ASSESSMENT OF DIVERSITY IN NATIVE ORCHIDS

By

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(2018 - 12 - 029)

DEPARTMENT OF FLORICULTURE AND LANDSCAPING

COLLEGE OF AGRICULTURE

VELLANIKKARA, THRISSUR - 680 656

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THESIS

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DEPARTMENT OF FLORICULTURE AND LANDSCAPING
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2021

DECLARATION

I, hereby declare that the thesis entitled **"Assessment of diversity in native orchids"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Introduction

1. INTRODUCTION

Orchids are marvelous flowers of enchanting beauty. Globally, they are admired for their stunningly graceful flowers of varying shape, size and colours. Their diversity has spread in a wide variety of habitats and accordingly, they are classified as saprophytic (growing on dead and decaying matter), terrestrial (growing on ground) and epiphytic (growing on trees or shrubs). Also, orchids are exhibiting two types of growth habits i.e. monopodial and sympodial.

The family Orchidaceae is highly developed and possess 600-800 genera and 25,000-35,000 species. Most of the cultivated orchids are native of tropical countries and are copiously seen in humid tropical forests of Asia and South America (Gangaprasad, 2014).

In India, the wide diverse climatic regions favored the occurrence of wide variance in orchid flora and hence the country harbor about 1331 species and 186 genera of orchids (Misra and Misra, 2007). Orchid flora present in India is of about 10 per cent of that of the world (Medhi and Chakrabarti, 2009), in which more than 50 per cent of the orchids are contributed by North Eastern region. The Western Ghats region of India is known for high degree of endemic orchids in Peninsular India (Jalal and Jayanthi, 2012). The parts in Kerala of Western Ghats are also known for orchid species diversity, in which dominant orchid genera are *Habenaria, Oberonia, Bulbophyllum* and *Dendrobium*.

Orchids are highly priced in the international market due to their delightful appearance and long lasting quality. Today, orchids occupy a prime position among the top ten cut flowers as well as pot plants in global floriculture trade. Also, orchids are the highest selling flower in Indian cut flower industry (Khuraijam *et al*., 2017).

A large number of Indian native orchids are the parents for producing many of the excellent hybrids. Some of the Indian orchid species with ornamental potential used for breeding purpose are *Aerides multiflorum, Aerides odoratum, Coelogyne elata, Coelogyne flavida, Cymbidium aloifolium, Dendrobium nobile, Dendrobium*

chrysanthum, *Dendrobium densiflorum*, *Dendrobium moschatum*, *Dendrobium fimbriatum*, *Renanthera imschootiana*, *Rhynchostylis retusa* and *Vanda cristata* (Singh, 1990).

The flower characteristics that are useful for developing new varieties of orchids are specific flower colour, colour patterns, branched flower spikes and most recently the fragrance. (Battacharjee and Das, 2008). In Kerala, underutilized species of orchids were tried for breeding new varieties and some hybrids were developed from TBGRI, Thiruvananthapuram.

Indian orchids belonging to the genera *viz.*, *Acampe*, *Aerides*, *Arundina*, *Anoectochilus*, *Dendrobium*, *Bulbophyllum*, *Cymbidium*, *Eulophia*, *Malaxis*, *Habenaria*, *Pholidota*, *Vanda etc.* were reported to have medicinal uses and are widely used in traditional medicines to treat various types of ailments like rheumatism, inflammation, diabetes, stomach ache *etc.* (Kaushik, 2013). Many of these therapeutic orchids are also proved to be good sources of a large number of phytochemicals such as alkaloids, flavonoids, carotenoids, anthocyanins and steroids.

Since wild orchids are showing greater ornamental value, therapeutic potential and useful as important source of phytochemicals, they remain one of the main plant group to be evaluated and studied.

Despite the diversity of orchid flora in Kerala, very few native species were evaluated for their potential for ornamental and other commercial traits. So, a detailed characterisation of native orchid flora will facilitate their accelerated use in research and crop improvement and also for safeguarding the valuable genetic resources.

In this context, the present study was undertaken with the following objective,

- To assess the diversity among native orchid accessions by evaluating their morphological characters.

Review of literature

2. REVIEW OF LITERATURE

Orchids are known for their magnificent flowers of various size, shape and colour. Orchidaceae is one of the largest families among angiosperms containing more than 20,000 species and classified under the class Liliopsida and order Asparagales. According to molecular phylogenetic studies, Orchidaceae comprises five subfamilies, including Apostasioideae, Cypripedioideae, Vanilloideae, Orchidoideae and Epidendroideae (Tsai *et al.*, 2008). The astonishing floral diversity of orchids makes them unique among the world flora.

The amazing floral diversity and high keeping quality of orchid flowers are attracted by international markets. Some of the orchids like *Aerides, Arundina, Coelogyne, Cymbidium, Dendrobium, Paphiopedilum, Renanthera, Rhynchostylis*, and *Vanda* are having great demand throughout the world for their ornamental value (Janakiram and Baskaran, 2018).

Orchids are marketed globally as cut flowers (for various purposes like corsages, floral arrangements and bouquets), as potted flowering plants and bedding plants. USDA reported an increase of wholesale value of potted orchids from $170 million in 2009 (USDA, 2010) to $293 million in 2018 (USDA, 2019).

2.1 DIVERSITY AND DISTRIBUTION OF ORCHIDS

Orchids differ from other plants in their morphological characteristics as well as structural organization of the flower. The unique characteristics of orchid flowers, such as pollinia (masses of pollen), the joining of the stamens and pistil to form a column and the tiny seeds without endosperm make them distinct from other flowering plants.

The family orchidaceae is distributed all over the world except polar regions and deserts (Hedge, 1997). This cosmopolitan family is highly developed in the tropical and subtropical regions of the world. Their diversity increases towards the tropics where in epiphytic species constitutes about 73 per cent of the orchid family (Gutierrez, 2010).

India is one among the major orchid habitats of the world. The highly varying climatic regions of India are reflected in the wide diversity of orchid flora in India. The major orchid regions of India are Eastern Himalayas and North Eastern region, North West Himalayas, Peninsular India and Andaman and Nicobar Islands (De *et al*., 2014).

India is home to 1,331 species of orchids, including 400 endemic species (Misra and Misra, 2007). Indian orchids represent about six per cent of the world orchid flora and seven per cent of the flowering plants in India (De *et al.,* 2014). Among them, North Western Himalayas harbours majorly terrestrial orchids, North Eastern India harbours epiphytic orchids and Western Ghats have mostly small flowered orchids (De and Medhi, 2014).

The orchid diversity and distribution in India are geographically located in North Eastern States, Andaman and Nicobar Islands, Andhra Pradesh (Eastern Ghats), Karnataka (Kodachadri, Kemmannagundi), Kerala (Travancore), Maharashtra (Mahendragiri, Sigaraja), West Bengal (Kalimpong and Darjeeling forest areas), Tamil Nadu (Nilgiris), and Uttar Pradesh (Kaflani, Dafia Dhoora); and large scale commercial cultivation of orchid hybrids are in Kalimpong, Darjeeling, Sikkim, Guwahati, Thiruvananthapuram and Chennai (Janakiram and Baskaran, 2018).

Among the 1331 species of orchids, belonging to 186 genera reported from India, Northeast India accommodates the highest number with about 856 species (De and Medhi, 2014). The distribution of orchids in other regions of India are approximately 200 species in North-Western Himalayas, 800 species in North-Eastern India, 300 species in Western Ghats (Pande *et al.,* 2010) and about 140 orchid species are reported from Andaman and Nicobar Islands (Karthigeyan *et al*., 2014).

In peninsular India, the Western Ghats region is a richest orchid habitat in the world (Abraham and Valsala, 1981). Western Ghats extends from the border of Gujarat and Maharashtra, and runs through the states Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu, and it is also one of the 34 Biodiversity Hotspots of the world (Myers *et al*., 2000).

Western Ghats alone harbors the highest number of endemic orchid species found in Peninsular India, in which, Kerala part of Western Ghats harbours maximum number of endemic orchids (Jalal and Jayanthi, 2012). Ajithkumar *et al*. (2017) reported 99 orchid species from Western Ghats region of Wayanad containing 39 native species with horticultural and commercial importance.

2.2 GENERAL CHARACTERISTICS OF ORCHIDS

2.2.1 Growth habit

Orchids are perennials and are well adapted to various habitats. They can be terrestrial, epiphytic, lithophytic or saprophytic (Ames and Correll, 1985). Epiphytic orchids grow on host trees, terrestrial orchids grow in the ground, lithophytes grow on exposed rock and saprophytes grow on dead organic matter like decaying leaves (Zhang *et al*., 2018).

Monopodial orchids are showing straight growth with single stem and without branches. Their main axis grows continuously onward year after year and produces new leaves at the apex and bear flowers on lateral shoots in the axils of the older leaves. Their vertical growth is unlimited and they will produce hard stem. They also produce aerial roots, which help them to anchor on to the supporting media.

In case of sympodial orchids, the stem lying in the media is horizontal and grows from one side to produce lead shoot and from lead shoots, pseudostems or pseudobulbs are formed. They have limited vertical growth and produce cluster of shoots. In sympodial type of growth, the inflorescence may be either terminal or borne on the side of the shoot on a short leafless branch.

Pseudobulbs are thickened secondary stems seen in sympodials with one to many internodes and bear leaves either throughout their entire length or only at the apex of stem, which serve as reservoirs of water and food (Correll, 1950). Pseudobulb can be globular like in *Bulbophyllum,* oblong like in *Eria* or elongated as in *Dendrobium.* Pseudobulb in sympodials can be either with one internode (heteroblastic) or with

several internodes (homoblastic) (Dressler, 1993). *Dendrobium* species are examples for homoblastic pseudobulb.

2.2.2 Leaves

Orchid leaves are one to many in number (Correll, 1950), typically as that of monocots with parallel veins and small inconspicuous connection between them (Dressler, 1993).

The leaf arrangement of orchids can be alternate, distichous, spiral or clustered. Large variations are seen in leaf types of orchids. Different types of leaf shapes observed in orchids are terete, strap, channelled, linear, elliptic, lanceolate, ovate, oblong, *etc.* (De *et al*., 2011).

2.2.3 Flower

Orchid flowers are hermaphrodite and zygomorphic. The inflorescence consists of one or more flowers and forms spike, simple raceme or panicle (Correll, 1950). An example for single flowered orchid is *Paphiopedilum* and many flowered orchids are *Rhynchostylis* and *Pholidota.* The flower size of orchids is varying from small inconspicuous to large flowers. Some species of *Oberonia* (0.15 cm across) to *Pecteilis gigantea* (10 cm. across) are examples.

The orchid flower consists of sepals and petals. The sepals are coloured parts having petal-like appearance and they protect the flower in the bud stage (Withner, 2001). Outer first whorl consists of three sepals, second whorl with three petals and six stamens as whorl of three each in fourth and fifth whorl (De and Bhattacharjee, 2011). Among the three petals, one appears unique which is called the lip (labellum). The lip can be seen in varying patterns (*viz.*, trumpet-shaped, fringed, curved, elongated, or formed like a pouch) with or without lip lobes and markings (Biswas and Singh, 2019). The lip or sometimes the whole flower will show modification for attracting insects for pollination.

One of the distinctive features of orchid flower is the column which is the single reproductive structure formed by a fusion of stamens and pistils (De and Bhattacharjee, 2011).

There are three stamens and three pistils in orchids, but usually, only the anther of one stamen remains functional (Withner, 1959). The anthers are situated near the tip of the column and stigmatic surface is situated just below it. In orchids, the pollen grains are aggregated to form pollinia and these pollinia, in most of the orchids, are seen as tetrad form (Shukla *et al*., 1998).

Resupination is another phenomenon seen in orchids. The term resupinate is used for orchids that have lip on the lower side (Dressler, 1993). As the orchid flower bud develops, the lip will be usually in uppermost position, while by the time of flower open, the flower stem twists to present the lip pointing downwards.

2.2.4 Pollination and seed set

A most fascinating natural phenomenon in Orchidaceae family is insect-pollination. Many of the orchids have spur that produces nectar to attract pollinators (Dressler, 1993). Colour, shape, size and fragrance are the other flower signals that attract pollinator (Tsai *et al*., 2008). When pollinators like bee, moth, butterflies, ants *etc*. enter the lip, they search for nectar. Then the caps are released and pollens fall on to insect head. Thus, when they visit another flower, pollinia will come in contact with stigma of that flower and it facilitates germination of pollen grains (De and Bhattacharjee, 2011).

Self pollination occurs in orchids like *Cypripedium* and *Neottia* spp. due to their different morphological structure of flower which favours self pollination (Bose *et al*., 1999). Natural hybrids aroused as cross between different species are also reported in some genera like *Oncidium* and *Cattleya*.

After pollination, the flower sheds and the ovary enlarge to form pods. The fruits of orchids are called as pods. They may be dry capsules and are varyingly shaped, commonly ovoid, ellipsoid or cylindrical. *Vanilla* beans are having cylindrical shaped

pods (Correll, 1950). In orchids, the pods formed takes about 14 months for its complete development, while within nine months itself it might form millions of seeds in the pod (Withner, 2001).

The seeds are minute, dust like in size. The embryo of the seeds is underdeveloped due to lack of nutrient tissues and it needs symbiotic association with a favorable fungus for germination (Biswas and Singh, 2019).

Understanding the phenology of orchids are helpful to know about the effect of environmental changes on distribution, abundance and interaction of orchids with other species (Memmott *et al*., 2007; Hegland *et al*., 2009). Temperature, photoperiod and moisture are the three environmental factors that influences phenological progress of a plant (Rathcke and Lacey,1985). Godinez (1996) stated that terrestrial orchids with year round water supply in its microhabitat can afford to bloom in dry season. Temperature dependent flowering behaviour was recorded in *Dendrobium crumentum* (Meesawat and Kanchanapoom, 2007).

2.3 CONSERVATION OF ORCHID GENETIC RESOURCES

Orchids are a highly specialized group of plants and have modified themselves to adapt in almost all ecosystems. They are having specialized mycorrhizal association for nutrition and germination. They are more vulnerable to the destruction of habitat loss and degradations due to natural threats, anthropogenic interference and pressure exerted by invasive species (Janakiram and Baskaran, 2018). All these factors urge for the conservation of orchid flora.

There are mainly three methods of conservation of genetic resources of orchid species. They are legislative measures, *In-situ* conservation and *Ex-situ* conservation. Under legislative measures in India, three genera and eleven species of orchids are being treated as protected under Schedule-VI of Wild Life Protection Act of 1972 and also under Appendix-I of CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora).

In-situ conservation of orchids in biosphere reserve, national parks, sacred groves, gene sanctuary, individual trees are some examples for maintenance of the germplasm in its natural habitat without any human interference. *Ex-situ* conservation strategies include orchidaria, field gene banks, botanical gardens, herbal gardens, *in vitro* conservation, cryopreservation, *etc*.

2.4 ECONOMIC IMPORTANCE OF ORCHIDS

Orchids are grown primarily as ornamentals and are valued as cut flowers not only because of their admiring beauty but also of their long shelf life. Even if orchids are grown primarily as ornamentals, some of them are used as herbal medicines and food (Arditii, 1992). Vanilla is an example of orchids being used as a spice.

Orchid hybrids of *Cymbidium, Dendrobium, Vanda, Phalaenopsis, Oncidium, Cattleya, Paphiopedilum, Mokara, Aranda, Renantanda etc.* are used as cut flowers, floral display and as exhibits (De and Medhi, 2015).

In North Eastern India, the terrestrial species of *Calanthe, Eulophia, Paphiopedilum, Pecteilis, Phaius* and *Spathoglottis etc.* are having great ornamental value (Singh, 1986). Since orchids are rich source of phytochemicals such as alkaloids, flavonoids, glycosides and carbohydrates, tribal people of North Eastern Region of India use wild orchids in folk medicine. *Acampe papillosa, Aerides odorata, Cymbidium aloefolium, Dendrobium nobile, Habenaria acuminata, Rhynchostylis retusa, Dendrobium densiflorum etc*. are some examples (Rao, 2004). Some *Dendrobium* species such as *Dendrobium aduncum*, *Dendrobium densiflorum*, *Dendrobium jenkinsii* and *Dendrobium nobile* are used in preparation of Chinese tonic 'Shi Hu', which is having aphrodisiac properties (Yi *et al*., 2005).

Among the orchid species of North Eastern India, four orchids i.e. *Jeevak* (*Malaxis muscifera*), *Rishabhak* (*Malaxis acuminata*), *Riddhi* (*Habenaria intermedia* and *Eulophia nuda*) and *Vriddhi* (*Habenaria edgeworthii*) are used in 'Astavarga' group of drugs in Ayurvedic system of medicine. Some of other orchid species being used in various Ayurveda medicines are *Jeevanti* (*Flickingeria macraei*), *Rasna* (*Vanda*

tessellata), *Munjatak* (O*rchis latifolia*), *Amarkand* (*Eulophia nuda*) *etc*. (Ninawe and Swapna, 2017).

Leaves, tubers and pseudobulbs of orchid species are used for edible purposes (De and Medhi, 2015). Leaves of some orchids belongs to the genus *Anoectochilus* are used as vegetables in Indonesia and Malaysia (De and Pathak, 2015).

Some of the Indian orchid species having worldwide attention in breeding programme are *Aerides multiflora, Cymbidium devonianum, Cymbidium elegans, Cymbidium lowianum, Cymbidium tracyanum, Dendrobium aggregatum, Dendrobium chrysotoxum, Dendrobium formosum, Dendrobium nobile, Paphiopedilum venustum, Vanda coerulea etc*. (Bose and Bhattacharjee, 1980). Most of Indian species of *Cymbidium, Dendrobium* and *Vanda* studied have been proved good to use in breeding programme mainly to produce primary hybrids due to their inherent attractiveness accompanied with their ability to pass on their ornamental traits to the hybrids (De and Medhi, 2015)

Fragrant orchids are another attraction now a days. Frowine (2005) listed out many orchid species having strong fragrance such as *Acampe papillosa, Aerides falcata, Cattleya loddigesii, Coelogyne pandurata, Dendrobium aureum etc.*

Fragrant orchids like *Aerides multiflorum, Aerides odoratum, Cattleya maxima, Coelogyne cristata, Coelogyne ochracea, Dendrobium chrysotoxum, Lycaste* species, *Oncidium sphaceolatum, Rhynchostylis retusa* and *Zygopetalum intermedium* are more suited in outdoor living spaces (De and Pathak, 2015).

2.5 MORPHOLOGICAL DIVERSITY ASSESSMENT STUDIES

Morphology describes structural features. size, shape, colour *etc*. are morphological characters of an organism. Evaluation of morphological characteristics of plant species is the basic step for understanding crop diversification in phylogenetic studies (Freudenstein and Chase, 2015).

De *et al*. (2015) developed morphological descriptors for qualitative and quantitative traits of *Vanda* orchids by evaluating 11 *Vanda* species, and those

descriptors can be used for characterization of orchids belonging to *Vanda* alliances *viz., Vandas, Aerides, Ascocentrum, Renanthera, Rhynchostylis, Aranda, Mokara* and *Kagawara.*

Hartati *et al.* (2019) showed that there were morphological diversities existing among six *Coelogyne spp.* collected from different locations with respect to qualitative morphological characters of the stem, pseudobulb, leaves, flowers and type of roots.

Diversity of 49 living wild *Rhynchostylis gigantea* accessions collected from 22 locations of Thailand were morphologically characterized for twelve quantitative and 30 qualitative characters (Anuttato *et al*., 2017) and the analysis showed highly significant differences in floral size and dorsal sepal width among the accessions.

Akshata *et al*. (2018) conducted morphological characterization of wild orchids of Western Ghats belonging to genera *Bulbophyllum, Coelogyne, Dendrobium, Luisia, Oberonia, Pholiodata, Spathoglottis, Trias* and *Vanda.* The result revealed considerable variations in the shoot height, number of leaves per pseudobulb, leaf length, leaf breadth and leaf ratio of wild orchids.

The studies conducted by researchers Hartati *et al.* (2019), Anuttato *et al*. (2017) and Akshata *et al*. (2018) confirmed that morphological diversity in orchids can be assessed by evaluating their morphological traits.

Materials and methods

3. MATERIALS AND METHODS

The study entitled "Assessment of diversity in native orchids" was conducted in the Department of Floriculture and Landscaping, College of Agriculture, Vellanikkara from July 2019 to June 2020. The objective of the study is to assess the diversity among native orchid accessions under AICRP on Floriculture by evaluating their morphological characters.

The materials used and the methodologies adopted for the investigation are given in this chapter.

1. LOCATION

Vellanikkara is situated at the latitude of 10º54' N and longitude of 76º28' E. The experimental area lies at 22.25 m above mean sea level.

2. CLIMATE

The site with tropical humid climate is having a maximum temperature of 36.40 °C and a minimum temperature of 21.40 °C during the period of research study. The mean relative humidity value ranged between 54 to 89 per cent. The total rainfall recorded during the period was 3243.60 mm. Weather data during the investigation period is given in appendix I.

3. MATERIALS

3.1 Morphological evaluation

3.1.1 Genotypes

Twenty three accessions in the native orchid germplasm conserved at AICRP on Floriculture, Vellanikkara Centre, were selected for evaluation (Plate 1-7). All the native orchid accessions were collected from different parts of Western Ghats, mainly from Kerala part of Western Ghats, *viz.*, Wayanad, Kannur, Kasaragode, Kozhikode, and Thrissur areas.

Table 1. The list of native orchid accessions selected for study

Sl. No.	Genus	Species	Accession code
1	*Acampe*	*Acampe praemorsa*	VKA/NOR-3

2	*Aerides*	*Aerides crispa*	VKA/NOR-2
3	*Bulbophyllum*	*Bulbophyllum* sp.	VKA/NOR-39
4	*Coelogyne*	*Coelogyne breviscapa*	VKA/NOR-33
5	*Cymbidium*	*Cymbidium aloifolium*	VKA/NOR-61
6		*Cymbidium ensifolium*	VKA/NOR-43
7		*Cymbidium* sp.	VKA/NOR-30
8		*Cymbidium* sp.	VKA/NOR-35
9	*Dendrobium*	*Dendrobium anceps*	VKA/NOR-24
10		*Dendrobium crumenatum*	VKA/NOR-34
11		*Dendrobium densiflorum*	VKA/NOR-22
12		*Dendrobium fimbriatum*	VKA/NOR-27
13		*Dendrobium haemoglossum*	VKA/NOR-41
14		*Dendrobium moschatum*	VKA/NOR-37
15		*Dendrobium ovatum*	VKA/NOR-60
16	*Eria*	*Eria fragrans*	VKA/NOR-25
17		*Eria* sp.	VKA/NOR-38
18	*Flickingeria*	*Flickingeria* sp.	VKA/NOR-32
19	*Luisia*	*Luisia* sp.	VKA/NOR-7
20	*Oberonia*	*Oberonia* sp.	VKA/NOR-58
21	*Pholidota*	*Pholidota imbricata*	VKA/NOR-29
22	*Rhynchostylis*	*Rhynchostylis retusa*	VKA/NOR-4
23	*Vanda*	*Vanda thwaitesii*	VKA/NOR-8

3.1.2 Orchidarium

The plants are housed in top ventilated greenhouse (15 m × 12 m) provided with green shade net (50% shade).

3.1.3 Media

Native orchids are maintained in clay pots and kept on aluminium meshed table to allow the growth of roots. The media consist of coconut husk pieces, brick and charcoal pieces which provides good drainage and aeration.

3.1.4 Management practices

The plants were managed according to the Package of Practices recommendations

Plate 1. Native orchid germplasm collection at Department of Floriculture and Landscaping

Acampe praemorsa
(VKA/NOR-3)

Vanda thwaitesii
(VKA/NOR-8)

***Bulbophyllum* sp.**
(VKA/NOR-39)

Cymbidium ensifolium
(VKA/NOR-43)

Plate 2a. Native orchid accessions evaluated

Aerides crispa
(VKA/NOR-2)

Dendrobium haemoglossum
(VKA/NOR-41)

***Flickingeria* sp.**
(VKA/NOR-32)

Cymbidium aloifolium
(VKA/NOR-61)

Plate 2b. Native orchid accessions evaluated

***Oberonia* sp.**
(VKA/NOR-58)

Dendrobium ovatum
(VKA/NOR-60)

***Eria* sp.**
(VKA/NOR-38)

Pholidota imbricata
(VKA/NOR-29)

Plate 2c. Native orchid accessions evaluated

Dendrobium crumenatum
(VKA/NOR-34)

Dendrobium densiflorum
(VKA/NOR-22)

Dendrobium moschatum
(VKA/NOR-37)

Dendrobium anceps
(VKA/NOR-24)

Plate 2d. Native orchid accessions evaluated

Rhynchostylis retusa **(VKA/NOR-4)**

Dendrobium fimbriatum **(VKA/NOR-27)**

Luisia **sp. (VKA/NOR-7)**

Eria fragrans **(VKA/NOR-25)**

Plate 2e. Native orchid accessions evaluated

***Cymbidium* sp.**
(VKA/NOR-30)

Coelogyne breviscapa
(VKA/NOR-33)

***Cymbidium* sp.**
(VKA/NOR-35)

Plate 2f. Native orchid accessions evaluated

KAU (KAU, 2016). Watering was given daily once in cooler months and twice in warmer months to maintain adequate humidity. Foliar application of nutrients NPK at 13:27:27 3g/l were given twice a week. Need based application of plant protection chemicals was also given.

3.1.5 Observations

Vegetative and floral characters were recorded during 2019 July to 2020 June among all 23 accessions. Qualitative characteristics were recorded based on descriptors available from National Research Centre for Orchids, Sikkim (Guidelines for DUS test on Orchids developed by NRC for Orchids and PPV & FR Authority (NRCO and PPV & FRA, 2012)). The descriptors used for morphological evaluation are given in appendix II, III and IV.

A. Growth habit

1. Monopodial type: Single main stem grows vertically and produces a series of leaves. Roots and flower stems emerge alternately along the main stem at the nodes above leaves.

2. Sympodial type: Orchids have a rhizome (main stem) at the base with a series of growths developing upward from it (pseudobulbs).

B. Vegetative characters (quarterly intervals)

I. QUANTITATIVE CHARACTERS

1. Plant height

Monopodials: The height of the plant was measured from the base to the growing apex at quarterly intervals and expressed in centimetres.

Sympodials: The height of the plant was measured from the base to the tip of newly emerging leaf at quarterly intervals and expressed in centimetres.

2. Plant spread

The plant spread was measured at quarterly intervals by recording NS and EW spread and expressed in centimetres.

3. Internodal length

The internodal length was measured for three internodes just above the base of the plant and expressed in centimetres.

4. Pseudobulb length

The length of pseudobulb was measured and expressed in centimetres.

5. Pseudobulb width

The circumference (girth) of pseudobulb was measured at the maximum wide area and expressed in centimetres.

6. Number of leaves per plant

Total number of leaves present at the time of each observation was counted and recorded as number of leaves per plant.

7. Leaf length

Length of leaf was measured from base to the tip for three full grown leaves and average was expressed in centimetres.

8. Leaf width

Maximum width of the expanded leaf was measured for three leaves and average was expressed in centimetres.

9. Leaf sheath length

The length of the sheath from the point of attachment to the shoot to the leaf lamina was measured and expressed in centimetres

10. Number of roots

For monopodial orchids, number of aerial roots were counted on quarterly basis and for sympodial orchids number of roots produced by the plant were recorded by counting the number of roots after taking out plant from the pot during the last quarter of observation and recorded.

II. QUALITATIVE CHARACTERS

1. **Leaf shape -** Terete, semi-terete, strap, channelled, narrow lanceolate, linear, narrow elliptic, elliptic, lanceolate, ovate, linear oblong, oblong, narrow oblong
2. **Leaf texture -** smooth, rigid, leathery, glabrous, pubescent, fleshy
3. **Leaf arrangement -** distichous, spiral, alternate, clustered at base
4. **Leaf orientation -** erect, semi erect, pendulous, straight, arching, deflexed, horizontal
5. **Leaf colour -** Colour of mature leaf was observed based on RHS (Royal Horticultural Society) colour chart (2015 edition)
6. **Branching of roots -** presence/absence
7. **Colour of roots -** grey/green/white

C. Floral characters

I. QUANTITATIVE CHARACTERS

1. Flowering time/season

The season of flowering was observed throughout the year for each accession and recorded.

2. Number of flower spikes per plant

Number of spikes produced on each plant were noted and recorded.

3. Number of florets per spike

The number of florets per spike in each plant was recorded.

4. Length of spike

The total length of the spike from the base of the spike to tip in each plant was recorded and expressed in centimetres.

5. Rachis length

The length of the flowering area (rachis) per spike in each plant was recorded and expressed in centimetres.

6. Stalk length

Stalk length of individual floret was measured for three florets and expressed in centimetres.

7. Girth of spike at base

The circumference of the spike at 5.0 cm from the point of attachment to the stem was recorded as the spike girth and expressed in centimetres.

8. Flower size

Size of individual floret was recorded as product of length (vertically) and breadth (across) and expressed in sq.cm.

9. Petal length

Length of petal was measured from point of attachment of petal to base of floret to the tip of petal and expressed in centimetres. Observation taken as average value of three florets.

10. Petal width

Maximum width of petal was measured and expressed in centimetres. Observation was taken as average value of three florets.

11. Petal to petal distance

Petal to petal distance was measured from tip of one petal to the other petal and expressed in centimetres.

12. Length of dorsal sepal

Length of dorsal sepal was measured from point of attachment of dorsal sepal to base of floret to the tip of dorsal sepal and expressed in centimetres. Observation taken as average value of three florets.

13. Width of dorsal sepal

Maximum width of dorsal sepal was measured and expressed in centimetres. Observation taken as average value of three florets.

14. Length of lateral sepal

Length of lateral sepal was measured from point of attachment of lateral sepal to base of floret to the tip of lateral sepal and expressed in centimetres. Observation taken as average value of three florets.

15. Width of lateral sepal

Maximum width of lateral sepal was measured and expressed in centimetres. Observation taken as average value of three florets.

16. Sepal to sepal distance

Sepal to sepal distance was measured between two lateral sepals and between dorsal and lateral sepal from tip of one sepal to the other sepal and expressed in centimetres.

17. Dorsal sepal to lip

Dorsal sepal to lip distance was measured from the tip of dorsal sepal to the tip of lip and expressed in centimetres.

18. Lip (labellum) length

Maximum length of the lip (labellum) was recorded and expressed in centimetres.

19. Lip (labellum) width

Maximum width of the lip (labellum) was recorded and expressed in centimetres.

20. Column length

Column length was measured from base to the tip of the column and expressed in centimetres.

21. Column width

Width of column was measured and expressed in centimetres

22. Frequency of flowering

Number of times flowering observed in orchid accessions during the study period was recorded.

23. Longevity of spike on the plant

Longevity of the spike was counted from the day of flower opening to the day of wilting of one floret in the spike.

24. Longevity of floret on the spike

Life of individual floret was counted for four florets per spike from the day of the floret opens to the day of wilting of four floret and expressed in number of days.

25. Pollen viability

Pollens were collected from the flowers on the first day of flower opening. They were collected to a Petri plate using a toothpick after lifting of anther cap. Pollen were dispersed using a drop of acetocarmine stain and then observed through compound microscope after putting cover slip. Viable pollen stained red and non-viable pollen did not show any colour. The observations were made on five different microscopic fields of one slide. It was repeated in three different slides. The mean percentage of viable pollen grain was then calculated as the ratio of total number of viable pollens to total number of pollens.

