ISSN: 1656-4707
E-ISSN: 2467-5903
Homepage: www.palawanscientist.org

Agromorphological and phytochemical variations of *Orthosiphon aristatus* (Blume) Miq. morphotypes in the Philippines

Gio Jenel M. Umali[1]*, Renerio P. Gentallan Jr.[1]*, Ericka Jane R. Pasamba[1], Kristine Joyce O. Quiñones-Arribado[3], Michael Cedric B. Bartolome[1], Daryl B. Ceribo[1], Andrea Mae G. Abiva[1], Leah E. Endonela[1], Nadine B. Coronado[3], Emmanuel Bonifacio S. Timog[4], Roselle E. Madayag[2], Jessabel B. Magtoltol[2], Kristen Danielle R. Cabarong[1], and Teresita H. Borromeo[1]

[1]1Institute of Crop Science, College of Agriculture and Food Science, University of the Philippines Los Baños (UPLB), College, Laguna, Philippines 4031;
[2]Agricultural Systems Institute, College of Agriculture and Food Science, University of the Philippines Los Baños (UPLB), College, Laguna, Philippines;
[3]Institute of Biological Sciences, College of Arts and Sciences, University of the Philippines Los Baños (UPLB), College, Laguna, Philippines;
[4]Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines Los Baños (UPLB), College, Laguna, Philippines

**Corresponding Author: gmumali1@up.edu.ph; rpgentallan@up.edu.ph*

Received: 25 June 2025 || Revised: 04 Sep. 2025 || Accepted: 29 Dec. 2025 || Available online: 27 Jan. 2026

How to cite:
Umali GJM, Gentallan Jr RP, Pasamba EJR, Quiñones-Arribado KJO, Bartolome MCB, Ceribo DB, Abiva AMG, Endonela LE, Coronado NB, Timog EBS, Madayag RE, Magtoltol JB, Cabarong KDR, Borromeo TH. 2026. Agromorphological and phytochemical variations of *Orthosiphon aristatus* (Blume) Miq. morphotypes in the Philippines. The Palawan Scientist. 18(1): 38-47. https://doi.org/10.69721/TPS.J.2026.18.1.04

ABSTRACT

Orthosiphon aristatus (Blume) Miq. is a medicinal plant valued for its diuretic properties and potential benefits in treating kidney and urinary diseases in the Philippines. Similar to other plants, intraspecific variation exists in *O. aristatus*, which often leads to ambiguity in the genotype utilized and hinders its effective utilization. Hence, we characterized and evaluated the agromorphological and phytochemical properties of three Philippine accessions of *O. aristatus* with different inflorescence colors through a field trial conducted in a completely randomized design, to select promising accessions that could serve as genetically stable reference materials. Differences were observed in 22 out of 31 quantitative traits, while variation occurred in 12 out of 18 qualitative traits. Phytochemical traits were negatively correlated with biomass. Philippine Biorepository Network (PBN) 2019-119 (white morphotype) exhibited the highest leaf count of 2,001.75 ± 311.40 per plant, shoot number of 53.25 ± 6.65 g/plant, and dry leaf yield of 25.16 ± 3.99 g/plant. However, PBN 2018-073 (purple morphotype) had the highest total flavonoid content of 31.05 ± 1.83 mg QE/g extract and rosmarinic acid content of 2.957 ± 0.22 mg/200 g sample. Based on both agronomic and phytochemical traits, PBN 2019-119 was identified as the most promising genotype, with a high agronomic yield and intermediate phytochemical content. This is the first study to evaluate *O. aristatus* accessions in the Philippines. It highlights the importance of understanding infraspecific variation in *O. aristatus* to improve its utilization and conservation.

Keywords: balbas pusa, Lamiaceae, rosmarinic acid, yield, and yield components

INTRODUCTION

Balbas pusa *Orthosiphon aristatus* (Blume) Miq. is a perennial medicinal herb native to tropical and subtropical Asia and Australia, including the Philippines, in the family Lamiaceae (POWO 2022). An erect, ascending herb that can grow up to 2 m tall, *O. aristatus* generally has 4-angled stems with hairs on younger parts and becomes glabrous when woody. It has narrowly elliptic to ovate leaves, terminal inflorescences up to 25 cm long, and white, pale-lilac, or lilac flowers. Its nutlets are broadly oblong and compressed (Bramley 2019).

The leaves are commonly brewed into a tea remedy for bacterial and urinary tract infections, inflammation, hypertension, rheumatism, and jaundice, due to their diuretic, antioxidant, and anti-inflammatory properties (Hsu et al. 2010; Dayrit and Guidote 2016). Several preclinical studies supporting its use in the traditional medical system have been conducted in Malaysia (Akowuah et al. 2005; Seyedan et al. 2017). These biological activities have been primarily attributed to phenolics and flavonoids, particularly sinensetin and rosmarinic acid (Tezuka et al. 2000; Olah et al. 2003; Akowuah et al. 2005). More than 20 phenolic compounds, including lipophilic flavones, flavonol glycosides, and caffeic acid, have been isolated from this plant. Rosmarinic acid, an ester of caffeic acid present in *O. aristatus*, gained primary interest because of its antioxidant, anti-inflammatory, antimicrobial, anticancer, and antiangiogenic activities (Gamaro et al. 2011). However, many studies mention *O. aristatus* only by its scientific name without properly identifying the genotype or morphotype. This is problematic because *O. aristatus* has synonyms commonly in literature, including *Orthosiphon stamineus* Benth. and *Oryctanthus spicatus* (Jacq.) Eichler. Consequently, literature searches may yield overlapping results under these three scientific names, which refer to the same botanical species. Findings for *O. aristatus* can then be expected from extensive reports under *O. stamineus* and *O. spicatus*.

