



# Unlocking Genetic Potential in Monopodial Orchids through Variability and Heritability Studies

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## Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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## ABSTRACT

Monopodial orchids are highly valued for their ornamental appeal, longevity, and adaptability. This study aimed to evaluate the genetic variability among selected monopodial orchid genotypes to support breeding programs for development of hybrid varieties. Twelve monopodial orchid varieties, including monogeneric and bigeneric hybrids were evaluated using a Completely Randomized Design (CRD) with twelve treatments and six replications. The selected materials were evaluated by recording observations on their vegetative and floral characters. Various parameters of variability, heritability and expected genetic advance were calculated. The mean and standard errors were worked out as per standard methods and then coefficients of variation were computed. Significant variations were observed among the genotypes, particularly in inflorescence length, flower count, and vase life, with high heritability and genetic advance estimates. These findings highlight the genetic potential of monopodial orchids for hybridization, emphasizing the importance of selecting

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genetically diverse parents to enhance flower quality, productivity, and stress resistance. This study contributes to the development of novel monopodial orchid hybrids with superior commercial traits for both domestic and international markets.

**Keywords:** *Monopodials; variability; heritability; genetic advance; GCV; PCV.*

## 1. INTRODUCTION

Orchids, with their bewildering range of flower colours, striking colour combinations, remarkable diversity in size, shape, fragrance and keeping quality captivate the attention and admiration of everyone. They are often regarded as the royalty of ornamental plants. Orchids belong to Orchidaceae, one of the largest and most diverse families comprise of flowering plants with 25,000 to 35,000 species belonging to 600-800 genera and covers 10% of the flowering plants (De and Medhi, 2017, Christenhusz and Byng, 2016). Orchids are considered highly evolved taxonomically and are among the most advanced monocotyledons with intricate floral structures and remarkable adaptability. Orchids are now dominating the cut flower and potted plant industries due to its prolonged bloom duration, high productivity, seasonal flowering and ease of packing and transportation (De *et al*, 2014).

Orchids exhibit two primary growth patterns: monopodial and sympodial. Monopodial orchids grow from a single bud, with the stem continuously elongating and producing new leaves from the apex each year. In contrast, sympodial orchids develop successive shoots that grow, bloom and are eventually replaced by new shoots (Arditti, 1992; Sailo *et al.*, 2014). Many monopodial orchids are very showy, attractive and have been extensively used as parents in hybridization programmes. These orchids have the comparative advantage over sympodial in that they are hardier, demanding lesser attention and care, however their market value remains relatively low due to the continued cultivation of older varieties leading to a lack of novelty. The cultivation of monopodial is gaining popularity due to the ease in cultural practices, diverse flower colour, shape, size and delicacy (De *et al*, 2019).

Despite India's rich indigenous orchid flora, varied agroclimatic conditions, skilled manpower and the desired technological advancement, orchid cultivation has not yet gained the attention and popularity that it deserves. A major challenge is the scarcity of locally adapted and reasonably priced quality planting material. There

is a need for orchid breeding programmes to address the issue on the development of our own indigenous hybrid materials which have the adaptability to our agroclimatic conditions as well as novelty and quality enough to compete with international standards. Against this backdrop, the present study was initiated with the objective of developing new monopodial orchid hybrids with commercial cut flower qualities for export market. The study aims to screen the monopodial orchid genotypes which include monogeneric and bigeneric commercial varieties to estimate the genetic variability and determine the genetic parameters among the selected genotypes.

The presence of variability in crop is important for genetic studies and genetic variability plays a crucial role in crop improvement, as it provides the foundation for selection and breeding programmes. Variability can manifest phenotypically through differences in floral morphology, leaf structure, or growth habit, as well as genotypically, which may enhance adaptability to various environmental stresses (Aswini *et al*, 2024). Biometric tools such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation(PCV), heritability and genetic advance are essential for measuring genetic divergence among genotypes and can be used to improve the various genera of monopodials for utilizing their potential for intra and intergeneric hybridization.

## 2. MATERIALS AND METHODS

The present investigation to evaluate the parent materials and estimation of genetic parameters of parents was undertaken in the Department of Plant Breeding and Genetics in the College of Agriculture, Vellayani, Thiruvananthapuram district, Kerala. The following methods were adopted for the evaluation of genetic variability in the inheritance of different characters for the adoption of genetic improvement programmes in different monopodial varieties.