II. QUALITATIVE CHARACTERS

1. **Spike orientation -** erect, horizontal, drooping, arching, pendulous
2. **Petal shape -** linear, oblong, elliptic, obovate, ovate, orbicular, lanceolate, round
3. **Petal curvature -** incurved with deflexed apex, incurved with straight apex, deflexed with incurved apex, straight, spiral, deflexed
4. **Lip (labellum) shape -** ovate, obovate, lanceolate, orbicular, oblanceolate, oblong, round
5. **Lip lobation** (lobed lip) - presence/absence

6. **Sepal colour -** colour of sepal was observed based on RHS (Royal Horticultural Society) colour chart (2015 edition)

7. **Petal colour -** colour of petal was observed based on RHS (Royal Horticultural Society) colour chart (2015 edition)

8. **Lip (labellum) colour** - colour of lip (labellum) was observed based on RHS (Royal Horticultural Society) colour chart (2015 edition)

9. **Column colour** -column colour was observed based on RHS (Royal Horticultural Society) colour chart (2015 edition)

10. **Marking on lip** - colour of marking present on lip was observed based on RHS (Royal Horticultural Society) colour chart (2015 edition)

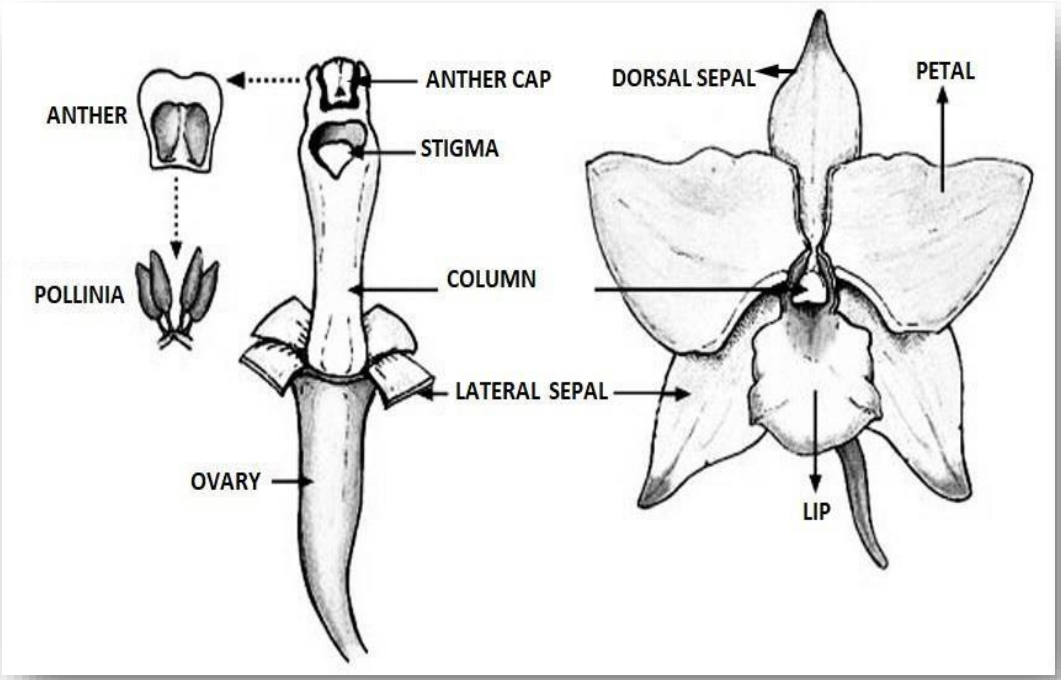
11. **Flower fragrance -** presence/ absence

General observations on incidence of pests, diseases and disorders were also recorded.

3.1.6 Statistical analysis

The data on quantitative vegetative characters and quantitative floral characters were subjected to One-way Anova and comparison of means using Web Agri Stat Package 2.0 (ICARGOA), an online-based tool for statistical analysis. Cluster analysis of the data was carried out using Minitab Statistical Software (Minitab 19).

MORPHOLOGY OF AN ORCHID FLOWER



Results

4. RESULTS

The results of investigation conducted on 'Assessment of diversity in native orchids' are presented in this chapter under the following sections.

4.1. GROWTH HABIT

According to the growth habits of native orchid accessions evaluated, the germplasm was classified in to monopodial orchids and sympodial orchids. Among the twenty-three native orchid accessions, five were monopodials and eighteen were sympodials (Table 2).

Table 2. Growth habit of native orchid accessions

Monopodial orchids		
Sl. No.	Accession code	Name
1	VKA/NOR-3	*Acampe praemorsa*
2	VKA/NOR-2	*Aerides crispa*
3	VKA/NOR-4	*Rhynchostylis retusa*
4	VKA/NOR-7	*Luisia* sp.
5	VKA/NOR-8	*Vanda thwaitesii*
Sympodial orchids		
1	VKA/NOR-22	*Dendrobium densiflorum*
2	VKA/NOR-24	*Dendrobium anceps*
3	VKA/NOR-27	*Dendrobium fimbriatum*
4	VKA/NOR-34	*Dendrobium crumenatum*
5	VKA/NOR-37	*Dendrobium moschatum*
6	VKA/NOR-41	*Dendrobium haemoglossum*
7	VKA/NOR-60	*Dendrobium ovatum*
8	VKA/NOR-25	*Eria fragrans*
9	VKA/NOR-38	*Eria* sp.
10	VKA/NOR-29	*Pholidota imbricata*
11	VKA/NOR-39	*Bulbophyllum* sp.
12	VKA/NOR-32	*Flickingeria* sp.
13	VKA/NOR-33	*Coelogyne breviscapa*
14	VKA/NOR-61	*Cymbidium aloifolium*
15	VKA/NOR-43	*Cymbidium ensifolium*
16	VKA/NOR-30	*Cymbidium* sp.
17	VKA/NOR-35	*Cymbidium* sp.
18	VKA/NOR-58	*Oberonia* sp.

4.2. VEGETATIVE CHARACTERS

4.2.1 Quantitative vegetative characters

4.2.1.1 Monopodial orchids

1. Plant height

Plant height recorded for monopodial orchids at quarterly intervals is presented in Table 3. Significant variation was observed throughout the entire period of study. *Acampe praemorsa* (VKA/NOR-3) recorded the highest value and *Rhynchostylis retusa* recorded the lowest value for plant height. In the last quarter (April-June 2020), *Acampe praemorsa* showed a maximum plant height of 43.36 cm and *Rhynchostylis retusa* (VKA/NOR-4) recorded minimum plant height of 23.64 cm.

2. Plant spread

A. Plant spread (N-S)

During the first quarter (July-Sept 2019) of study, *Luisia* sp. (VKA/NOR-7) recorded the highest plant spread (N-S) (40.54 cm) (Table 4) which was on par with *Acampe praemorsa* (VKA/NOR-3) (33.16 cm), followed by *Aerides crispa* (27.37 cm) which was on par with *Rhynchostylis retusa* (VKA/NOR-4) (27.22 cm). *Vanda thwaitesii* (VKA/NOR-8) recorded the lowest value for plant spread (15.12 cm). Almost similar trend was observed in the next three quarters including the final quarter. In the last quarter (April-June 2020), plant spread (N-S) was the highest for *Luisia* sp. (VKA/NOR-7) (43.24 cm) which was on par with *Acampe praemorsa* (VKA/NOR-3) (37.10 cm), and the minimum plant spread (N-S) was recorded for *Vanda thwaitesii* (VKA/NOR-8) (17.82 cm).

B. Plant spread (E-W)

Plant spread (E-W) also showed almost similar trend throughout the entire study period (Table 5). At the end of study period (April-June 2020), *Luisia* sp. (VKA/NOR-7) (35.40 cm) recorded significantly the highest plant spread (E-W) compared to all other species. The minimum plant spread (E-W) among monopodials was recorded for *Vanda thwaitesii* (VKA/NOR-8) (6.70 cm).

Table 3. Plant height (cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant height (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	37.42	38.60	41.30	43.36
2	VKA/NOR-2	*Aerides crispa*	25.90	27.82	30.62	31.20
3	VKA/NOR-4	*Rhynchostylis retusa*	18.02	19.92	22.46	23.64
4	VKA/NOR-7	*Luisia* sp.	23.82	26.26	27.70	28.64
5	VKA/NOR-8	*Vanda thwaitesii*	20.56	23.60	26.82	28.06
CD (0.05)			**5.89**	**4.88**	**3.24**	**12.90**

Table 4. Plant spread (N-S) (cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant spread N-S (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	33.16	33.32	33.64	37.10
2	VKA/NOR-2	*Aerides crispa*	27.37	27.80	29.40	29.90
3	VKA/NOR-4	*Rhynchostylis retusa*	27.22	27.60	28.00	32.80
4	VKA/NOR-7	*Luisia* sp.	40.54	41.44	42.84	43.24
5	VKA/NOR-8	*Vanda thwaitesii*	15.12	16.02	17.02	17.82
CD (0.05)			**8.50**	**11.34**	**10.63**	**10.66**

Table 5. Plant spread (E-W) (cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant spread E-W (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	17.18	18.58	21.38	21.40
2	VKA/NOR-2	*Aerides crispa*	7.82	8.92	10.80	11.26
3	VKA/NOR-4	*Rhynchostylis retusa*	11.82	12.50	16.42	18.70
4	VKA/NOR-7	*Luisia* sp.	32.84	33.90	34.80	35.40
5	VKA/NOR-8	*Vanda thwaitesii*	4.10	5.50	5.90	6.70
CD (0.05)			**7.67**	**6.04**	**5.34**	**7.70**

Table 6. Plant spread area (sq.cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant spread area (sq.cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	562.25	621.78	737.98	835.70
2	VKA/NOR-2	*Aerides crispa*	213.45	259.36	306.20	353.82
3	VKA/NOR-4	*Rhynchostylis retusa*	339.03	380.64	479.70	643.20
4	VKA/NOR-7	*Luisia* sp.	1412.75	1,446.74	1,540.09	1571.28
5	VKA/NOR-8	*Vanda thwaitesii*	61.96	93.60	105.60	133.60
CD (0.05)			**399.36**	**403.94**	**444.16**	**517.01**

C. Plant spread (sq.cm)

Plant spread recorded in terms of area showed appreciable variation in monopodials (Table 6). *Luisia* sp. (VKA/NOR-7) recorded the maximum plant spread (1571.28 sq.cm), and it was followed by *Acampe praemorsa* (VKA/NOR-3) (835.70 sq.cm) in the final quarter (April-June 2020). *Vanda thwaitesii* (VKA/NOR-8) recorded minimum plant spread (sq.cm) throughout the entire period of observation period and it was 133.60 sq.cm at the end of study period (April-June 2020). The plant spread of *Rhynchostylis retusa* (VKA/NOR-4) was found on par with *Aerides crispa* (VKA/NOR-2) and it was 643.20 sq.cm and 353.82 sq.cm, respectively, for both species in the final quarter (April-June 2020) of observation period.

3. Internodal length

A noticeable variation in internodal length was observed in the monopodial accessions (Table 7). *Acampe praemorsa* (VKA/NOR-3) recorded the highest internodal length throughout the entire period of study and it was significantly superior to all other accessions. In the last quarter (April-June 2020) of observation *Acampe praemorsa* (VKA/NOR-3) recorded an internodal length of 2.40 cm, while all other accessions were found on par with respect to internodal length. The lowest internodal length was recorded in *Luisia* sp. (VKA/NOR-7) (1.04 cm) till the end of study period (April-June 2020).

4. Number of leaves

Significant difference was observed in number of leaves of the selected monopodial accessions (Table 8). *Luisia* sp. (VKA/NOR-7) recorded the maximum number of leaves (89.20) and during the entire period of study it was significantly highest compared to all other accessions. The minimum number of leaves were recorded for *Rhynchostylis retusa* (VKA/NOR-4) (8.00) and it was found that *Aerides crispa* (VKA/NOR-2) (10.00) was on par with *Rhynchostylis retusa* (VKA/NOR-4) in number of leaves.

Table 7. Internodal length (cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Internodal length (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	2.00	2.14	2.08	2.40
2	VKA/NOR-2	*Aerides crispa*	1.00	1.10	1.40	1.64
3	VKA/NOR-4	*Rhynchostylis retusa*	0.86	1.24	1.28	1.42
4	VKA/NOR-7	*Luisia* sp.	0.70	0.98	1.02	1.04
5	VKA/NOR-8	*Vanda thwaitesii*	1.17	1.26	1.30	1.32
CD (0.05)			**0.37**	**0.31**	**0.49**	**0.69**

Table 8. Number of leaves per plant in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Number of leaves per plant			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	9.60	12.00	12.00	13.00
2	VKA/NOR-2	*Aerides crispa*	7.20	9.80	10.00	10.00
3	VKA/NOR-4	*Rhynchostylis retusa*	6.00	7.20	7.40	8.00
4	VKA/NOR-7	*Luisia* sp.	74.60	85.60	86.20	89.20
5	VKA/NOR-8	*Vanda thwaitesii*	35.25	37.00	37.20	37.40
CD (0.05)			**28.03**	**24.67**	**24.79**	**24.86**

Table 9. Leaf length (cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf length (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	22.56	22.88	23.02	23.94
2	VKA/NOR-2	*Aerides crispa*	16.58	18.58	18.74	19.04
3	VKA/NOR-4	*Rhynchostylis retusa*	16.48	19.48	20.82	21.00
4	VKA/NOR-7	*Luisia* sp.	16.01	16.54	16.60	17.62
5	VKA/NOR-8	*Vanda thwaitesii*	12.76	13.00	14.40	14.80
CD (0.05)			**3.94**	**4.01**	**3.82**	**4.00**

Table 10. Leaf width (cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf width (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	2.67	2.68	2.74	2.76
2	VKA/NOR-2	*Aerides crispa*	2.02	2.12	2.28	2.36
3	VKA/NOR-4	*Rhynchostylis retusa*	2.26	2.30	2.32	2.34
4	VKA/NOR-7	*Luisia* sp.	0.82	0.96	0.99	1.02
5	VKA/NOR-8	*Vanda thwaitesii*	1.52	1.54	1.55	1.57
CD (0.05)			**0.31**	**0.20**	**0.23**	**0.46**

5. Leaf length

A marked difference in leaf length was recorded among the monopodial accessions (Table 9). During the first quarter (July-Sept 2019) leaf length of *Acampe praemorsa* (VKA/NOR-3) (22.56 cm) showed significantly high value than all other accessions, but during final quarters maximum leaf length of *Acampe praemorsa* (VKA/NOR-3) (23.94 cm) was on par with *Rhynchostylis retusa* (VKA/NOR-4) (21.00 cm). Minimum leaf length was recorded in *Vanda thwaitesii* (VKA/NOR-8) (14.80 cm). The accessions *Aerides crispa* (VKA/NOR-2) and *Luisia* sp. (VKA/NOR-7) recorded 19.04 cm and 17.62 cm, respectively for leaf length, which were on par in the final quarter (April-June 2020) of study.

6. Leaf width

Differences in leaf width among monopodial accessions were clearly evident during early period of observation (July-Sept 2019) (Table 10). *Acampe praemorsa* (VKA/NOR-3) was significantly superior to all other accessions. During the last quarter (April-June 2020) of observation, maximum leaf width of 2.76 cm was recorded for *Acampe praemorsa* (VKA/NOR-3) which was on par with *Aerides crispa* (VKA/NOR-2) (2.36 cm) and *Rhynchostylis retusa* (VKA/NOR-4) (2.34 cm). Minimum leaf width of 1.02 cm was recorded in *Luisia* sp. (VKA/NOR-7).

7. Leaf sheath length

The leaf sheath length was very noticeable among the five monopodial accessions studied (Table 11). Throughout the entire study period, the highest sheath length was recorded by *Acampe praemorsa* (VKA/NOR-3) which was on par with *Vanda thwaitesii* (VKA/NOR-8) and *Aerides crispa* (VKA/NOR-2). During the last quarter (April-June 2020) of observation, *Acampe praemorsa* (VKA/NOR-3) recorded the maximum value of 3.60 cm and the lowest value was recorded for *Luisia* sp. (VKA/NOR-7) (0.52 cm).

Table 11. Leaf sheath length (cm) in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf sheath length (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	3.32	3.36	3.44	3.60
2	VKA/NOR-2	*Aerides crispa*	3.02	3.08	3.10	3.10
3	VKA/NOR-4	*Rhynchostylis retusa*	1.98	2.00	2.04	2.08
4	VKA/NOR-7	*Luisia* sp.	0.46	0.48	0.50	0.52
5	VKA/NOR-8	*Vanda thwaitesii*	3.04	3.06	3.08	3.10
CD (0.05)			**0.65**	**0.71**	**0.77**	**0.81**

Table 12. Number of roots in monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Number of roots			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-3	*Acampe praemorsa*	5.00	7.60	7.60	7.80
2	VKA/NOR-2	*Aerides crispa*	5.60	7.16	7.20	7.22
3	VKA/NOR-4	*Rhynchostylis retusa*	4.60	4.80	6.20	6.40
4	VKA/NOR-7	*Luisia* sp.	9.00	9.20	9.20	9.80
5	VKA/NOR-8	*Vanda thwaitesii*	9.20	9.20	9.80	10.60
CD (0.05)			**NS**	**NS**	**NS**	**NS**

8. Number of roots

There was no significant difference observed in number of aerial roots produced by monopodial orchid accessions during the entire period of study (Table 12). The number of roots ranged in between 6.40 and 10.60 towards the final quarter (April-June 2020). Highest number of roots was recorded for *Vanda thwaitesii* (VKA/NOR-8) (10.60) and lowest for *Rhynchostylis retusa* (VKA/NOR-4) (6.40).

4.2.1.2 Sympodial orchids

1. Plant height

Plant height recorded for sympodial orchids at quarterly intervals are given in the Table 13. High significant difference was observed for plant height in all the sympodial accessions studied. During the first quarter (July-Sept 2019), *Dendrobium moschatum* (VKA/NOR-37) recorded the highest plant height of 71.85 cm which was on par with *Dendrobium crumenatum* (VKA/NOR-34) (59.76 cm). Almost similar trend was continued throughout the observation period, and in final quarter (April-June 2020), *Dendrobium moschatum* (VKA/NOR-37) recorded a plant height of 75.20 cm and it was on par with *Dendrobium crumenatum* (VKA/NOR-34) with a plant height of 67.70 cm.

Among the sympodial accessions, *Bulbophyllum* sp. (VKA/NOR-39) recorded the minimum plant height. During the first quarter (July-Sept 2019), the minimum value for plant height was recorded for *Bulbophyllum* sp. (VKA/NOR-39) (10.40 cm) followed by *Dendrobium anceps* (VKA/NOR-24) (13.88 cm) and almost similar trend was repeated throughout the study period. During the last quarter the plant heights of *Bulbophyllum* sp. (VKA/NOR-39) and *Dendrobium anceps* (VKA/NOR-24) recorded were 12.00 cm and 17.23 cm respectively.

Among the seven *Dendrobium* species studied, *Dendrobium moschatum* (VKA/NOR-37) recorded highest value for height (75.20 cm) compared to other *Dendrobium* accessions. The lowest value was recorded for *Dendrobium anceps* (VKA/NOR-24) and it was 17.23 cm in the last quarter (April-June 2020). Throughout the study, the plant height of *Dendrobium haemoglossum* (VKA/NOR-41) was on par

with *Dendrobium ovatum* (VKA/NOR-60) and *Dendrobium densiflorum* (VKA/NOR-22), which was 31.68 cm, 25.10 cm and 21.28 cm respectively in the last quarter (April-June 2020).

Plant height recorded for the two *Eria* sp. *viz., Eria fragrans* (VKA/NOR-25) and *Eria* sp. (VKA/NOR-38) was found on par throughout the study period. The highest value was recorded for *Eria fragrans* (VKA/NOR-25) (29.26 cm) and lowest for *Eria* sp. (VKA/NOR-38) (27.34 cm) during the final quarter (April-June 2020).

Among the four *Cymbidium* accessions studied, VKA/NOR-35 (*Cymbidium* sp.) recorded the highest value for plant height which was on par with all other *Cymbidium* accessions and lowest plant height recorded was for *Cymbidium ensifolium* (VKA/NOR-43) throughout the study period. At the end of study period, *Cymbidium* sp. (VKA/NOR-35) recorded 39.82 cm and *Cymbidium ensifolium* (VKA/NOR-43) recorded 27.12 cm respectively for plant height.

2. Plant spread

A. Plant spread (N-S)

Noticeable difference was recorded with regard to plant spread (N-S) in sympodial orchid accessions (Table 14). Throughout the entire period of study *Dendrobium crumenatum* (VKA/NOR-34) was significantly superior to all other sympodial accessions. In the first quarter of study period (July-Sept 2019), the plant spread (N-S) recorded by *Dendrobium crumenatum* (VKA/NOR-34) (59.40 cm), which was on par with *Eria* sp. (VKA/NOR-38) and *Cymbidium ensifolium* (VKA/NOR-43) with plant spreads of 55.63 cm and 53.48 cm, respectively. Almost similar trend was followed in next three quarters and during the last quarter *Dendrobium crumenatum* (VKA/NOR-34) recorded a maximum value of 63.12 cm which was on par with *Cymbidium ensifolium* (VKA/NOR-43) (59.12 cm) and *Eria* sp. (VKA/NOR-38) (57.32 cm).

Throughout the entire period of study *Oberonia* sp. (VKA/NOR-58) recorded the lowest plant spread (N-S) which was 6.96 cm in first quarter (July-Sept 2019) and 9.42 cm in last quarter (April-June 2020). Also, D*endrobium* accessions like

Dendrobium densiflorum (VKA/NOR-22), *Dendrobium moschatum* (VKA/NOR-37) and *Dendrobium ovatum* (VKA/NOR-60) were on par with *Oberonia* sp. (VKA/NOR-58) throughout the entire study period with plant spreads (N-S) of 18.56 cm, 14.90 cm and 11.38 cm for the three accessions at the end of study period (April-June 2020).

Among the seven *Dendrobium* accessions plant spread (N-S) recorded was maximum for *Dendrobium crumenatum* (VKA/NOR-34) and it was significantly highest value compared to all other *Dendrobium* accessions. The value recorded for *Dendrobium crumenatum* (VKA/NOR-34) was 63.12 cm during last quarter (April-June 2020) of the study.

The *Dendrobium* species showing lowest plant spread (N-S) was *Dendrobium moschatum* (VKA/NOR-37) in first two quarters and *Dendrobium ovatum* (VKA/NOR-60) in last two quarters. Throughout the period of study, the spread (N-S) recorded for *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium moschatum* (VKA/NOR-37) and *Dendrobium ovatum* (VKA/NOR-60) were on par, and it was 18.56 cm, 14.90 cm and 11.38 cm respectively in the final quarter. The plant spread recorded for *Dendrobium ovatum* (VKA/NOR-60) was found to have reduced in last two quarters (Jan-June 2020) because the plant was leafless during those periods.

Among the two *Eria* species *viz.*, VKA/NOR-25 (*Eria fragrans*) and VKA/NOR-38 (*Eria* sp.), the accession VKA/NOR-38 showed significantly higher value for plant spread (N-S) than VKA/NOR-25 (*Eria fragrans*) in all the quarters of observation period. At the end of the study, the values recorded were 57.32 cm for *Eria* sp. (VKA/NOR-38) and 36.90 cm for *Eria fragrans* (VKA/NOR-25).

Plant spread (N-S) recorded among the four *Cymbidium* species showed a significantly high value for *Cymbidium ensifolium* (VKA/NOR-43) compared to other *Cymbidium* accessions. Throughout the entire period of observation plant spreads (N-S) recorded for *Cymbidium* sp. VKA/NOR-30, *Cymbidium aloifolium* (VKA/NOR-61)

Table 13. Plant height (cm) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant height (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-Mar 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	19.84	19.98	20.10	21.28
2	VKA/NOR-24	*Dendrobium anceps*	13.88	14.28	15.62	17.23
3	VKA/NOR-27	*Dendrobium fimbriatum*	49.00	52.66	54.06	57.78
4	VKA/NOR-34	*Dendrobium crumenatum*	59.76	60.36	63.20	67.70
5	VKA/NOR-37	*Dendrobium moschatum*	71.85	72.30	73.10	75.20
6	VKA/NOR-41	*Dendrobium haemoglossum*	26.78	27.50	30.28	31.68
7	VKA/NOR-60	*Dendrobium ovatum*	22.50	23.22	24.20	25.10
8	VKA/NOR-25	*Eria fragrans*	23.80	25.20	28.56	29.26
9	VKA/NOR-38	*Eria* sp.	19.04	19.54	22.34	27.34
10	VKA/NOR-29	*Pholidota imbricata*	15.10	16.90	17.22	18.78
11	VKA/NOR-39	*Bulbophyllum* sp.	10.40	10.48	10.50	12.00
12	VKA/NOR-32	*Flickingeria* sp.	35.46	36.00	38.10	40.20
13	VKA/NOR-33	*Coelogyne breviscapa*	17.36	17.96	18.74	20.10
14	VKA/NOR-61	*Cymbidium aloifolium*	31.60	31.80	35.80	38.30
15	VKA/NOR-43	*Cymbidium ensifolium*	24.60	25.80	26.68	27.12
16	VKA/NOR-30	*Cymbidium* sp.	29.92	31.72	33.92	34.56
17	VKA/NOR-35	*Cymbidium* sp.	36.32	37.20	37.58	39.82
18	VKA/NOR-58	*Oberonia* sp.	14.06	15.22	17.02	17.92
CD (0.05)			**13.13**	**13.55**	**13.09**	**13.34**

Table 14. Plant spread (N-S) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant Spread N-S (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-Mar 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	16.72	17.30	17.56	18.56
2	VKA/NOR-24	*Dendrobium anceps*	19.54	22.98	23.30	24.10
3	VKA/NOR-27	*Dendrobium fimbriatum*	18.12	19.42	21.80	23.44
4	VKA/NOR-34	*Dendrobium crumenatum*	59.40	60.18	61.50	63.12
5	VKA/NOR-37	*Dendrobium moschatum*	8.80	9.30	12.70	14.90
6	VKA/NOR-41	*Dendrobium haemoglossum*	29.54	30.70	33.08	33.62
7	VKA/NOR-60	*Dendrobium ovatum*	12.10	12.70	11.32	11.38
8	VKA/NOR-25	*Eria fragrans*	32.40	32.94	35.40	36.90
9	VKA/NOR-38	*Eria* sp.	55.63	55.77	56.44	57.32
10	VKA/NOR-29	*Pholidota imbricata*	41.90	47.40	48.32	49.60
11	VKA/NOR-39	*Bulbophyllum* sp.	24.60	24.90	25.60	27.20
12	VKA/NOR-32	*Flickingeria* sp.	31.64	32.56	34.96	37.14
13	VKA/NOR-33	*Coelogyne breviscapa*	25.90	28.00	29.90	31.02
14	VKA/NOR-61	*Cymbidium aloifolium*	39.00	40.18	42.10	43.50
15	VKA/NOR-43	*Cymbidium ensifolium*	53.48	55.68	58.08	59.12
16	VKA/NOR-30	*Cymbidium* sp.	40.24	41.52	42.22	42.96
17	VKA/NOR-35	*Cymbidium* sp.	38.25	41.70	41.80	43.20
18	VKA/NOR-58	*Oberonia* sp.	6.96	7.50	8.58	9.42
CD (0.05)			**12.26**	**11.59**	**11.14**	**9.18**

and *Cymbidium* sp. VKA/NOR-35 were on par and during final quarter of observation (April-June 2020), *Cymbidium ensifolium* (VKA/NOR-43) recorded maximum spread (N-S) of 59.12 cm and *Cymbidium* sp. VKA/NOR-30 recorded minimum plant spread (N-S) of 42.96 cm.

B. Plant spread (E-W)

The data regarding plant spread (E-W) of sympodial accessions is given in Table 15. The maximum plant spread was recorded for *Dendrobium crumenatum* (VKA/NOR-34) (52.58 cm) which was on par with *Eria* sp. (VKA/NOR- 38) (47.64 cm) followed by *Pholidota imbricata* (VKA/NOR-29) (31.64 cm) in the first quarter (July-Sept 2019) of observation period. Almost similar trend was repeated in all other quarters. In the final quarter (April-June 2020), maximum plant spread (E-W) was recorded by *Dendrobium crumenatum* (VKA/NOR-34) (61.52 cm) and *Eria* sp. (VKA/NOR- 38) (53.48 cm), followed by *Flickingeria* sp. (VKA/NOR- 32*)* (37.52 cm) was on par with *Pholidota imbricata* (VKA/NOR- 29) (35.68 cm).

The minimum plant spread was recorded for *Dendrobium moschatum* (VKA/NOR-37) (4.92 cm) in first quarter (July-Sept 2019) and *Dendrobium ovatum* (VKA/NOR-60) towards final quarters. Throughout the entire period of study, the plant spread (E-W) of *Dendrobium moschatum* (VKA/NOR-37), *Oberonia* sp. (VKA/NOR-58) and *Dendrobium ovatum* (VKA/NOR-60) were on par with values 7.58 cm, 7.50cm, 4.44 cm respectively in the last quarter.

Among the seven *Dendrobium* accessions, *Dendrobium crumenatum* (VKA/NOR-34) was superior to all other accessions when observed for plant spread (E-W). In the first quarter (July-Sept 2019), *Dendrobium crumenatum* (VKA/NOR-34) recorded a spread of 52.58 cm and in final quarter (July-Sept 2019) it was gradually increased to 61.52 cm. The minimum plant spread (E-W) was recorded for *Dendrobium moschatum* (VKA/NOR-37) (4.92 cm) in first quarter (July-Sept 2019) and *Dendrobium moschatum* (VKA/NOR-37) (7.58 cm) was on par with *Dendrobium ovatum* (VKA/NOR-60) in final quarter (April-June 2020) having a plant spread (E-W) of 4.44 cm.

A noticeable difference was found in the plant spread (E-W) value recorded among the two *Eria* species studied. *Eria* sp. VKA/NOR-38 recorded highest value of 53.48 cm and *Eria fragrans* (VKA/NOR-25) recorded lowest value of 29.20 cm at the end of study period (April-June 2020).

Among the four *Cymbidium* accessions studied, the plant spread (E-W) recorded were on par throughout the study period. The maximum spread was recorded in VKA/NOR-30 and minimum in *Cymbidium ensifolium* (VKA/NOR-43) with 34.12 cm and 28.78 cm respectively in the final quarter (April-June 2020).

C. Plant spread (sq.cm)

Marked difference was recorded in plant spread in terms of area occupied by the plant (Table 16). *Dendrobium crumenatum* (VKA/NOR-34) recorded maximum plant spread (sq.cm) which was on par with *Eria* sp. (VKA/NOR-38) in first two quarters. In the second quarter the plant spread recorded by *Dendrobium crumenatum* (VKA/NOR-34) and *Eria* sp. (VKA/NOR-38) was 3289.10 sq.cm and 2759.41 sq. cm respectively. In final two quarters *Dendrobium crumenatum* (VKA/NOR-34) was significantly superior to other accessions for plant spread (sq.cm), and it was 3979.22 sq.cm in the last quarter of study (April-June 2020).

The minimum plant spread (sq.cm) was recorded in *Oberonia* sp. (VKA/NOR-58) during first two quarter with a value of 46.96 sq.cm in first quarter and 49.09 sq.cm in second quarter (Oct - Dec 2019). While in next two quarters *Oberonia* sp. (VKA/NOR-58) was on par with *Dendrobium ovatum* (VKA/NOR-60) and *Dendrobium ovatum* (VKA/NOR-60) recorded the minimum value of 50.27 sq.cm for plant spread area.

Among the seven *Dendrobium* accessions, plant spread area of *Dendrobium crumenatum* (VKA/NOR-34) was significantly superior to all other *Dendrobium* accessions, followed by *Dendrobium haemoglossum* (VKA/NOR-41) recorded highest value throughout the period of study. It was 3979.22 sq.cm and 811.78 sq.cm respectively at the end of study period (April-June 2020) for both the species. All other *Dendrobium* accessions were on par in plant spread area with a minimum plant spread (sq.cm) for *Dendrobium ovatum* (VKA/NOR-60). The lowest value for plant spread

Table 15. Plant spread (E-W) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant Spread E-W (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-Mar 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	13.94	15.54	15.60	16.36
2	VKA/NOR-24	*Dendrobium anceps*	18.14	20.40	21.74	22.06
3	VKA/NOR-27	*Dendrobium fimbriatum*	19.10	19.48	19.88	20.98
4	VKA/NOR-34	*Dendrobium crumenatum*	52.58	55.48	59.86	61.52
5	VKA/NOR-37	*Dendrobium moschatum*	4.92	5.22	7.22	7.58
6	VKA/NOR-41	*Dendrobium haemoglossum*	19.26	20.26	22.34	22.90
7	VKA/NOR-60	*Dendrobium ovatum*	5.00	5.20	4.24	4.44
8	VKA/NOR-25	*Eria fragrans*	23.50	24.10	28.10	29.20
9	VKA/NOR-38	*Eria* sp.	47.64	49.72	50.74	53.48
10	VKA/NOR-29	*Pholidota imbricata*	31.64	33.30	34.10	35.68
11	VKA/NOR-39	*Bulbophyllum* sp.	19.40	19.50	19.98	22.50
12	VKA/NOR-32	*Flickingeria* sp.	30.78	32.96	34.76	37.52
13	VKA/NOR-33	*Coelogyne breviscapa*	20.04	20.84	23.10	23.94
14	VKA/NOR-61	*Cymbidium aloifolium*	25.10	26.60	28.74	31.04
15	VKA/NOR-43	*Cymbidium ensifolium*	23.88	25.40	26.88	28.78
16	VKA/NOR-30	*Cymbidium* sp.	26.34	28.86	32.14	34.12
17	VKA/NOR-35	*Cymbidium* sp.	25.52	26.92	31.90	32.86
18	VKA/NOR-58	*Oberonia* sp.	6.70	6.92	7.16	7.50
CD (0.05)			**7.04**	**7.77**	**7.08**	**7.80**

Table 16. Plant spread area (sq.cm) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Plant Spread area (sq.cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-Mar 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	232.80	269.70	274.02	306.24
2	VKA/NOR-24	*Dendrobium anceps*	354.58	469.93	506.59	531.87
3	VKA/NOR-27	*Dendrobium fimbriatum*	340.31	382.22	436.71	493.19
4	VKA/NOR-34	*Dendrobium crumenatum*	3167.63	3289.10	3792.98	3979.22
5	VKA/NOR-37	*Dendrobium moschatum*	73.14	81.69	115.69	147.77
6	VKA/NOR-41	*Dendrobium haemoglossum*	625.58	671.94	781.88	811.78
7	VKA/NOR-60	*Dendrobium ovatum*	60.95	66.15	47.67	50.27
8	VKA/NOR-25	*Eria fragrans*	751.20	787.02	1027.80	1096.40
9	VKA/NOR-38	*Eria* sp.	2640.61	2759.41	2851.53	3064.06
10	VKA/NOR-29	*Pholidota imbricata*	1289.75	1512.00	1584.41	1732.38
11	VKA/NOR-39	*Bulbophyllum* sp.	479.80	488.00	511.44	623.99
12	VKA/NOR-32	*Flickingeria* sp.	975.48	1072.39	1230.11	1392.29
13	VKA/NOR-33	*Coelogyne breviscapa*	555.24	630.70	724.66	774.10
14	VKA/NOR-61	*Cymbidium aloifolium*	938.55	1043.88	1175.79	1320.74
15	VKA/NOR-43	*Cymbidium ensifolium*	1270.19	1404.59	1557.47	1700.80
16	VKA/NOR-30	*Cymbidium* sp.	1060.61	1199.27	1355.72	1485.28
17	VKA/NOR-35	*Cymbidium* sp.	968.98	1129.99	1338.44	1428.48
18	VKA/NOR-58	*Oberonia* sp.	46.96	49.09	61.31	70.80
CD (0.05)			**568.12**	**547.71**	**656.17**	**576.64**

area was recorded in *Dendrobium ovatum* (VKA/NOR-60) (50.27 sq.cm) at the end of study.

