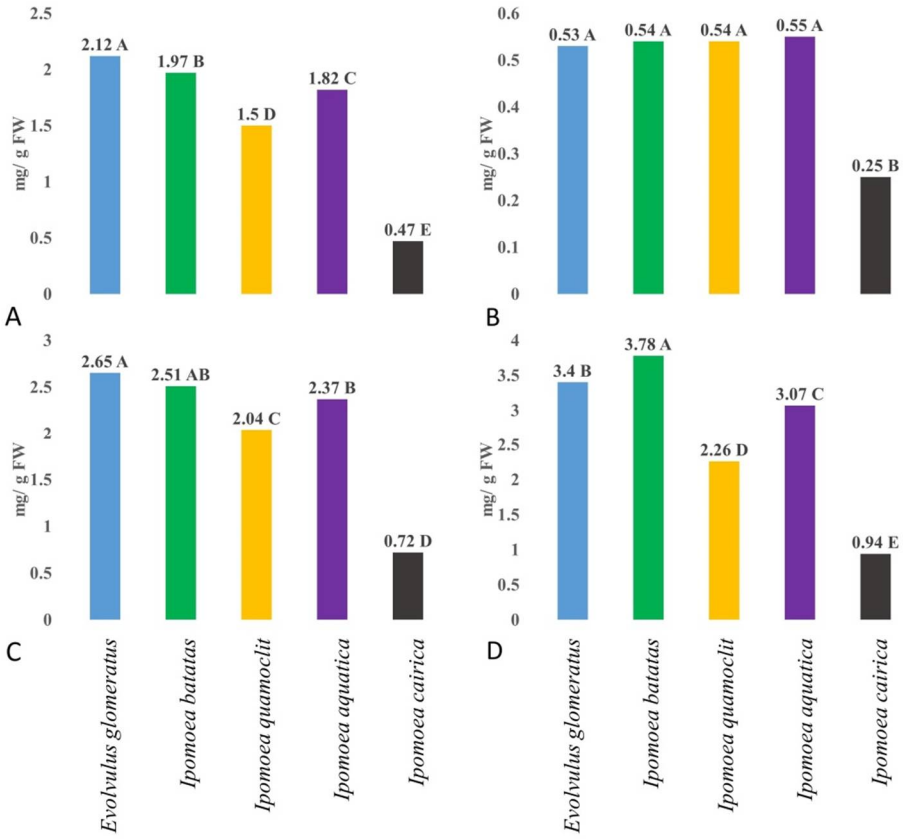

Fig. 2. Leaf pigment profile of *Evolvulus glomeratus* and *Ipomoea* species. A: Chlorophyll a content, B: Chlorophyll b content, C: Total chlorophyll content and D: Total carotenoid content.

Regarding anthocyanin content, *I. aquatica* had the highest level at 0.32 µg/g FW, followed by *I. cairica* at 0.25 µg/g FW. *Ipomoea quamoclit* displayed a moderate level at 0.12 µg/g FW, while both *E. glomeratus* and *I. batatas* showed no detectable anthocyanins (0.00 µg/g FW) (Fig. 1C).

The total antioxidant capacity (TAC) of five Convolvulaceae species varied significantly, ranging from 2.21 to 6.68 mg AAE/g FW (Fig. 1D), indicating distinct antioxidant potentials among them. This family has attracted attention for its antioxidant properties, with multiple studies revealing beneficial TAC levels. Once again, *E. glomeratus* had the highest antioxidant capacity (6.68 mg AAE/g FW), followed by *I. aquatica* (4.33 mg AAE/g FW), *I. batatas* (3.22 mg AAE/g FW), and *I. cairica* (2.85 mg AAE/g FW). *I. quamoclit* recorded the lowest TAC at 2.21 mg AAE/g FW (Fig. 1D). Notably, *E. glomeratus* showed potent antioxidant activity due to its polyphenolic compounds, while *I. aquatica* demonstrated significant antioxidant potential, especially in acetone extracts. These findings underscore the promise of the Convolvulaceae family as a natural source of antioxidants, which may contribute to human health and disease prevention.

The study found significant variation in tannin content among selected species, with values ranging from 0.96 to 4.63 mg GAE/g FW (Fig. 1E). *Evolvulus glomeratus* had the highest concentration of tannins at 4.63 mg GAE/g FW, followed by *I. cairica* at 1.96 mg GAE/g FW and *I. aquatica* at 1.83 mg GAE/g FW. *I. quamoclit* displayed moderate tannin content at 1.69 mg GAE/g FW, while *I. batatas* had the lowest concentration at 0.96 mg GAE/g FW. The presence of tannins and anthocyanins across various Convolvulaceae species highlights their biochemical diversity. Tannins serve as a defense mechanism against herbivores and pathogens, whereas anthocyanins provide pigmentation and enhance antioxidant capacity (Kowalska 2011). The highest proline accumulation (224.94 µg/g FW) was observed in *I. batatas*, indicating a strong osmo-protective response to environmental stress (Fig. 1F). This was significantly higher than in the other species examined. However, *I. aquatica* (52.68 µg/g FW), *E. glomeratus* (51.01 µg/g FW), and *I. cairica* (44.30 µg/g FW) possessed moderate amounts of proline, while *I. quamoclit* recorded the lowest proline content at 33.11 µg/g FW (Fig. 1F).