The experiment was laid out in a Completely Randomized Design (CRD) with six replications and twelve treatments. The experimental

material consisted of twelve monopodial orchid varieties including six monogeneric and six bigeneric hybrids belonging to the genera *Arachnis*, *Aranda*, *Aranthera* and *Vanda*. Crop management practices were carried out according to the package of practices recommendations of Kerala Agricultural University (KAU,2024). The selected parent materials were evaluated by recording observations on their vegetative and floral characters.

The vegetative characters that were evaluated include length of cane (cm), number of leaves per cane, number of aerial roots, length of aerial roots (cm), thickness of stem (cm), length of internode (cm), length of leaf (cm), width of leaf (cm), thickness of leaf (cm), leaf area (cm<sup>2</sup>). The floral characters that were evaluated include days to first flower opening from inflorescence emergence, days to last flower opening from first flower opening, number of spikes per cane, length of inflorescence (cm), length of scape (cm), diameter of inflorescence axis (cm), number of flowers per inflorescence, length of internode (cm), length of flower (cm), width of flower (cm) and vase life (days).

The coefficient of variations was computed using standard statistical measures. The selected materials were evaluated and observations were recorded frequently in order to study the genetic variability for both vegetative and floral characters. Estimates of heritability and genetic advance as percentage of mean were also calculated. The statistical analysis was carried out to compute the genotypic coefficient of variation, phenotypic coefficient of variation, heritability (broad sense) and genetic advance as percentage of mean for important quantitative characters as per the method suggested by Singh and Chaudhary (1985). Broad sense heritability ( $h^2$ ) was calculated as the ratio of the genotypic variance to the phenotypic variance using the formula proposed by Allard 1960.

### 3. RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among all the parental genotypes with respect to all the biometric characters studied. The coefficients of variation at genotypic and phenotypic levels were studied. High phenotypic and genotypic coefficients of variation were observed for number of aerial roots (GCV= 56.83%, PCV=61.98%) leaf area (GCV= 51.74%, PCV=55.06%) and width of leaf (GCV= 50.16%, PCV=51.88%) indicating high variability for these

characters and scope for improvement through selection. The phenotypic coefficient of variation was found to be higher than the genotypic coefficient of variation for all the characters studied indicating significant influence of environment in the expression of these characters. It is obvious because PCV includes variability due to genotypes, environment and genotypes x environment interaction. Heritability per cent was categorized as suggested by Allard as low (<30), moderate (30-70) and high(>70) (1960). On that account vegetative characters like length of cane (cm), number of aerial roots, thickness of stem (cm), length of leaf (cm), width of leaf (cm), thickness of leaf (cm), leaf area (cm<sup>2</sup>) and floral characters like days to first flower opening from inflorescence emergence, length of inflorescence (cm), length of scape (cm), diameter of inflorescence axis (cm), number of flowers per inflorescence, length of internode (cm), length of flower (cm), width of flower (cm) and vase life (days) exhibited high heritability (>70%) indicating additive gene action for these characters suggesting very little influence of the environment in the expression of these characters. This suggests that improvement could be attained by practicing selection on the above traits. A wide range of values were observed for the characters under study for genetic advance. According to Robinson *et al.*, characters with values >20% were considered to have high genetic advance (1949). The highest value was observed for number of aerial roots, width of leaf, leaf area and number of flowers per inflorescence. High heritability (>70%) combined with high genetic advance (>20%) was exhibited by majority of the characters studied like number of aerial roots, width of leaf, leaf area and number of flowers per inflorescence indicating additive gene action for these characters. This suggests that permanent improvement could be attained by practicing selection on the above traits.

A detailed analysis of vegetative and floral characters is significant for understanding the diversity among the monopodial orchids and for selecting the parents for a successful hybridization programme. McDonald (1991) emphasized that the success of an orchid hybrid depends on floral beauty, bloom size and floriferous nature with greater flower substance thus emphasizing the importance of vegetative vigour. While selecting parents for any hybridization programme, general plant health and vegetative characters are important. The study revealed considerable variation in