The *O. aristatus* has two accepted infraspecifics, namely *O. aristatus* var. *aristatus* and *O. aristatus* var. velteri Suddee & A.J.Paton (POWO 2022). The variety *aristatus* has petiolate leaves with a cuneate base, acute bracts, and an acuminate or cuspidate apex (Suddee et al. 2004). Meanwhile, variety *velteri* has sessile or subsessile leaves, usually a truncate base, and bracts with a truncate or apiculate apex. In Indonesia, three morphotypes of *O. aristatus* have been identified based on color of their flowers: white, purple, and intermediate (white-purple) (Faramayuda and Mariani 2022).

In the production of medicinal products, mixtures of different genotypes are commonly practiced due to a lack of reference plant material (DOST-PCHRD 2022). This recurring problem in medicinal plant production, where infraspecific variation is often overlooked, causes ambiguity and misidentification, which could result in poor utilization. Therefore, characterization and evaluation of *O. aristatus* germplasm will elucidate genotypic traits that aid proper identification and ensure appropriate genetic resources are utilized.

The environment, genetic composition, and their interaction influence the quality, yield, and diversity of phytochemicals in medicinal plants (Ncube et al. 2012); thus, it is essential to determine the most suitable types for specific environmental conditions. Lee (2004) reported that purple-flowered *O. aristatus* had more abundant bioactive compounds than the white morphotype. Hence, we hypothesize that the white-flowered and purple-flowered morphotypes of *O. aristatus* in the Philippines differ significantly in their agromorphological and phytochemical traits.

In the Philippines, *O. aristatus* is a commonly used medicinal plant. Its leaves are boiled to treat dysentery and kidney troubles (Dayrit and Guidote 2016). The Food and Drug Administration (FDA)-approved herbal teas and food supplements containing *O. aristatus* are sold in the Philippines (FDA 2020). Despite its wide utilization, morphotype variation also exists in the country. Thus, we aim to elucidate the agromorphological and phytochemical variation among selected Philippine accessions of *O. aristatus* and to identify promising genotypes that could be utilized as genetically stable raw material sources for herbal production and research.

METHODS

Environmental Data During Characterization and Evaluation

Data on the climatic factors in the field were gathered from the Agrometeorological Station University of the Philippines Los Baños (UPLB). At the same time, the soil analysis of the plot was conducted at the College of Agriculture and Food Science-Agricultural System Institute (CAFS-ASI) Analytical Services Laboratory. The soil had medium to high organic matter content, calcium, and cation exchange capacity; medium to low total nitrogen; low phosphorus; and high to medium potassium. The soil was composed of 26-33% sand, 36-42% silt, and 25-39% clay.

Planting Materials and Experimental Design

Herbarium specimens of *O. aristatus* accessions were prepared to verify plant species identity. These exhibited typical characteristics of *O.*

aristatus var. *aristatus* with petiolate leaves, cuneate base, acute bracts, acuminate or cuspidate apex, and exserted stamens extending more than 2 cm from the corolla tube (Suddee et al. 2005; Bramley 2019). The voucher specimens used in the study were deposited at the Philippine Herbarium of Cultivated Plants, Institute of Crop Science, UPLB, under the identification numbers ICROPS-ID-2018-073, ICROPS-ID-2019-119, and ICROPS-ID-2019-571.

Plots for three preselected *O. aristatus* accessions (Table 1) were established at the ICropS field genebank, CAFS, UPLB (N 14 °09'47" E 121 °14'48") from 10 May to 27 September 2024, following a completely randomized design (CRD) with two replicates per accession, which were utilized for agromorphological and phytochemical evaluation. Each replicate was set up in a 3 m × 2 m plot with 0.60 m spacing between plants. Two plants were sampled per replicate. The accessions were propagated from three-node stem cuttings approximately 20 cm in length, initially planted in pots inside a greenhouse and then transplanted to the field after 21 days.

Characterization and Evaluation of Agromorphological Traits

Traits were observed and measured at reproductive maturity, approximately 14 weeks after transplanting, when 80% of the population was flowering. Using a preliminary descriptor list, 29 quantitative and 18 qualitative agromorphological characteristics were recorded (Zainuddin et al. 2023). The Royal Horticultural Society color chart (Royal Horticultural Society 2015) was used to describe the color of plant parts. Quantitative characteristics were reported as mean ± standard error of the mean.

Phytochemical Screening

Phytochemicals were screened from ethanolic extracts. Leaves were dried at 50°C using a forced convection oven. After drying, the leaves were ground with a mortar and pestle and sieved using Mesh #18. For each replicate, 10 g of sample was macerated with 200 mL of 70% ethanol. The mixture was sonicated and filtered. The ethanolic solution was then evaporated at 45°C in a forced-convection oven to obtain a crude extract. These extracts were sealed, labeled, and refrigerated for subsequent analyses.

Detection of flavonoids. A mixture of 2.0 mL of stock extract solution and 1.0 mL of 0.1 N NaOH solution was prepared in a test tube. The development of yellow coloration indicated the presence of flavonoids.

Detection of saponins. A test tube was filled with 5.0 mL of stock extract solution and covered with parafilm. It was then shaken vigorously for about 3 minutes, left to stand for 5 minutes, and observed for frothing. The presence of saponins was confirmed when the froth persisted for 5 to 10 minutes.

Detection of tannins. A test tube containing 2.0 mL of stock extract solution was treated with 5 to 10 drops of 1% $FeCl_3$ solution. The appearance of a blue-to-black color indicated the presence of tannins.