The current investigation examining chlorophyll a content in leaf tissues of five Convolvulaceae species found significant variation, with concentrations ranging from 0.47 to 2.12 mg/g FW (Fig. 2A). *Evolvulus glomeratus* had the highest concentration at 2.12 mg/g FW, followed by *I. batatas* at 1.97 mg/g FW and *I. aquatica* at 1.82 mg/g FW. *Ipomoea quamoclit* exhibited moderate levels at 1.50 mg/g FW, while *I. cairica* had the lowest concentration at 0.47 mg/g FW. Chlorophyll b content also varied significantly among the five species; *I. aquatica* exhibited the highest chlorophyll b content (0.55 mg/g FW), closely followed by *I. quamoclit* and *I. batatas*, both at 0.54 mg/g FW, as well as *E. glomeratus* at 0.53 mg/g FW (Fig. 2B). These four species demonstrated no statistically significant differences in chlorophyll b content. In contrast, *I. cairica* showed the lowest chlorophyll b content at 0.25 mg/g FW. Again, among the species studied, *I. batatas* had the highest total carotenoid concentration, 3.78 mg/g FW, followed by *E. glomeratus* (3.40 mg/g FW) and *I. aquatica* (3.07 mg/g FW). *Ipomoea quamoclit* contained 2.26 mg/g FW, while *I. cairica* had the lowest, 0.94 mg/g FW (Fig. 2D).

A two-way clustering heatmap was constructed to demonstrate relationships among species based on measured biochemical traits (Fig. 3). The five MAPs studied formed three major clusters: Cluster-1 (C-1), Cluster-2 (C-2), and Cluster-3 (C-3). The C-1 comprised *E. glomeratus* and *I. batatas*, which exhibited higher concentrations of major phytochemicals. The C-2 included *I. quamoclit* and *I. aquatica*, characterized by moderate phytochemical concentrations. *I. cairica* was separated into C-3, reflecting a relatively lower amount of most phytochemicals, except for total anthocyanins. In the other direction, photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophyll, and total carotenoids) and total flavonoid content showed a closer association, which grouped into Group-1 (G-1). In contrast, the remaining measured attributes, such as total anthocyanin, total phenolic compounds, total antioxidant capacity, total tannins, and proline content, were interrelated and grouped together as G-2.

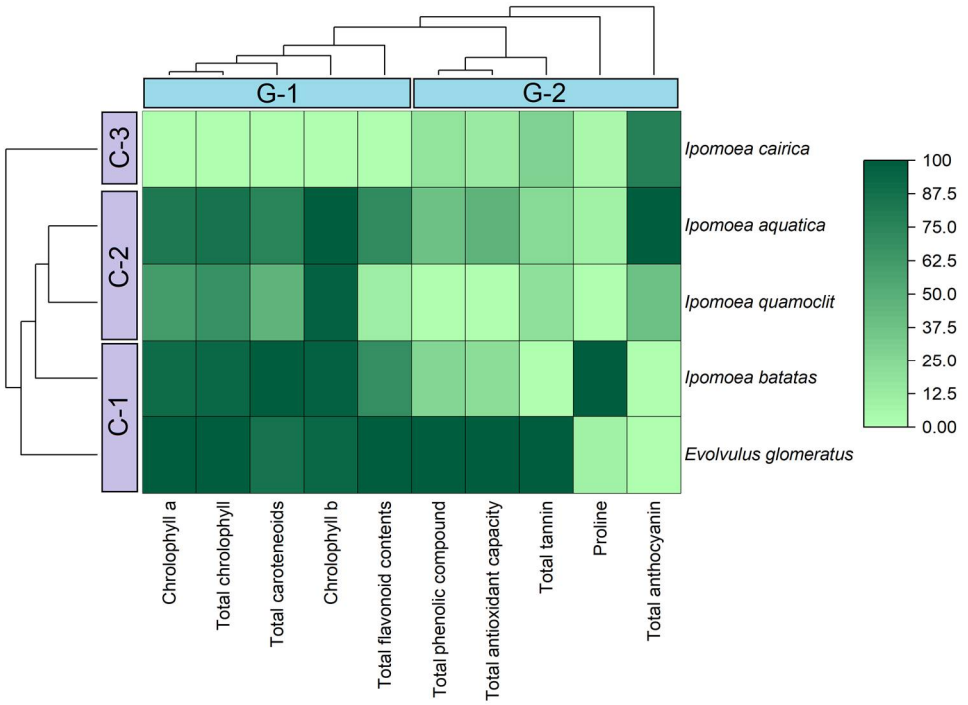

Fig. 3. Two-way clustering heatmap with dendrogram showing the classification of species and traits. The phytochemical constituents were normalized to a 0 to 100 scale and represented as low to high levels using light green to dark green colours, respectively.

Members of the family Convolvulaceae exhibit significant biochemical diversity, especially in photosynthetic pigments and secondary metabolites. Notably, *E. glomeratus* contains the highest levels of bioactive compounds, including phenolics, flavonoids, and antioxidants, highlighting its pharmacological potential. In contrast, *I. batatas* shows high proline and carotenoid content, indicating stress resilience and nutritional benefits. The study highlights the pharmacological and nutritional potential of members of the Convolvulaceae and recommends further research to isolate and evaluate their compounds.

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