**Table 1. Mean performance of twelve parental genotypes of monopodial orchids for quantitative vegetative characters**

Parental genotypes	Length of cane (cm)	No. of leaves per cane	No. of aerial roots	Length of aerial root (cm)	Thickness of stem (cm)	Length of internode (cm)	Length of leaf (cm)	Width of leaf(cm)	Thickness of leaf (cm)	Leaf area (cm <sup>2</sup> )
P1	9.25	35.00	7.67	32.65	1.14	1.95	11.25	2.63	0.20	23.54
P2	112.63	45.17	9.17	34.23	1.13	2.24	10.77	2.55	0.22	22.04
P3	111.57	33.00	6.17	34.93	1.06	2.91	11.15	3.08	0.19	25.07
P4	105.77	23.33	14.33	54.95	0.70	4.03	9.03	0.53	0.10	5.84
P5	101.50	26.67	14.67	60.18	0.72	3.87	8.13	0.48	0.10	5.29
P6	116.20	27.33	17.00	57.23	0.74	4.06	13.45	0.52	0.11	7.20
P7	52.13	24.83	7.17	51.52	1.51	2.50	14.60	4.03	0.16	43.47
P8	60.63	28.17	5.17	36.38	1.28	2.62	14.55	2.88	0.20	32.14
P9	75.47	28.83	4.33	33.92	1.02	2.25	12.15	3.02	0.15	28.44
P10	77.02	24.33	3.83	53.20	1.75	2.18	10.90	3.07	0.19	26.24
P11	68.43	22.83	4.33	47.50	0.83	2.51	10.93	2.62	0.22	22.83
P12	89.37	28.17	3.67	37.60	0.48	2.32	9.30	2.30	0.18	17.79
SEm	4.441	1.640	0.820	2.871	0.058	0.282	0.478	0.125	0.010	1.665
CD(0.05)	12.561	4.639	2.320	8.121	0.165	0.797	1.353	0.354	0.027	4.709