Plant spread area recorded among the two *Eria* species recorded a detectable difference. *Eria* sp. (VKA/NOR-38) recorded the highest value (3064.06 sq.cm) and *Eria fragrans* (VKA/NOR-25) recorded the lowest value (1096.40 sq.cm) at the end of study period (April-June 2020).

Appreciable difference was not obtained in the plant spread area (sq.cm) recorded among the four *Cymbidium* accessions. Throughout the entire study period all the four species were on par in plant spread (sq.cm). Maximum value was recorded in *Cymbidium ensifolium* (VKA/NOR-43) and minimum was for *Cymbidium aloifolium* (VKA/NOR-61). The plant spread (sq.cm) recorded was 1270.19 sq.cm and 938.55 sq.cm in first quarter (July-Sept 2019) and gradually increased to 1700.80 sq.cm and 1320.74 sq.cm respectively for both the species.

3. Number of leaves

Significant difference was noticed among native orchid accessions when observed for number of leaves (Table 17). Throughout the entire period of study, higher number of leaves were recorded in *Dendrobium crumenatum* (VKA/NOR-34) followed by *Eria* sp. (VKA/NOR-38) which was on par with *Dendrobium anceps* (VKA/NOR-24) and *Bulbophyllum* sp. (VKA/NOR-39). In the first quarter (July-Sept 2019), the number of leaves recorded were 91.80, 45.30, 38.60 and 35.60 respectively by each accession and similar trend was followed throughout the entire study period and in final quarter, the number of leaves recorded was 95.80, 49.70, 42.80 and 40.20 in the above accessions.

The minimum number of leaves among sympodial orchid accessions was recorded in *Cymbidium ensifolium* (VKA/NOR-43). In the final quarter, both *Cymbidium aloifolium* (VKA/NOR-61) (5.80) and *Cymbidium ensifolium* (VKA/NOR-43) (5.80) was on par with respect to number of leaves. While *Dendrobium ovatum* (VKA/NOR-60) was found leafless during third and fourth quarters (Jan- June 2020).

Among seven *Dendrobium* accessions, *Dendrobium crumenatum* (VKA/NOR-34) produced significantly greater number of leaves compared to all other *Dendrobium* accessions. The number of leaves recorded in *Dendrobium crumenatum* (VKA/NOR-34) was followed by *Dendrobium anceps* (VKA/NOR-24) throughout the entire period of study. During the end of study period (April- June 2020), *Dendrobium crumenatum* (VKA/NOR-34) recorded 95.80 leaves and *Dendrobium anceps* (VKA/NOR-24) recorded 42.80 leaves. The minimum number of leaves among the *Dendrobium* accessions was recorded in *Dendrobium densiflorum* (VKA/NOR-22) in first two quarters and *Dendrobium ovatum* (VKA/NOR-60) in next two quarters. During the end of study period (April- June 2020), *Dendrobium densiflorum* (VKA/NOR-22) recorded 6.20 leaves and *Dendrobium ovatum* (VKA/NOR-60) was leafless.

Number of leaves recorded among the two *Eria* species showed an appreciable difference. *Eria* sp. (VKA/NOR-38) recorded the highest number of leaves (49.70) and *Eria fragrans* (VKA/NOR-25) recorded the lowest number of leaves (9.20) at the end of study period (April-June 2020).

All the *Cymbidium* accessions were on par with respect to number of leaves throughout the entire period of study. *Cymbidium* sp. (VKA/NOR-30) recorded the maximum number of leaves (14.20), *Cymbidium aloifolium* (VKA/NOR-61) and *Cymbidium ensifolium* (VKA/NOR-43) recorded minimum number of leaves (5.80) during the last quarter of observation period (April-June 2020).

4. Leaf length

A considerable variation was obtained in leaf length of sympodial orchid accessions (Table 18). The longest leaf was observed in *Cymbidium* accessions among all other sympodial orchid accessions. Maximum leaf length was recorded in *Cymbidium ensifolium* (VKA/NOR-43) (43.50 cm) which was on par with *Cymbidium aloifolium* (VKA/NOR-61) (41.00 cm) followed by *Cymbidium* accessions VKA/NOR-35 and VKA/NOR-30 which are on par with leaf length 38.13 cm and 35.24 cm, respectively in the final quarter (April-June 2020). Lowest leaf length was found in *Dendrobium anceps* (VKA/NOR-24) throughout the period of study and it was 4.50 cm

Table 17. Number of leaves in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Number of leaves per plant			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-Mar 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	4.80	5.00	5.40	6.20
2	VKA/NOR-24	*Dendrobium anceps*	38.60	40.80	41.40	42.80
3	VKA/NOR-27	*Dendrobium fimbriatum*	13.78	13.80	14.00	14.40
4	VKA/NOR-34	*Dendrobium crumenatum*	91.80	92.20	94.60	95.80
5	VKA/NOR-37	*Dendrobium moschatum*	6.60	6.80	7.00	7.20
6	VKA/NOR-41	*Dendrobium haemoglossum*	22.00	22.60	23.80	24.60
7	VKA/NOR-60	*Dendrobium ovatum*	6.80	7.10	-	-
8	VKA/NOR-25	*Eria fragrans*	7.20	7.60	8.4	9.20
9	VKA/NOR-38	*Eria* sp.	45.30	46.10	47.50	49.70
10	VKA/NOR-29	*Pholidota imbricata*	6.20	7.00	7.20	7.80
11	VKA/NOR-39	*Bulbophyllum* sp.	35.60	37.60	39.00	40.20
12	VKA/NOR-32	*Flickingeria* sp.	16.00	17.20	18.80	19.60
13	VKA/NOR-33	*Coelogyne breviscapa*	9.20	9.60	10.20	12.00
14	VKA/NOR-61	*Cymbidium aloifolium*	4.20	5.00	5.40	5.80
15	VKA/NOR-43	*Cymbidium ensifolium*	3.80	4.40	5.20	5.80
16	VKA/NOR-30	*Cymbidium* sp.	12.80	13.20	13.80	14.20
17	VKA/NOR-35	*Cymbidium* sp.	5.92	6.32	7.20	8.60
18	VKA/NOR-58	*Oberonia* sp.	6.40	6.60	7.60	8.00
CD (0.05)			**25.94**	**24.47**	**22.68**	**13.72**

at the end of study period (April-June 2020). Also, it was observed that *Dendrobium ovatum* (VKA/NOR-60) became leafless during last two quarters.

Among seven *Dendrobium* accessions the leaf length of *Dendrobium haemoglossum* (VKA/NOR-41), *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium ovatum* (VKA/NOR-60) and *Dendrobium crumenatum* (VKA/NOR-34) were almost on par throughout the period of observation. A maximum leaf length of 12.14 cm was recorded in *Dendrobium haemoglossum* (VKA/NOR-41) and minimum leaf length of 4.50 cm was recorded in *Dendrobium anceps* (VKA/NOR-24) in the final quarter (April-June 2020) of observation period.

Leaf length recorded among the two *Eria* species showed a considerable variation. *Eria* sp. (VKA/NOR-38) recorded the highest value of 32.29 cm and *Eria fragrans* (VKA/NOR-25) recorded the lowest value of 26.84 cm for leaf length at the end of study period (April-June 2020).

5. Leaf width

Significant difference was noticed when sympodial accessions were observed for leaf width (Table 19). Two *Eria* sp. recorded maximum leaf width compared to all other accessions and it was 4.84 cm and 4.62 cm respectively for *Eria fragrans* (VKA/NOR-25) and *Eria* sp. (VKA/NOR-38) in first quarter (July-Sept 2019) of observation period. Towards the final quarter (April-June 2020), *Eria fragrans* (VKA/NOR-25) recorded highest leaf width of 5.22 cm, which was on par with *Eria* sp. (VKA/NOR-38) and *Pholidota imbricata* (VKA/NOR-29) with values of 4.96 cm and 4.88 cm respectively. The lowest value for leaf width was recorded in *Dendrobium haemoglossum* (VKA/NOR-41) throughout the period of study and it was 0.96 cm at the end of study period (April-June 2020).

Among seven *Dendrobium* accessions, *Dendrobium densiflorum* (VKA/NOR-22) was significantly superior to all other accessions when observed for leaf width.

Table 18. Leaf length (cm) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf length (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-Mar 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	9.98	10.72	10.84	11.02
2	VKA/NOR-24	*Dendrobium anceps*	4.08	4.38	4.42	4.50
3	VKA/NOR-27	*Dendrobium fimbriatum*	9.22	9.28	10.14	10.56
4	VKA/NOR-34	*Dendrobium crumenatum*	7.43	7.60	7.71	8.06
5	VKA/NOR-37	*Dendrobium moschatum*	8.20	9.10	10.10	10.22
6	VKA/NOR-41	*Dendrobium haemoglossum*	10.54	10.88	11.52	12.14
7	VKA/NOR-60	*Dendrobium ovatum*	7.52	7.62	-	-
8	VKA/NOR-25	*Eria fragrans*	24.32	24.98	26.20	26.84
9	VKA/NOR-38	*Eria* sp.	30.93	31.27	31.87	32.29
10	VKA/NOR-29	*Pholidota imbricata*	28.20	28.34	29.64	29.92
11	VKA/NOR-39	*Bulbophyllum* sp.	10.12	10.24	10.84	11.71
12	VKA/NOR-32	*Flickingeria* sp.	16.16	16.28	16.82	17.12
13	VKA/NOR-33	*Coelogyne breviscapa*	15.82	15.88	16.36	16.92
14	VKA/NOR-61	*Cymbidium aloifolium*	39.50	39.98	40.52	41.00
15	VKA/NOR-43	*Cymbidium ensifolium*	40.68	41.56	42.96	43.50
16	VKA/NOR-30	*Cymbidium* sp.	33.36	34.06	34.82	35.24
17	VKA/NOR-35	*Cymbidium* sp.	35.16	37.13	37.64	38.13
18	VKA/NOR-58	*Oberonia* sp.	14.82	14.94	15.12	15.66
CD (0.05)			**4.33**	**4.41**	**4.70**	**4.35**

Table 19. Leaf width (cm) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf width (cm)			
			Quarter 1 (July-Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan-Mar 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	2.60	2.62	2.66	2.67
2	VKA/NOR-24	*Dendrobium anceps*	1.08	1.23	1.27	1.28
3	VKA/NOR-27	*Dendrobium fimbriatum*	2.00	2.02	2.30	2.46
4	VKA/NOR-34	*Dendrobium crumenatum*	1.67	1.95	1.98	2.06
5	VKA/NOR-37	*Dendrobium moschatum*	1.90	1.90	1.92	1.96
6	VKA/NOR-41	*Dendrobium haemoglossum*	0.90	0.92	0.94	0.96
7	VKA/NOR-60	*Dendrobium ovatum*	2.00	2.06	-	-
8	VKA/NOR-25	*Eria fragrans*	4.84	4.88	5.00	5.22
9	VKA/NOR-38	*Eria* sp.	4.62	4.66	4.72	4.96
10	VKA/NOR-29	*Pholidota imbricata*	4.24	4.30	4.70	4.88
11	VKA/NOR-39	*Bulbophyllum* sp.	1.64	1.68	1.72	1.74
12	VKA/NOR-32	*Flickingeria* sp.	2.34	2.36	2.50	2.66
13	VKA/NOR-33	*Coelogyne breviscapa*	1.36	1.38	1.52	1.60
14	VKA/NOR-61	*Cymbidium aloifolium*	2.82	2.86	2.90	2.96
15	VKA/NOR-43	*Cymbidium ensifolium*	1.44	1.46	1.54	1.58
16	VKA/NOR-30	*Cymbidium* sp.	2.18	2.20	2.46	2.58
17	VKA/NOR-35	*Cymbidium* sp.	2.57	2.59	2.64	2.68
18	VKA/NOR-58	*Oberonia* sp.	2.32	2.38	2.42	2.50
CD (0.05)			**0.53**	**0.54**	**0.49**	**0.50**

Dendrobium haemoglossum (VKA/NOR-41) recorded the lowest leaf width which was on par with *Dendrobium anceps* (VKA/NOR-24). *Dendrobium densiflorum* (VKA/NOR-22) recorded maximum leaf width of 2.67 cm and *Dendrobium haemoglossum* (VKA/NOR-41) recorded minimum leaf width of 0.96 cm during April-June (2020). During last two quarters *Dendrobium ovatum* (VKA/NOR-60) was leafless.

When four *Cymbidium* accessions were observed for leaf width, the maximum value was recorded in *Cymbidium aloifolium* (VKA/NOR-61) and minimum value in *Cymbidium ensifolium* (VKA/NOR-43) throughout the entire study period. The highest value for leaf width was recorded by *Cymbidium aloifolium* (VKA/NOR-61) (2.96 cm) and lowest value was recorded by *Cymbidium ensifolium* (VKA/NOR-43) (1.58 cm) in the last quarter (April-June 2020). Towards the end of the observation period (April-June 2020) *Cymbidium aloifolium* (VKA/NOR-61) (2.96 cm), *Cymbidium* sp. VKA/NOR-35 (2.68 cm) and *Cymbidium* sp. VKA/NOR-30 (2.58 cm) were found on par with respect to leaf width.

6. Pseudobulb length

Out of the eighteen sympodial accessions studied pseudobulb length and width (girth) measurements were taken for sympodial accessions producing cane and bulbous type pseudobulbs. Pseudobulb length recorded from thirteen sympodial accessions is given in Table 20. *Dendrobium moschatum* (VKA/NOR-37) recorded significantly higher value for pseudobulb length followed by *Dendrobium crumenatum* (VKA/NOR-34) throughout the entire period of study. In the first quarter (July-Sept 2019), *Dendrobium moschatum* (VKA/NOR-37) recorded pseudobulb length of 71.85 cm followed by *Dendrobium crumenatum* (VKA/NOR-34) (59.75 cm), which gradually increased to 75.20 cm and 67.70 cm respectively for both the accession in the final quarter (April-June 2020).

Shortest pseudobulbs were observed in *Bulbophyllum* sp. (VKA/NOR-39). Throughout the period of observation, pseudobulb length recorded for *Pholidota imbricata* (VKA/NOR-29) was on par with *Bulbophyllum* sp. (VKA/NOR- 39),

followed by *Coelogyne breviscapa* (VKA/NOR-33) and *Eria* sp. (VKA/NOR-38) were on par. In final quarter (April-June 2020) of observation, *Pholidota imbricata* (VKA/NOR-29) and *Bulbophyllum* sp. (VKA/NOR-39) recorded pseudobulb length of 5.06 cm and 4.33 cm respectively.

Considerable difference was observed in pseudobulb length recorded in the seven *Dendrobium* accessions. Maximum pseudobulb length of 75.20 cm was recorded in *Dendrobium moschatum* (VKA/NOR-37) and minimum pseudobulb length of 16.34 cm was recorded in *Dendrobium anceps* (VKA/NOR-24) at the end of study period (April-June 2020).

Among two *Eria* sp., maximum pseudobulb length was recorded in *Eria fragrans* (VKA/NOR-25) compared to *Eria* sp. VKA/NOR-38 throughout the entire period of study. During the end of observation period (April-June 2020), *Eria fragrans* (VKA/NOR-25) recorded maximum pseudobulb length of 8.03 cm followed by *Eria* sp. (VKA/NOR-38) recorded 6.43 cm for pseudobulb length.

7. Pseudobulb width

Significant variation was observed in pseudobulb width (girth) recorded for thirteen sympodial accessions and the results are shown in Table 21. In the first quarter (July-Sept 2019) maximum pseudobulb width (girth) of 5.13 cm was recorded in *Eria* sp. (VKA/NOR-38). While in third (Jan-March 2020) and final quarter (April-June 2020) *Pholidota imbricata* (VKA/NOR-29) recorded maximum pseudobulb width (girth) (7.06 cm) which was on par with *Eria fragrans* (VKA/NOR-25) (6.50 cm). *Dendrobium haemoglossum* (VKA/NOR-41) recorded minimum pseudobulb width (girth) during entire period of study, and it was 0.90 cm in the first quarter (July-Sept 2019) and 1.20 cm at the end of study period (April-June 2020).

Among the seven *Dendrobium* accessions, *Dendrobium densiflorum* (VKA/NOR-22) had significantly higher pseudobulb width (girth) (5.40 cm) than other *Dendrobium* accessions in the final quarter (April-June 2020). This was followed by *Dendrobium crumenatum* (VKA/NOR-34) and *Dendrobium moschatum* (VKA/NOR-37) which were on par throughout the study period. They recorded 4.40 cm and 4.10 cm respectively in the final quarter (April-June 2020) of study period.

Table 20. Pseudobulb length (cm) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Pseudobulb length (cm)			
			Quarter 1 (July- Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan- March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	19.80	19.98	20.10	21.28
2	VKA/NOR-24	*Dendrobium anceps*	13.29	13.52	14.44	16.34
3	VKA/NOR-27	*Dendrobium fimbriatum*	49.00	52.62	54.02	57.69
4	VKA/NOR-34	*Dendrobium crumenatum*	59.75	60.38	63.20	67.70
5	VKA/NOR-37	*Dendrobium moschatum*	71.85	72.30	73.10	75.20
6	VKA/NOR-41	*Dendrobium haemoglossum*	24.86	26.16	29.02	29.96
7	VKA/NOR-60	*Dendrobium ovatum*	21.66	22.34	24.20	25.10
8	VKA/NOR-25	*Eria fragrans*	6.00	6.50	7.26	8.03
9	VKA/NOR-38	*Eria* sp.	5.43	5.96	6.16	6.43
10	VKA/NOR-29	*Pholidota imbricata*	4.50	4.66	4.86	5.06
11	VKA/NOR-39	*Bulbophyllum* sp.	3.46	3.93	4.00	4.33
12	VKA/NOR-32	*Flickingeria* sp.	23.66	24.66	27.66	30.63
13	VKA/NOR-33	*Coelogyne breviscapa*	5.03	5.46	6.23	6.60
CD (0.05)			**1.42**	**1.37**	**1.31**	**1.05**

Table 21. Pseudobulb width (cm) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Pseudobulb width (girth of pseudobulb) (cm)			
			Quarter 1 (July- Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan- March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	4.30	4.60	5.00	5.40
2	VKA/NOR-24	*Dendrobium anceps*	1.40	1.50	1.59	1.63
3	VKA/NOR-27	*Dendrobium fimbriatum*	2.63	2.96	3.20	3.33
4	VKA/NOR-34	*Dendrobium crumenatum*	3.46	3.70	4.03	4.40
5	VKA/NOR-37	*Dendrobium moschatum*	3.66	3.73	3.90	4.10
6	VKA/NOR-41	*Dendrobium haemoglossum*	0.90	0.96	1.00	1.20
7	VKA/NOR-60	*Dendrobium ovatum*	1.70	1.83	1.93	2.20
8	VKA/NOR-25	*Eria fragrans*	4.33	5.43	5.83	6.50
9	VKA/NOR-38	*Eria* sp.	5.13	5.36	5.66	5.80
10	VKA/NOR-29	*Pholidota imbricata*	4.60	4.90	6.20	7.06
11	VKA/NOR-39	*Bulbophyllum* sp.	3.86	3.96	4.00	4.33
12	VKA/NOR-32	*Flickingeria* sp.	3.10	3.46	3.50	3.73
13	VKA/NOR-33	*Coelogyne breviscapa*	3.00	3.63	4.20	4.63
CD (0.05)			**0.83**	**0.85**	**0.60**	**0.57**

The lower pseudobulb width (girth) among the seven *Dendrobium* accessions was recorded in *Dendrobium haemoglossum* (VKA/NOR-41) with a value of 1.20 cm in the final quarter (Table 21).

Pseudobulb width (girth) recorded in two *Eria* sp. showed maximum value in *Eria* sp. (VKA/NOR-38) compared to *Eria fragrans* (VKA/NOR-25) in the first quarter (July-Sept 2019) with values 5.13 cm and 4.33 cm respectively, while in next two quarters *Eria fragrans* (VKA/NOR-25) recorded maximum value for pseudobulb width (girth) which was on par with *Eria* sp. (VKA/NOR-38). During the end of observation period (April-June 2020), *Eria fragrans* (VKA/NOR-25) recorded 6.50 cm and *Eria* sp. (VKA/NOR-38) recorded 5.80 cm respectively for pseudobulb width (girth).

8. Internodal length

Among eighteen sympodial orchid accessions studied, internodal length was measurable only in eight accessions *viz.*, *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium haemoglossum* (VKA/NOR-41), *Dendrobium ovatum* (VKA/NOR-60), and *Flickingeria* sp. (VKA/NOR-32) (Table 22). In the first three quarters of study period, *Dendrobium densiflorum* (VKA/NOR-22) recorded maximum internodal length which was on par with *Dendrobium moschatum* (VKA/NOR-37), it was 4.00 cm and 3.93 cm respectively in third quarter (Jan-March 2020). During the end of study period, *Dendrobium moschatum* (VKA/NOR-37) recorded maximum internodal length of 4.23 cm which was on par with *Dendrobium densiflorum* (VKA/NOR-22) with a value of 4.20 cm.

Minimum internodal length was observed for *Dendrobium anceps* (VKA/NOR-24) throughout the entire period of study. In the first quarter (July-Sept 2019), internodal length of *Dendrobium haemoglossum* (VKA/NOR-41) was on par with *Dendrobium anceps* (VKA/NOR-24), while in all other quarters, *Dendrobium anceps* (VKA/NOR-24) recorded the lowest value for internodal length followed by *Dendrobium*

Table 22. Internodal length (cm) in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Internodal length (cm)			
			Quarter 1 (July- Sept 2019)	Quarter 2 (Oct-Dec 2019)	Quarter 3 (Jan- March 2020)	Quarter 4 (April-June 2020)
1	VKA/NOR-22	*Dendrobium densiflorum*	3.90	3.93	4.00	4.20
2	VKA/NOR-24	*Dendrobium anceps*	1.10	1.20	1.33	1.40
3	VKA/NOR-27	*Dendrobium fimbriatum*	2.66	2.93	3.03	3.30
4	VKA/NOR-34	*Dendrobium crumenatum*	2.80	2.93	3.23	3.46
5	VKA/NOR-37	*Dendrobium moschatum*	3.50	3.80	3.93	4.23
6	VKA/NOR-41	*Dendrobium haemoglossum*	1.56	2.03	2.36	2.46
7	VKA/NOR-60	*Dendrobium ovatum*	2.20	2.76	2.83	2.90
8	VKA/NOR-32	*Flickingeria* sp.	2.56	2.93	3.06	3.20
CD (0.05)			**0.54**	**0.48**	**0.31**	**0.42**

haemoglossum (VKA/NOR-41) and it was 1.40 cm and 2.46 cm respectively in the final quarter (April-June 2020).

9. Number of roots

For sympodial orchid accessions, the number of roots were counted after taking out the whole plant from the pot during the last quarter of observation (April-June 2020). Significant difference was observed in number of roots produced by sympodial orchid accessions (Table 23). Maximum number of roots (138.60) were produced by *Dendrobium crumenatum* (VKA/NOR-34) and it was followed by *Oberonia* sp. (VKA/NOR-58) (98.20). Minimum number of roots was recorded in *Cymbidium ensifolium* (VKA/NOR-43) (5.75) at the end of the study period of observation (April-June 2020).

Among the *Dendrobium* accessions, *Dendrobium crumenatum* (VKA/NOR-34) recorded higher number of roots (138.60) followed by *Dendrobium ovatum* (VKA/NOR-60) (36.25). The number of roots recorded in *Dendrobium anceps* (VKA/NOR-24), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium densiflorum* (VKA/NOR-22) and *Dendrobium haemoglossum* (VKA/NOR-41) were found on par (18.20, 17.80, 13.00 and 13.00) for each species.

Maximum number of roots recorded among two *Eria* sp. was higher in *Eria* sp. VKA/NOR-38 compared *to Eria fragrans* (VKA/NOR-25) and it was 66.20 and 24.30 for each of them. In the case of four *Cymbidium* sp., significant difference were not observed in number of roots produced by them. It was 15.80, 14.40, 10.60 respectively for *Cymbidium* sp. VKA/NOR-30, VKA/NOR-35, VKA/NOR-61 and *Cymbidium ensifolium* (VKA/NOR-43) recorded a minimum number of 5.75 roots.

Table 23. Number of roots in sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Number of roots
1	VKA/NOR-22	*Dendrobium densiflorum*	13.00
2	VKA/NOR-24	*Dendrobium anceps*	18.20
3	VKA/NOR-27	*Dendrobium fimbriatum*	27.00
4	VKA/NOR-34	*Dendrobium crumenatum*	138.60
5	VKA/NOR-37	*Dendrobium moschatum*	17.80
6	VKA/NOR-41	*Dendrobium haemoglossum*	13.00
7	VKA/NOR-60	*Dendrobium ovatum*	36.25
8	VKA/NOR-25	*Eria fragrans*	24.20
9	VKA/NOR-38	*Eria* sp.	66.20
10	VKA/NOR-29	*Pholidota imbricata*	30.20
11	VKA/NOR-39	*Bulbophyllum* sp.	66.00
12	VKA/NOR-32	*Flickingeria* sp.	66.00
13	VKA/NOR-33	*Coelogyne breviscapa*	55.50
14	VKA/NOR-43	*Cymbidium ensifolium*	5.75
15	VKA/NOR-30	*Cymbidium* sp.	15.80
16	VKA/NOR-61	*Cymbidium aloifolium*	10.60
17	VKA/NOR-35	*Cymbidium* sp.	14.40
18	VKA/NOR-58	*Oberonia* sp.	98.20
CD (0.05)			**20.64**

4.2.2 Qualitative vegetative characters

Qualitative vegetative characters of native orchid accessions such as leaf shape (Plate 8-13), leaf texture, leaf colour, leaf arrangement, leaf orientation, root colour and root branching observed are presented in Table 24 to Table 28.

Considerable variation was noticed among the accessions with respect to qualitative vegetative characters. Leaf shape observed among monopodial accessions showed three types of leaves (Table 24). *Acampe praemorsa* (VKA/NOR-3), *Aerides crispa* (VKA/NOR-2) and *Rhynchostylis retusa* (VKA/NOR-4) recorded strap shaped leaves. *Luisia* sp. (VKA/NOR-7) was found to have terete leaves, while *Vanda thwaitesii* (VKA/NOR-8) recorded channelled leaves.

Leaf shape recorded among sympodial accessions also showed wide variation (Table 25). Lanceolate leaves were recorded in *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium ovatum* (VKA/NOR-60), *Eria* sp. (VKA/NOR-25, VKA/NOR-38), *Pholidota imbricata* (VKA/NOR-29 and *Oberonia* sp. (VKA/NOR-58). Narrow lanceolate leaf was recorded in *Bulbophyllum* sp. (VKA/NOR-39). *Dendrobium haemoglossum* (VKA/NOR-41), *Coelogyne breviscapa* (VKA/NOR-33) and *Cymbidium ensifolium* (VKA/NOR-43) recorded linear leaves. *Cymbidium aloifolium* (VKA/NOR-61) and *Cymbidium* sp. VKA/NOR-35 and VKA/NOR-30 recorded linear oblong leaves. *Dendrobium crumenatum* (VKA/NOR-34) was found to have narrow elliptic leaves. *Flickingeria* sp. (VKA/NOR-32) was having narrow oblong leaves.

Leaves of all the monopodial accessions were smooth and rigid regarding the texture (Table 24). Among sympodial orchid accessions, leaves of *Dendrobium anceps* (VKA/NOR-24) and *Oberonia* sp. (VKA/NOR-58) were fleshy (Table 25). The leaf texture of *Pholidota imbricata* (VKA/NOR-24), *Cymbidium aloifolium* (VKA/NOR-61) and *Cymbidium* species VKA/NOR-35 and VKA/NOR-30 was smooth and leathery, while all other accessions had smooth leaves.

Leaf colour of native orchid accessions belonged to mostly green group. They belonging to RHS-NN 137A (Green group NN137, greyish olive green A), RHS-NN 137B (Green group NN137, greyish olive green B), RHS-137A (Green group 137, moderate olive green A) and RHS-137 B (Green group 137, moderate olive green B) (Table 24 and Table 26). Yellow green group was also noticed in some accessions. *Vanda thwaitesii* (VKA/NOR-8), *Dendrobium anceps* (VKA/NOR-24), *Bulbophyllum* sp. (VKA/NOR-39) and *Flickingeria* sp. (VKA/NOR-32) recorded RHS-146A (Yellow green group 146, moderate olive green A). *Eria* sp. (VKA/NOR-25 and VKA/NOR-38) and *Oberonia* sp. (VKA/NOR-58) recorded leaf colour RHS-146B (Yellow green group 146, moderate yellow green B).

Leaf orientation observed in monopodial accessions was mainly arching type whereas, *Luisia* sp. (VKA/NOR-7) had straight and arching type of leaves (Table 24). Variation was also noticed in sympodial orchid accessions with respect to leaf orientation (Table 25). Except *Dendrobium anceps* (VKA/NOR-24), all other *Dendrobium* accessions were having horizontal leaf orientation. *Dendrobium anceps* (VKA/NOR-24), *Flickingeria* sp. (VKA/NOR-32) and *Oberonia* sp. (VKA/NOR-58) are having erect leaves. The leaf orientation of *Eria* sp. (VKA/NOR-25 and VKA/NOR-38), *Bulbophyllum* sp. (VKA/NOR-39), *Coelogyne breviscapa* (VKA/NOR-33) and all *Cymbidium* accessions except *Cymbidium ensifolium* (VKA/NOR-43) was semi erect. Arching type of leaf was observed in *Pholidota imbricata* (VKA/NOR-29) and *Cymbidium ensifolium* (VKA/NOR-43).

Alternate distichous leaf arrangement is seen in most of the native orchid accessions. Among monopodial accessions, alternate spiral arrangement was found in *Luisia* sp. (VKA/NOR-7) (Table 224). In sympodial accessions like *Eria* species (VKA/NOR-25 and VKA/NOR-38), *Pholidota imbricata* (VKA/NOR-29), *Bulbophyllum* sp. (VKA/NOR-39), *Flickingeria* sp. (VKA/NOR-32) and *Coelogyne breviscapa* (VKA/NOR-33) the leaves were arranged on the apex of the pseudobulb (Table 25). In *Dendrobium densiflorum* (VKA/NOR-22), leaves were arranged near the apex of pseudobulb i.e. subterminally in alternate distichous manner. Leaf arrangement in all other *Dendrobium* accessions was alternate distichous along the stem.