Detection of alkaloids. A mixture of 5.0 mL of stock extract solution and 5.0 mL of 0.1 N HCl solution was prepared in a test tube. The solution was placed in a water bath and agitated for 2 minutes until a color alteration occurred. While still warm, it was filtered using coarse filter paper. The filtrate was collected, and 10 drops of Wagner's reagent were added. The solution was then left to stand for 5 minutes. The formation of a red to brown precipitate indicated the presence of alkaloids.

Total Flavonoid Content (TFC) Determination

Serial dilutions of quercetin were prepared using 70% ethanol at concentrations between 0.96 µg/mL and 0.025 µg/mL. For the standard solution, 0.5 mL of quercetin solution, 1.5 mL of 70% ethanol, 0.1 mL of 10% aluminum chloride, and 0.1 mL of 1M potassium acetate were transferred to a test tube, then brought to volume by adding 2.8 mL of distilled water. The blank contained the same solution as the standard without quercetin. Absorbance values were measured in a 10-mm cuvette using a spectrophotometer (DeNovix® DS-11+). The wavelength with the highest quercetin absorbance was used to plot the calibration curve and obtain the linear equation for quantifying quercetin equivalence (mg QE/g extract) of the *O. aristatus* samples.

High Performance Thin Layer Chromatography (HPTLC) of Rosmarinic Acid

The solvent system consisted of toluene, ethyl acetate, formic acid, and water in a ratio of 3:3:1:0.2. The sample solution was prepared by dissolving 200 mg of the sample in 10 mL of 98% ethanol and sonicated to ensure complete dissolution. A 5 µL of the rosmarinic acid, together with the standards, was spotted onto the HPTLC plate.

Table 1. *Orthosiphon aristatus* accessions used in this study. *Based on inflorescence color (Faramayuda and Mariani 2022).

Accession no.	Morphotype*	Municipality
PBN 2018-073	Purple	Lobo, Batangas
PBN 2019-119	White	Castillejos, Zambales
PBN 2019-571	White	Guindulman, Bohol

Then, dried at 65°C for 30 minutes using a hot plate. The TLC plate was then placed in a developing chamber saturated with the solvent system and dried at 60°C for 5 minutes using a TLC plate heater III. The plate was visualized under UV light at 254 nm and 365 nm using a TLC Visualizer 2, and densitometric scanning was performed at 328 nm. Additionally, the concentration of rosmarinic acid was further analyzed using the Gelanalyzer 23.1.1 by uploading the image of the plate under 365 nm UV light.

Statistical Analyses

To determine differences among accessions, parametric statistical testing via analysis of variance (ANOVA) was conducted. Prior to this, the Shapiro-Wilk test and Levene's test were used to assess normality and homogeneity of variances, respectively. When assumptions were met, ANOVA was followed by pairwise-mean comparison using Tukey's Honest Significant Difference (HSD) test at 5% significance level. The non-parametric Kruskal-Wallis test was used for variables that did not meet the assumptions, followed by pairwise comparison using Dunn's test with Bonferroni correction at the same significance level. Principal component analysis (PCA) using a Pearson correlation matrix was performed to summarize the agromorphological and phytochemical evaluation data, and select the promising genotypes. Analyses were performed using XLSTAT 2016.

RESULTS

Agromorphological Characteristics of *O. aristatus*

Morphological trait differences. Morphological differences were observed among the three accessions (Figure 1, Table 2). The PBN 2018-073 has purple inflorescence, whereas PBN 2019-119 and 2019-571 both exhibit white inflorescences. Additionally, PBN 2018-073 is distinguished by the purple coloration of the flowers, calyces, and leaf veins (Table 3). Another unique trait that differentiates the accessions is leaf shape: PBN 2018-073 and 2019-571 possess rhomboid leaves, while PBN 2019-119 has elliptic leaves. These trait variations between accessions were consistent and observed in their mother plants and asexually propagated individuals in different plots (replicates). Thus, these phenotypic variations are highly stable and indicate genetic differences among the selected accessions.

