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Fruit Biometry and Descriptive Statistical Evaluation of Papilionaceae from Eastern Maharashtra, India

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Abstract
The present investigation deals with the fruit biometric analysis and descriptive statistical evaluation of 24 taxa of Papilionoideae collected from different localities of eastern Maharashtra, India, particularly Chandrapur district and adjoining regions. Fruit morphological parameters including length, width, and thickness were measured and statistically analyzed using mean, mode, median, standard deviation, and coefficient of variation. Considerable interspecific variation was observed among the studied taxa. The longest fruits were recorded in Sesbania grandiflora, whereas the smallest fruits were observed in Melilotus alba. High coefficients of variation in certain taxa indicated substantial morphological variability. The study highlights the taxonomic significance of fruit biometric characters in species delimitation and contributes baseline data for systematic, ecological, and evolutionary studies in Papilionaceae.

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INTRODUCTION

The family Fabaceae is one of the largest and economically important angiosperm families, comprising numerous species distributed throughout tropical and subtropical regions of the world. The subfamily Papilionoideae exhibits remarkable diversity in floral and fruit morphology and has significant ecological, medicinal, agricultural, and taxonomic importance. Fruit morphology has long been considered a reliable taxonomic character for species identification and classification in legumes (Lewis et al., 2005).

Biometric analysis of fruits provides quantitative information regarding phenotypic variability and adaptive strategies of plant taxa. Morphometric studies involving fruit length, width, thickness, and their statistical interpretation have been effectively used in taxonomic delimitation and diversity assessment (Judd et al., 2016). Descriptive statistical parameters such as mean, median, mode, standard deviation, and coefficient of variation help evaluate the extent of morphological variation within and among species.

Several researchers have emphasized the significance of fruit morphometry in legume taxonomy and phylogeny (LPWG, 2017; Singh and Sharma, 2021). Recent investigations on Fabaceae from different regions of India have revealed substantial variation in pod morphology associated with ecological adaptation and genetic diversity (Patel et al., 2022). However, comprehensive biometric studies on Papilionoideae taxa from eastern Maharashtra remain limited.

Eastern Maharashtra, especially Chandrapur district, possesses rich floristic diversity due to its varied climatic and edaphic conditions. The present study was therefore undertaken to evaluate fruit biometric characters of selected Papilionoideae taxa and to analyze their descriptive statistical attributes for taxonomic interpretation.

MATERIALS AND METHODS

Study area

The present study was conducted in eastern Maharashtra, India, a region characterized by tropical dry deciduous climatic conditions. The area experiences a distinct seasonal pattern comprising hot summers, a monsoon season, and mild winters. Summers are generally dry and warm, while the southwest monsoon brings moderate to high seasonal rainfall, which supports luxuriant vegetation growth and reproductive activities in plant species. The annual rainfall varies considerably across the region and contributes to the development of diverse forest ecosystems. The vegetation is predominantly composed of tropical dry deciduous forests with rich floristic diversity, including several leguminous taxa. Such climatic and ecological conditions provide a suitable environment for the growth, flowering, fruiting, and seed development of Papilionaceae species.

Collection of Plant Material

Twenty-four taxa belonging to the subfamily Papilionoideae were collected during extensive field surveys conducted across different localities of eastern Maharashtra, India. The surveys were carried out during various seasons to ensure proper collection of flowering and fruiting specimens required for accurate taxonomic identification and biometric evaluation. Sampling sites were selected based on the occurrence and distribution of leguminous species in natural habitats, roadside vegetation, forest margins, agricultural fields, and wastelands.

For each collected taxon, detailed field observations were recorded, including habitat characteristics, phenological condition, growth form, and associated vegetation. Geographic coordinates of the collection sites were documented using a Global Positioning System (GPS) device to ensure precise localization of the taxa. Details regarding sampling localities and coordinates are provided in Table 1.

Collected plant materials were processed following standard herbarium techniques, including pressing, drying, poisoning, and mounting on herbarium sheets. Taxonomic identification of the specimens was carried out using regional floras, monographs, and standard taxonomic literature. Important diagnostic morphological characters such as leaf arrangement, floral structure, pod morphology, and seed characteristics were critically examined for confirmation of species identity. Whenever necessary, authenticated herbarium specimens and relevant published references were consulted to ensure accurate identification of the taxa.

Table 1: List of sampling sites of examined taxa.