Table 24. Leaf characters of monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf shape	Leaf texture	Leaf colour (RHS colour chart)	Leaf arrangement	Leaf orientation
1	VKA/NOR-3	*Acampe praemorsa*	Strap	Smooth, rigid	RHS-NN 137B (Green group NN137, greyish olive green B)	Alternate, distichous	Arching
2	VKA/NOR-2	*Aerides crispa*	Strap	Smooth, rigid	RHS-NN 137B (Green group NN137, greyish olive green B)	Alternate, distichous	Arching
3	VKA/NOR-4	*Rhynchostylis retusa*	Strap	Smooth, rigid	RHS-137B (Green group 137, moderate olive green B)	Alternate, distichous	Arching, closely arranged
4	VKA/NOR-7	*Luisia* sp.	Terete	Smooth, rigid	RHS-NN 137A (Green group NN137, greyish olive green A)	Alternate, spiral	Arching, straight
5	VKA/NOR-8	*Vanda thwaitesii*	Chanelled	Smooth, rigid	RHS-146A (Yellow green group 146, moderate olive green A)	Alternate, distichous	Arching, closely arranged

Table 25. Leaf characters of sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf shape	Leaf texture	Leaf arrangement	Leaf orientation
1	VKA/NOR-22	*Dendrobium densiflorum*	Lanceolate	Smooth	Alternate, distichous, near apex of pseudobulb	Horizontal
2	VKA/NOR-24	*Dendrobium anceps*	Lanceolate	Fleshy	Alternate, distichous	Erect
3	VKA/NOR-27	*Dendrobium fimbriatum*	Lanceolate	Smooth	Alternate, distichous	Horizontal
4	VKA/NOR-34	*Dendrobium crumenatum*	Narrow elliptic	Smooth	Alternate, distichous	Horizontal
5	VKA/NOR-37	*Dendrobium moschatum*	Lanceolate	Smooth	Alternate, distichous	Horizontal
6	VKA/NOR-41	*Dendrobium haemoglossum*	Linear	Smooth	Alternate, distichous	Horizontal
7	VKA/NOR-60	*Dendrobium ovatum*	Lanceolate	Smooth	Alternate, distichous	Horizontal
8	VKA/NOR-25	*Eria fragrans*	Lanceolate	Smooth	On apex of pseudobulb	Semi erect
9	VKA/NOR-38	*Eria* sp.	Lanceolate	Smooth	On apex of pseudobulb	Semi erect
10	VKA/NOR-29	*Pholidota imbricata*	Lanceolate	Smooth, leathery	On apex of pseudobulb	Arching
11	VKA/NOR-39	*Bulbophyllum* sp.	Narrow lanceolate	Smooth	On apex of pseudobulb	Semi erect
12	VKA/NOR-32	*Flickingeria* sp.	Narrow oblong	Smooth	On apex of pseudobulb	Erect
13	VKA/NOR-33	*Coelogyne breviscapa*	Linear	Smooth	On apex of pseudobulb	Semi erect
14	VKA/NOR-61	*Cymbidium aloifolium*	Linear -oblong	Smooth, leathery	Clustered, basal	Semi erect
15	VKA/NOR-43	*Cymbidium ensifolium*	Linear	Smooth	Clustered, basal	Arching
16	VKA/NOR-35	*Cymbidium* sp.	Linear -oblong	Smooth, leathery	Clustered, basal	Semi erect
17	VKA/NOR-30	*Cymbidium* sp.	Linear -oblong	Smooth, leathery	Clustered, basal	Semi erect
18	VKA/NOR-58	*Oberonia* sp.	Lanceolate	Fleshy	Alternate, equitant	Erect

Table 26. Variation in leaf colour of sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Leaf colour
1	VKA/NOR-22	*Dendrobium densiflorum*	RHS-137A (Green group 137, moderate olive green A)
2	VKA/NOR-24	*Dendrobium anceps*	RHS-146A (Yellow green group 146, moderate olive green A)
3	VKA/NOR-27	*Dendrobium fimbriatum*	RHS-NN 137B (Green group NN137, greyish olive green B)
4	VKA/NOR-34	*Dendrobium crumenatum*	RHS-143A (Green group 143, strong yellow green A)
5	VKA/NOR-37	*Dendrobium moschatum*	RHS-NN 137B (Green group NN137, greyish olive green B)
6	VKA/NOR-41	*Dendrobium haemoglossum*	RHS-NN 137B (Green group NN137, greyish olive green B)
7	VKA/NOR-60	*Dendrobium ovatum*	RHS-NN 137B (Green group NN137, greyish olive green B)
8	VKA/NOR-25	*Eria fragrans*	RHS-146B (Yellow green group 146, moderate yellow green B)
9	VKA/NOR-38	*Eria* sp.	RHS-146B (Yellow green group 146, moderate yellow green B)
10	VKA/NOR-29	*Pholidota imbricata*	RHS-NN 137A (Green group NN137, greyish olive green A)
11	VKA/NOR-39	*Bulbophyllum* sp.	RHS-146A (Yellow green group 146, moderate olive green A)
12	VKA/NOR-32	*Flickingeria* sp.	RHS-146A (Yellow green group 146, moderate olive green A)
13	VKA/NOR-33	*Coelogyne breviscapa*	RHS-NN 137B (Green group NN137, greyish olive green B)
14	VKA/NOR-61	*Cymbidium aloifolium*	RHS-NN 137B (Green group NN137, greyish olive green B)
15	VKA/NOR-43	*Cymbidium ensifolium*	RHS-NN 137B (Green group NN137, greyish olive green B)
16	VKA/NOR-35	*Cymbidium* sp.	RHS-NN 137B (Green group NN137, greyish olive green B)
17	VKA/NOR-30	*Cymbidium* sp.	RHS-NN 137B (Green group NN137, greyish olive green B)
18	VKA/NOR-58	*Oberonia* sp.	RHS-146B (Yellow green group 146, moderate yellow green B)

In all the *Cymbidium* accessions, leaves were found basally clustered. *Oberonia* sp. (VKA/NOR-58) had leaf arrangement of alternate equitant type.

Among the accessions, colour of roots and branching of roots were also observed. Only slight variation could be observed with respect to root colour of monopodial orchid accessions (Table 27). *Luisia* sp. (VKA/NOR-7) had greyish brown roots. However, rest of the monopodial accessions were found to have greenish grey coloured roots.

Root colour in sympodial orchid accessions showed grey, green, white and brown shades (Table 28). White coloured roots were observed in *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium crumenatum* (VKA/NOR-34), *Flickingeria* sp. (VKA/NOR-32) and all *Cymbidium* accessions. *Dendrobium ovatum* (VKA/NOR-56) and *Eria* sp. (VKA/NOR-25 and VKA/NOR-38) had brown coloured roots. *Pholidota imbricata* (VKA/NOR-29) was found to have greenish brown coloured roots. Greenish grey coloured roots were recorded in *Dendrobium moschatum* (VKA/NOR-37) and *Dendrobium haemoglossum* (VKA/NOR-41). *Bulbophyllum* sp. (VKA/NOR-39) and *Coelogyne breviscapa* (VKA/NOR-33) was found to have root colour of greyish brown shade and *Oberonia* sp. (VKA/NOR-58) was found to have green coloured roots.

Root branching was present in all of the monopodial orchid accessions (Table 25), while in sympodial accessions (Table 28), except *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium moschatum* (VKA/NOR-37) and *Dendrobium ovatum* (VKA/NOR-60), all others have branching roots.

Plate 3a. Leaf shape of native orchid accessions (A) *Luisia* sp. (VKA/NOR-7) (B) *Dendrobium crumenatum* (VKA/NOR-34) (C*) Eria fragrans* (VKA/NOR-25) (D) *Acampe praemorsa* (VKA/NOR-3)

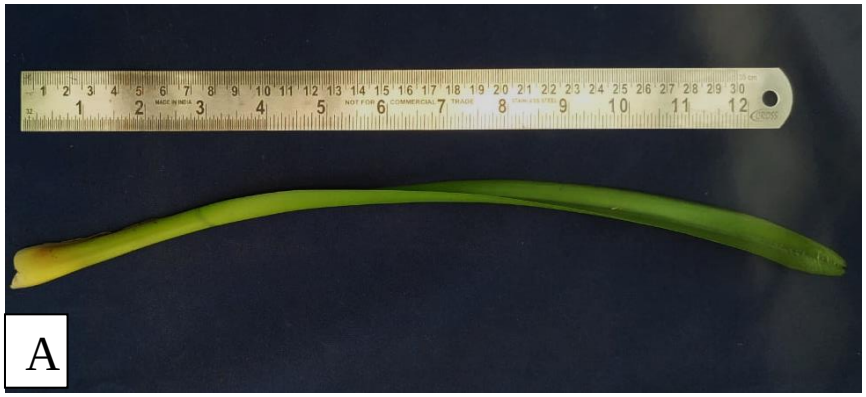


Plate 3b. Leaf shape of native orchid accessions (A) *Cymbidium aloifolium* (VKA/NOR-61) (B) *Dendrobium haemoglossum* (VKA/NOR-41) (C) *Pholidota imbricata* (VKA/NOR-29) (D) *Dendrobium fimbriatum* (VKA/NOR-27)

Plate 3c. Leaf shape of native orchid accessions (A) *Oberonia* sp. (VKA/NOR-58) (B) *Cymbidium* sp. (VKA/NOR-35) (C) *Dendrobium ovatum* (VKA/NOR-60) (D) *Flickingeria* sp. (VKA/NOR-32)

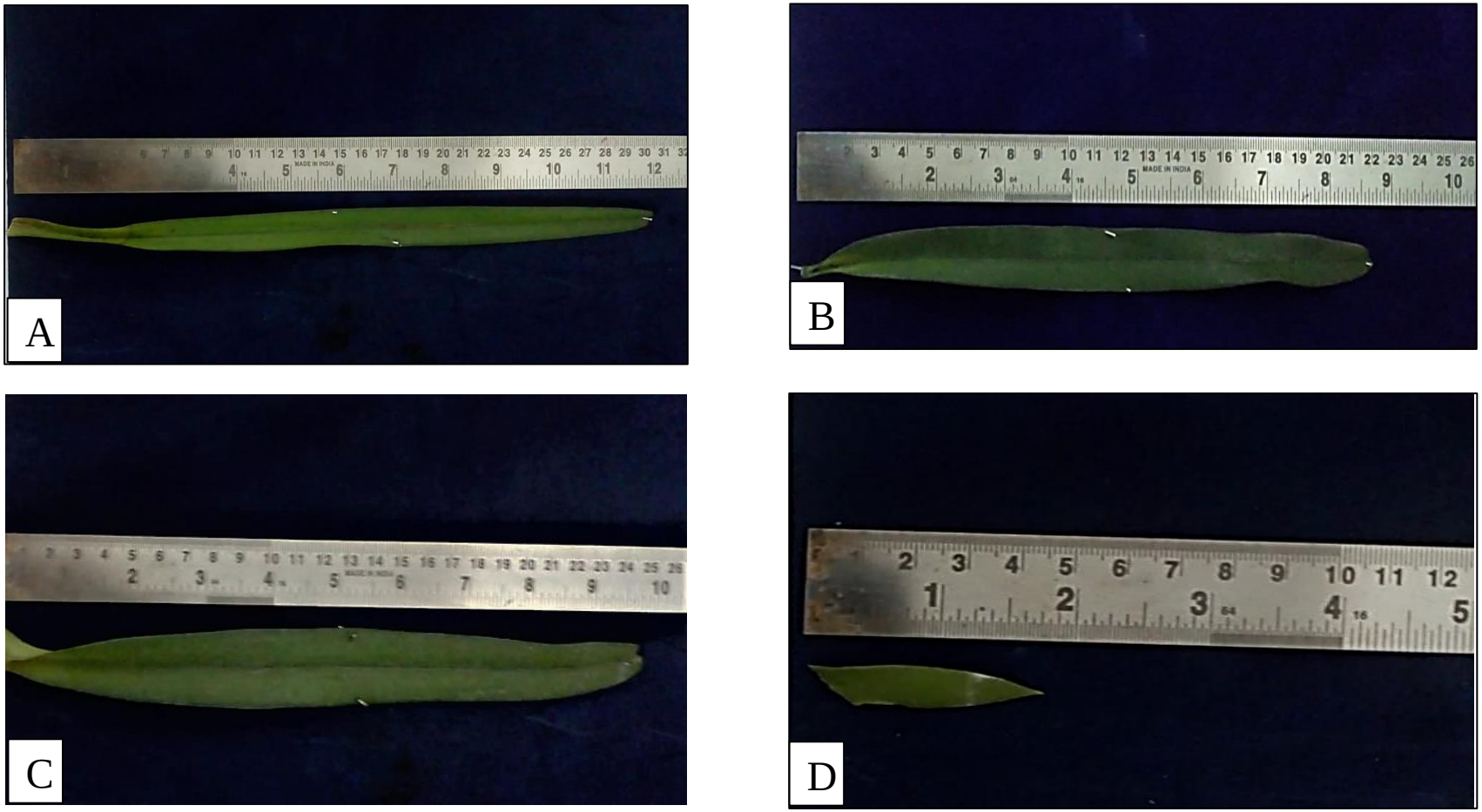


Plate 3d. Leaf shape of native orchid accessions (A) *Cymbidium* sp. (VKA/NOR-30) (B) *Aerides crispa* (VKA/NOR-2) (C) *Vanda thwaitesii* (VKA/NOR-8) (D) *Dendrobium anceps* (VKA/NOR-24)

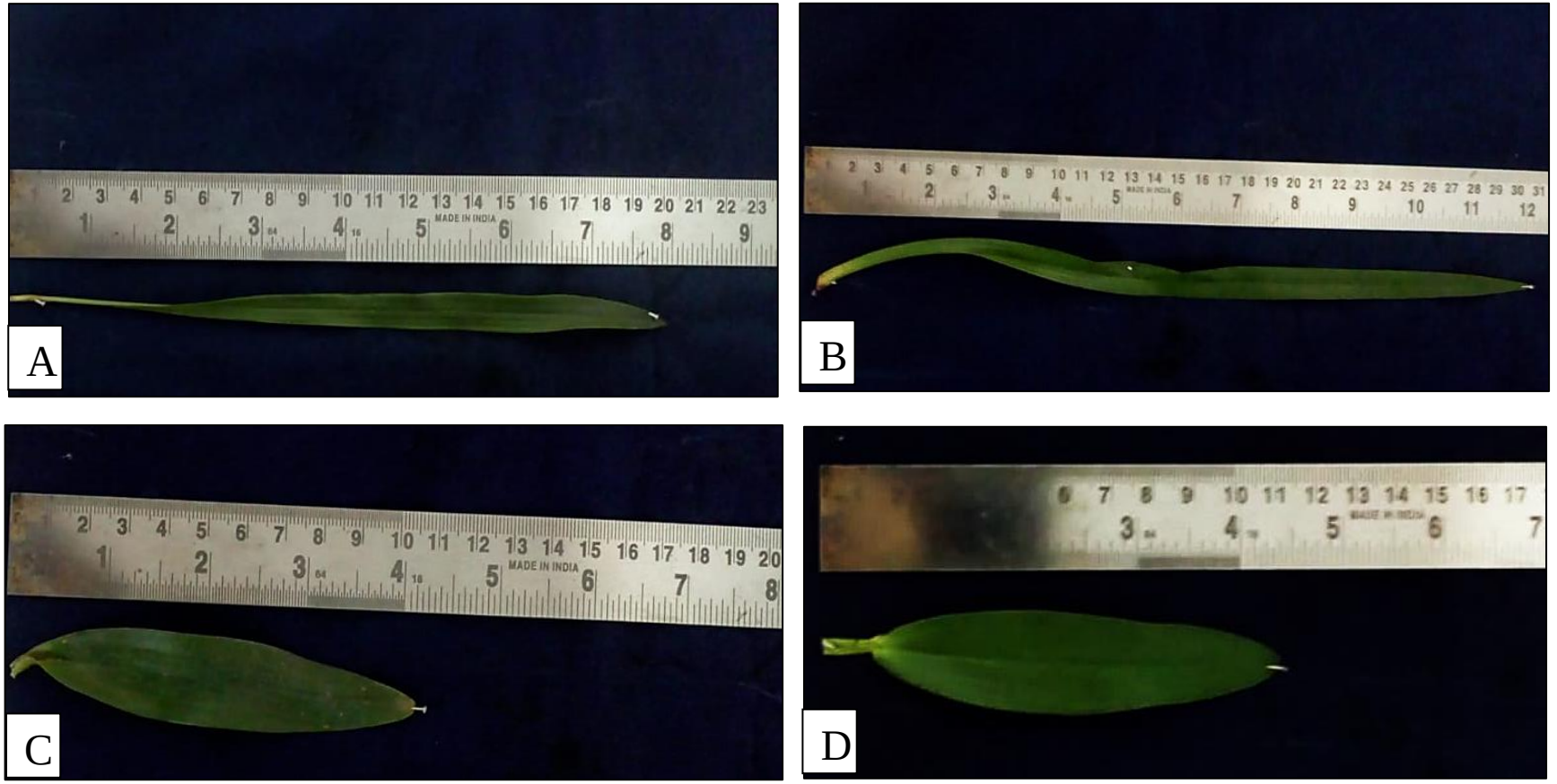


Plate 3e. Leaf shape of native orchid accessions (A) *Coelogyne breviscapa* (VKA/NOR-33) (12) *Cymbidium ensifolium* (VKA/NOR-43) (C) *Dendrobium moschatum* (VKA/NOR-37) (D) *Dendrobium densiflorum* (VKA/NOR-22)

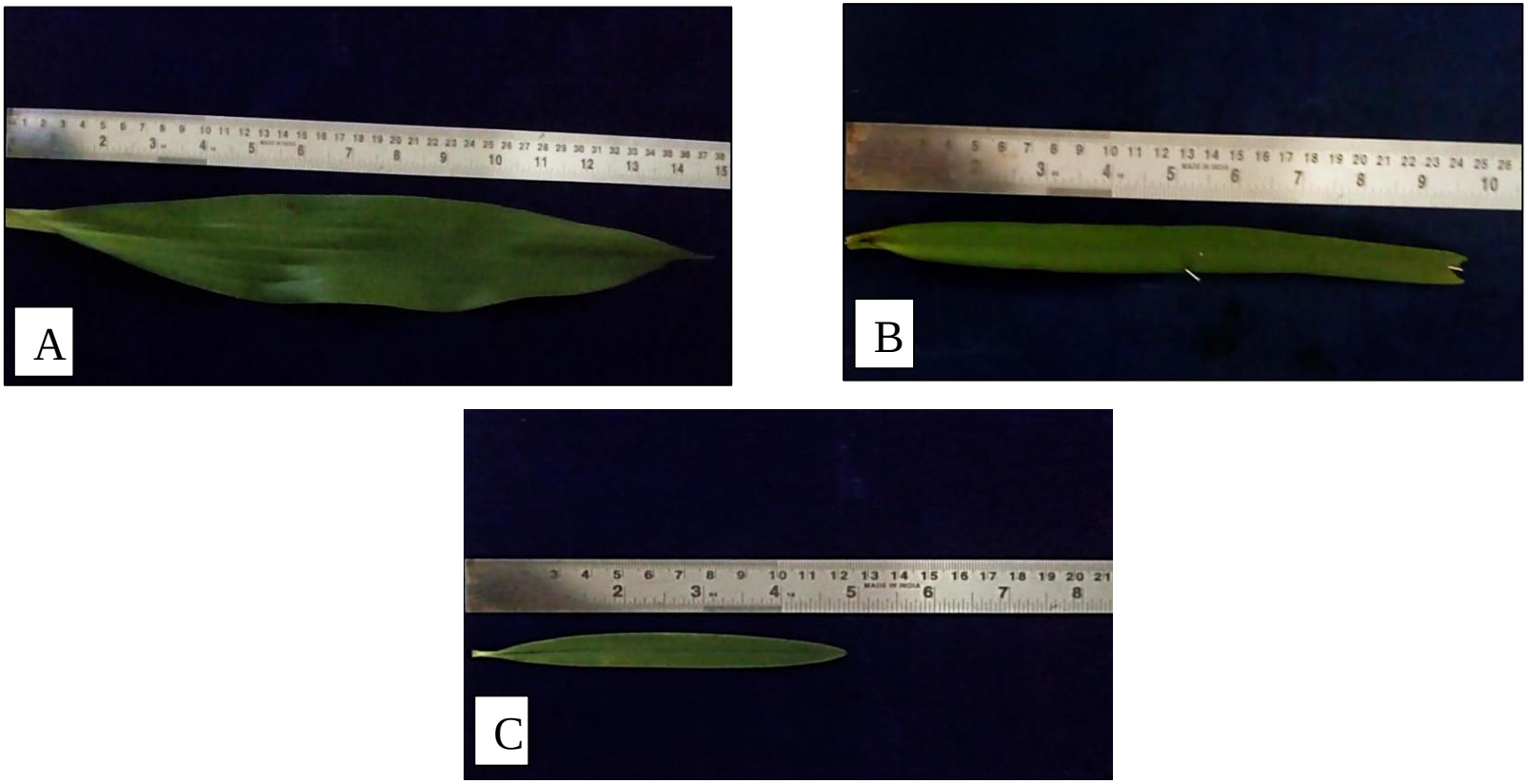


Plate 3f. Leaf shape of native orchid accessions (A) *Eria* sp. (VKA/NOR-38) (B) *Rhynchostylis retusa* (VKA/NOR-4) (C) *Bulbophyllum* sp. (VKA/NOR-39)

Table 27. Root characters of monopodial orchid accessions

Sl. No.	Accession code	Name of the accession	Root colour	Root branching
1	VKA/NOR-3	*Acampe praemorsa*	Greenish grey	Present
2	VKA/NOR-2	*Aerides crispa*	Greenish grey	Present
3	VKA/NOR-4	*Rhynchostylis retusa*	Greenish grey	Present
4	VKA/NOR-7	*Luisia* sp.	Greyish brown	Present
5	VKA/NOR-8	*Vanda thwaitesii*	Greenish grey	Present

Table 28. Root characters of sympodial orchid accessions

Sl. No.	Accession code	Name of the accession	Root colour	Branching of roots
1	VKA/NOR-22	*Dendrobium densiflorum*	White	Absent
2	VKA/NOR-24	*Dendrobium anceps*	White	Present
3	VKA/NOR-27	*Dendrobium fimbriatum*	White	Present
4	VKA/NOR-34	*Dendrobium crumenatum*	White	Present
5	VKA/NOR-37	*Dendrobium moschatum*	Greenish grey	Absent
6	VKA/NOR-41	*Dendrobium haemoglossum*	Greenish grey	Present
7	VKA/NOR-60	*Dendrobium ovatum*	Brown	Absent
8	VKA/NOR-25	*Eria fragrans*	Brown	Present
9	VKA/NOR-38	*Eria* sp.	Brown	Present
10	VKA/NOR-29	*Pholidota imbricata*	Greenish brown	Present
11	VKA/NOR-39	*Bulbophyllum* sp.	Greyish brown	Present
12	VKA/NOR-32	*Flickingeria* sp.	White	Present
13	VKA/NOR-33	*Coelogyne breviscapa*	Greyish brown	Present
14	VKA/NOR-61	*Cymbidium aloifolium*	White	Present
15	VKA/NOR-43	*Cymbidium ensifolium*	White	Present
16	VKA/NOR-35	*Cymbidium* sp.	White	Present
17	VKA/NOR-30	*Cymbidium* sp.	White	Present
18	VKA/NOR-58	*Oberonia* sp.	Green	Present

4.3 FLORAL CHARACTERS

4.3.1 Quantitative floral characters

The observations on nine orchid accessions flowered during the study period were recorded at blooming phases (Plate 14-22). The accessions flowered are *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Eria fragrans* (VKA/NOR-25), *Pholidota imbricata* (VKA/NOR-29), *Acampe praemorsa* (VKA/NOR-3) and *Rhynchostylis retusa* (VKA/NOR-4).

1. Flowering time/season

Considerable variation was observed among the accessions with respect to flowering time (Table 29). Among the native orchid accessions evaluated, single flowering season was observed in *Dendrobium densiflorum* (VKA/NOR-22) (February), *Dendrobium fimbriatum* (VKA/NOR-27) (April), *Dendrobium moschatum* (VKA/NOR-37) (April), *Acampe praemorsa* (VKA/NOR-3) (April), *Pholidota imbricata* (VKA/NOR-29) (June- July), *Rhynchostylis retusa* (VKA/NOR-4) (May-June) and *Dendrobium ovatum* (VKA/NOR-60) (Jan- February).

Three flowering seasons among the accessions was noted in *Dendrobium crumenatum* (VKA/NOR-34) (April-May, October, Dec-Jan). Among the other accessions, *Eria fragrans* (VKA/NOR-25) recorded long flowering season from May to October compared to all other native orchid accessions.

2. Frequency of flowering

Data on frequency of flowering of native orchid accessions are given in Table 29. *Dendrobium crumenatum* (VKA/NOR-34) flowered about 5 times during the flowering season, followed by *Eria fragrans* (VKA/NOR-25) flowered 4 times in its blooming period. *Dendrobium ovatum* (VKA/NOR-60), *Pholidota imbricata* (VKA/NOR-29) and *Rhynchostylis retusa* (VKA/NOR-4) flowered twice in its flowering period, while all other accessions flowered only once in its flowering season.

3. Number of spikes per plant

Data pertaining to the spike character of native orchid accessions flowered during observation period are given in Table 29. Significant difference was observed with respect to number of spikes per plant produced by native orchid accessions. *Dendrobium crumenatum* (VKA/NOR-34) produced significantly higher number of spikes (5.76) followed by *Acampe praemorsa* (VKA/NOR-3) (3.50) which was on par with *Dendrobium ovatum* (VKA/NOR-60) (3.33). The accessions *Pholidota imbricata* (VKA/NOR-29), *Rhynchostylis retusa* (VKA/NOR-4) and *Eria fragrans* (VKA/NOR-25) produced number of spikes with a value of 2.66, 2.00 and 1.75 respectively which were on par. Minimum number of spikes per plant was observed in *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium densiflorum* (VKA/NOR-22) both of them produced only 1.00 spike per plant.

4. Number of florets per spike

The number of florets per spike produced by native orchid accessions were shown in Table 29. *Rhynchostylis retusa* (VKA/NOR-4) had higher florets per spike (99.33) and it was followed by *Pholidota imbricata* (VKA/NOR-29) (63.33). All other accessions were found on par with each other with respect to number of florets per spike. Lesser number of florets per spike among native orchid accessions was recorded in *Dendrobium crumenatum* (VKA/NOR-34) (3.75).

5. Spike length

Distinguishable difference was observed with respect to spike length recorded among native orchid accessions (Table 29). Maximum spike length (49.66cm) was record in *Pholidota imbricata* (VKA/NOR-29) followed by *Rhynchostylis retusa* (VKA/NOR-4) and *Dendrobium crumenatum* (VKA/NOR-34) was having a spike length of 29.83 cm and 25.50 cm respectively which were on par. It was found that spike length recorded in *Dendrobium ovatum* (VKA/NOR-60) (4.33 cm) was on par with *Acampe praemorsa* (VKA/NOR-3) (4.21 cm).

6. Rachis length

Among native orchid accessions investigated, *Pholidota imbricata* (VKA/NOR-29) recorded the longest rachis of 23.50 cm (Table 29). The accessions *Rhynchostylis retusa* (VKA/NOR-4), *Dendrobium crumenatum* (VKA/NOR-34) and *Eria fragrans* (VKA/NOR-25) recorded rachis length of 18.46 cm, 16.25 cm and 16.12 cm respectively which were found to be on par. The rachis length recorded in *Dendrobium ovatum* (VKA/NOR-60) (2.43 cm) was on par with *Acampe praemorsa* (VKA/NOR-3) and *Acampe praemorsa* (VKA/NOR-3) recorded shortest rachis of 1.37 cm.

7. Girth of spike at base

Considerable difference was noticed in girth of spike at the base among native orchid accessions (Table 29). Maximum girth was recorded in *Dendrobium densiflorum* (VKA/NOR-22) (1.30 cm) which was on par with *Rhynchostylis retusa* (VKA/NOR-4) (1.26 cm). The girth of spike at base recorded for *Dendrobium crumenatum* (VKA/NOR-34) and *Eria fragrans* (VKA/NOR-25) were on par with values 0.95 cm and 0.76 cm respectively. It was also observed that girth of spike at the base recorded in *Acampe praemorsa* (VKA/NOR-3) (0.41 cm), *Pholidota imbricata* (VKA/NOR-29) (0.37 cm) was on par with *Dendrobium ovatum* (VKA/NOR-60) (0.36 cm).

8. Stalk length

Among the nine native orchid accessions flowered, the longest floret stalks were in *Dendrobium densiflorum* (VKA/NOR-22) (5.04 cm) followed by *Dendrobium moschatum* (VKA/NOR-37) (4.26 cm) (Table 29). Among them *Eria fragrans* (VKA/NOR-25) was on par with *Pholidota imbricata* with respect to stalk length and it was 0.93 cm and 0.66 cm respectively for each of them.

Table 29. Quantitative floral characters of native orchid accessions

Sl. No.	Accession code	Scientific name	Flowering time/season	Frequency of flowering	No. of spikes /plant	No. of florets /spike	Spike length (cm)	Rachis length (cm)	Girth of spike at base (cm)	Stalk length (cm)
1	VKA/NOR-22	*Dendrobium densiflorum*	February	1	1.00	16.00	13.00	8.00	1.30	5.04
2	VKA/NOR-27	*Dendrobium fimbriatum*	April	1	1.00	4.00	13.25	10.25	0.51	3.25
3	VKA/NOR-60	*Dendrobium ovatum*	Jan- February	2	3.33	6.80	4.33	2.43	0.36	1.36
4	VKA/NOR-34	*Dendrobium crumenatum*	April - May, Oct, Dec- Jan	5	5.76	3.75	25.50	16.25	0.95	1.41
5	VKA/NOR-37	*Dendrobium moschatum*	April	1	2.00	7.50	16.65	13.24	0.60	4.26
6	VKA/NOR-25	*Eria fragrans*	May- Oct	4	1.75	9.41	18.76	16.12	0.76	0.93
7	VKA/NOR-29	*Pholidota imbricata*	June- July	2	2.66	63.33	49.66	23.50	0.37	0.66
8	VKA/NOR-3	*Acampe praemorsa*	April	1	3.50	8.25	4.21	1.37	0.41	1.16
9	VKA/NOR-4	*Rhynchostylis retusa*	May-June	2	2.00	99.33	29.83	18.46	1.26	1.55
CD (0.05)					**1.383**	**22.339**	**5.658**	**2.887**	**0.183**	**0.271**

The shortest floret stalk was recorded for *Pholidota imbricata* (VKA/NOR-29) (0.66 cm).

9. Flower size

Data regarding the flower size of different native orchid accessions that flowered during the study period are given in Table 30. Maximum flower size was recorded in *Dendrobium moschatum* (VKA/NOR-37) (54.37 sq.cm) and it was significantly superior to all other accessions followed by *Dendrobium crumenatum* (VKA/NOR-34) and *Dendrobium fimbriatum* (VKA/NOR-27) which were on par with values 15.74 sq.cm and 14.04 sq.cm respectively. It was found that *Dendrobium densiflorum* (VKA/NOR-22) (4.61 sq.cm), *Acampe praemorsa* (VKA/NOR-3) (2.55 sq.cm), *Rhynchostylis retusa* (VKA/NOR-4) (2.52 sq.cm) and *Dendrobium ovatum* (VKA/NOR-60) (2.45 sq.cm) were also on par. The lowest floret size of 0.31 sq.cm was recorded in *Pholidota imbricata* (VKA/NOR-29).

10. Petal length

Among the accessions flowered, *Dendrobium moschatum* (VKA/NOR-37) was significantly superior to all other accessions flowered with respect to petal length (Table 30). Maximum petal length of 3.98 cm was observed in *Dendrobium moschatum* (VKA/NOR-37) this was followed by *Eria fragrans* (VKA/NOR-25) (2.16 cm), *Dendrobium fimbriatum* (VKA/NOR-27) (2.05 cm) and *Dendrobium crumenatum* (VKA/NOR-34) (1.82 cm) were found on par in petal length. Also, it was observed that petal lengths of *Acampe praemorsa* (VKA/NOR-3) (0.81 cm), *Dendrobium ovatum* (VKA/NOR-60) (0.76 cm) and *Rhynchostylis retusa* (VKA/NOR-4) (0.76 cm) were on par. The lowest petal length was recorded for *Pholidota imbricata* (VKA/NOR-29) which recorded a value of 0.46 cm.

11. Petal width

Significant difference was recorded among native orchid accessions with respect to petal width (Table 30). Maximum petal width was recorded in *Dendrobium moschatum* (VKA/NOR-37) (2.94 cm) and minimum in *Pholidota imbricata* (VKA/NOR-29) (0.12 cm). It was also noticed that petal width of *Dendrobium densiflorum* (VKA/NOR-22) (1.41 cm) was on par with *Dendrobium fimbriatum*

Plant

Bud development

Spike **Floret**

Plate 4. Flowering phase of *Acampe praemorsa* (VKA/NOR-3)

Plate 5. Flowering phase of *Dendrobium crumenatum* (VKA/NOR-34)

Plant

Spike

Bud

Floret

Plate 6. Flowering phase of *Dendrobium densiflorum* (VKA/NOR-22)

Plant

Spike

Bud

Floret

Plate 7. Flowering phase of *Dendrobium fimbriatum* (VKA/NOR-27)

Plant

Spike

Bud

Floret

Plate 8. Flowering phase of *Dendrobium moschatum* (VKA/NOR-37)

Plant

Spike

Bud

Floret

Plate 9. Flowering phase of *Eria fragrans* (VKA/NOR-25)

Plant

Floret

Development of spike

Spike

Plate 10. Flowering phase of *Pholidota imbricata* (VKA/NOR-29)

Plant

Floret

Bud development

Spike

Plate 11. Flowering phase of *Rhynchostylis retusa* (VKA/NOR-4)

Plant

Bud

Spike

Floret

Plate 12. Flowering phase of *Dendrobium ovatum* (VKA/NOR-60)

(VKA/NOR-27) (1.32 cm). *Rhynchostylis retusa* (VKA/NOR-4) was on par with *Eria fragrans* (VKA/NOR-25) and *Acampe praemorsa* (VKA/NOR-3) with values 0.41 cm, 0.38 cm and 0.33 cm respectively for three of the accessions.