**Table 2. Mean performance of twelve parental genotypes of monopodial orchids for quantitative floral characters**

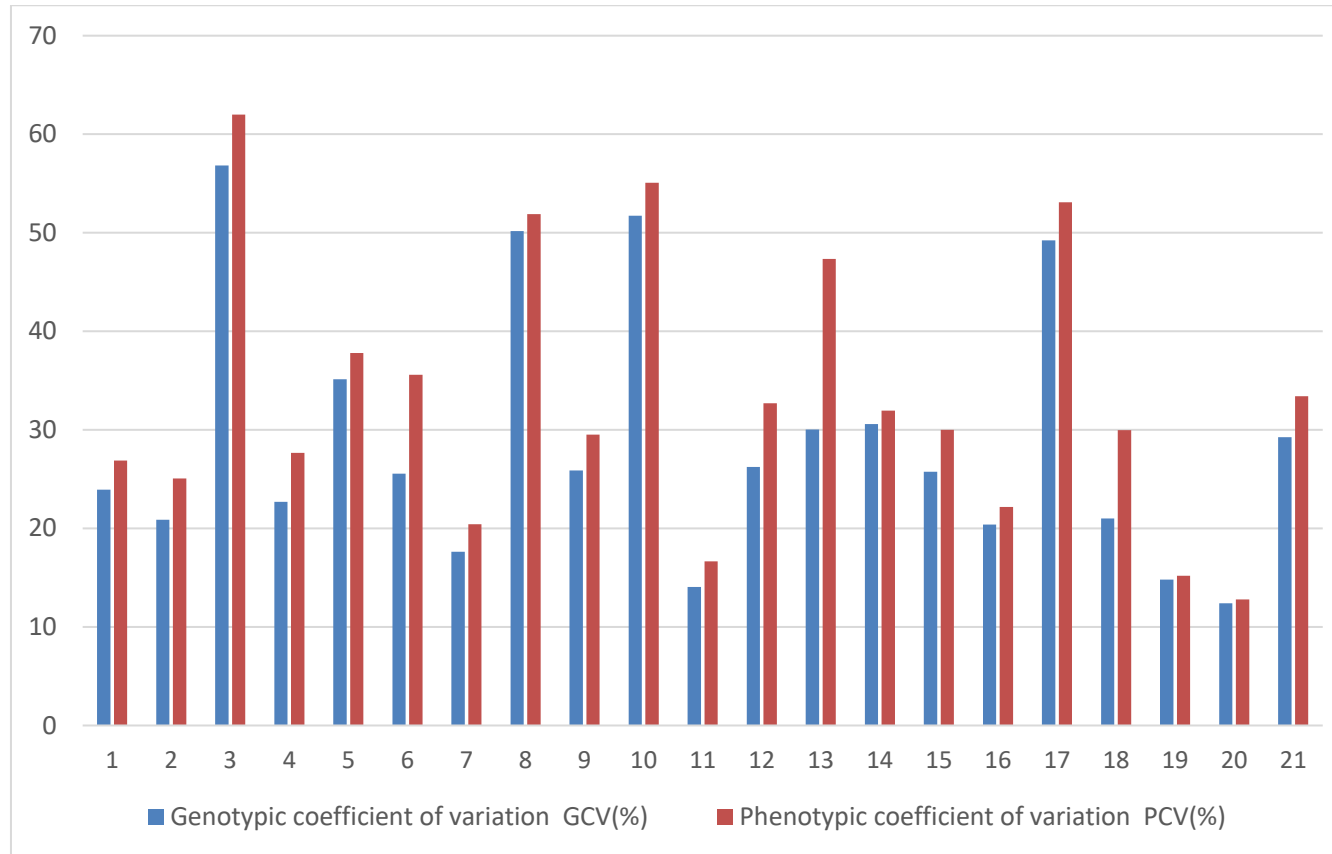
Parental genotypes	Days to first flower opening from inflorescence emergence	Days to last opening from first flower opening	No. of spikes per cane	Length of inflorescence (cm)	Length of scape(cm)	Diameter of inflorescence axis (cm)	No. of flowers per inflorescence	Length of internode(cm)	Length of flower (cm)	Width of flower(cm)	Vase life (days)
P1	40.50	17.33	9.83	50.90	17.53	0.52	8.00	4.24	8.08	7.12	17.83
P2	41.83	19.17	12.50	46.22	16.55	0.53	8.17	3.64	8.27	7.63	16.83
P3	43.50	14.83	5.33	28.35	7.57	0.47	7.00	3.11	6.22	6.05	20.17
P4	29.50	8.67	5.33	31.18	20.25	0.53	4.50	2.58	7.12	6.57	6.50
P5	28.00	7.67	7.00	28.63	14.55	0.54	5.17	2.77	6.45	6.02	6.67
P6	28.17	8.00	6.00	32.68	19.95	0.43	4.50	3.00	7.08	7.00	5.67
P7	36.67	13.00	6.83	33.58	12.37	0.49	7.17	3.32	5.85	6.63	14.67
P8	34.67	15.67	5.67	36.88	19.02	0.78	6.00	3.03	7.47	6.28	13.67
P9	34.17	12.17	6.33	25.67	12.22	0.40	6.67	2.04	4.52	5.32	11.83
P10	36.50	14.00	5.67	62.17	17.33	0.51	18.17	2.61	6.78	5.23	13.00
P11	39.50	14.33	4.50	58.37	24.00	0.39	8.50	4.09	7.05	6.13	13.00
P12	37.83	12.83	5.67	46.47	16.20	0.44	14.33	2.13	6.48	5.15	14.00
SEm	1.301	1.046	1.004	1.510	1.032	0.019	0.664	0.266	0.096	0.081	1.101
CD(0.05)	3.680	2.959	2.839	4.272	2.919	0.051	1.877	0.753	0.273	0.230	3.114