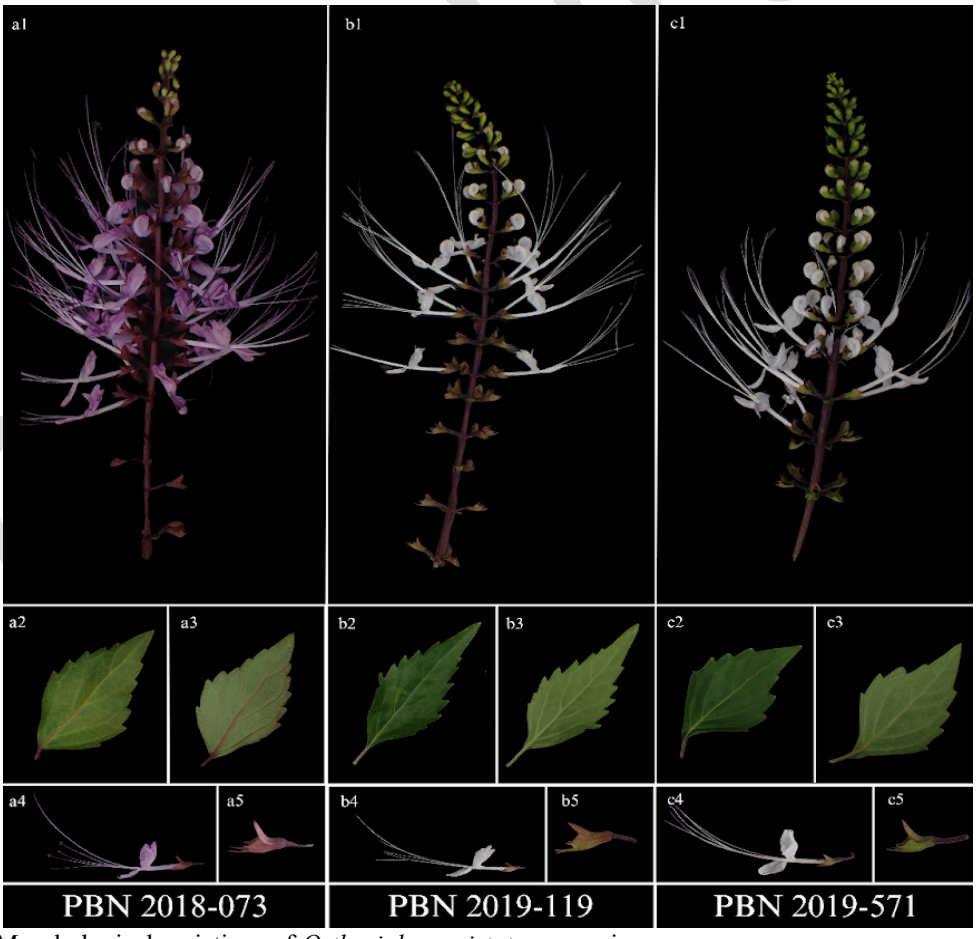

Figure 1. Morphological variations of *Orthosiphon aristatus* accessions.

Table 2. Qualitative morphological characteristics of *Orthosiphon aristatus.*

Character	PBN Accession No.		
	2018-073	**2019-119**	**2019-571**
Growth habit	Erect	Semi-erect	Erect
Stem color	Reddish	Reddish	Reddish
Anthocyanin coloration in stem	Strong	Weak	Weak
Leaf shape	Rhomboid	Elliptic	Rhomboid
Anthocyanin coloration in the leaf	Present	Absent	Absent
Leaf shape base	Oblique	Oblique	Oblique
Leaf apex shape	Acute	Acuminate	Acute
Leaf color	Green	Green	Green
Leaf vein color	Purple	Light green	Light green
Leaf glossiness	Weak	Weak	Weak
Leaf undulation of margin	Very Weak	Very Weak	Very Weak
Corolla color	Purple	White	White
Calyx color	Purple	Light Green	Light Green
Corolla tube hairiness	Dense	Dense	Dense
Upper calyx degree of anthocyanin	Strong	Moderate	Moderate
Filament color	Dark Violate	White	White
Style color	Dark Violate	White	White
Stigma shape	Close	Close	Close

Table 3. Quantitative morphological characteristics of *Orthosiphon aristatus.* Measurements reported as mean ± SEM (n = 10); ^{a,b,c} indicate significant differences in ANOVA; ^{x,y,z} indicate significant differences in Kruskal-Wallis at $\alpha = 0.05$.

Character	PBN Accession No.		
	2018-073	**2019-119**	**2019-571**
Leaf blade length (mm)	29.71 ± 0.69^{x}	56.975 ± 2.35^{y}	49.271 ± 0.92^{y}
Leaf blade width (mm)	17.44 ± 0.65^{b}	25.922 ± 1.20^{a}	28.834 ± 0.98^{a}
Roundness of leaf	0.51 ± 0.01^{x}	0.43^{y}	0.48 ± 0.01^{xy}
Solidity of leaf	0.89 ± 0.01^{x}	0.85^{y}	0.88^{xy}
Petiole length (mm)	3.91 ± 32^{x}	7.097 ± 0.50^{y}	9.809 ± 0.58^{y}
Number of days to flowering	65	77	66
Corolla tube length (mm)	19.66 ± 0.69^{x}	11.828 ± 0.25^{y}	11.705 ± 0.42^{y}
Corolla tube diameter (mm)	1.38 ± 0.06^{b}	1.443 ± 0.07^{b}	1.791 ± 0.06^{a}
Lower lip length (mm)	8.6 ± 0.46^{b}	8.392 ± 0.29^{b}	10.091 ± 0.38^{a}
Lower lip width (mm)	2.61 ± 0.16	2.856 ± 0.28	3.268 ± 0.32
Upper lip length (mm)	8.88 ± 0.18	8.292 ± 0.31	9.161 ± 0.27
Upper lip width (mm)	8.14 ± 0.18	8.142 ± 0.32	8.282 ± 0.59
Calyx length (mm)	6.62 ± 0.17^{b}	7.19 ± 0.17^{a}	6.347 ± 0.30^{b}
Calyx opening width (mm)	4.65 ± 0.14^{b}	5.148 ± 0.19^{a}	4.379 ± 0.16^{b}
Pedicel length (mm)	3.87 ± 0.15	3.955 ± 0.31	4.052 ± 0.16
Stigma length (mm)	57.82 ± 1.62^{y}	57.591 ± 3.16^{y}	46.486 ± 1.24^{x}

Yield performance. There were significant differences in dry leaf yield among the three *O. aristatus* accessions. Specifically, PBN 2019-119 (white-flowered) produced the highest dry leaf yield of 25.16 ± 7.99 g/plant, compared to the purple-flowered PBN 2018-073, which produced only 7.23 ± 2.16 g/plant (Table 4). The PBN 2019-119 also had higher plant height, number of branches, leaf number, and leaf area per plant. However, no significant difference was found in dry leaf yield between the accessions with white inflorescences.

Phytochemical Content of *O. aristatus*

Flavonoids, tannins, saponins, and alkaloids were detected in all accessions (Table 5). Quantitative differences were observed in the TFC and rosmarinic acid levels. The highest TFC was found in PBN 2018-073 (31.05 ± 1.83 mg QE/g extract), while the lowest was observed in PBN 2019-571 (26.06 ± 1.76 mg QE/g extract). Similarly, the highest rosmarinic acid concentration was found in PBN 2018-073 (2.957 ± 0.22 mg/200g sample), whereas the lowest was observed in PBN 2019-571 (1.594 ± 0.09 mg/200g sample).