12. Petal to petal distance

Marked difference was observed with regard to petal to petal distance among native orchid accessions (Table 30). *Dendrobium moschatum* (VKA/NOR-37) was significantly superior to other accessions with a value of 6.89 cm petal to petal distance, which was followed by *Dendrobium fimbriatum* (VKA/NOR-27) recording a value of 4.47 cm. The lowest value for petal to petal distance was recorded in *Pholidota imbricata* (VKA/NOR-29) (0.25 cm) during flowering phase.

13. Length of dorsal sepal

As represented in Table 30, maximum dorsal sepal length among nine native orchid accessions was recorded in *Dendrobium moschatum* (VKA/NOR-37) (3.49 cm) followed by *Eria fragrans* (VKA/NOR-25) (2.51 cm). Also, it was found that the dorsal sepal length of *Rhynchostylis retusa* (VKA/NOR-4) was on par with *Dendrobium ovatum* (VKA/NOR-60) and *Pholidota imbricata* (VKA/NOR-29) which was showing a dorsal sepal length of 0.83 cm, 0.73 cm, 0.55 cm respectively. *Pholidota imbricata* (VKA/NOR-29) recorded the minimum dorsal sepal length (0.55 cm).

14. Width of dorsal sepal

Noticeable variation was observed in dorsal sepal width recorded among nine native orchid accessions (Table 30). *Dendrobium moschatum* (VKA/NOR-37) was again superior to all other accessions with respect to width of dorsal sepal recording a value of 1.63 cm. *Dendrobium fimbriatum* (VKA/NOR-27) (1.45 cm) was found on par with *Dendrobium densiflorum* (VKA/NOR-22) (1.41 cm). The minimum value for dorsal sepal width was recorded in *Eria fragrans* (VKA/NOR-25) and it was observed

Table 30. Quantitative floral characters of native orchid accessions contd.

Sl. No.	Accession code	Scientific name	Flower size (sq.cm)	Petal length (cm)	Petal width (cm)	Petal to petal distance (cm)	Length of dorsal sepal (cm)	Width of dorsal sepal (cm)	Length of lateral sepal (cm)	Width of lateral sepal (cm)
1	VKA/NOR-22	*Dendrobium densiflorum*	4.61	1.24	1.41	1.99	1.21	1.41	1.58	1.57
2	VKA/NOR-27	*Dendrobium fimbriatum*	14.04	2.05	1.32	4.47	2.05	1.45	2.05	1.98
3	VKA/NOR-60	*Dendrobium ovatum*	2.45	0.76	0.71	1.66	0.73	0.41	0.81	0.43
4	VKA/NOR-34	*Dendrobium crumenatum*	15.74	1.82	1.10	3.31	1.70	0.92	2.85	0.95
5	VKA/NOR-37	*Dendrobium moschatum*	54.37	3.98	2.94	6.89	3.49	1.63	3.01	1.52
6	VKA/NOR-25	*Eria fragrans*	11.72	2.16	0.38	3.15	2.51	0.38	2.42	0.43
7	VKA/NOR-29	*Pholidota imbricata*	0.31	0.46	0.12	0.25	0.55	0.39	0.49	0.25
8	VKA/NOR-3	*Acampe praemorsa*	2.55	0.81	0.33	1.32	1.10	0.50	1.10	0.50
9	VKA/NOR-4	*Rhynchostylis retusa*	2.52	0.76	0.41	1.50	0.83	0.62	0.90	0.81
CD (0.05)			**3.322**	**0.404**	**0.096**	**0.567**	**0.366**	**0.076**	**0.245**	**0.067**

that dorsal sepal width of *Dendrobium ovatum* (VKA/NOR-60) (0.41 cm), *Pholidota imbricata* (VKA/NOR-29) (0.39 cm) and *Eria fragrans* (VKA/NOR-25) (0.38 cm) are on par.

15. Length of lateral sepal

Significant variation was recorded in length of lateral sepal recorded among native orchid accessions (Table 30). *Dendrobium moschatum* (VKA/NOR-37) recorded maximum length of 3.01cm which was on par with *Dendrobium crumenatum* (VKA/NOR-34) (2.85 cm). Length of lateral sepal of *Rhynchostylis retusa* (VKA/NOR-4) (0.90 cm) and *Dendrobium ovatum* (VKA/NOR-60) (0.81 cm) were on par. The lowest length of lateral sepal was noticed in *Pholidota imbricata* (VKA/NOR-29) (0.49 cm).

16. Width of lateral sepal

Considerable difference was observed with respect to lateral sepal width recorded among native orchid accessions bloomed (Table 30). Significantly highest lateral sepal width was recorded in *Dendrobium fimbriatum* (VKA/NOR-27) (1.98 cm) followed by *Dendrobium densiflorum* (VKA/NOR-22) (1.57 cm) which was on par with *Dendrobium moschatum* (VKA/NOR-37) (1.52 cm). *Pholidota imbricata* (VKA/NOR-29) recorded the minimum lateral sepal width and it was 0.25 cm. The accessions *Dendrobium ovatum* (VKA/NOR-60) (0.43 cm) and *Eria fragrans* (VKA/NOR-25) (0.43 cm) were on par with respect to lateral sepal width.

17. Sepal to sepal distance

Marked difference was also noticed with regard to sepal to sepal distance recorded among nine native orchid accessions (Table 31). *Dendrobium crumenatum* (VKA/NOR-34) recorded maximum value (4.70 cm) for sepal to sepal distance, this was followed by *Dendrobium fimbriatum* (VKA/NOR-27) which was on par with *Eria fragrans* (VKA/NOR-25) with values 3.95 cm and 3.72 cm, respectively. Similarly, *Dendrobium moschatum* (VKA/NOR-37) (2.86 cm) and *Dendrobium densiflorum* (VKA/NOR-22) (2.29 cm) were on par with respect to sepal to sepal distance. Among the other accessions *Pholidota imbricata* (VKA/NOR-29) recorded the least sepal to sepal distance (0.48 cm).

Table 31. Quantitative floral characters of native orchid accessions contd.

Sl. No.	Accession code	Scientific name	Sepal to sepal distance (cm)	Dorsal sepal to lip (cm)	Lip length (cm)	Lip width (cm)	Column length (cm)	Column width (cm)
1	VKA/NOR-22	*Dendrobium densiflorum*	2.29	2.15	1.66	1.68	0.40	0.12
2	VKA/NOR-27	*Dendrobium fimbriatum*	3.95	3.66	2.05	1.89	0.55	0.15
3	VKA/NOR-60	*Dendrobium ovatum*	1.53	1.46	0.91	0.43	0.22	0.19
4	VKA/NOR-34	*Dendrobium crumenatum*	4.70	3.35	2.75	1.66	1.78	0.45
5	VKA/NOR-37	*Dendrobium moschatum*	2.86	3.96	2.48	2.28	1.20	0.58
6	VKA/NOR-25	*Eria fragrans*	3.72	3.23	1.06	0.39	0.59	0.21
7	VKA/NOR-29	*Pholidota imbricata*	0.48	0.78	0.55	0.45	0.27	0.21
8	VKA/NOR-3	*Acampe praemorsa*	1.72	1.50	0.90	0.40	0.31	0.25
9	VKA/NOR-4	*Rhynchostylis retusa*	1.81	1.43	1.62	1.65	0.52	0.22
CD (0.05)			**0.668**	**0.859**	**0.135**	**0.101**	**0.040**	**0.052**

18. Dorsal sepal to lip distance

Dorsal sepal to lip distance was recorded maximum for *Dendrobium moschatum* (VKA/NOR-37) (3.96 cm) which was on par with *Dendrobium fimbriatum* (VKA/NOR-27) (3.66 cm), *Dendrobium crumenatum* (VKA/NOR-34) (3.35 cm) and *Eria fragrans* (VKA/NOR-25) (3.23 cm) (Table 31). It was also noticed that the dorsal sepal to lip distance of *Dendrobium densiflorum* (VKA/NOR-22) (2.15 cm), *Acampe praemorsa* (VKA/NOR-3) (1.50 cm), *Dendrobium ovatum* (VKA/NOR-60) (1.46 cm) and *Rhynchostylis retusa* (VKA/NOR-4) (1.43 cm) were on par. The lowest dorsal sepal to lip distance was recorded in *Pholidota imbricata* (VKA/NOR-29) which is 0.78 cm.

19. Lip (labellum) length

Significant variation was observed with respect to lip (labellum) length among the native orchid accessions flowered (Table 31). Maximum lip (labellum) length was recorded for *Dendrobium crumenatum* (VKA/NOR-34) (2.75 cm) which was followed by *Dendrobium moschatum* (VKA/NOR-37) (2.48 cm) and *Dendrobium fimbriatum* (VKA/NOR-27) (2.05 cm). It was observed that the lip (labellum) length of *Dendrobium densiflorum* (VKA/NOR-22) (1.66 cm) and *Rhynchostylis retusa* (VKA/NOR-4) (1.62 cm) are on par. Also, *Dendrobium ovatum* (VKA/NOR-60) was on par with *Acampe praemorsa* (VKA/NOR-3) with values 0.91 cm and 0.90 cm respectively for both species with respect to lip (labellum) length. Minimum lip (labellum) length was detected in *Pholidota imbricata* (VKA/NOR-29) (0.55 cm).

20. Lip (labellum) width

Detectable difference was also recorded with respect to lip (labellum) width (Table 31); *Dendrobium moschatum* (VKA/NOR-37) was significantly superior to all other native orchid accessions flowered. *Dendrobium moschatum* (VKA/NOR-37) recorded maximum lip (labellum) width of 2.28 cm which was followed by *Dendrobium fimbriatum* (VKA/NOR-27) (1.89 cm). The lip width of *Dendrobium densiflorum* (VKA/NOR-22) (1.68 cm), *Dendrobium crumenatum* (VKA/NOR-34) (1.66 cm) and *Rhynchostylis retusa* (VKA/NOR-4) (1.65 cm) were found to be on par. Among the nine native orchid accessions, *Pholidota imbricata* (VKA/NOR-29) (0.45

cm), *Dendrobium ovatum* (VKA/NOR-60) (0.43 cm) and *Acampe praemorsa* (VKA/NOR-3) (0.40 cm) were on par with respect to lip (labellum) width. *Eria fragrans* (VKA/NOR-25) recorded the minimum lip (labellum) width of 0.39 cm.

21. Column length

Variation in the length of column recorded among nine native orchid accessions are shown in Table 31. *Dendrobium crumenatum* (VKA/NOR-34) recorded the highest value of 1.78 cm followed by *Dendrobium moschatum* (VKA/NOR-37) (1.20 cm). This was followed by *Eria fragrans* (VKA/NOR-25) (0.59 cm) and *Dendrobium fimbriatum* (VKA/NOR-27) (0.55 cm). It was observed that length of column recorded in *Acampe praemorsa* (VKA/NOR-3) (0.31 cm) was on par with *Pholidota imbricata* (VKA/NOR-29) (0.27 cm). *Dendrobium ovatum* (VKA/NOR-60) recorded lowest value of 0.22 cm.

22. Column width

Significant variation was observed among native orchid accessions for column width (Table 31). *Dendrobium moschatum* (VKA/NOR-37) recorded maximum column width of 0.58 cm followed by *Dendrobium crumenatum* (VKA/NOR-34) (0.45 cm). Both *Eria fragrans* (VKA/NOR-25) and *Pholidota imbricata* (VKA/NOR-29) shown same column width of 0.21 cm. Column width of *Acampe praemorsa* (VKA/NOR-3) (0.25 cm) and *Rhynchostylis retusa* (VKA/NOR-4) (0.22 cm) were found to be on par. The column width of *Dendrobium fimbriatum* (VKA/NOR-27) (0.15 cm) was found to be on par with *Dendrobium densiflorum* (VKA/NOR-22) (0.12 cm) which was the minimum column width recorded among native orchid accessions flowered.

23. Longevity of spike on plant (days)

Longevity of spike on plant (days) counted till the wilting of single floret on the spike showed maximum number of days for *Dendrobium ovatum* (VKA/NOR-60) (Table 32) followed by *Rhynchostylis retusa* (VKA/NOR-4) which was on par with *Acampe praemorsa* (VKA/NOR-3), they recorded 12.00, 11.33 and 10.50 days respectively. The spike longevity (days) recorded for *Eria fragrans* (VKA/NOR-25) (4.25) was on par with *Dendrobium moschatum* (VKA/NOR-37) (4.00) and

Dendrobium densiflorum (VKA/NOR-22) (4.00). Further, it was observed that *Dendrobium crumenatum* (VKA/NOR-34) recorded minimum number of 1.00 days of spike longevity.

24. Longevity of floret on spike (days)

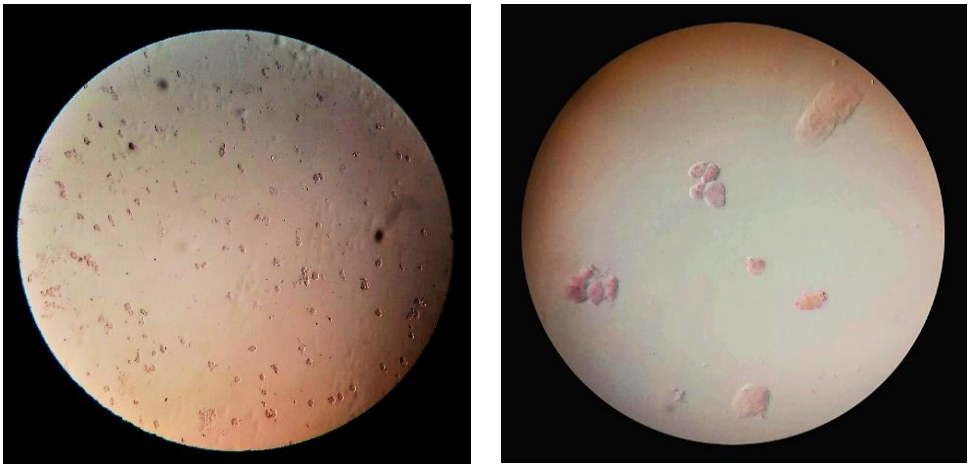
Longevity of floret on spike (days) counted among nine native orchid accessions recorded significant variations. Highest was noticed in *Acampe praemorsa* (VKA/NOR-3) (19.00) followed by *Dendrobium ovatum* (VKA/NOR-60) (16.00) and *Rhynchostylis retusa* (VKA/NOR-4) (13.33) (Table 32). Among the accessions, the longevity of floret on spike (days) counted was on par for *Dendrobium moschatum* (VKA/NOR-37) (7.50) and *Pholidota imbricata* (VKA/NOR-29) (7.00). Also, *Dendrobium fimbriatum* (VKA/NOR-27) (4.50) was on par with *Dendrobium densiflorum* (VKA/NOR-22) (4.00). While the longevity was less for *Dendrobium crumenatum* (VKA/NOR-34) (1.93)

25. Pollen viability (%)

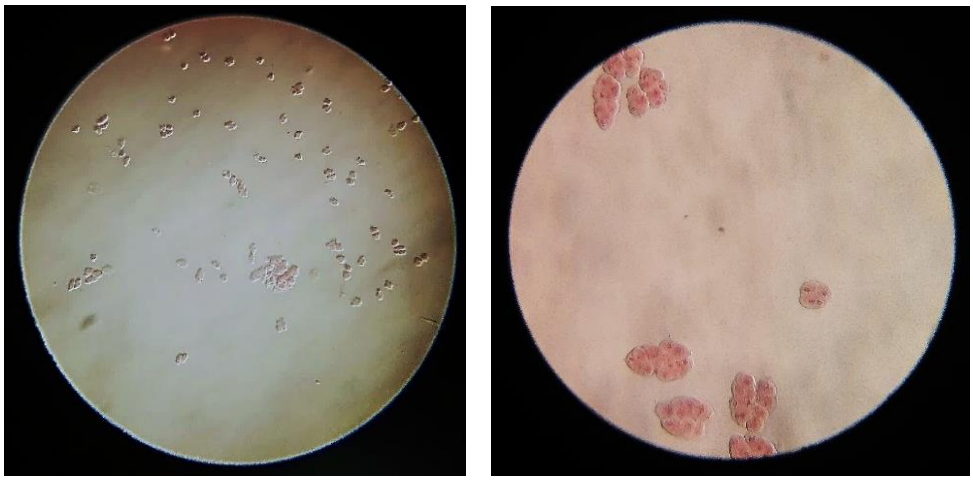
The pollen viability percentage observed in native orchid accessions are represented in Table 32 and pollen images are presented in Plate 23 to 25. Pollen viability was highest for *Rhynchostylis retusa* (VKA/NOR-4) (98.27 %) which was followed by *Acampe praemorsa* (VKA/NOR-3) and *Pholidota imbricata* (VKA/NOR-29) were on par with values 94.75 per cent and 94.61 per cent respectively. The lowest pollen viability percentage was recorded for *Dendrobium ovatum* (VKA/NOR-60) (92.03 %). All other accessions were on par with respect to pollen viability.

Table 32. Quantitative floral characters of native orchid accessions contd.

Sl. No.	Accession code	Scientific name	Longevity of spike on plant (days)	Longevity of floret on spike (days)	Pollen viability (%)
1	VKA/NOR-22	*Dendrobium densiflorum*	4.00	4.00	92.57
2	VKA/NOR-27	*Dendrobium fimbriatum*	2.20	4.50	94.01
3	VKA/NOR-60	*Dendrobium ovatum*	12.00	16.00	92.03
4	VKA/NOR-34	*Dendrobium crumenatum*	1.00	1.93	92.77
5	VKA/NOR-37	*Dendrobium moschatum*	4.00	7.50	93.03
6	VKA/NOR-25	*Eria fragrans*	4.25	5.50	93.75
7	VKA/NOR-29	*Pholidota imbricata*	5.00	7.00	94.61
8	VKA/NOR-3	*Acampe praemorsa*	10.50	19.00	94.75
9	VKA/NOR-4	*Rhynchostylis retusa*	11.33	13.33	98.27
CD (0.05)			**2.286**	**2.379**	**2.480**

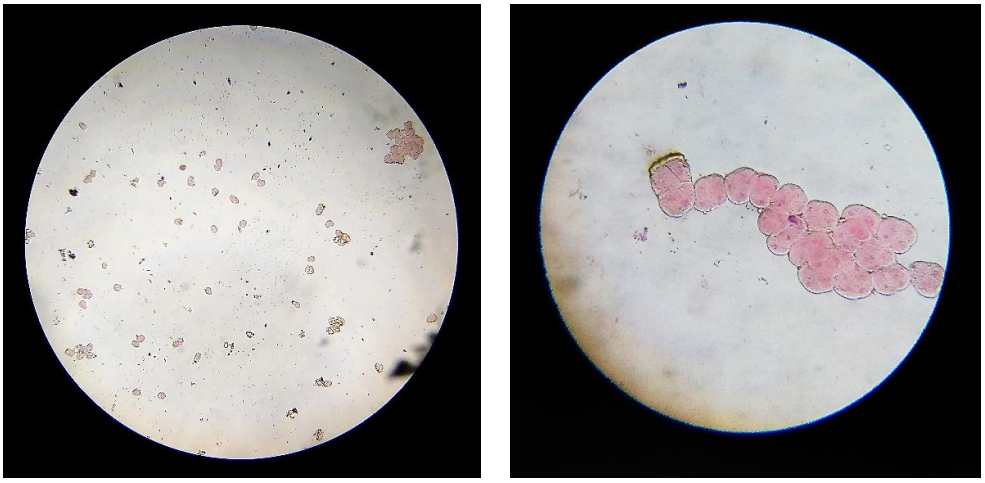


A. *Acampe praemorsa*

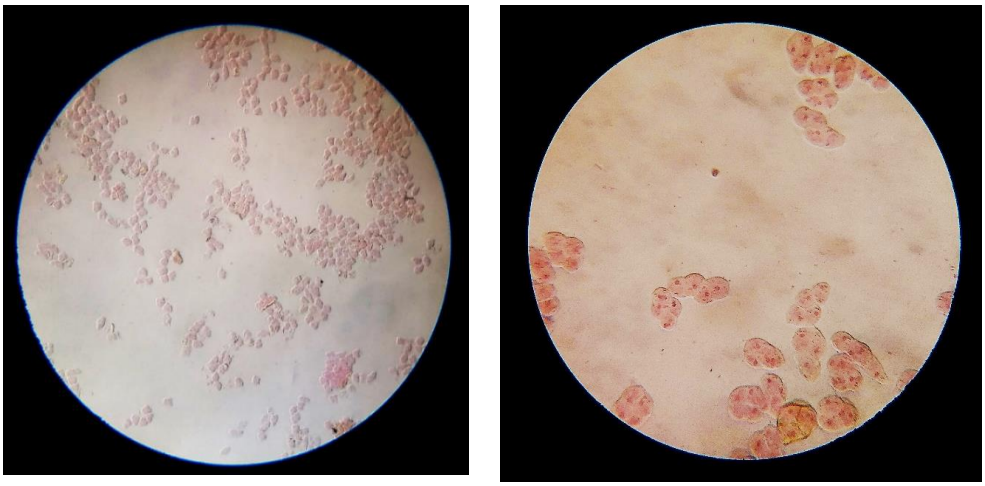


B. *Rhynchostylis retusa*

Plate 13a. Microscopic images of pollen grains of different accessions observed under 10X and 40X lenses.

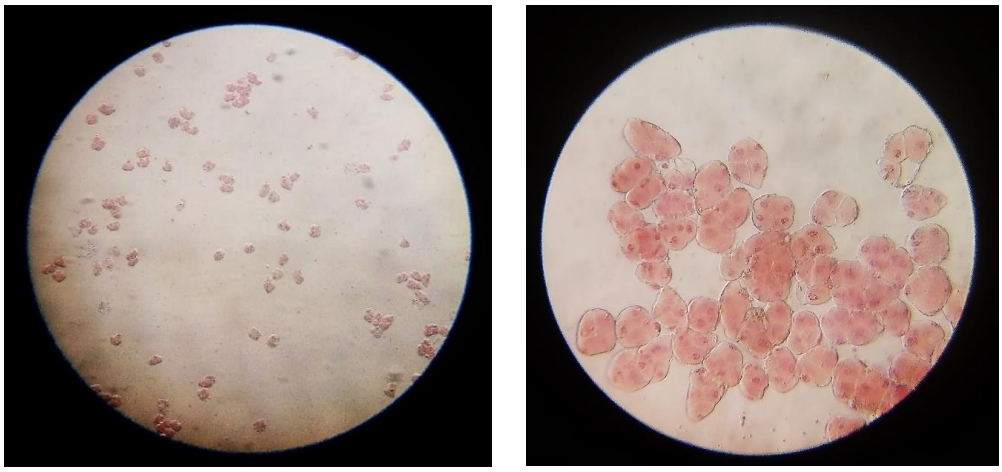


C. *Dendrobium ovatum*

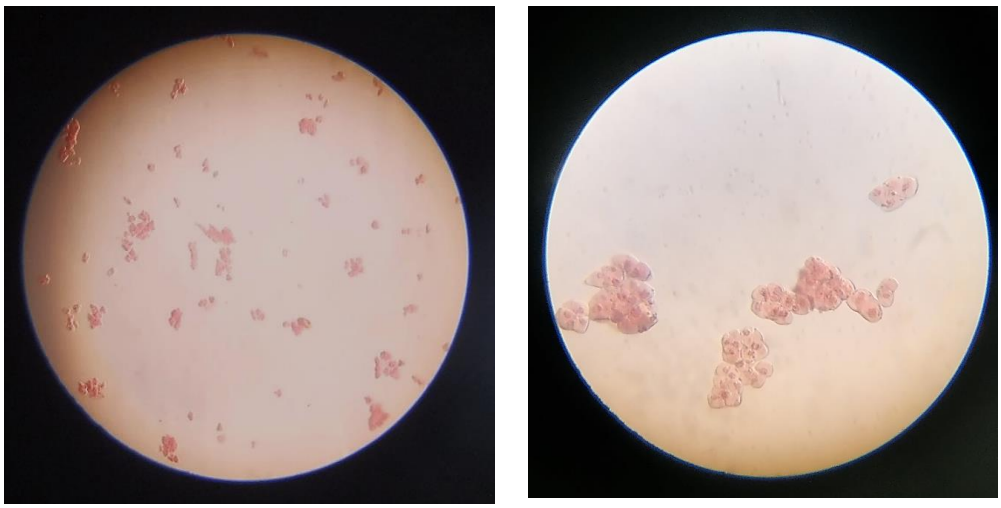


D. *Dendrobium crumenatum*

Plate 13b. Microscopic images of pollen grains of different accessions observed under 10X and 40X lenses.



E. *Eria fragrans*



F. *Pholidota imbricata*

Plate 13c. Microscopic images of pollen grains of different accessions observed under 10X and 40X lenses.

4.3.2 Qualitative floral characters

Details regarding the qualitative floral characters of nine native orchid accessions flowered are given in Tables 33 - 38.

Spike orientation in all the accessions showed considerable variation (Table 33). Three type spike orientation was observed, *viz.,* pendulous, drooping and erect or arching type. The spikes in *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37) were oriented in pendulous manner. Drooping spikes were observed in *Pholidota imbricata* (VKA/NOR-29) and *Rhynchostylis retusa* (VKA/NOR-4), while in *Dendrobium crumenatum* (VKA/NOR-34), *Eria fragrans* (VKA/NOR-25) and *Dendrobium ovatum*, (VKA/NOR-60) the spikes were oriented in erect to arching manner. Erect spike opposed by leaf was observed in *Acampe praemorsa* (VKA/NOR-3).

Images of floral parts of the accessions are shown in Plate 26 - 28. Petal shape was ovate in *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium moschatum* (VKA/NOR-37) and *Rhynchostylis retusa* (VKA/NOR-4), while it was sub orbicular in *Dendrobium densiflorum* (VKA/NOR-22) (Table 33). Ovate to lanceolate petals were found in *Acampe praemorsa* (VKA/NOR-3), and *Eria fragrans* (VKA/NOR-25) was observed to have lanceolate petals. *Pholidota imbricata* (VKA/NOR-29) recorded oblong petals. *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium crumenatum* (VKA/NOR-34) were found to have elliptic petal shape.

Petal curvature also showed noticeable variation among the accessions (Table 33). *Eria fragrans* (VKA/NOR-25) and *Dendrobium ovatum* (VKA/NOR-60) showed deflexed petals. Incurved with straight apex was noticed in *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Acampe praemorsa* (VKA/NOR-3) and *Pholidota imbricata* (VKA/NOR-29). The petals of *Dendrobium crumenatum* (VKA/NOR-34) were straight with slightly deflexed apex. Incurved curvature was recorded in *Dendrobium densiflorum* (VKA/NOR-22). *Rhynchostylis retusa* (VKA/NOR-4) was found to have straight petals.

Table 33. Qualitative floral characters of different orchid accessions

Sl. No.	Accession code	Scientific name	Spike orientation	Flower fragrance (presence/absence)	Petal shape	Petal curvature
1	VKA/NOR-22	*Dendrobium densiflorum*	Pendulous	Absent	Sub orbicular	Incurved
2	VKA/NOR-27	*Dendrobium fimbriatum*	Pendulous	Present	Elliptic	Incurved with straight apex
3	VKA/NOR-60	*Dendrobium ovatum*	Erect to arched	Absent	Ovate	Deflexed
4	VKA/NOR-34	*Dendrobium crumenatum*	Erect to arched	Present	Elliptic	Straight with deflexed at apex
5	VKA/NOR-37	*Dendrobium moschatum*	Pendulous	Present	Ovate	Incurved with straight apex
6	VKA/NOR-25	*Eria fragrans*	Erect to arched	Present	Lanceolate	Deflexed
7	VKA/NOR-29	*Pholidota imbricata*	Drooping	Absent	Oblong	Incurved with straight apex
8	VKA/NOR-3	*Acampe praemorsa*	Erect	Present	Ovate -lanceolate	Incurved with straight apex
9	VKA/NOR-4	*Rhynchostylis retusa*	Drooping	Present	Ovate	Straight

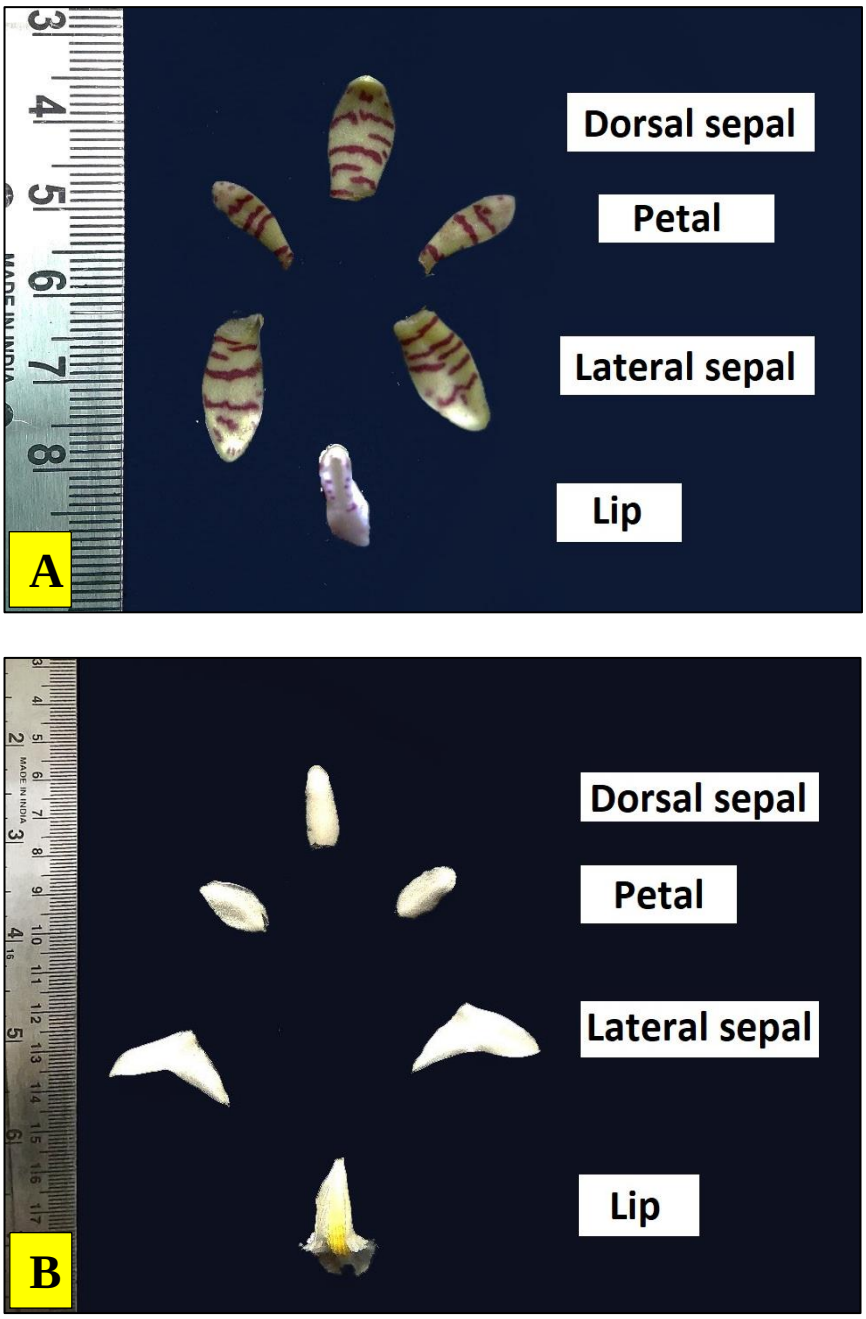


Plate 14a. Floral parts of native orchid accessions (A) *Acampe praemorsa* (VKA/NOR-3) (B) *Dendrobium crumenatum* (VKA/NOR-34)