**Table 3. Variability parameters for morphological characters in twelve parental genotypes of monopodial orchids**

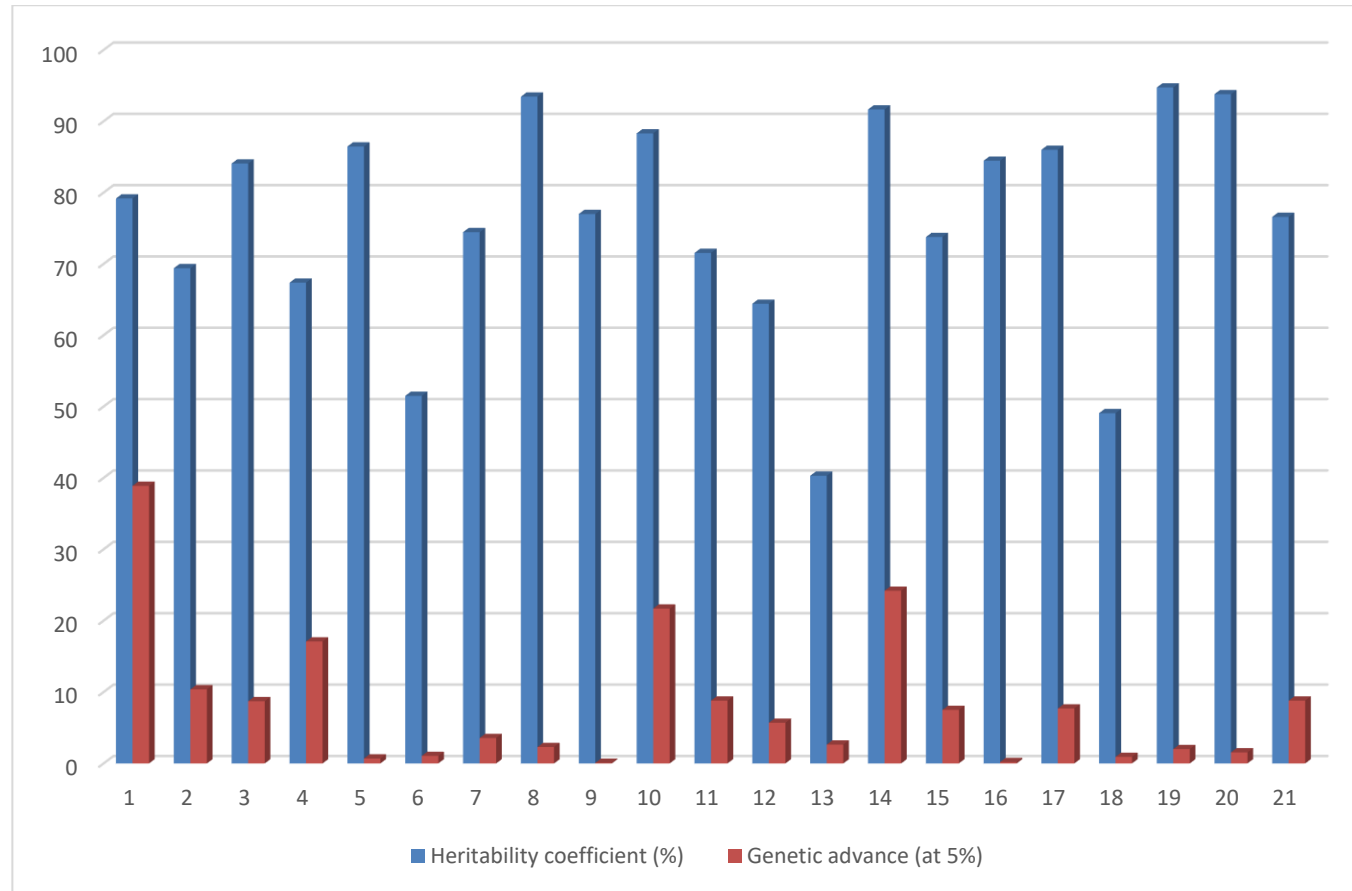
SI. No	Morphological characters	Genotypic variance	Phenotypic variance	Environmental variance	Genotypic coefficient of variation GCV(%)	Phenotypic coefficient of variation PCV(%)
1	Length of cane (cm)	450 .072	568.414	118.342	23.93	26.90
2	Number of leaves per cane	36.607	52.746	16.139	20.88	25.07
3	Number of aerial roots	21 .323	25.359	4.036	56.83	61.98
4	Length of aerial roots (cm)	102.127	151.587	49.460	22.70	27.65
5	Thickness of stem (cm)	0.130	0. 151	0.021	35.14	37.79
6	Length of internode(cm)	0.506	0.983	0.477	25.55	35.60
7	Length of leaf(cm)	4.002	5.375	1.373	17.62	20.42
8	Width of leaf(cm)	1.342	1.436	0.094	50.16	51.88
9	Thickness of leaf (cm)	0.002	0.002	0.000	25.89	29.50
10	Leaf area(cm <sup>2</sup> )	125.547	142.180	16.633	51.74	55.06
11	Days to first flower opening from inflorescence emergence	25.531	35.690	10.159	14.07	16.64
12	Days to last flower opening from first flower opening	11.885	18.451	6.566	26.24	32.69
13	Number of spikes per cane	4.080	1 0.125	6.045	30.05	47.33
14	Length of inflorescence (cm)	150.481	164.170	13.689	30.60	31.96
15	Length of scape (cm)	17.974	24.363	6.389	25.75	29.99
16	Diameter of inflorescence axis (cm)	0.010	0.012	0.002	20.39	22.18
17	Number of flowers per inflorescence	16.229	18.870	2.641	49.24	53.10
18	Length of internode of inflorescence(cm)	0.409	0.834	0.425	21.00	29.98
19	Length of flower (cm)	1.005	1.061	0.056	14.79	15.19
20	Width of flower (cm)	0.602	0.642	0.040	12.39	12.80
21	Vase life (days)	23.805	31.080	7.275	29.25	33.42