The HPTLC chromatogram of *O. aristatus* accessions under 365 nm UV light revealed that PBN 2019-119 and 2019-571 contained additional phytochemicals with RF values of 0.664 and 0.708, which were not present in PBN 2018-073 (Figure 2). These consistent variations across replications suggest further phytochemical differentiation between the white and purple morphotypes.

Table 4. Comparison of the agronomic yield of *Orthosiphon aristatus* accessions. Measurements reported as mean ± SEM (n = 4); ^{a,b,c} indicate significant differences in ANOVA; ^{x,y,z} indicate significant differences in Kruskal-Wallis at α = 0.05.

Character	PBN Accession No.		
	2018-073	2019-119	2019-571
Fresh leaf yield (g plant^{-1})	31.36 ± 6.12 ^{x}	106.53 ± 16.46^{y}	41.54 ± 7.71^{xy}
Dry leaf yield (g plant^{-1})	7.23 ± 1.08^{x}	25.16 ± 3.99^{y}	9.49 ± 1.28^{xy}
Stem fresh weight (g plant^{-1})	42.58 ± 4.33	129.92 ± 25.77	59.35 ± 16.99
Stem dry weight (g plant^{-1})	13.12 ± 1.97^{y}	29.69 ± 5.43^{x}	13.44 ± 2.86^{xy}
Root fresh weight (g plant^{-1})	9.66 ± 0.14^{xy}	43.42 ± 16.49^{x}	6.59 ± 1.16^{y}
Root dry weight (g plant^{-1})	6.17 ± 0.23^{xy}	18.25 ± 5.47^{x}	4.30 ± 0.62^{y}
Dry recovery, %	33.17 ± 4.87	26.12 ± 0.56	25.69 ± 3.68
Number of branches	38.75 ± 12.61	53.25 ± 6.65	44.75 ± 1.84
Leaf number (g plant^{-1})	822.25 ± 141.10^{x}	2001.75 ± 311.40^{y}	1144.75 ± 198.28^{xy}
Leaf area (plant-1, cm2)	68828.09 ± 4472.62^{xy}	91265.54 ± 9965.18^{x}	62462.49 ± 4431.77^{y}
Leaf area index	191.19 ± 12.42^{xy}	253.52 ± 27.68^{x}	173.51 ± 12.31^{y}
Diameter of spread (cm)	67.25 ± 3.68^{b}	93.50 ± 7.04^{a}	68.38. ± 4.85^{b}
Plant height (cm)	64.40 ± 1.69	76 ± 5.17	64.33 ± 6.28

Table 5. Descriptive phytochemical detection in *Orthosiphon aristatus* accessions. Indication: + (present), - (absent). Measurement reported as mean ± SEM (n = 4). ^{a,b,c} indicate significant differences in ANOVA. ^{x,y,z} indicate significant difference in Kruskal-Wallis at α = 0.05.

Phytochemical	PBN Accession No.		
	2018 - 073	2019 - 119	2019 - 571
Flavonoids	+	+	+
Tannins	+	+	+
Saponins	+	+	+
Alkaloids	+	+	+
TFC (mg QE/g EXTRACT)	31.05 ± 1.83^{a}	26.06 ± 1.76^{b}	20.73 ± 0.56^{c}
RA CONC. (mg/200g SAMPLE)	2.957 ± 0.22^{x}	2.423 ± 0.27^{xy}	1.594 ± 0.09^{y}

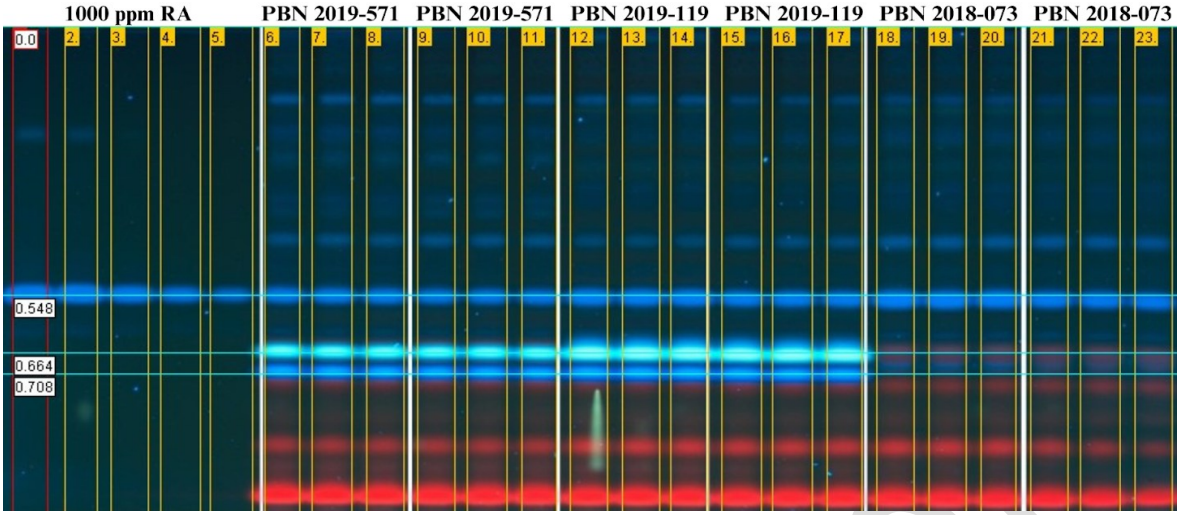

Figure 2. Retention factor (Rf) of potential different phytochemicals present in *Orthosiphon aristatus* accessions under 365 nm UV light, as viewed using GelAnalyzer.