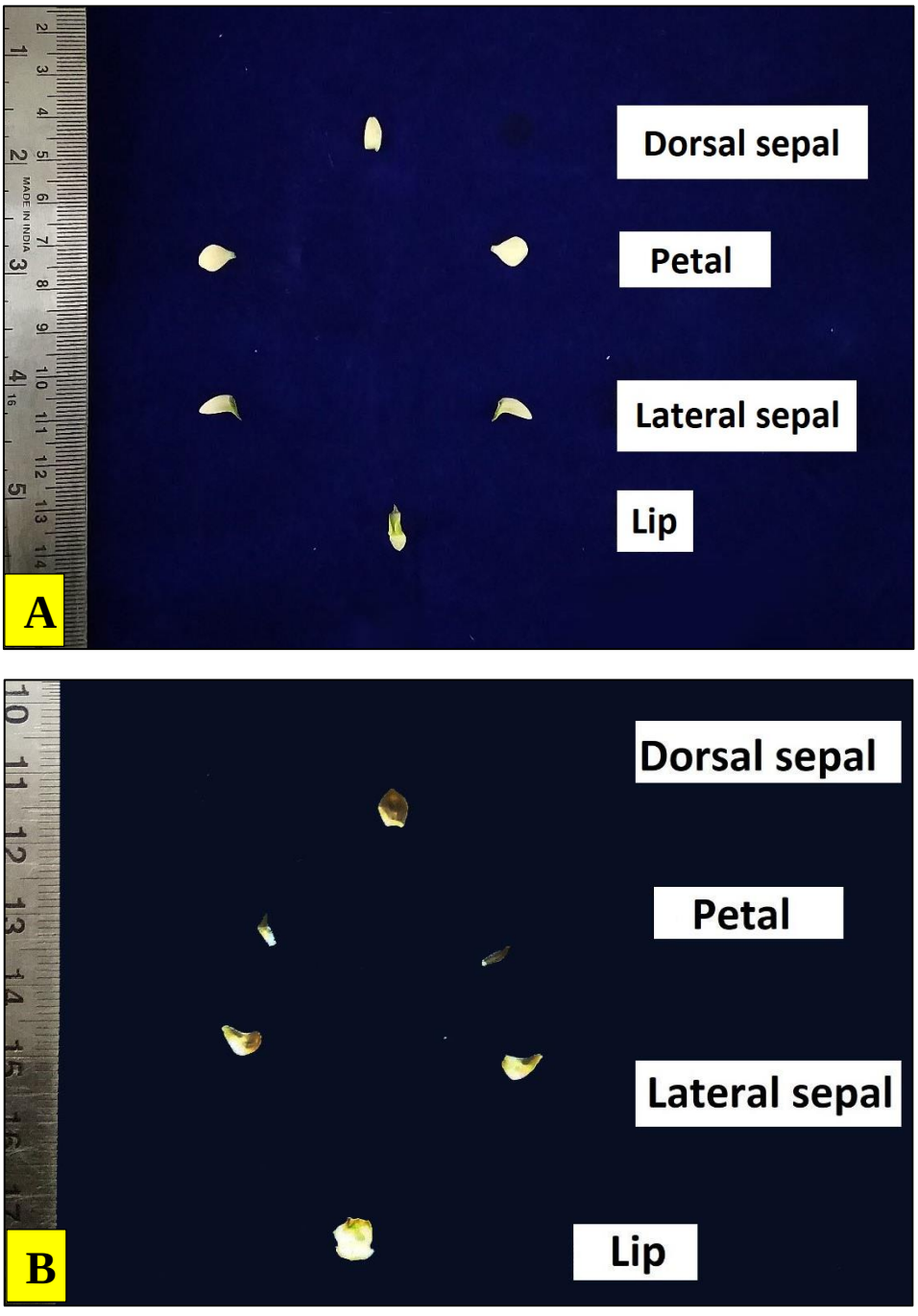


Plate 14b. Floral parts of native orchid accessions (A) *Dendrobium ovatum* (VKA/NOR-60) (B) *Pholidota imbricata* (VKA/NOR-29)

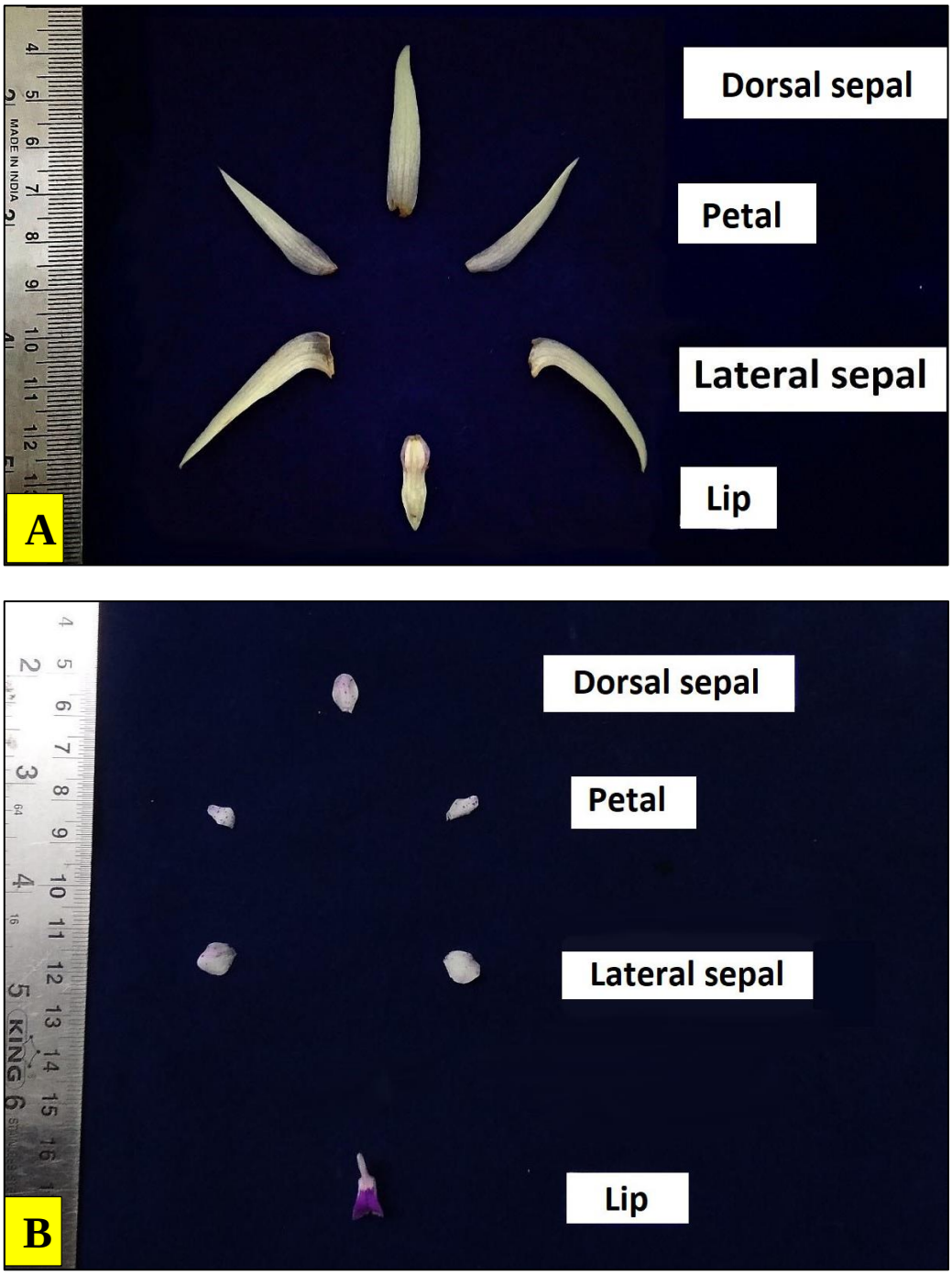


Plate 14c. Floral parts of native orchid accessions (A) *Eria fragrans* (VKA/NOR-25) (B) *Rhynchostylis retusa* (VKA/NOR-4)

The lip shape of *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium densiflorum* (VKA/NOR-22) was orbicular (Table 34). *Dendrobium moschatum* (VKA/NOR-37) was found to have produced hemispherical open-mouthed pouch, and *Pholidota imbricata* (VKA/NOR-29) was having sac like concaved lip. The mid lobe observed in *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium crumenatum* (VKA/NOR-34) and *Acampe praemorsa* (VKA/NOR-3) was ovate. Oblong lip shape was recorded in *Eria fragrans* (VKA/NOR-25) and obovate in *Rhynchostylis retusa* (VKA/NOR-4).

Except *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium moschatum* (VKA/NOR-37) all other accession had lobation present on lips (Table 34).

Among the accessions flowered, fragrance was noted for *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Acampe praemorsa* (VKA/NOR-3), *Rhynchostylis retusa* (VKA/NOR-4) and *Eria fragrans* (VKA/NOR-25) (Table 33). *Dendrobium crumenatum* (VKA/NOR-34) was strongly fragrant compared to all other accessions.

The colour of floral parts such as sepal colour, petal colour, lip colour, column colour and colour of markings on lip also showed considerable variation among the accessions (Table 35-38 and Table 34). The predominant color groups observed were yellow, orange, white and purple violet.

The variation in sepal colour is presented in Table 35. They are RHS-13C (Yellow group 13, brilliant yellow C) in *Dendrobium densiflorum* (VKA/NOR-22), RHS-17D (Yellow orange group 17, light yellow D) in *Dendrobium fimbriatum* (VKA/NOR-27), RHS-24D (Orange group 24, orange yellow D) in *Dendrobium moschatum* (VKA/NOR-37), RHS-NN 155D (White group 155, white D) in *Dendrobium crumenatum* (VKA/NOR-34), RHS-3C (Yellow group 3, light greenish yellow C) with transverse stripes RHS-187B (Greyed purple group 187, dark red B) in

Table 34. Variation in lip characters of the accessions

Sl. No.	Accession code	Scientific name	Lip shape	Lip lobation (presence/absence)	Marking on lip
1	VKA/NOR-22	*Dendrobium densiflorum*	Orbicular	Absent	Absent
2	VKA/NOR-27	*Dendrobium fimbriatum*	Orbicular	Absent	RHS-203B (Black group 203, black B)
3	VKA/NOR-60	*Dendrobium ovatum*	Ovate	Present	RHS-N144C (Yellow green group N144, strong yellow green C)
4	VKA/NOR-34	*Dendrobium crumenatum*	Ovate towards tip	Present	RHS-7A (Yellow group 7, brilliant yellow A)
5	VKA/NOR-37	*Dendrobium moschatum*	Hemispherical open-mouthed pouch	Absent	Two blotches: RHS-53A (Red group 53, deep red A)
6	VKA/NOR-25	*Eria fragrans*	Oblong	Present	Purple at edges RHS-N 80A (Purple violet group N 80, strong purple A)
7	VKA/NOR-29	*Pholidota imbricata*	Saccate (sac like)	Present	Absent
8	VKA/NOR-3	*Acampe praemorsa*	Ovate	Present	Narrow streaks RHS-N 78A (Purple group, N78, strong reddish purple A)
9	VKA/NOR-4	*Rhynchostylis retusa*	Obovate	Present	RHS-N 80A (Purple violet group N80, strong purple A)

Table 35. Variation in sepal colour of the accessions

Sl. No.	Accession code	Scientific name	Sepal colour
1	VKA/NOR-22	*Dendrobium densiflorum*	RHS-13C (Yellow group 13, brilliant yellow C)
2	VKA/NOR-27	*Dendrobium fimbriatum*	RHS-17D (Yellow orange group 17, light yellow D)
3	VKA/NOR-60	*Dendrobium ovatum*	RHS-155C (White group 155, greenish white C)
4	VKA/NOR-34	*Dendrobium crumenatum*	RHS-NN 155D (White group 155, white D)
5	VKA/NOR-37	*Dendrobium moschatum*	RHS-24D (Orange group 24, orange yellow D)
6	VKA/NOR-25	*Eria fragrans*	RHS-155C (White group 155, greenish white C)
7	VKA/NOR-29	*Pholidota imbricata*	RHS-158B (Yellow white group 158, pale yellow B)
8	VKA/NOR-3	*Acampe praemorsa*	RHS-3C (Yellow group 3, light greenish yellow C) Transverse stripes; RHS-187B (Greyed purple group 187, dark red B)
9	VKA/NOR-4	*Rhynchostylis retusa*	RHS-NN 155C (White group 155, white C) Spots; RHS-N 80A (Purple violet group N 80, strong purple A)

Acampe praemorsa (VKA/NOR-3), RHS-158B (Yellow white group 158, pale yellow B) in *Pholidota imbricata* (VKA/NOR-29), RHS-NN155C (White group 155, white C) with spots RHS-N 80A (Purple violet group N 80, strong purple A) in *Rhynchostylis retusa* (VKA/NOR-4) and RHS-155C (White group 155, greenish white C) in *Eria fragrans* (VKA/NOR-25) and *Dendrobium ovatum (*VKA/NOR-60).

The variation in petal colour observed are shown in Table 36. RHS-13C (Yellow group 13, brilliant yellow C) in *Dendrobium densiflorum* (VKA/NOR-22), RHS-21C (Yellow orange group 21, brilliant yellow C) in *Dendrobium fimbriatum* (VKA/NOR-27), RHS-24D (Orange group 24, orange yellow D) in *Dendrobium moschatum* (VKA/NOR-37), RHS-NN 155D (White group 155, white D) in *Dendrobium crumenatum* (VKA/NOR-34), RHS-3C (Yellow group 3, light greenish yellow C) with transverse stripes RHS-187B (Greyed purple group 187, dark red B) in *Acampe praemorsa* (VKA/NOR-3), RHS-158B (Yellow white group 158, pale yellow B) in *Pholidota imbricata* (VKA/NOR-29), RHS-NN 155C (White group 155, white C) with spots RHS-N 80A (Purple violet group N 80, strong purple A) in *Rhynchostylis retusa* (VKA/NOR-4) and RHS-155C (White group 155, greenish white C) in *Eria fragrans* (VKA/NOR-25) and *Dendrobium ovatum* (VKA/NOR-60).

Different lip (labellum) colours observed were RHS-N 25C (Orange group N25, strong orange C) in *Dendrobium densiflorum* (VKA/NOR-22) and RHS-23A (Yellow orange group 23, vivid orange yellow A) in *Dendrobium fimbriatum* (VKA/NOR-27). *Dendrobium moschatum* (VKA/NOR-37) was found to have RHS-N 25C (Orange group N25, strong orange C) on the inner side and RHS-22B (Yellow orange group 22, light orange yellow B) towards tip. RHS-NN 155D (White group 155, white D) was observed in *Dendrobium crumenatum* (VKA/NOR-34) and *Acampe praemorsa* (VKA/NOR-3); and RHS-NN 155A (White group 155, yellowish white A) was observed in *Pholidota imbricata* (VKA/NOR-29). *Rhynchostylis retusa* (VKA/NOR-4) was found to have RHS-NN 155C (White group 155, white C) towards inner side of lip and RHS-N 80A (Purple violet group N 80, strong purple A) towards apex. RHS-155C (White group 155, greenish white C) was recorded in *Eria fragrans* (VKA/NOR-25), and *Dendrobium ovatum* (VKA/NOR-60) recorded two colours *viz.*, RHS-N144C

Table 36. Variation in petal colour of the accessions

Sl. No.	Accession code	Scientific name	Petal colour
1	VKA/NOR-22	*Dendrobium densiflorum*	RHS-13C (Yellow group 13, brilliant yellow C)
2	VKA/NOR-27	*Dendrobium fimbriatum*	RHS-21C (Yellow orange group 21, brilliant yellow C)
3	VKA/NOR-60	*Dendrobium ovatum*	RHS-155C (White group 155, greenish white C)
4	VKA/NOR-34	*Dendrobium crumenatum*	RHS-NN 155D (White group 155, white D)
5	VKA/NOR-37	*Dendrobium moschatum*	RHS-24D (Orange group 24, orange yellow D)
6	VKA/NOR-25	*Eria fragrans*	RHS-155C (White group 155, greenish white C)
7	VKA/NOR-29	*Pholidota imbricata*	RHS-158B (Yellow white group 158, pale yellow B)
8	VKA/NOR-3	*Acampe praemorsa*	RHS-3C (Yellow group 3, light greenish yellow C) Transverse stripes; RHS-187B (Greyed purple group 187, dark red B)
9	VKA/NOR-4	*Rhynchostylis retusa*	RHS-NN 155C (White group 155, white C) Spots; RHS-N 80A (Purple violet group N 80, strong purple A)

Table 37. Variation in lip (labellum) colour of the accessions

Sl. No.	Accession code	Scientific name	Lip (labellum) colour
1	VKA/NOR-22	*Dendrobium densiflorum*	RHS-N 25C (Orange group N25, strong orange C)
2	VKA/NOR-27	*Dendrobium fimbriatum*	RHS-23A (Yellow orange group 23, vivid orange yellow A)
3	VKA/NOR-60	*Dendrobium ovatum*	RHS-N144C (Yellow green group N144, strong yellow green C) Towards tip; RHS-155C (White group 155, greenish white C)
4	VKA/NOR-34	*Dendrobium crumenatum*	RHS-NN 155D (White group 155, white D)
5	VKA/NOR-37	*Dendrobium moschatum*	Inner side: RHS-N 25C (Orange group N25, strong orange C) Towards tip: RHS-22B (Yellow orange group 22, light orange yellow B)
6	VKA/NOR-25	*Eria fragrans*	RHS-155C (White group 155, greenish white C)
7	VKA/NOR-29	*Pholidota imbricata*	RHS-NN 155A (White group 155, yellowish white A)
8	VKA/NOR-3	*Acampe praemorsa*	RHS- NN 155D (White group 155, white D) Markings; RHS-N 78A (Purple group, N78, strong reddish purple A)
9	VKA/NOR-4	*Rhynchostylis retusa*	RHS-NN 155C (White group 155, white C) Towards tip: RHS-N 80A (Purple violet group N 80, strong purple A)

(Yellow green group N144, strong yellow green C) towards inner side and RHS-155C (White group 155, greenish white C) towards tip of the lip (Table 37).

The colour of column of the flower observed in different accessions were RHS-13C (Yellow group 13, brilliant yellow C) in *Dendrobium densiflorum* (VKA/NOR-22), RHS-22D (Yellow orange group 22, pale orange yellow D) in *Dendrobium fimbriatum* (VKA/NOR-27), RHS-23B (Yellow orange group 23, brilliant orange yellow B) in *Dendrobium moschatum* (VKA/NOR-37), RHS-NN 155D (White group 155, white D) in *Dendrobium crumenatum* (VKA/NOR-34), RHS-3C (Yellow group 3, light greenish yellow C) in *Acampe praemorsa* (VKA/NOR-3), RHS-NN 155A (White group 155, yellowish white A) in *Pholidota imbricata* (VKA/NOR-29), RHS-NN 155C (White group 155, white C) with small spots RHS-N 80A (Purple violet group N 80, strong purple A) in *Rhynchostylis retusa* (VKA/NOR-4), RHS-NN 155D (White group 155, white D) with light Marking of RHS-N 80A (Purple violet group N 80, strong purple A) in *Eria fragrans* (VKA/NOR-25) and RHS-NN 143C (Green group 143, strong yellow green C) in *Dendrobium ovatum* (VKA/NOR-60) (Table 38).

Marking on the lip was absent in *Dendrobium densiflorum* (VKA/NOR-22) and *Pholidota imbricata* (VKA/NOR-29) (Table 34). The different coloured markings on lip was observed in the accession are RHS-203B (Black group 203, black B) towards inner side in *Dendrobium fimbriatum* (VKA/NOR-27), two blotches of RHS-53A (Red group 53, deep red A) in *Dendrobium moschatum* (VKA/NOR-37), a single marking of RHS-7A (Yellow group 7, brilliant yellow A) in *Dendrobium crumenatum* (VKA/NOR-34), narrow streaks of RHS-N 78A (Purple group, N78, strong reddish purple A) in *Acampe praemorsa* (VKA/NOR-3), RHS-N 80A (Purple violet group N80, strong purple A) colouration towards lip apex in *Rhynchostylis retusa* (VKA/NOR-4), RHS-N144C (Yellow green group N144, strong yellow green C) in *Dendrobium ovatum* (VKA/NOR-60) and RHS-N 80A (Purple violet group N 80, strong purple A) at the edges of *Eria fragrans* (VKA/NOR-25).

Table 38. Variation in column colour of the accessions

Sl. No.	Accession code	Scientific name	Column colour
1	VKA/NOR-22	*Dendrobium densiflorum*	RHS-13C (Yellow group 13, brilliant yellow C)
2	VKA/NOR-27	*Dendrobium fimbriatum*	RHS-22D (Yellow orange group 22, pale orange yellow D)
3	VKA/NOR-60	*Dendrobium ovatum*	RHS-NN 143C (Green group 143, strong yellow green C)
4	VKA/NOR-34	*Dendrobium crumenatum*	RHS-NN 155D (White group 155, white D)
5	VKA/NOR-37	*Dendrobium moschatum*	RHS-23B (Yellow orange group 23, brilliant orange yellow B)
6	VKA/NOR-25	*Eria fragrans*	RHS-NN 155D (White group 155, white D) Marking; RHS-N 80A (Purple violet group N 80, strong purple A)
7	VKA/NOR-29	*Pholidota imbricata*	RHS-NN 155A (White group 155, yellowish white A)
8	VKA/NOR-3	*Acampe praemorsa*	RHS-3C (Yellow group 3, light greenish yellow C)
9	VKA/NOR-4	*Rhynchostylis retusa*	RHS-NN 155C (White group 155, white C) Spots; RHS-N 80A (Purple violet group N 80, strong purple A)

4.4 CLUSTER ANALYSIS

Grouping of germplasm based on extent of diversity is important in diversity assessment studies and it is highly useful for the successful conduct of any breeding programme also. Cluster analysis of quantitative traits was performed and the accessions were classified into different groups based on their morphological resemblance.

4.4.1 Cluster analysis of quantitative vegetative characters

Cluster analysis of quantitative vegetative characters was carried out at 75 per cent similarity and dendrogram was constructed using Minitab 19 statistical software.

4.4.1.1 Monopodials

During the cluster analysis of plant characters *viz.*, plant height, plant spread, number of leaves per plant, leaf length, leaf width, number of roots, internodal length and sheath length grouped the five monopodial accessions into three clusters *viz.*, Cluster A, Cluster B and Cluster C. Cluster A and B have two accessions each and cluster C have one accession (Table 39). Accessions in Cluster A showed 86.55 % similarity and accessions in cluster B showed 84.55% similarity. Cluster A exhibited highest cluster mean with respect to plant height (33.50 cm), leaf length (22.47 cm), leaf width (2.55 cm) and internodal length (1.91 cm) (Table 40). Cluster B showed highest cluster mean for leaf sheath length (3.10 cm), while Cluster C showed highest cluster mean for plant spread (1571.28 sq.cm), number of leaves (89.20) and number of roots (9.80). Number of leaves (10.50) and number of roots (7.10) were found to have minimum value in Cluster A. Cluster B exhibited the least value of cluster mean for plant spread (243.71 sq.cm) and leaf length (16.92 cm). Cluster C was distinct from other clusters with the lowest cluster means for leaf width (1.02 cm), internodal length (1.04 cm) and leaf sheath length (0.52 cm).

The mean inter cluster distance was ranged from 496.21 to1329.59 (Table 41). It was observed that cluster A had the lowest distance with cluster B (496.21) indicating

Table 39. Distribution of monopodial accessions into different clusters

Sl. No.	Cluster	Similarity (%)	Number of accessions in each cluster	Accession names
1	Cluster A	86.55 %	2	*Acampe praemorsa* (VKA/NOR-3), *Rhynchostylis retusa* (VKA/NOR-4)
2	Cluster B	84.55%	2	*Aerides crispa* (VKA/NOR-2), *Vanda thwaitesii* VKA/NOR-8)
3	Cluster C	24.76%	1	*Luisia sp.* (VKA/NOR-7)

Table 40. Mean values of clusters for vegetative characters in monopodials

Variable	**Cluster A**	**Cluster B**	**Cluster C**
Plant height (cm)	33.50	29.63	28.64
Plant spread N-S (cm)	34.95	23.86	43.24
Plant spread E-W (cm)	20.05	8.98	35.40
Plant spread area (sq.cm)	739.45	243.71	1571.28
Number of leaves per plant	10.50	23.70	89.20
Leaf length (cm)	22.47	16.92	17.62
Leaf width (cm)	2.55	1.96	1.02
Number of roots	7.10	8.90	9.80
Internodal length (cm)	1.91	1.48	1.04
Leaf sheath length (cm)	2.84	3.10	0.52

Table 41. Mean inter cluster distances for vegetative characters in monopodials

	Cluster A	**Cluster B**	**Cluster C**
Cluster A	0.000	496.21	835.76
Cluster B	496.21	0.00	1329.59
Cluster C	835.76	1329.59	0.00

close relation between the clusters. Cluster A showed the maximum distance with Cluster C (835.76), similarly Cluster B also showed a wider distance with Cluster C (1329.59).

4.4.1.2 Sympodials

Cluster analysis was carried out for vegetative characters such as plant height, plant spread, number of leaves per plant, leaf length, leaf width and number of roots. The analysis revealed four clusters at 75 per cent similarity. The clusters obtained are Cluster A, Cluster B, Cluster C and Cluster D with nine, one, seven and one members respectively in each cluster (Table 42). The percent similarity within the clusters were 87.11%, 76.60%, 96.86% and 76.60% respectively in Cluster A, B, C and D respectively. The mean value of clusters was showing the highest value for plant height (67.70 cm), plant spread (3979.22 sq.cm), number of leaves (95.80) and number of roots (138.60) in Cluster B (Table 43). Cluster A showed the lowest value for plant spread (423.33 sq.cm) and leaf width (1.97 cm). Cluster C was found to have the maximum cluster mean for leaf length (33.11 cm), and the minimum cluster mean for number of leaves per plant (10.14) and number of roots (23.85). Cluster D exhibited maximum cluster mean for leaf width (4.96 cm).

The mean inter cluster distance was found maximum between Cluster A and Cluster B (3558.87) and minimum between Cluster B and Cluster D (920.44) (Table 44).

4.4.2 Cluster analysis of quantitative floral characters

The distribution of native orchid accessions into different clusters based on quantitative floral characters are given in Table 45. During the cluster analysis of quantitative floral characters grouped the nine native orchid accessions in to two main clusters Cluster A and Cluster B (Table 45). Cluster A was having seven members with 54.88% similarity and Cluster B was having two members with 60.22% similarity. The floral characters such as frequency of flowering, number of spikes produced per plant, stalk length, flower size, petal length, petal width, petal to petal distance, length of

Table 42. Distribution of sympodial orchid accessions into different clusters

Sl. No.	Cluster	Number of accessions in each cluster	Similarity (%)	Accession names
1	Cluster A	9	87.11%	*Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium haemoglossum* (VKA/NOR-41), *Dendrobium ovatum* (VKA/NOR-60), *Bulbophyllum sp.* (VKA/NOR-39), *Oberonia sp*. (VKA/NOR-58) and *Coelogyne breviscapa* (VKA/NOR-33)
2	Cluster B	1	76.60%	*Dendobium crumenatum* (VKA/NOR-34)
3	Cluster C	7	96.86%	*Eria fragrans* (VKA/NOR-25), *Pholidota imbricata* (VKA/NOR-29), *Flickingeria sp*. (VKA/NOR-32), *Cymbidium aloifolium* (VKA/NOR-61), *Cymbidium ensifolium* (VKA/NOR-43), *Cymbidium sp*. (VKA/NOR-30) and *Cymbidium sp.* (VKA/NOR-35)
4	Cluster D	1	76.60%	*Eria sp.* (VKA/NOR-38)

Table 43. Mean values of clusters for vegetative characters in sympodial orchids

Variable	Cluster A	Cluster B	Cluster C	Cluster D
Plant height (cm)	30.92	67.70	32.58	27.34
Plant spread N-S (cm)	21.51	63.12	44.63	57.32
Plant spread E-W (cm)	16.47	61.52	32.74	53.48
Plant spread area (sq.cm)	423.33	3979.22	1450.91	3064.06
Number of leaves per plant	18.05	95.80	10.14	49.70
Leaf length (cm)	11.14	8.06	33.11	32.29
Leaf width (cm)	1.97	2.06	3.22	4.96
Number of roots	38.32	138.60	23.85	66.20

Table 44. Mean inter cluster distances for vegetative characters in sympodial orchids

	Cluster A	Cluster B	Cluster C	Cluster D
Cluster A	0.00	3558.87	1028.33	2641.65
Cluster B	3558.87	0.00	2532.96	920.44
Cluster C	1028.33	2532.96	0.00	1614.38
Cluster D	2641.65	920.44	1614.38	0.00

Table 45. Distribution of native orchid accessions into different clusters based on quantitative floral characters

Sl. No.	Cluster	Number of accessions in each cluster	Similarity (%)	Accession names
1	Cluster A	7	54.88%	*Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Eria fragrans* (VKA/NOR-25) and *Acampe praemorsa* (VKA/NOR-3)
2	Cluster B	2	60.22%	*Pholidota imbricata* (VKA/NOR-29) and *Rhynchostylis retusa* (VKA/NOR-4)

Table 46. Mean values of clusters for floral characters in native orchid accessions

Variable	Cluster A	Cluster B
Frequency of flowering	2.14	2.00
No. of spikes /plant	2.62	2.33
No. of florets /spike	7.95	81.33
Spike length (cm)	13.67	39.74
Rachis length (cm)	9.66	20.98
Girth of spike at base (cm)	0.69	0.81
Stalk length (cm)	2.48	1.10
Flower size (sq.cm)	15.06	1.41
Petal length (cm)	1.83	0.61
Petal width (cm)	1.17	0.26
Petal to petal distance (cm)	3.25	0.87
Length of dorsal sepal (cm)	1.82	0.69
Width of dorsal sepal (cm)	0.95	0.50
Length of lateral sepal (cm)	1.97	0.69
Width of lateral sepal (cm)	1.05	0.53
Sepal to sepal distance (cm)	2.96	1.14
Dorsal sepal to lip (cm)	2.75	1.10
Lip length (cm)	1.68	1.08
Lip width (cm)	1.24	1.05
Column length (cm)	0.72	0.39
Column width (cm)	0.27	0.21
Longevity of spike on plant (days)	5.42	8.16
Longevity of floret on spike (days)	8.34	10.16
Pollen viability (%)	93.27	96.44

Table 47. Mean inter cluster distances for floral characters in native orchid accessions

	Cluster A	Cluster B
Cluster A	0.0000	80.10
Cluster B	80.10	0.0000

dorsal sepal, width of dorsal sepal, length of lateral sepal, width of lateral sepal, sepal to sepal distance, dorsal sepal to lip, lip length, lip width, column length and column width exhibited the highest cluster mean in Cluster A, while Cluster B showed the highest cluster mean for number of florets per spike, spike length, rachis length, girth of spike at base, longevity of spike on plant, longevity of floret on spike and pollen viability (Table 46). The mean inter cluster distance between two clusters was found to be 80.10 (Table 47).

4.5 INCIDENCE OF PEST AND DISEASES

Incidence of pest problem was noticed in the field during the study period. Major pests were snails and grasshoppers. Snails feed on leaves, roots and resulted in defoliation and degradation of roots. Grass hopper attack was noticed highly in *Dendrobium* accessions, which also resulted in defoliation. Snails were controlled by applying Snail Kill (metaldehyde) tablet per pot and to control grasshopper Quinalphos 2 ml per litre spray was given. There was no major disease incidence observed in the field during the period of study.

Discussion

5. DISCUSSION

Orchids are known for their attracting and charming flowers of contrasting colour, shape, form and size. They are also noted for the different growth habits exhibited by them. Globally orchid plants are traded as cut flower (De *et al*., 2014) as well as potted plant (USDA, 2016).

The orchidaceae family is wide spread everywhere in the globe except polar and dessert regions (Hedge, 1997). Orchid diversity is distributed mainly in tropical and subtropical regions of the world (Vij and Pathak, 2001). India is one among the major orchid habitats of the world, showing wide diversity of orchid flora with 400 endemic species (Misra and Misra, 2007). The Eastern Himalayas, North Eastern, North West Himalayas, Peninsular India, and Andaman and Nicobar Islands are the major orchid diversity regions in India (De *et al*., 2014).

Due to the varying climatic conditions in different parts of the world, many of the wild orchids become native of specific regions. Evaluation and characterization of those native species are important for conserving the rare and endangered species and also for producing hybrids with novel floral characters. Native orchid species are vital in breeding programmes due to their astonishing morphological characteristics.

The present study entitled ‘Assessment of diversity in native orchids’ has evaluated morphological characteristics of 23 native orchid accessions in the orchid germplasm at Department of Floriculture and Landscaping, College of Agriculture, Vellanikkara, and the results obtained are discussed under this chapter.

5.1 GROWTH HABIT

The vegetative structure of orchids is modified according to their diverse growth habits. Orchids are found to exhibit two type of growth habits such as monopodial and sympodial type of growth. Monopodials are having straight upward growth and sympodials are producing pseudo stems from the sides of main stem. Sympodial orchids show very limited upward growth. Presence of aerial roots are other feature of monopodial orchids while it is absent in sympodial orchids. Sympodial orchids produce

pseudobulbs which are the bulblike stem act as storage organ of moisture and nutrients (Biswas and Singh, 2019).