**Table 4. Heritability and genetic advance for morphological characters in twelve parental genotypes of monopodial orchids**

Sl. No	Morphological characters	Heritability coefficient (%)	Genetic advance (at 5%)	Genetic advance (% mean)
1.	Length of cane (cm)	79.18	38.89	43.87
2.	Number of leaves per cane	69.40	10.38	35.83
3.	Number of aerial roots	84.08	8.72	107.26
4.	Length of aerial roots (cm)	67.37	17.09	38.38
5.	Thickness of stem (cm)	86.46	0.69	66.99
6.	Length of internode(cm)	51.50	1.05	37.63
7.	Length of leaf(cm)	74.45	3.56	31.37
8.	Width of leaf(cm)	93.46	2.30	99.83
9.	Thickness of leaf (cm)	77.00	0.08	47.06
10.	Leaf area(cm <sup>2</sup> )	88.30	21.69	100.14
11.	Days to first flower opening from inflorescence emergence	71.54	8.80	24.51
12.	Days to last flower opening from first flower opening	64.41	5.70	43.38
13.	Number of spikes per cane	40.30	2.64	39.29
14.	Length of inflorescence (cm)	91.66	24.19	60.34
15.	Length of scape (cm)	73.77	7.50	45.57
16.	Diameter of inflorescence axis (cm)	84.47	0.19	38.00
17.	Number of flowers per inflorescence	86.00	7.70	94.13
18.	Length of internode of inflorescence(cm)	49.07	0.92	30.16
19.	Length of flower (cm)	94.74	2.01	29.65
20.	Width of flower (cm)	93.80	1.55	24.76
21.	Vase life (days)	76.59	8.80	52.76



**Fig. 1. GCV and PCV for twenty one traits in twelve parental genotypes of monopodial orchids**



**Fig. 2. Heritability ( $H^2$ ) and genetic advance (G.A.) for twenty one traits in twelve parental genotypes of monopodial orchids**

vegetative characters among the parental genotypes. The wide range of variations may be because of the fact that the majority of the parental genotypes employed in the study are higher order monogeneric, bigeneric hybrids (Mercy and Dale, 1997). Hurst (1898) had reported that higher order multigeneric hybrids exhibit a wider range of character variation as compared to lower order primary hybrids. Similar results have been observed in orchids by McConnel and Kamemoto (1983)

The important floral characters under study were length of inflorescence, number of flowers per inflorescence, length of scape, length of internode of inflorescence and thickness of inflorescence axis. Days to first flower opening from inflorescence emergence is decided by the length of inflorescence and its rate of growth (Rani,2002) Length of inflorescence has been pointed out as a character of prime importance in any orchid breeding programme (McDonald, 1991) Number of flowers per inflorescence is a character of prime importance in orchid breeding, as has been pointed out by Kamemoto (1983), McConnel and Kamemoto (1983), Singh (1986) and McDonald (1991). As all the parents used in the present study are themselves higher order hybrids the increased average flower number of seven to eighteen exhibited by the majority of the parents is in accordance with the observations of Singh (1982) that in orchids, higher order hybrids show increased number of flowers per spike. High genotypic and phenotypic coefficients of variation were observed for number of flowers per inflorescence and vase life which was found in conformity with the results of Thomas in monopodial orchids (2008). Most traits in the present study exhibited high heritability and genetic advance which was in conformity with the findings in several monopodial orchid genotypes (Thomas and Lekha, 2017).

#### 4. CONCLUSION

This study highlights the significant genetic variability present among selected parental monopodial orchid genotypes, for most of the vegetative and floral characters studied. The observed diversity, combined with heritability and genetic advance estimates, indicates their potential for use as parent plants in breeding programs to develop improved hybrids. By selecting and crossing genetically distinct individuals, breeders can enhance traits such as flower color, size, shape, and resistance to environmental stresses. These findings

emphasize the importance of genetic diversity in breeding efforts and its role in producing high-quality, commercially viable monopodial orchid hybrids for both domestic and international markets.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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