Promising Genotype of *O. aristatus*

The PCA biplot shows the contribution of 14 quantitative traits of three *O. aristatus* accessions, with a total variance of 100%, indicating that these traits can be summarized into two principal components (Figure 3). Agronomic yield characteristics, such as fresh leaf yield, dry leaf yield, leaf blade width, stem dry weight, and root fresh weight, were negatively correlated with phytochemical characteristics, rosmarinic acid and TFC. This indicates that accessions with superior phytochemical and agronomic properties are difficult to select simultaneously. Although PBN 2018-073 is a good putative source of bioactive ingredients, PBN 2019-119 demonstrated superior characteristics with high biomass, comparable rosmarinic acid content, and an intermediate level of flavonoid content. We also inferred that variations within morphotypes exist. For example, although white morphotypes evaluated generally exhibited higher agronomic yield, PBN 2019-571 and PBN 2019-119 still showed significant variations, such as diameter of spread, leaf area, and root dry weight. These significant variations were also observed in their total flavonoid content.

DISCUSSION

The results demonstrate clear genetic and phenotypic distinctions among the three *O. aristatus* accessions. Dayrit and Guidote (2016) detected the same bioactive compounds in *O. aristatus,* which contribute to its pharmacological properties. The PBN 2018-073 is notable for its anthocyanin-rich purple pigmentation and higher levels of bioactive compounds such as flavonoids and rosmarinic acid. This purple color is strongly associated with the anthocyanins present in PBN 2018-073 (Kalusalingam et al. 2024). The high total flavonoid content of this accession denotes elevated concentrations of important bioactives belonging to the flavonoid class identified in *O. aristatus*, particularly sinensetin, 3′-hydroxy-5,6,7,4′-tetramethoxyflavone (TMF), and eupatorin (Abd Aziz et al. 2021). The difference in rosmarinic acid content, a phenolic compound, also contributes to various beneficial properties, including antioxidant and anti-inflammatory effects (Noor et al. 2022). The values obtained were consistent and within the range of the phytochemical evaluation data recorded by Bovani et al. (2024). These findings indicate that PBN 2018-073 possesses superior phytochemical properties among the accessions evaluated. However, this phytochemical richness appears to trade off with agronomic yield, aligning with the source-sink relationship concept, in which resources are allocated to secondary metabolite production at the expense of biomass (Alem et al. 2021). These differences were previously observed by Bovanni et al. (2024), Faramayuda and Mariani (2022); however, we confirmed these differences through our replicated field experiment. Although our observations were generally consistent with reports in the literature, we recognize that ecological factors can influence the growth of different *O. aristatus* morphotypes. Therefore, we recommend conducting future experiments across multiple geographic locations.