All the native orchid accessions under the present study were observed for their growth habit at quarterly intervals for one year. Among the accessions evaluated, *Acampe praemorsa* (VKA/NOR-3), *Aerides crispa* (VKA/NOR-2), *Rhynchostylis retusa* (VKA/NOR-4), *Luisia* sp. (VKA/NOR-7) and *Vanda thwaitesii* (VKA/NOR-8) were grouped under monopodial orchids due to their straight upward growth and presence of aerial roots. All other native orchid accessions such as *Bulbophyllum sp* (VKA/NOR-39), *Coelogyne breviscapa* (VKA/NOR-33), *Cymbidium aloifolium* (VKA/NOR-61), *Cymbidium ensifolium* (VKA/NOR-43), *Cymbidium* sp. (VKA/NOR-30), *Cymbidium* sp.(VKA/NOR-35), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium haemoglossum* (VKA/NOR-41), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium ovatum* (VKA/NOR-60), *Eria fragrans* (VKA/NOR-25), *Eria* sp. (VKA/NOR-38), *Flickingeria* sp. (VKA/NOR-32), *Oberonia* sp. (VKA/NOR-58) and *Pholidota imbricata* (VKA/NOR-29) exhibited sympodial type of growth, since they are found to lack aerial roots and are producing side shoots from the main stem at the base of the plant.

5.2 VEGETATIVE CHARACTERS

5.2.1 **Quantitative vegetative characters**

Vegetative character of plants is controlled by both the genotype and environment. Orchids are exhibiting wide diversity in vegetative characters as well as floral characters. Akshata *et al*. (2018) characterized wild orchids of Western Ghats belonging to the genera *Bulbophyllum, Coelogyne, Cottonia, Dendrobium, Luisia, Oberonia, Pholiodata, Spathoglottis, Trias* and *Vanda* based on morphological parameters such as shoot height, leaf length, leaf breadth, number of leaves, leaf ratio and leaf shape, and the results indicated wide range of variations among the species. Significant variation in vegetative characters was also reported by Kaveriamma (2007) among monopodial orchids (varieties or hybrids of *Arachnis, Vanda, Phalaenopsis, Aranda, Aranthera, Ascosenda, Renantanda,Aeridachnis, Vascostylis, Mokara* and

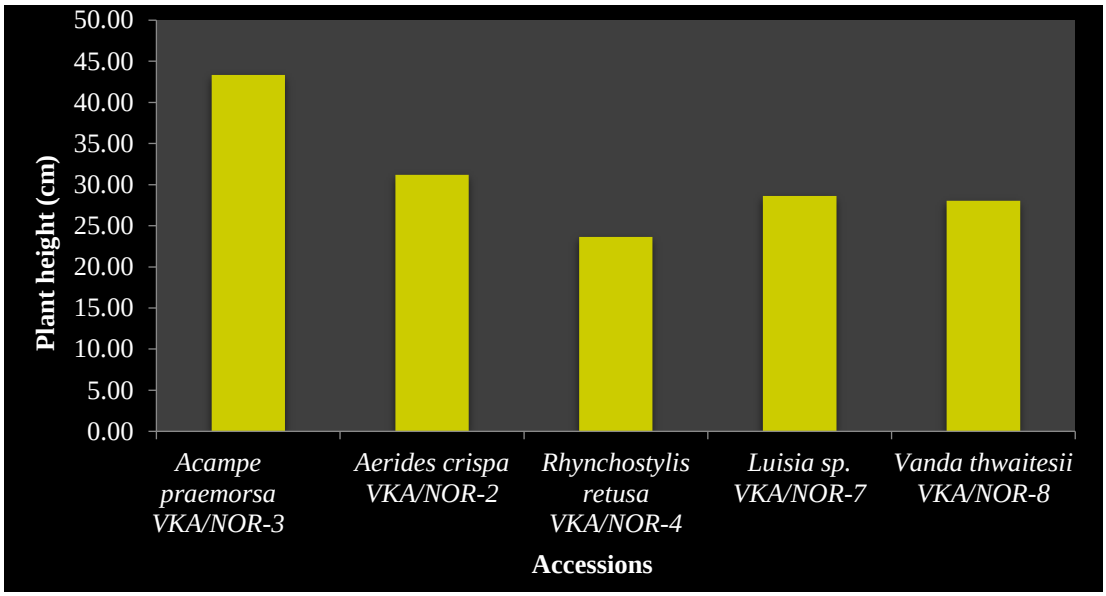


Fig. 1. Variation in plant height among monopodial orchid accessions

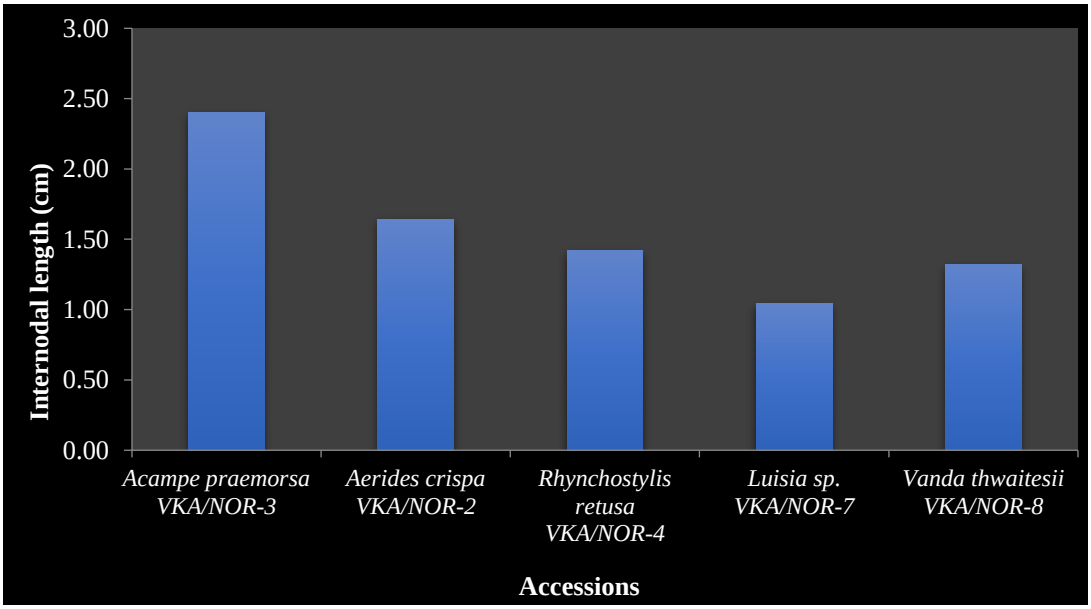


Fig. 2. Variation in internodal length among monopodial orchid accessions

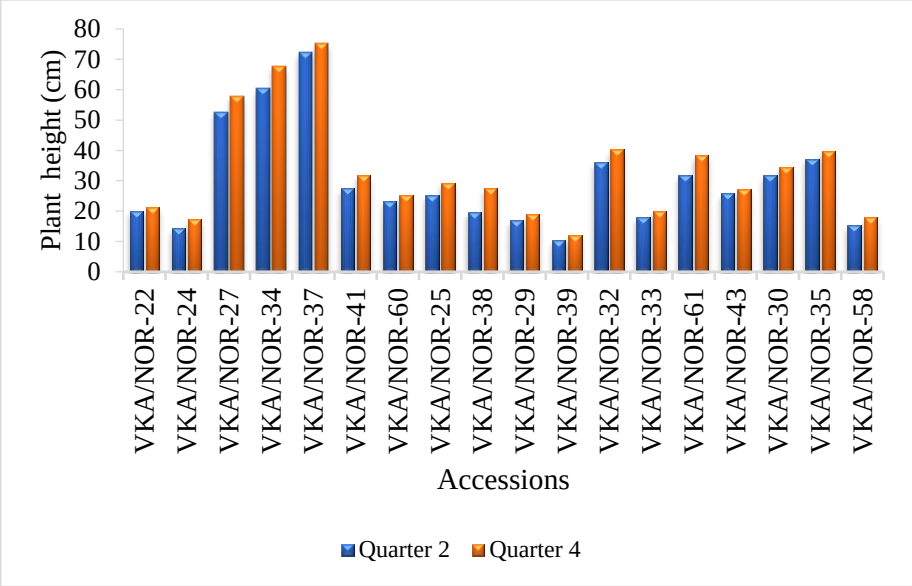


Fig. 3. Variation in plant height among sympodial orchid accessions at quarterly interval

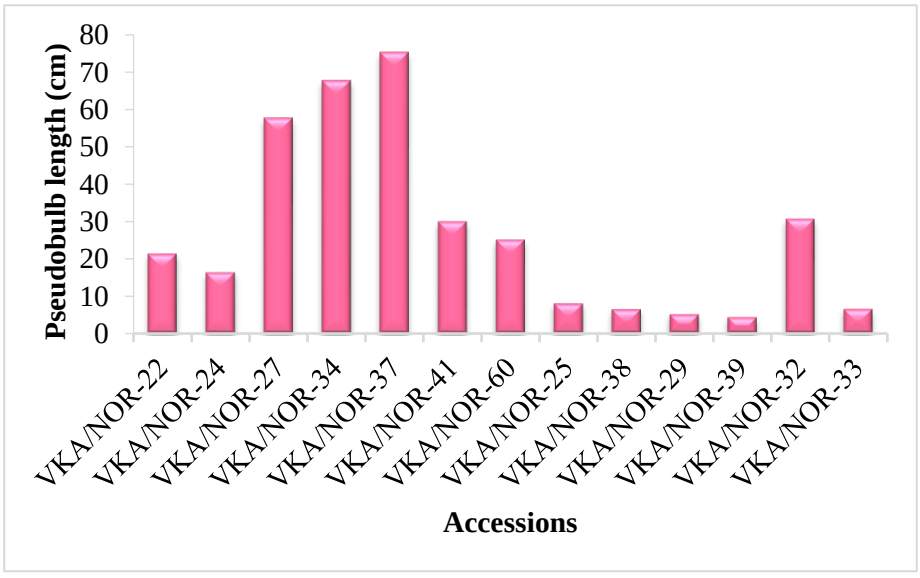


Fig. 4. Variation in pseudobulb length among sympodial orchid accessions

Holttumara) and by Sugapriya *et al*. (2012) among *Dendrobium* orchids. The quantitative vegetative characters of native orchid accessions evaluated under this study are plant height, plant spread, internodal length, pseudobulb length, pseudobulb width, leaf sheath length, leaf length, leaf width, number of leaves and number of roots.

During the entire study period, all the native orchid accessions performed very well under the tropical humid and warm climate of the current study location. Good performance in vegetative character was observed during the rainy season (June-Oct), because orchids are the plants having ability to show high magnitude of diversity as well as high response to the environment it grows (Abraham and Valsala, 1981).

Height of the plants is inherent genetic character which may be influenced by its growing condition. Plant height is highly correlated to other traits such as leaf mass per area, canopy area, time to reproduction and life span (Moles *et al*., 2009). Internodal length of the plant also contributes to the height differences of the plants. In the present study maximum plant height among monopodials was recorded in *Acampe praemorsa* (VKA/NOR-3) (Fig. 1). The species also recorded the highest internodal length (Fig. 2). So, the superiority of *Acampe praemorsa* (VKA/NOR-3) might be due to the genetic makeup of the species. The results are in conformity with that of Sebastian (2015) and Deepa (2017). Though *Luisia* sp. (VKA/NOR-7) recorded the lowest internodal length, it was not the smallest plant, because *Luisia* sp. (VKA/NOR-7) had straight oriented terete leaves, and that might have contributed to plant height in *Luisia* sp. (VKA/NOR-7). The lowest plant height among monopodials was recorded in *Rhynchostylis retusa* (VKA/NOR-4), it was also noted that *Rhynchostylis retusa* (VKA/NOR-4) had the minimum number of leaves compared to others.

Among the sympodial orchid accessions, maximum plant height was recorded for *Dendrobium moschatum* (VKA/NOR-37) which was on par with *Dendrobium crumenatum* (VKA/NOR-34) (Fig. 3). Both these species also showed the highest pseudobulb length and it was found that in cane type pseudobulbs as in *Dendrobium*, the plant height is determined by pseudobulb length. Because, in some species pseudobulbs are often referred to as distinct organ that replaces the stem (Rasmussen, 1986), hence instead of stem, pseudobulb was found to have contributed to the plant

height. *Dendrobium moschatum* (VKA/NOR-37) also recorded maximum internodal length, which contributed to its plant height. Wide variation was observed among the seven *Dendrobium* accessions with respect to plant height and it is in line with the findings of Roychowdhury *et al*. (2004). Sugapriya (2009) while evaluating *Dendrobium* orchids stated that as the internodal length decreases the plant will appear bushier and hence are shorter in plant height. So, when internodal length increases the plants will be more oriented towards sun light and that might be the reason for the maximum plant height and pseudobulb length (Fig. 4) in *Dendrobium* accessions with respect to other genera.

The internodal length was not measurable in *Coelogyne breviscapa* (VKA/NOR-33), *Bulbophyllum* sp. (VKA/NOR-39), *Eria* species (VKA/NOR-25, VKA/NOR-38) and *Cymbidium* species (VKA/NOR-61, VKA/NOR-43, VKA/NOR-30, VKA/NOR-35). Because, the pseudobulbs of *Coelogyne breviscapa* (VKA/NOR-33), *Bulbophyllum* sp. (VKA/NOR-39) and *Eria* species (VKA/NOR-25, VKA/NOR-38) was heteroblastic (with single internode), while in *Cymbidium* species (VKA/NOR-61, VKA/NOR-43, VKA/NOR-30, VKA/NOR-35), the leaves formed a clump at the base of the plant and so internodal length was not distinguishable. Based on number of internodes, pdeudobulbs are classified as heteroblastic and homoblastic (Hew and Yong, 2004). Heteroblastic are with single internode and homoblastic are with many internodes. In this study genus *Dendrobium* and *Flickingeria* were observed to have homoblastic pseudobulbs.

Spread of plant is an indication of area occupied by the plant, which determines the number of plants that could be accommodated in a given space. According to Deepa (2017), the plant spread is greatly determined by leaf characteristics such as leaf length, leaf width, leaf arrangement and leaf orientation in monopodial orchid like *Vanda*. Among monopodials, maximum plant spread was recorded in *Luisia* sp. (VKA/NOR-7) (Fig. 5), as this was the only monopodial accession showing branching habit. The minimum plant spread among monopodial accessions was recorded for *Vanda thwaitesii* (VKA/NOR-8) since it is having smallest leaf with arching tendency. These results are also in conformity with the findings of Kaveriamma (2007) and Sharmao (2019) in monopodials.

Plant spread recorded among sympodial orchid accessions was maximum in *Dendrobium crumenatum* (VKA/NOR-34) (Fig. 7) and it was also found to have more number of pseudostems and a greater number of leaves (Fig. 8). The plant spread of some accession like *Dendrobium ovatum* (VKA/NOR-60) was found to have decreased during the last two quarters (Jan-June 2020) because the plant was leafless during the period of observation. Minimum plant spread among the accessions was recorded for *Oberonia* sp. (VKA/NOR-58). It was noticed that, in *Oberonia* sp. (VKA/NOR-58) instead of pseudostem the alternating leaf bases were closely arranged to form the stem portion. In *Dendrobium anceps* (VKA/NOR-24) the pseudobulb were found to have covered with fan like leaves overlapping at the base.

Leaf characters such as number of leaves, leaf length, width, and leaf sheath characters are directly contributed to the photosynthetic efficiency of the plant (Sebastian, 2015; Deepa, 2017). Leaf length, width, and leaf sheath length recorded among monopodials were maximum in *Acampe praemorsa* (VKA/NOR-3) (Fig. 6, 9 and 10), while leaf width was minimum in *Luisia* sp. (VKA/NOR-7) and it was found to have terete tubular leaves (Akshata *et al*., 2018).

In orchids leaf sheaths are the basal portion of leaf which forms a sheath around stem and give support to the growing portion with soft internodes (Dressler, 1993). Among the accessions evaluated, leaf sheath was more prominent in monopodial accessions, while in sympodials it was observed in some *Dendrobium* accessions only.

According to Akshata *et al*. (2018), leaf length and leaf width are two key factors that influences total photosynthetic ability of the plant and thereby spread of the plant. Significant difference was observed with regards to leaf length among the sympodial accessions. *Cymbidium ensifolium* (VKA/NOR-43) was found to have longest leaf, which was on par with *Cymbidium aloifolium* (VKA/NOR-61) and *Dendrobium anceps* (VKA/NOR-24) recorded the smallest leaf length (Fig. 11). Abbas (2016) evaluated orchid accessions collected from Central Western Ghats, and recorded highest leaf length for *Cymbidium* accessions compared to all other accessions belonging to the genera *Acampae, Aerides, Bulbophyllum, Cattleya, Coelogyne* and *Dendrobium*. Leaf width among sympodials was maximum for the two *Eria* species

(Fig. 12). Towards the end of study period the leaf width of *Eria fragrans* (VKA/NOR-25), *Eria sp.* VKA/NOR-38 and *Pholidota imbricata* (VKA/NOR-29) was on par.

Maximum number of leaves among monopodials was recorded in *Luisia* sp. (VKA/NOR-7) (Fig. 13) which was the contributing factor for maximum plant spread in *Luisia* sp. (VKA/NOR-7).

Among sympodial accessions, the number of leaves per pseudobulb was also showing variation. Accessions belonging to the genera *Dendrobium* produced more than two leaves per pseudobulb. It was found that *Eria*, *Bulbophyllum* and *Coelogyne* produced two leaves per pseudobulb, whereas *Flickingeria* (Rasmussen, 1986) and *Pholidota* (Chen and Wood, 2009) produced only one leaf per pseudobulb.

Girth of pseudobulb imparts sturdiness to the pseudobulb and also help it to withstand lodging (Sugapriya *et al*., 2012). Among the accessions, maximum pseudobulb girth was recorded in *Pholidota imbricata* (VKA/NOR-29) which was on par with *Eria fragrans* (VKA/NOR-25) (Fig. 15).

Monopodial orchids produce aerial roots, they are normally thick and strong with super absorption capabilities (Biswas and Singh, 2019). All the monopodial orchids were on par with respect to number of aerial roots produced by them (Fig. 14). In sympodial orchids, the roots are restricted to the rhizomatous part of the plant and they are seen just below the shoots (Rasmussen, 1986). Among the sympodial accessions evaluated, maximum number of roots was recorded in *Dendrobium crumenatum* (VKA/NOR-34) and minimum was recorded in *Cymbidium ensifolium* (VKA/NOR-43) (Fig. 16). *Dendrobium crumenatum* (VKA/NOR-34) has a greater number of pseudobulbs and maximum number of roots per pseudobulb, and that might be the reason for a higher number of roots in the plant.

5.2.2 Qualitative vegetative characters

The qualitative vegetative characters of native orchid accessions showed wide diversity both in monopodial as well as sympodial orchids. Qualitative vegetative characters such as leaf shape, leaf texture, leaf colour, leaf arrangement, leaf orientation, root colour and root branching were observed.

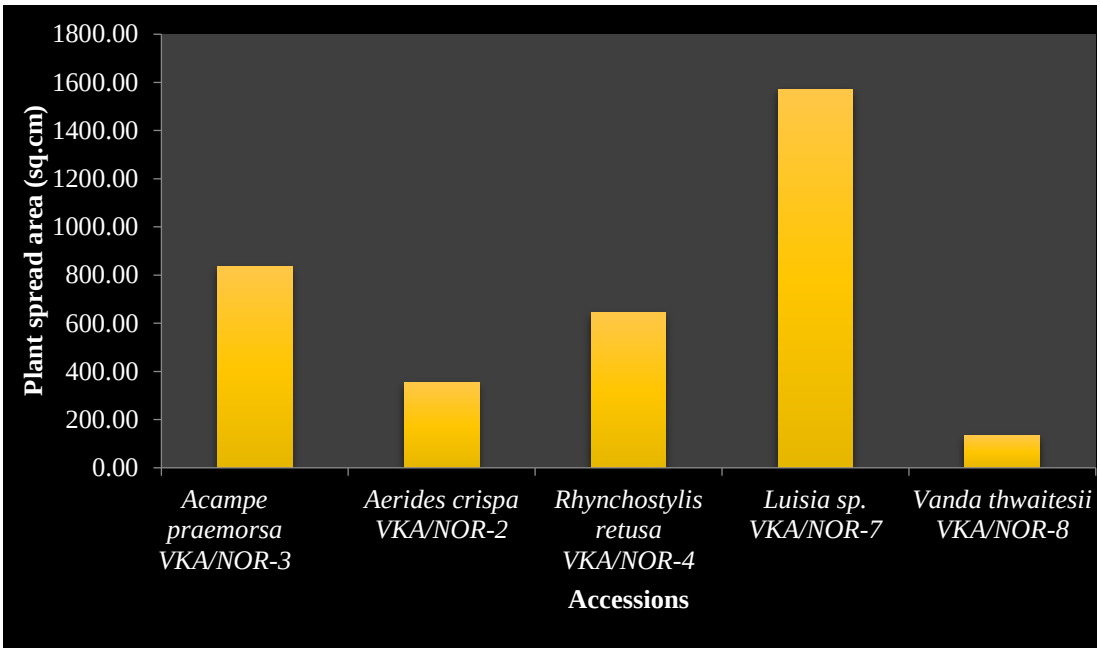


Fig. 5. Variation in plant spread area among monopodial orchid accessions

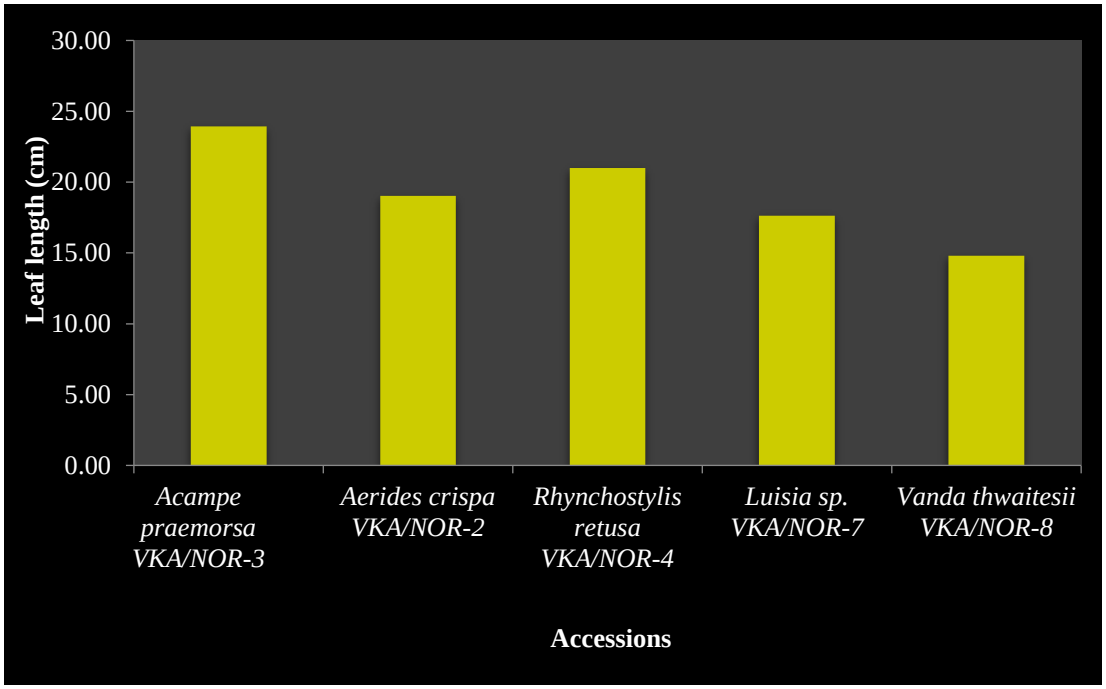


Fig. 6. Variation in leaf length among monopodial orchid accessions

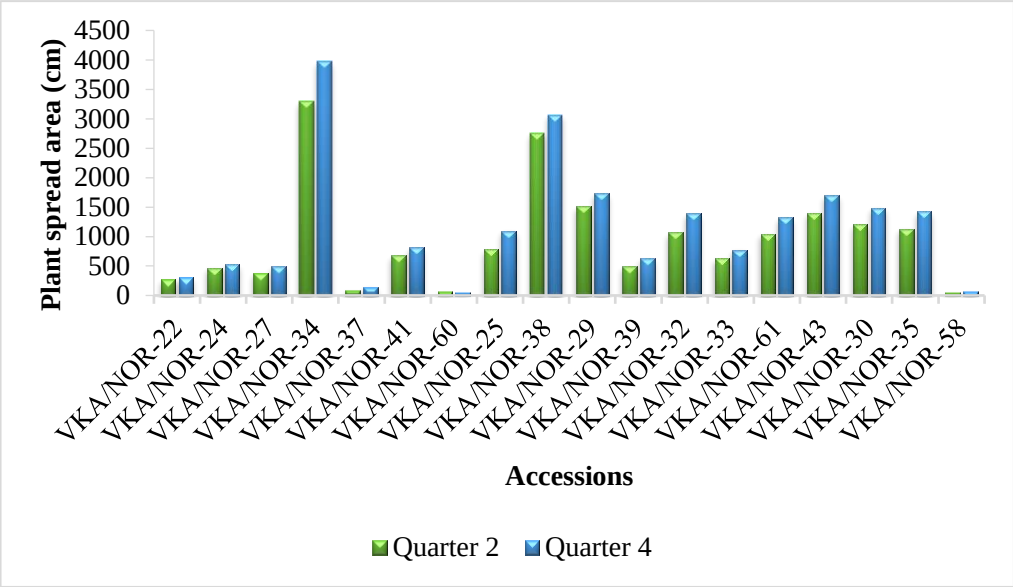


Fig. 7. Variation in plant spread area among sympodial orchid accessions at quarterly interval

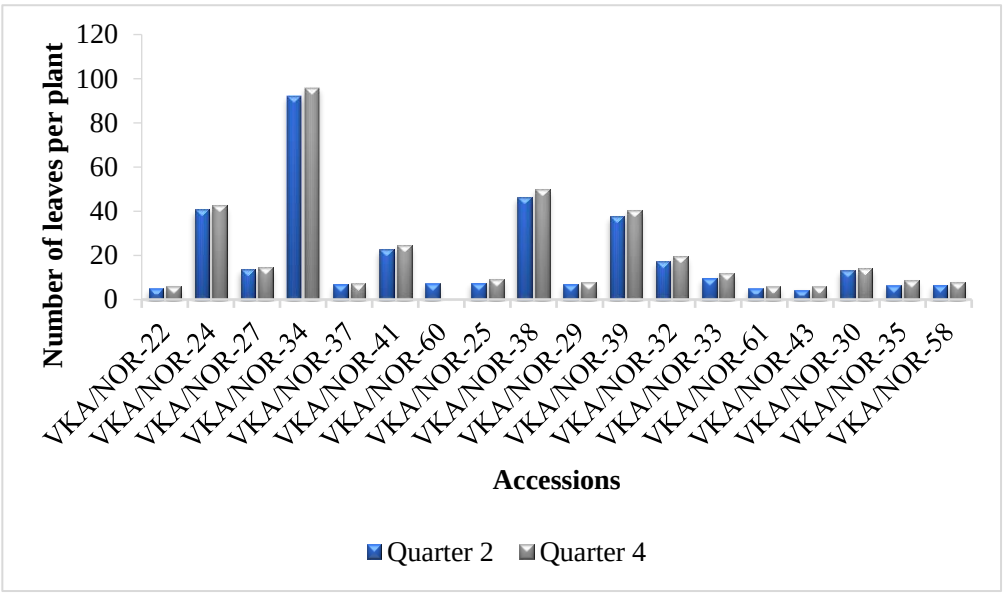


Fig. 8. Variation in number of leaves per plant among sympodial orchid accessions at quarterly interval

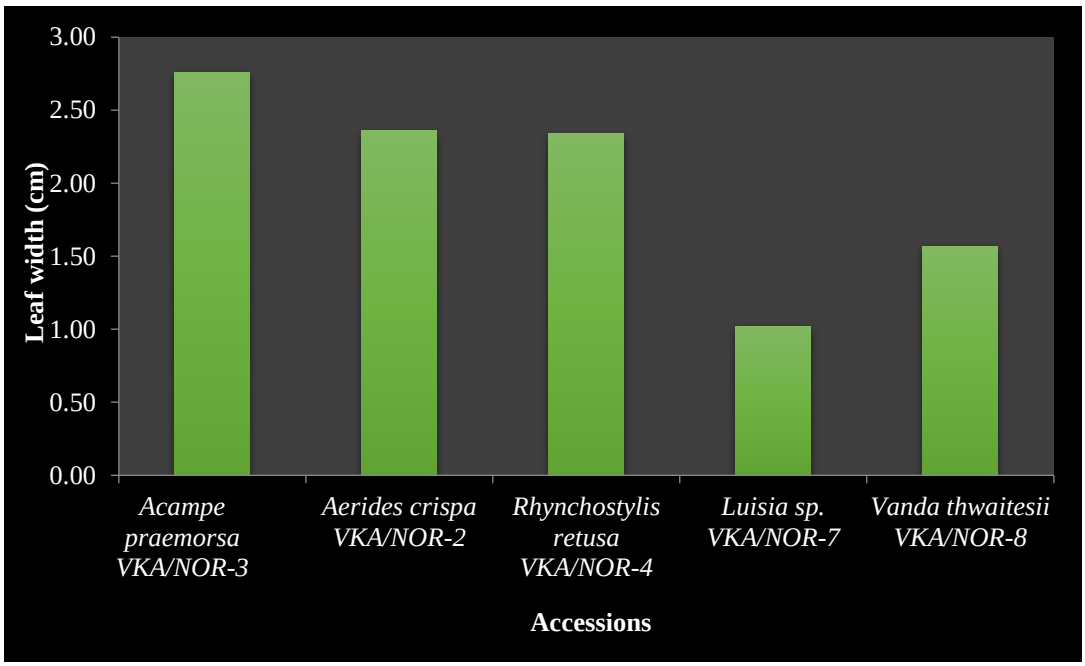


Fig. 9. Variation in leaf width among monopodial orchid accessions

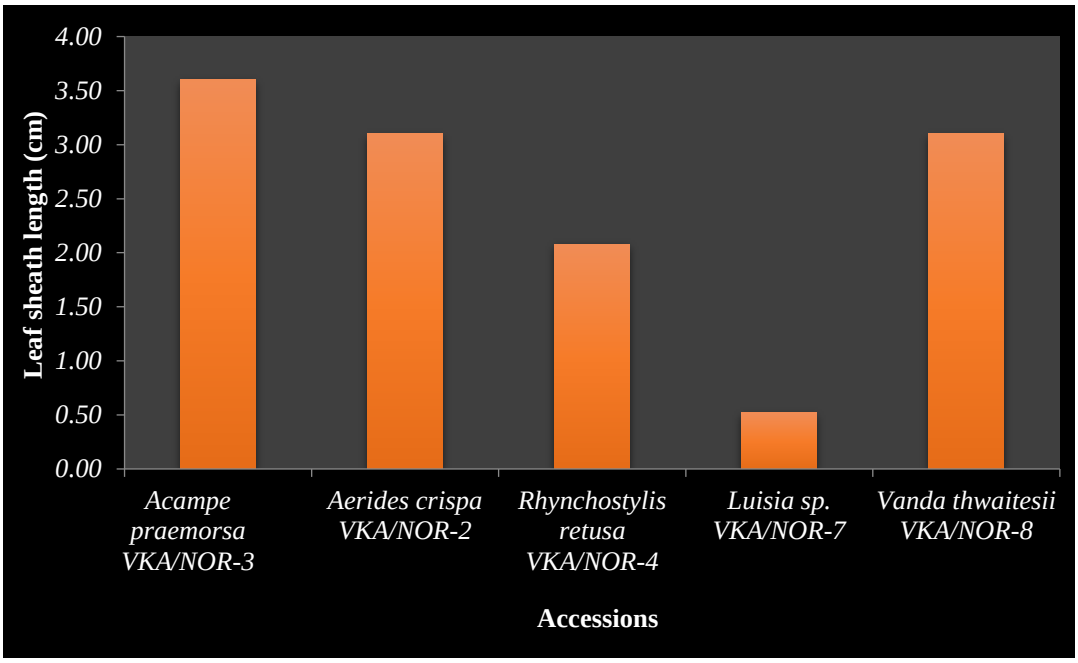


Fig. 10. Variation in leaf sheath length among monopodial orchid accessions

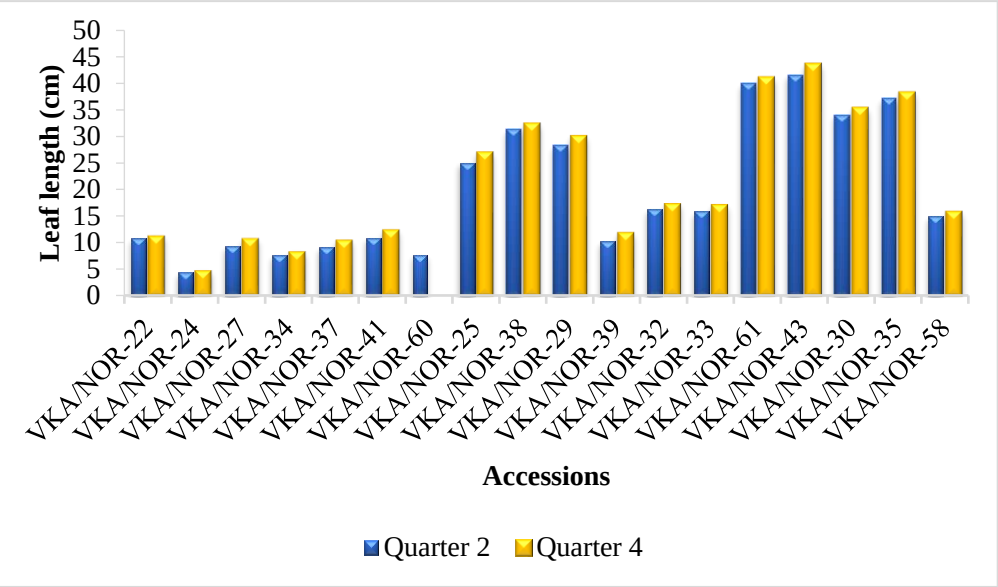


Fig. 11. Variation in leaf length among sympodial orchid accessions at quarterly interval