Sr. No.	Plant Species	Collection Site	Coordinates	
			Latitude	Longitude
1	*Abrus precatorius* Linn.	Visapur, Chandrapur	19.889542°	79.331245°
2	*Aeschynomene americana* Linn.	Arvi, Gadchandur Road	19.767369°	79.336389°
3	*Cajanus cajan* (L.) Millsp.	Manoli, Bk. Chandrapur	19.836321°	79.334687°
4	*Canavalia gladiata* (Jacq.) DC.	Gadchandur Road, Arvi	19.767298°	79.336212°
5	*Clitoria ternatea* Linn.	Bamani, Ballarpur	19.821296°	79.394382°

6	*Clitoria ternatea* Linn.var.*pilosula*	Babupeth-Junona Road	19.923239°	79.338399°
7	*Crotalaria retusa* L.	Chandrapur	20.078185°	79.188144°
8	*Crotalaria verrucosa* L.	Arvi, Gadchandur Road	19.767298°	79.336212°
9	*Dalbergia lanceolaria* Linn.	Ballarpur Road, Chandrapur	19.906812°	79.3279°
10	*Dalbergia rubiginosa* Roxb.	Yenbodi-Gondpipari Road	19.817227°	79.450214°
11	*Dalbergia sissoo* Roxb.ex DC.	Ballarpur Road, Chandrapur	19.913073°	79.326229°
12	*Flemingia lineata* (Linn) Roxb.	Sasti, Chandrapur	19.805576°	79.341042°
13	*Indigofera colutea* (Burm.f.) Merrill	Visapur, Chandrapur	19.876968°	79.337967°
14	*Lathyrus sativus* Linn.	Mathara, Gadchandur Road	19.770484°	79.337962°
15	*Melilotus alba* Medicus.	Tadali, Chandrapur	20.037574°	79.200978°
16	*Cullen corylifolia* (Linn.) Media.	Arvi, Gadchandur Road	19.767369°	79.336389°
17	*Rhynchosia minima* (Linn.) DC, var. *laxiflora*	Bamani, Ballarpur	19.823509°	79.392536°
18	*Sesbania bispinosa* (Jacq.) Wight	Mathara, Gadchandur Road	19.767825°	79.336171°
19	*Sesbania grandiflora* (Linn.) Pers.	Sasti, Chandrapur	19.805576°	79.341042°
20	*Tephrosia purpurea* (Linn.) Pers.	Chandrapur, Ballarpur Road	19.907256°	79.327588°
21	*Tephrosia villosa* (Linn.) Pers.	Gadchandur road, Rajura	19.776797°	79.349499°
22	*Teramnus labialis* (Linn.f.) Spreng.	BTS, Ballarpur	19.839866°	79.36819°
23	*Trigonella foenum-graecum* L.	Tadali, Chandrapur	20.037574°	79.200978°
24	*Vigna radiata* (Linn.) Wilczeck	Pendhari,Gadchandur Road	19.775395°	79.347414°

Fruit Biometric Analysis

Ripened fruits were manually collected from selected healthy mother trees growing in different localities of the study area. Collection was carried out during the peak fruiting season to ensure complete maturity of the fruits. Only visually healthy, intact, undamaged, disease-free, pest-free, and non-deformed fruits were selected for biometric evaluation in order to maintain accuracy and reliability in the observations. A representative sample consisting of fifty fruits and fifty seeds from each taxon was used for the study.

The collected samples were carefully cleaned and examined prior to measurement. Quantitative fruit characteristics were analyzed using standard biometric procedures. Longitudinal fruit length was measured from the base to the apex of the fruit using a ruler and expressed in centimeters. Fruit width and thickness were measured at the median or broadest region of the fruit with the help of a digital Vernier caliper having an accuracy of 0.05 mm. Similar measurements were also recorded for seeds wherever required.

All measurements were taken under uniform laboratory conditions to minimize observational errors. Multiple observations were recorded to ensure precision and reproducibility of the data. The biometric data obtained from the measurements were systematically tabulated and subjected to descriptive statistical analysis. Statistical parameters including range, mean, median, mode, standard deviation, and coefficient of variation were calculated to evaluate the extent of morphological variability

among the studied taxa. These statistical measures provided a reliable assessment of interspecific variation and contributed to the comparative understanding of fruit morphology within the examined Papilionoideae species.