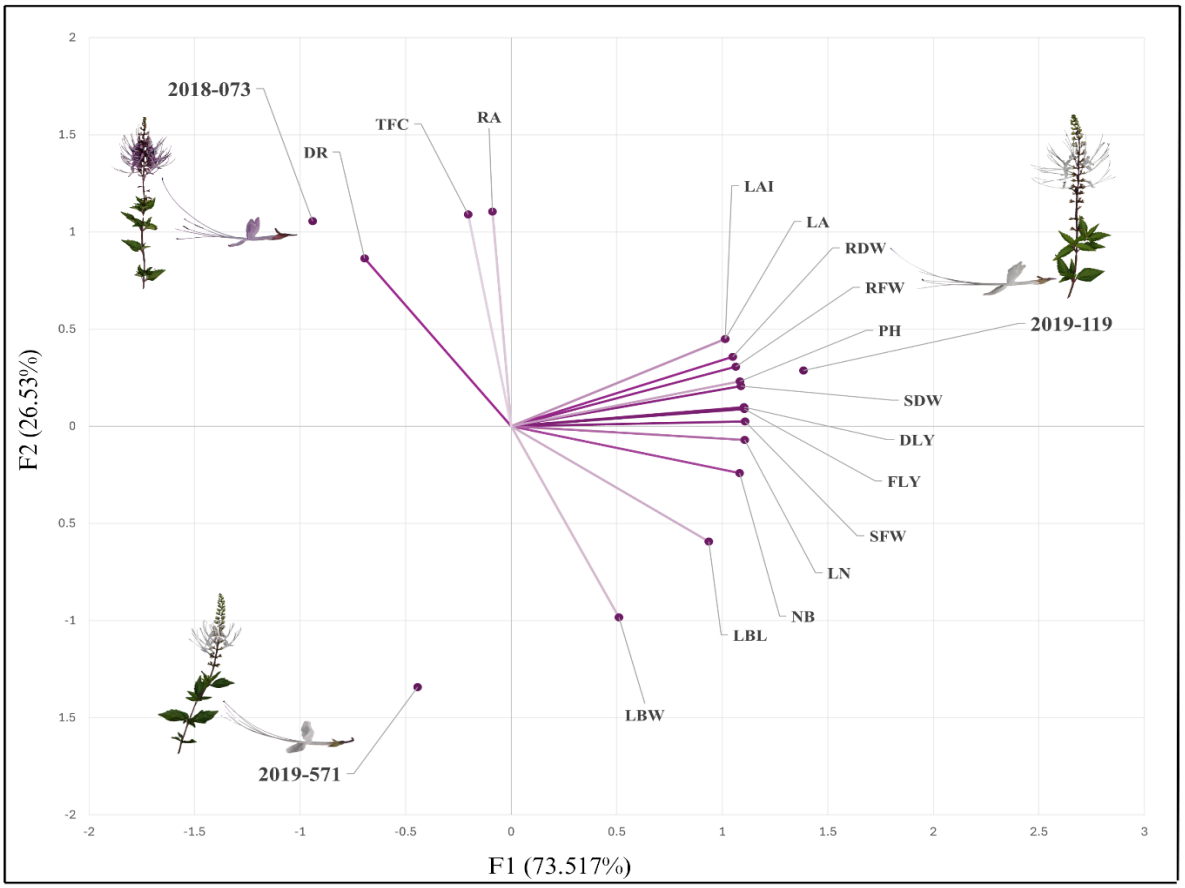

Figure 3. Principal component analysis biplot of *Orthosiphon aristatus* accessions. Lines pointing in similar directions indicate the correlation of traits along the two principal components. Legend: RA - rosmarinic acid; TFC – total flavonoid content; DR – dry recovery; DLY – dry leaf yield; FLY – fresh leaf yield; LA – leaf area; LAI – leaf area index; LBL – leaf blade length; LBW – leaf blade width; LN – leaf number; NB – number of branches; PH – plant height; RDW – root dry weight; RFW – root fresh weight; STW – stem dry weight; and SFW – stem fresh weight.

The PBN 2019-119, on the other hand, produced significantly higher biomass and dry leaf yield. Its intermediate phytochemical content and high yield make it a promising genotype for both medicinal and production purposes. The PCA analysis supports this finding by showing an inverse relationship between yield and phytochemical levels. This is the first report on the yield and yield component evaluation of *O. aristatus* accessions in the Philippines.

Variations even among morphologically similar accessions (e.g., white-flowered types) suggest that selection for both agronomic and phytochemical traits must consider intraspecific variability. This study affirms that phenotypic traits are highly stable and can serve as reliable indicators for genotype selection.

The three accessions of *O. aristatus* in the Philippines were successfully evaluated for their agromorphological and phytochemical performance. Agronomic and phytochemical variations consistently differentiate white and purple inflorescence types. Moreover, phytochemical levels increase as yield decreases, and vice versa. Despite this, we identified PBN 2019-119 as the most promising genotype with high dry leaf yield and intermediate phytochemical content. This is the first report of phytochemical and agronomic evaluation and the selection of promising genotypes of *O. aristatus* in the Philippines. With their distinct, uniform, and stable characteristics observed in the performance trials, these genetic materials can serve as reference accessions, providing well-characterized genetically stable planting materials for herbal production, direct utilization, breeding, and further research.

FUNDING

The authors would like to acknowledge the Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), the Department of Science and Technology-Philippine Council for Health Research and Development

(DOST-PCHRD), and the Department of Agriculture-Biotechnology Program Office (DA-BPO) for their support.

GENERATIVE AI STATEMENT

The authors declare that no generative artificial intelligence (AI) tools were used in the writing, data analysis, or preparation of this article. All content, interpretations, and conclusions presented herein are the original work of the authors.

ETHICAL CONSIDERATIONS

This study was conducted in accordance with the ethical guidelines for research involving plants and agricultural resources. The plant materials used in this research were collected and propagated with complete documentation and appropriate permission from relevant authorities. No endangered or protected species were used. All procedures involving field experimentation and data collection were carried out with integrity, transparency, and adherence to local biodiversity regulations. The researchers ensured that data handling, analysis, and reporting were done honestly, without fabrication, falsification, or misrepresentation of results.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no conflict of interest.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the reviewers for their valuable time, insightful comments, and constructive suggestions, which greatly contributed to improving the quality and clarity of this manuscript.

REFERENCES

Abd Aziz NA, Hasham R, Sarmidi MR, Suhaimi SH, Idris MKH. 2021. A review on extraction techniques and therapeutic value of polar bioactives from Asian medicinal herbs: Case study on *Orthosiphon aristatus*, *Eurycoma longifolia* and *Andrographis paniculata*. Saudi Pharmaceutical Journal. 29(2):143–165 https://doi.org/10.1016/j.jsps.2020.12.016

Akowuah GA, Ismail Z, Norhayati I, Sadikun A. 2005. The effects of different extraction solvents of varying polarities on polyphenols of *Orthosiphon stami*neus and evaluation of the free radical-scavenging activity. Food Chemistry. 93(2):311–317. https://doi.org/10.1016/j.foodchem.2004.09.028

Alem H, Torregrosa L, Rigou P, Schneider R, Ojeda H. 2021. Effect of the plant sink/source balance on the metabolic content of the *Vitis vinifera* L. red grape. European Journal of Agronomy. 122:126168. https://doi.org/10.1016/j.eja.2020.126168

Bovani RP, Liwanda N, Batubara I, Ambarsari L, Nurcholis W. 2024. Phytochemical content and antioxidant capacity of ethyl acetate extracts from fifteen *Orthosiphon aristatus* leaves genotypes. Biodiversitas Journal of Biological Diversity, 25(2). https://doi.org/10.13057/biodiv/d250236

Dayrit FB, Guidote AM. 2016. Encyclopedia of the medicinal plants of the Philippines. Quezon City Philippines: Philippine Institute of Traditional and Alternative Health Care.

Bramley G. 2019. Flora Malesiana. Series 1 Volume 23: Seed plants Lamiaceae (Labiatae) / (G.L.C. Bramley). Leiden: Naturalis Biodiversity Center. 444 p.

DOST-PCHRD (Department of Science and Technology-Philippine Council for Health Research and Development). 2022. Philippines towards a Science-Based Herbal Industry: Initiatives, Challenges, Solutions. [accessed 2024 Sep 10]. https://www.pchrd.dost.gov.ph/news_and_updates/philippines-towards-a-science-based-herbal-industry-initiatives-challenges-solutions/

Faramayuda F, Mariani TS. 2022. Sinensetin Contents of Purple and White Purple Variety of *Orthosiphon aristatus* (Blume) Miq. Jordan Journal of Biological Sciences. 15(1):127-132. https://doi.org/doi:10.54319/jjbs/150117

FDA (Food and Drug Administration). 2020. All Food Products. [accessed 2024 Sep 30] https://verification.fda.gov.ph/All_FoodProductsview.php?showdetail=&ACCOUNTCODE=FR-4000003539275

Gamaro GD, Suyenaga E, Borsoi M, Lermen J, Pereira P, Ardenghi P. 2011. Effect of rosmarinic and caffeic acids on inflammatory and nociception process in rats. International Scholarly Research Notices. 2011(1):451682. https://doi.org/10.5402/2011/451682

Hsu CL, Hong BH, Yu YS, Yen GC. 2010. Antioxidant and anti-inflammatory effects of *O. aristatus* and its bioactive compounds. Journal of Agricultural and Food Chemistry. 58(4):2150-2156. https://doi.org/10.1021/jf903557c

Kalusalingam A, Hasnu DN, Khan A, Tan CS, Menon B, Narayanan V, Goh KW, Mohd Ikmal A, Talip N, Subramanian P and others. 2024. An Updated Review of Ethnobotany, Ethnopharmacology, Phytochemistry and Pharmacological Activities of *Orthosiphon stamineus* Benth. Malaysian Applied Biology. 53(1):1-18. https://doi.org/10.55230/mabjournal.v53i1.2774

Lee W. 2004. Micropropagation and cell culture of misai kucing (*Orthosiphon stamineus* Benth.) and detection of rosmarinic acid in the in vitro cultures. [Master's Thesis]. [Malaysia]: Universiti Sains Malaysia. [accessed 2024 Aug 13].

Ncube B, Finnie JF, Van Staden J. 2012. Quality from the field: The impact of environmental factors as quality determinants in medicinal plants. South African Journal of Botany. 82: 11-20. https://doi.org/10.1016/j.sajb.2012.05.009

Noor S, Mohammad T, Rub MA, Raza A, Azum N, Yadav DK, Hassan MI, Asiri AM. 2022. Biomedical features and therapeutic potential of rosmarinic acid. Archives of Pharmacal Research. 45(4):205–228.

https://doi.org/10.1007/s12272-022-01378-2

Olah NK, Radu L, Mogoşan C, Hanganu D. Gocan S. 2003. Phytochemical and pharmacological studies on *Orthosiphon stamineus* Benth. (Lamiaceae) hydroalcoholic extracts. Journal of Pharmaceutical and Biomedical Analysis. 33(1):117–123. https://doi.org/10.1016/S0731-7085(03)00227-9

POWO (Plants of the World Online). 2022. *Orthosiphon aristatus* (Blume) Miq. [accessed 2024 Aug 22]. https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:453446-1

Royal Horticultural Society. 2015. Royal Horticultural Society color chart. 6th ed. Royal Horticultural Society, London, UK.

Seyedan A, Alshawsh MA, Alshagga MA, Mohamed Z. 2017. Antiobesity and lipid lowering effects of *Orthosiphon stamineus* in high-fat diet-induced obese mice. Planta Medica. 83(08):684-692. https://doi.org/10.1055/s-0042-121754

Suddee S, Paton AJ, Parnell JAN. 2004. A Taxonomic Revision of Tribe *Ocimeae Dumort*. (Lamiaceae) in Continental South East Asia II. Plectranthinae. Kew Bulletin. 59(3):379-414. https://doi.org/10.2307/4110950

Tezuka Y, Stampoulis P, Banskota AH, Awale S, Tran KQ, Saiki I, Kadota S. 2000. Constituents of the Vietnamese Medicinal Plant Orthosiphon stamineus. Chemical and Pharmaceutical Bulletin. 48(11):1711–1719. https://doi.org/10.1248/cpb.48.1711

Zainuddin IM, Salsabil M, Muktabar MG, Sumardi D. 2023. Effect of PGPM and goat manure doses on biomass yield and rosmarinic acid content in cat's whiskers plant (*Orthosiphon aristatus* Bl. Miq). Current Research on Biosciences and Biotechnology. 4(2):289-298. https://doi.org/10.5614/crbb.2023.4.2/LIGQIUMZ

ROLE OF AUTHORS: *GJMU: Conceptualization (lead), Data curation (lead), Funding acquisition (equal), Project administration (lead), Resources (lead), Supervision (lead), Formal analysis (equal), Investigation (equal), Writing – original draft (equal), Writing – review and editing (lead). RPG: Conceptualization (lead), Data curation (lead), Funding acquisition (equal), Project administration (lead), Resources (lead), Supervision (lead), Formal analysis (equal), Investigation (equal), Writing – original draft (equal), Writing – review and editing (lead). EJRP, DBC, MCBB, KJOQA: Data curation (equal), Supervision (supporting), Formal analysis (supporting). EBST: Conceptualization (supporting), Supervision (supporting), Formal analysis (supporting), Investigation (supporting). NBC and LEE: Methodology (supporting), Formal analysis (supporting), Investigation (supporting), Writing – original draft (supporting), Validation (supporting), Writing – review and editing (supporting). REM, JBM, and THB: Conceptualization (supporting), Resources (supporting), Formal analysis (supporting), Investigation (supporting), Validation (supporting).*

Responsible Editor: Luz G. Asio, PhD