Statistical Analysis

The recorded biometric data were systematically tabulated and subjected to descriptive statistical analysis to evaluate the extent of morphological variation among the examined taxa. Statistical parameters including range, mean, mode, median, standard deviation, and coefficient of variation (CV%) were calculated separately for each quantitative morphological character such as fruit length, width, and thickness. These statistical measures provided a comprehensive understanding of the distribution pattern and variability of the observed traits.

The coefficient of variation (CV%) was used to assess the relative degree of variation present within each character and was calculated using the following formula:

$CV = (\sigma / \bar{x}) \times 100$

Where:

- CV = Coefficient of Variation
- σ = Standard deviation
- $\bar{x}$ = Mean of the observations

RESULTS

The biometric evaluation of fruits of 24 examined taxa revealed substantial variation in fruit dimensions and statistical attributes (Table-2). Among the studied taxa, *Sesbania grandiflora* exhibited the maximum mean fruit length (40.31 cm), followed by *Sesbania bispinosa* (22.27 cm) and *Canavalia gladiata* (16.93 cm). In contrast, the minimum mean fruit length was recorded in *Melilotus alba* (0.31 cm) and *Cullen corylifolia* (0.41 cm).

The highest mean fruit width was observed in *Canavalia gladiata* (2.31 cm), whereas the lowest width was recorded in *Cullen corylifolia* (0.20 cm). Fruit thickness varied considerably among taxa, with the highest value in *Canavalia gladiata* (1.68 cm). Descriptive statistical analysis demonstrated varying degrees of dispersion among the taxa. The coefficient of variation for fruit length ranged from 1.10% in *Canavalia gladiata* to 41.58% in *Rhynchosia minima*, indicating considerable variability in the latter species. Fruit width showed the highest coefficient of variation in *Aeschynomene americana* (30.86%), while fruit thickness exhibited maximum variation in *Indigofera colutea* and *Tephrosia purpurea* (30.86%).

The mean, mode, and median values for most taxa were closely related, indicating relatively symmetrical distribution of measurements. Standard deviation values remained comparatively low in several taxa, suggesting measurement consistency and limited intraspecific variation.

The examined taxa also differed markedly in fruit shape and size, reflecting species-specific morphological adaptations. Such quantitative differences are taxonomically significant and useful for species delimitation within Papilionoideae.

Table-2: Fruit biometric evaluation of examined species.

Sr. No.	Species	Parameter	Length (cm)	Width (cm)	Thickness (cm)
1	*Abrus precatorius* Linn.	Range	3.8-4.2	1.4-1.6	0.6-0.8
		Mean	3.94	1.49	0.73
		Mode	3.90	1.50	0.75
		Median	3.90	1.50	0.75
		Standard Deviation	± 0.143	± 0.066	± 0.035
		Coefficient of variation (%)	3.62	4.42	4.794
2	*Aeschynomene americana* Linn.	Range	0.9-1.8	0.2-0.3	0.1-0.2
		Mean	1.46	0.23	0.15

		Mode	1.50	0.25	0.17
		Median	1.50	0.25	0.16
		Standard Deviation	± 0.222	± 0.071	± 0.025
		Coefficient of variation (%)	15.20	30.86	16.66
3	*Cajanus cajan* (L.) Millsp.	Range	5.8-6.2	0.6-0.8	0.6-0.7
		Mean	6.11	0.71	0.65
		Mode	5.90	0.74	0.64
		Median	5.90	0.72	0.65
		Standard Deviation	± 0.637	± 0.025	± 0.028
		Coefficient of variation (%)	10.42	3.52	4.30
4	*Canavalia gladiata* (Jacq.) DC.	Range	16.6-17.2	2.2-2.4	1.6-1.8
		Mean	16.93	2.31	1.68
		Mode	16.90	2.30	1.70
		Median	16.90	2.30	1.70
		Standard Deviation	± 0.187	± 0.057	± 0.057
		Coefficient of variation (%)	1.10	2.46	3.39
5	*Clitoria ternatea* Linn.	Range	6.1-6.5	0.9-1.2	0.3-0.4
		Mean	6.37	1.03	0.34
		Mode	6.40	1.00	0.35
		Median	6.40	1.00	0.35
		Standard Deviation	± 0.121	± 0.091	± 0.021
		Coefficient of variation (%)	1.89	8.83	6.17
6	*Clitoria ternatea* Linn.var. *pilosula*	Range	7.3-7.8	0.7-0.9	0.3-0.4
		Mean	7.51	0.78	0.38
		Mode	7.60	0.80	0.36
		Median	7.50	0.80	0.36
		Standard Deviation	± 0.133	± 0.071	± 0.058
		Coefficient of variation (%)	1.77	9.10	15.26
7	*Crotalaria retusa* Linn.	Range	3.9-4.4	1.1-1.3	0.5-0.7
		Mean	4.12	1.20	0.59
		Mode	4.20	1.20	0.60
		Median	4.20	1.20	0.60
		Standard Deviation	± 0.176	± 0.670	± 0.079
		Coefficient of variation (%)	4.27	0.583	13.38
8	*Crotalaria verrucosa* Linn.	Range	3.7-4.0	0.4-0.5	0.7-0.9
		Mean	3.99	0.45	0.78
		Mode	3.90	0.45	0.80
		Median	3.80	0.45	0.80
		Standard Deviation	± 1.207	± 0.025	± 0.071
		Coefficient of variation (%)	13.25	5.55	9.10
9	*Dalbergia lanceolaria* Linn.	Range	3.9-4.6	1.7-1.8	0.10-0.15
		Mean	4.2	1.75	0.12
		Mode	4.2	1.76	0.13
		Median	4.2	1.76	0.13
		Standard Deviation	± 0.206	± 0.024	± 0.012
		Coefficient of variation (%)	4.90	1.37	10.00
10	*Dalbergia rubiginosa* Roxb.	Range	7.6- 9.3	0.8-1.1	0.3-0.4
		Mean	8.25	0.96	0.34
		Mode	7.6	0.90	0.35

		Median	7.8	1.00	035
		Standard Deviation	± 0.685	± 0.091	± 0.021
		Coefficient of variation (%)	8.30	9.47	6.17
11	*Dalbergia sissoo* Roxb. ex DC.	Range	6.5-7.3	1-1.8	0.10-0.13
		Mean	6.89	1.45	0.11
		Mode	6.9	1.5	0.11
		Median	6.9	1.5	0.11
		Standard Deviation	± 0.230	± 0.200	± 0.008
		Coefficient of variation (%)	3.33	13.79	7.27
12	*Flemingia lineata* (Linn) Roxb.	Range	1.2-1.5	0.4-0.6	0.2-0.3
		Mean	1.33	0.49	0.25
		Mode	1.30	0.50	0.25
		Median	1.30	0.50	0.25
		Standard Deviation	± 0.077	± 0.060	± 0.051
		Coefficient of variation (%)	5.78	12.24	20.40
13	*Indigofera colutea* (Burm.f.) Merrill	Range	2.3-2.6	0.2-0.3	0.2-0.3
		Mean	2.45	0.24	0.23
		Mode	2.40	0.30	0.25
		Median	2.40	0.30	0.25
		Standard Deviation	± 0.089	± 0.049	± 0.071
		Coefficient of variation (%)	3.70	20.41	30.86
14	*Lathyrus sativus* Linn.	Range	5.5-5.9	0.4-0.7	0.2-0.3
		Mean	5.69	0.56	0.25
		Mode	5.70	0.60	0.25
		Median	5.70	0.60	0.25
		Standard Deviation	± 0.120	± 0.088	± 0.025
		Coefficient of variation (%)	2.10	15.71	10.00
15	*Melilotus alba* Medicus	Range	0.2-0.4	0.2-0.3	0.2-0.3
		Mean	0.31	0.26	0.24
		Mode	0.35	0.26	0.25
		Median	0.34	0.26	0.25
		Standard Deviation	± 0.060	± 0.025	± 0.024
		Coefficient of variation (%)	19.35	9.61	10.00
16	*Cullen corylifolia* (Linn.) Medik.	Range	0.40-0.43	0.20-0.22	0.20-0.22
		Mean	0.41	0.20	0.20
		Mode	0.41	0.21	0.21
		Median	0.41	0.21	0.21
		Standard Deviation	± 0.008	± 0.006	± 0.006
		Coefficient of variation (%)	1.95	3.00	3.00
17	*Rhynchosia minima* (Linn.) DC.	Range	10.8-13.9	0.5-0.7	0.12-0.15
		Mean	11.27	0.62	0.13
		Mode	13.50	0.65	0.13
		Median	13.50	0.65	0.14
		Standard Deviation	± 4.867	± 0.059	± 0.009
		Coefficient of variation (%)	41.58	9.51	6.92
18	*Sesbania bispinosa* (Jacq.) Wight	Range	19-25	0.20-0.30	0.20-0.24
		Mean	22.27	0.25	0.22
		Mode	23	0.27	0.22
		Median	23	0.27	0.22
		Standard Deviation	± 1.650	± 0.031	± 0.011

		Coefficient of variation (%)	7.40	12.40	5.00
19	*Sesbania grandiflora* (Linn.) Pers.	Range	34.5-45.1	0.6-0.9	0.4-0.5
		Mean	40.31	0.76	0.44
		Mode	42.00	0.80	0.45
		Median	39.00	0.80	0.45
		Standard Deviation	± 3.172	± 0.097	± 0.025
		Coefficient of variation (%)	7.86	12.76	5.68
20	*Tephrosia purpurea* (Linn.) Pers.	Range	3.8-4.4	0.3-0.4	0.2-0.3
		Mean	4.08	0.35	0.23
		Mode	4.20	0.36	0.25
		Median	4.10	0.37	0.25
		Standard Deviation	± 0.194	± 0.026	± 0.071
		Coefficient of variation (%)	4.75	7.40	30.86
21	*Tephrosia villosa* (Linn.) Pers.	Range	2.8-3.4	0.4-0.6	0.2-0.3
		Mean	3.09	0.50	0.24
		Mode	3.10	0.50	0.24
		Median	3.10	0.50	0.24
		Standard Deviation	± 0.162	± 0.056	± 0.026
		Coefficient of variation (%)	5.24	11.20	10.83
22	*Teramnus labialis* (Linn.f.) Spreng	Range	4.2-4.9	0.2-0.3	0.2-0.3
		Mean	4.58	0.25	0.25
		Mode	4.60	0.26	0.24
		Median	4.60	0.26	0.24
		Standard Deviation	± 0.199	± 0.026	± 0.029
		Coefficient of variation (%)	4.34	10.40	11.60
23	*Trigonella foenum-graecum* Linn.	Range	8.8-9.5	0.4-0.7	0.2-0.3
		Mean	9.13	0.51	0.29
		Mode	9.20	0.50	0.27
		Median	9.20	0.50	0.25
		Standard Deviation	± 0.210	± 0.083	± 0.015
		Coefficient of variation (%)	2.30	16.27	5.27
24	*Vigna radiata* (Linn.) Wilczeck	Range	10.5-11.3	0.3-0.5	0.4-0.5
		Mean	11.01	0.41	0.44
		Mode	10.90	0.40	0.45
		Median	10.90	0.40	0.45

DISCUSSION

Fruit morphology plays an important role in the taxonomy and identification of leguminous taxa. The present study revealed considerable diversity in fruit biometric characters among Papilionoideae species from eastern Maharashtra. Similar observations have been reported in previous studies on Fabaceae morphology and systematics (Lewis et al., 2005; LPWG, 2017).

The exceptionally large fruits observed in *Sesbania grandiflora* and *Canavalia gladiata* may represent adaptive strategies associated with seed protection and dispersal efficiency. In contrast, smaller fruits in taxa such as *Melilotus alba* and *Cullen corylifolia* indicate reduced biomass allocation to fruit development.

High coefficients of variation observed in certain taxa suggest greater phenotypic plasticity and ecological adaptability. According to Singh and Sharma (2021), morphological variability in legumes is often influenced by environmental conditions, genetic factors, and habitat heterogeneity. The substantial variation recorded in *Rhynchosia minima* may therefore

reflect ecological adaptation to local environmental conditions.

The close association among mean, median, and mode values in most taxa indicates relatively normal distribution of measurements and reliability of biometric observations. Similar statistical trends have been reported in morphometric investigations of Indian legumes by Patel et al. (2022).

The present findings support the utility of fruit biometric parameters as reliable taxonomic markers in Papilionoideae. Quantitative morphological data generated through descriptive statistical analysis provide important baseline information for systematic studies, biodiversity assessment, and future phylogenetic investigations.

CONCLUSION

The present study demonstrates significant interspecific variation in fruit biometric characters among Papilionoideae taxa from eastern Maharashtra. Fruit length, width, thickness, and associated statistical parameters proved useful in evaluating morphological diversity and taxonomic distinctiveness. The generated biometric database contributes valuable information for future taxonomic, ecological, and evolutionary studies of Fabaceae in India.

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