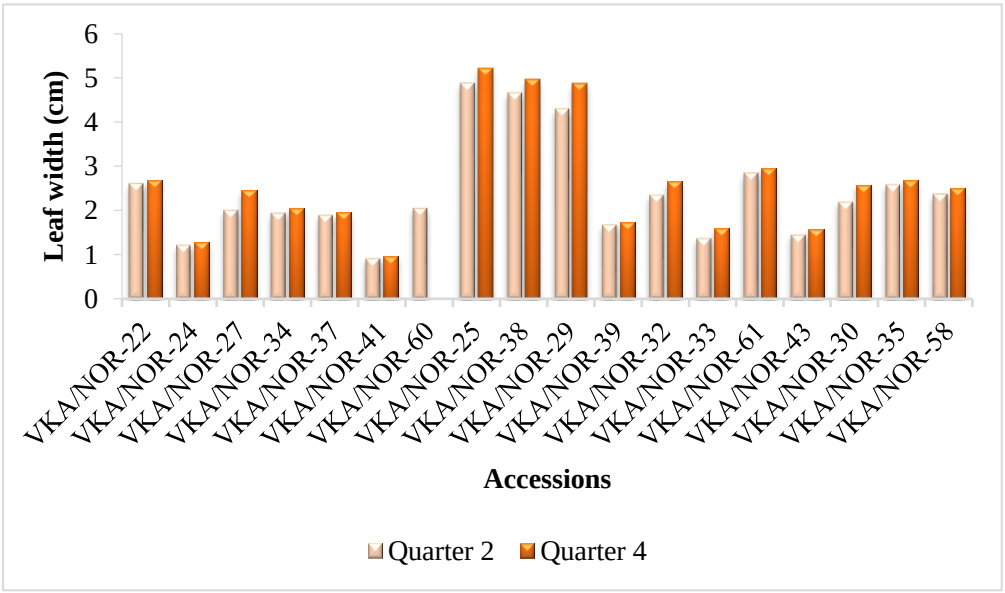


Fig. 12. Variation in leaf width among sympodial orchid accessions at quarterly interval

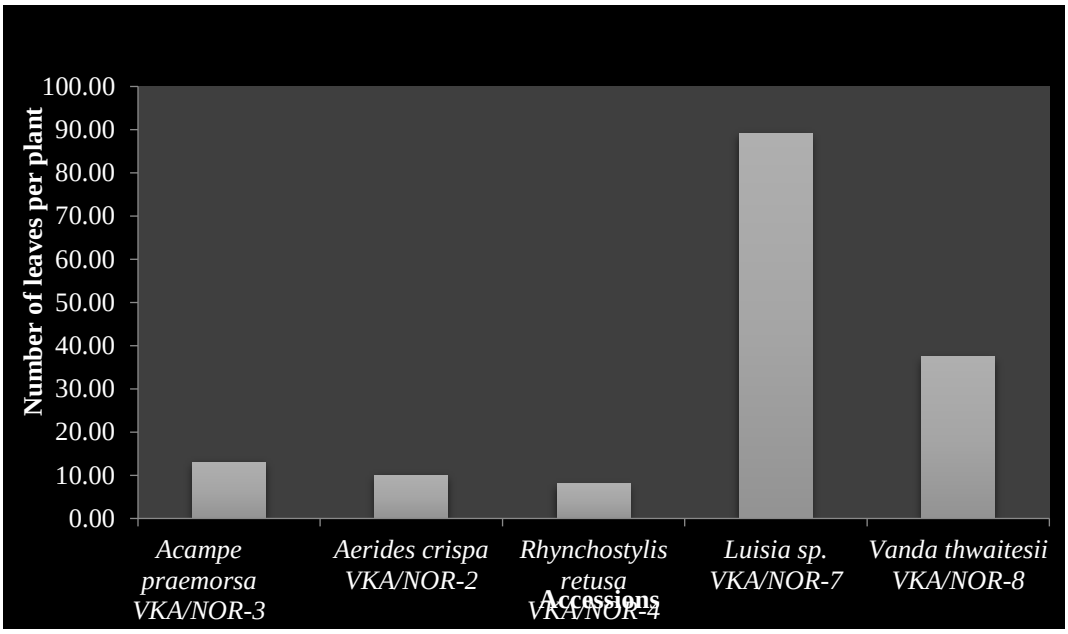


Fig. 13. Variation in number of leaves per plant among monopodial orchid accessions

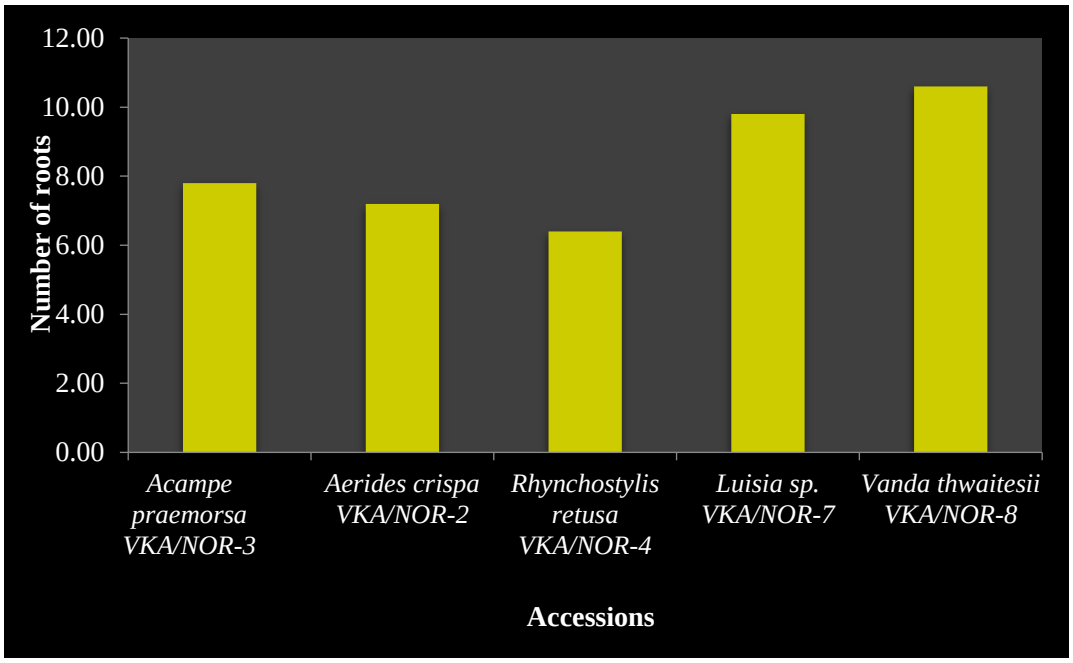


Fig. 14. Variation in number of roots among monopodial orchid accessions

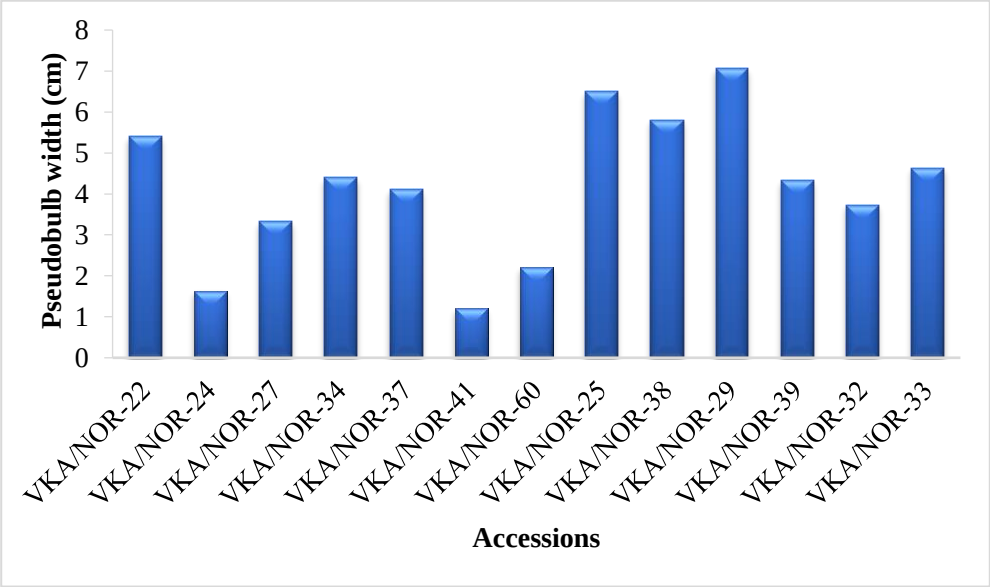


Fig. 15. Variation in pseudobulb width (girth) among sympodial orchid accessions

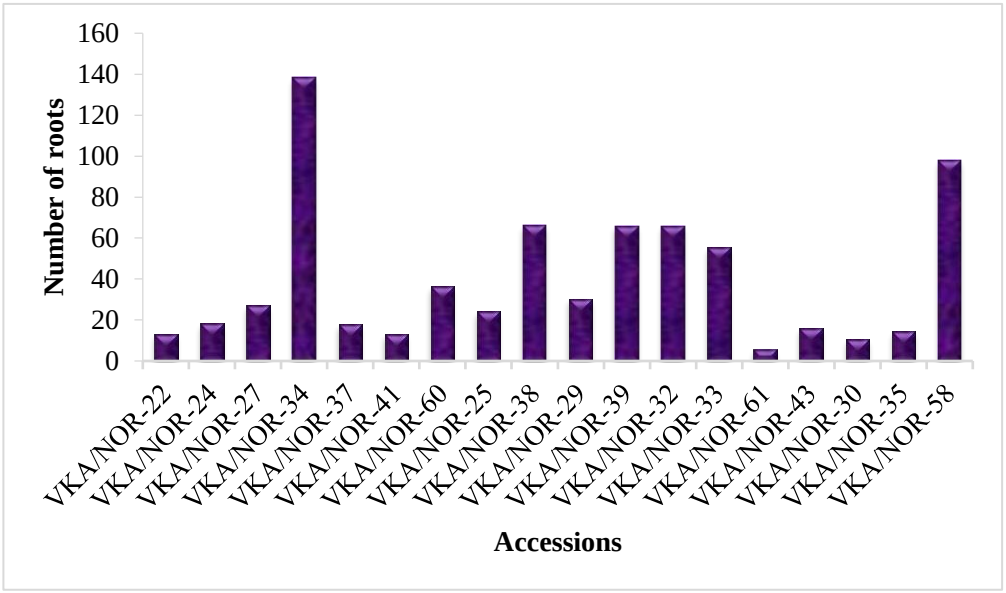


Fig. 16. Variation in number of roots among sympodial orchid accessions

Among the 23 accessions, 39 percentage of the accessions was found to have lanceolate leaves (Fig. 17). Lanceolate leaf shape was observed among sympodial accessions. Among monopodial accessions, except *Luisia* sp. (VKA/NOR-7) and *Vanda thwaitesii* (VKA/NOR-8) all other monopodials were having strap shaped leaves. The leaves of *Luisia* sp. (VKA/NOR-7) were terete and that of *Vanda thwaitesii* (VKA/NOR-8) were channelled. Similar variation in leaf shape was also reported by Akshata *et al*. (2018) while evaluating wild orchids of Western Ghats.

The different leaf texture of the native orchid accessions observed were smooth, rigid, fleshy and leathery. Among them, 52 percentage plants were found to have smooth leaf texture, and it was sympodial accessions showing smooth textured leaves (Fig. 18). All the monopodial accessions were found to have smooth and rigid textured leaves.

In the present study, the different leaf arrangement observed among the accessions are alternate distichous, alternate spiral, clustered basal, alternate equitant and on apex of pseudobulb. Forty eight percentage of the native orchid accessions were showing alternate distichous leaf arrangement (Fig. 19). Moniruzzaman and Ara (2012) also reported opposite leaf arrangement among the twenty native *Dendrobium* orchids evaluated for physio morphological and yield performance. Bulbous sympodials like *Eria* species (VKA/NOR-25 and VKA/NOR-39), *Flickingeria* sp. (VKA/NOR-32) and *Coelogyne breviscapa* (VKA/NOR-33), were found to have the leaves arranged on the apex of pseudobulb.

All the *Cymbidium* accessions (VKA/NOR-61, VKA/NOR-43, VKA/NOR-30, VKA/NOR-35) evaluated were observed to have leaves arranged as basal cluster. Correll (1950) also explained similar type leaf arrangement in the genera *Habenaria* and *Spiranthes* among the native orchids of North America. *Oberonia* sp. (VKA/NOR-58) had leaf arrangement of alternate equitant type. This type of leaf arrangement was also observed by Chen *et al*. (2009) while describing the characteristics of genus *Oberonia.*

Among the native orchid accessions, arching, straight, horizontal, erect and semi erect leaf orientation were observed with a high (31%) percentage relative

frequency for semi erect type (Fig. 20). Leaves of all the native orchid accessions were green in colour. While root colour varied from white to brown shades. Most of the accessions were having white coloured roots (39 %) (Fig. 21), and it was seen in sympodial accessions. Eighty seven percentage of the native orchids showed branching of roots (Fig. 22) and 13 percentage showed no branching of roots.

5.3 FLORAL CHARACTERS

5.3.1 Quantitative floral characters

The floral characters of orchids exhibit wide diversity in size, shape, form and colouration (Dressler, 1993). They have three sepals, three petals arranged in a whorl shape, and a reproductive structure called 'column' (Biswas and Singh, 2019). The lip (labellum) is the modified petal, which is the showy part of an orchid flower. A wide range of variation could be observed with respect to the floral characters recorded among nine native orchid accessions bloomed. Regarding the flowering habit, *Dendrobium crumenatum* (VKA/NOR-34) was having three flowering seasons as well as highest frequency of flowering (Fig. 23).

Wang *et al*. (2019) stated that, in some orchids the flowering is influenced by change in ambient temperature. It was found that *Dendrobium crumenatum* (VKA/NOR-34) showed blooming when it acquired lower temperature in the atmosphere resulted after a rain.

Among the accessions, the number of spikes per plant produced was highest in *Dendrobium crumenatum* (VKA/NOR-34) (Fig. 24) and number of florets per spike was maximum in *Rhynchostylis retusa* (VKA/NOR-4) followed by *Pholidota imbricata* (VKA/NOR-29) (Fig. 25). On the spikes, the flower bud initiation takes place only when spike attained an appropriate length (Lee and Lin, 1984).

The number of flowers per inflorescence is an important character in orchid breeding (Connel and Kamemoto,1983; Donald,1991). More number of florets gives beautiful appearance to the plant. Spike length of orchids are important while selecting orchids as cut flowers. The results found that *Pholidota imbricata* (VKA/NOR-29) had

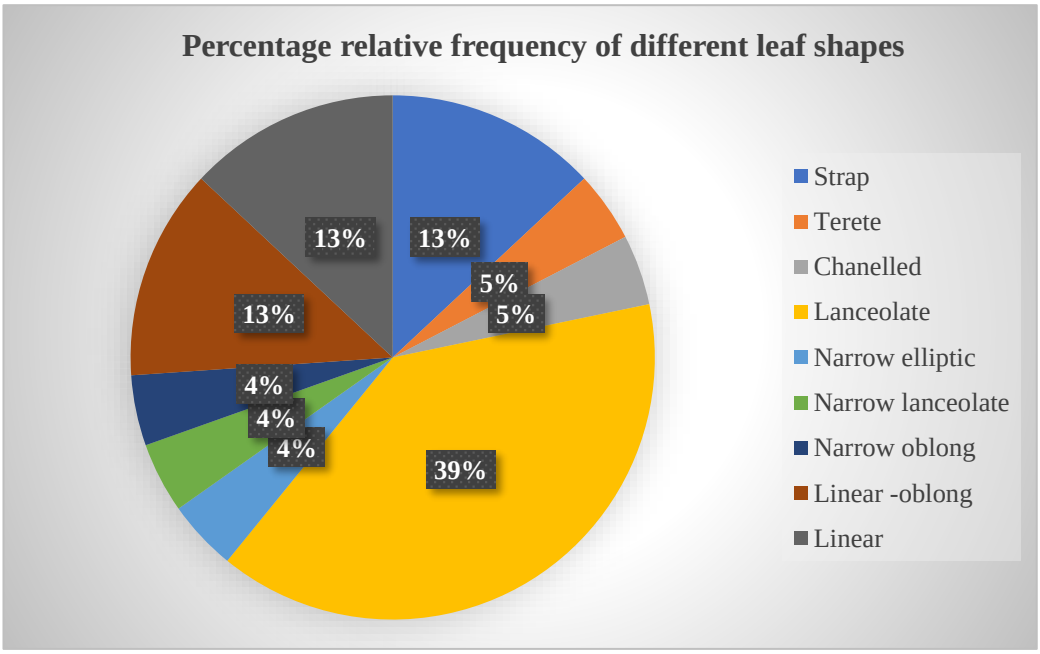


Fig. 17. Percentage relative frequency of different leaf shapes

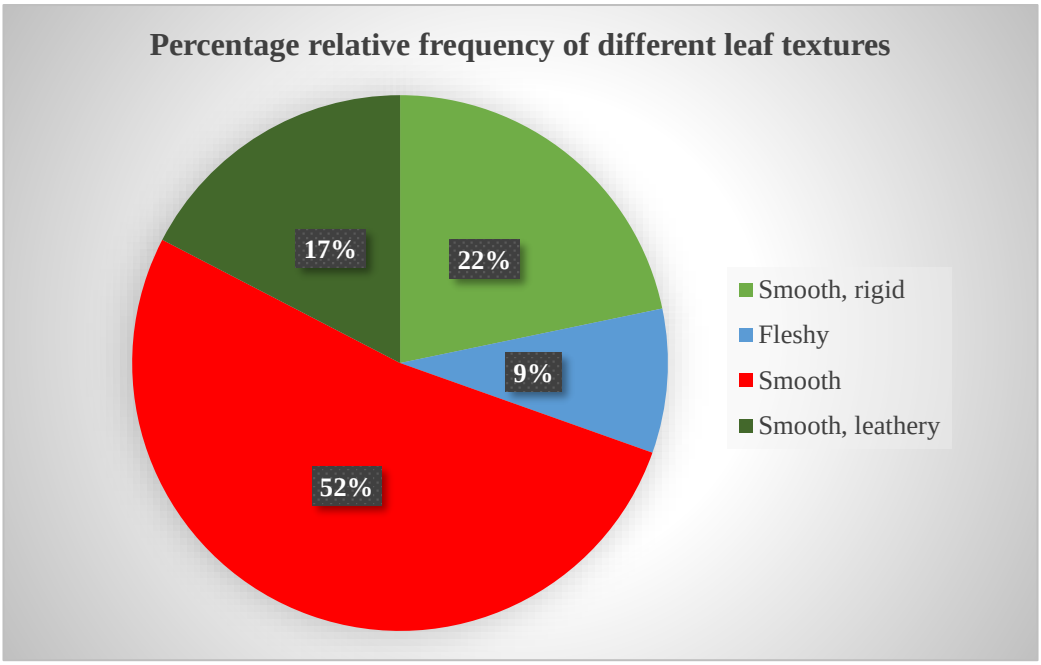


Fig. 18. Percentage relative frequency of different leaf textures

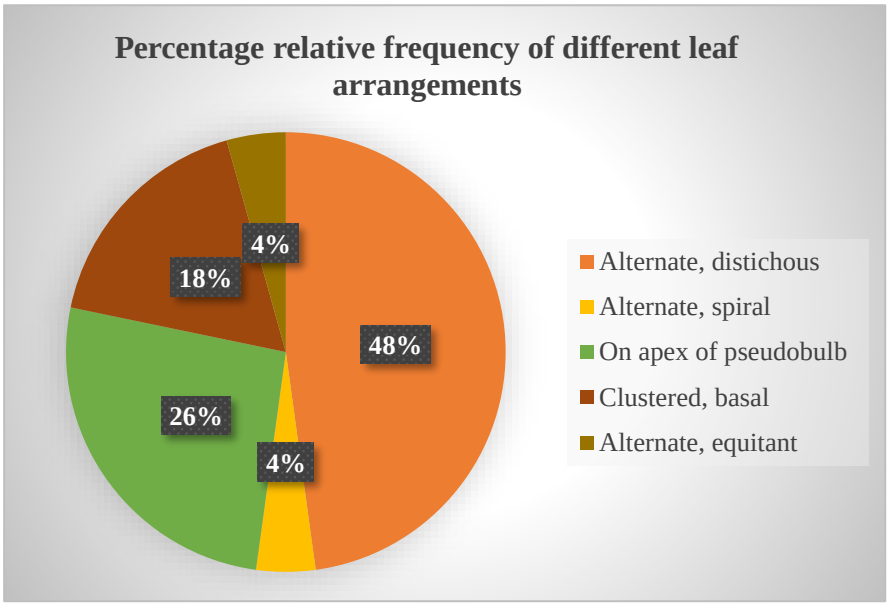


Fig. 19. Percentage relative frequency of different leaf arrangements

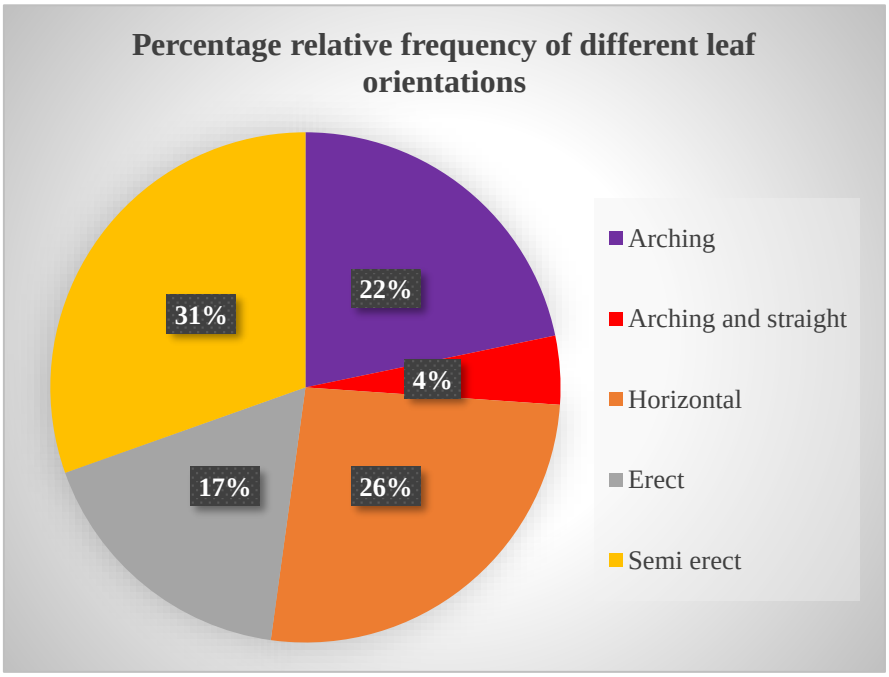


Fig. 20. Percentage relative frequency of different leaf orientations

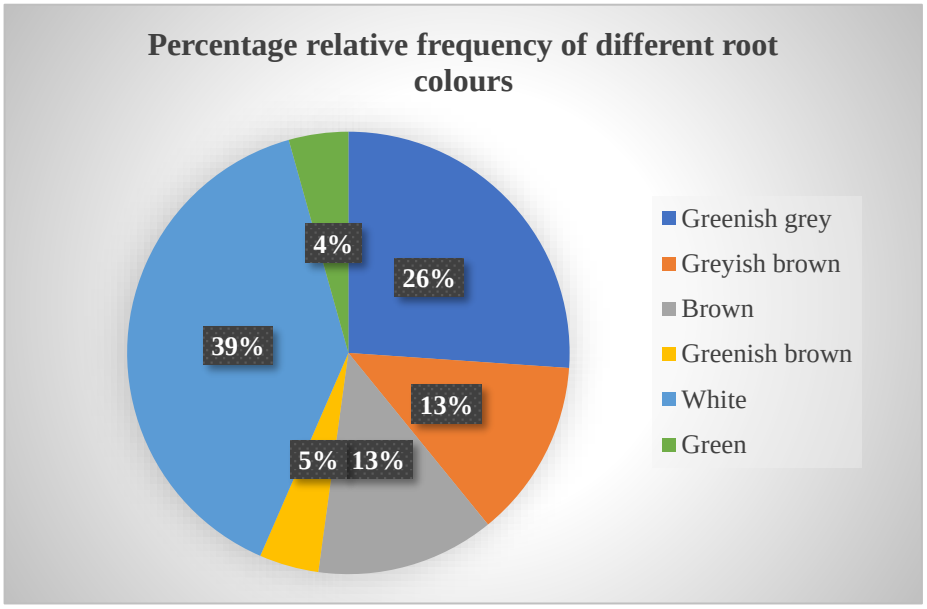


Fig. 21. Percentage relative frequency of different root colours

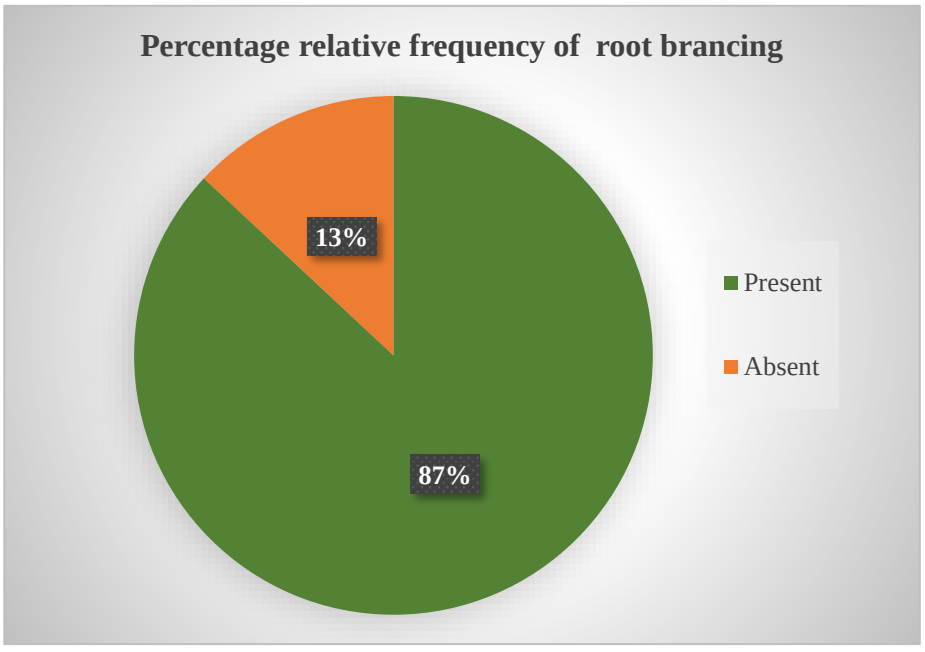


Fig. 22. Percentage relative frequency of root branching

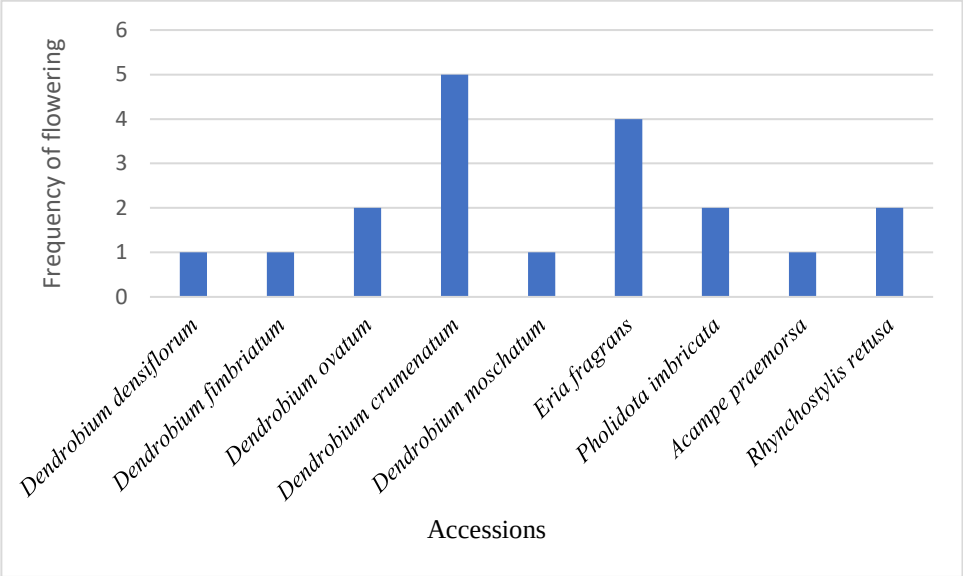


Fig. 23. Variation in frequency of flowering among native orchid accessions

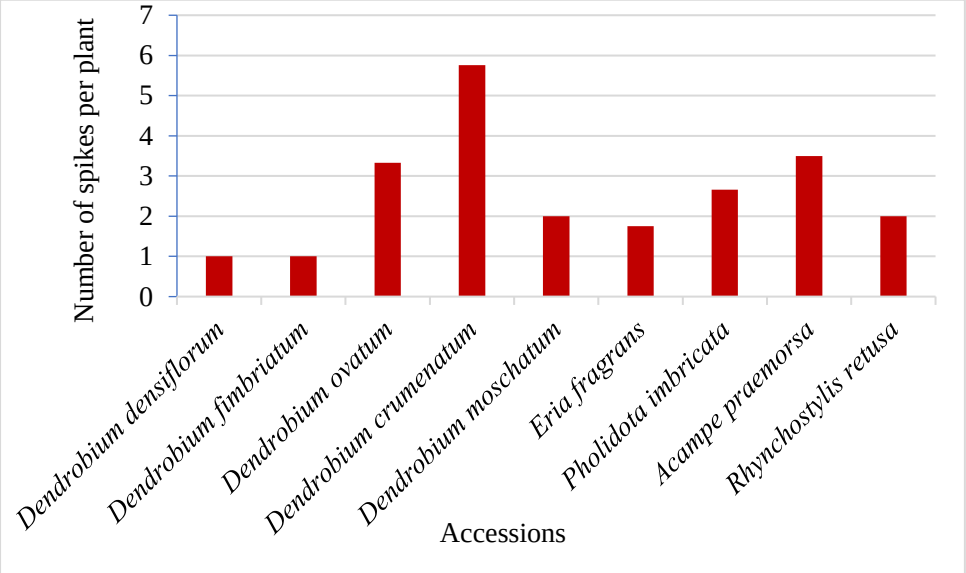


Fig. 24. Variation in number of spikes per plant among native orchid accessions

maximum spike length and rachis length (Fig. 26 and 27). Rachis length indicates the area on the spike bearing the florets.

Girth of spike at base indicates the ability of spike to hold the florets. It is also considered for selecting cut flower types. The spike with good girth will be more sturdier. It was found that *Dendrobium densiflorum* (VKA/NOR-22) and *Rhynchostylis retusa* (VKA/NOR-4) are having maximum girth of spike at the base (Fig. 28). Among the accessions, stalk length of individual florets was found maximum in *Dendrobium densiflorum* (VKA/NOR-22) and minimum in *Pholidota imbricata* (VKA/NOR-29).

Quantitative parameters such as petal length, petal width, petal to petal distance, length and width of dorsal sepal and lateral sepal, sepal to sepal distance, dorsal sepal to lip distance, lip length, lip width *etc.* influences ornamental value of a flower. *Dendrobium moschatum* (VKA/NOR-37) has recorded the maximum flower size and highest petal length, petal width, petal to petal distance, length of dorsal sepal, width of dorsal sepal, and length and width of lateral sepal.

Lip or labellum is the most showy and attractive part of orchid flower. The present study has investigated maximum lip length for *Dendrobium crumenatum* (VKA/NOR-34) and lip width for *Dendrobium moschatum* (VKA/NOR-37). Column length and width are important in hybridisation programmes for considering effective pollination. Among the accessions, *Dendrobium crumenatum* (VKA/NOR-34) recorded the longest column and *Dendrobium moschatum* (VKA/NOR-37) recorded the widest column.

Spike longevity is a parameter mainly used for selecting as cut flower type or as pot plant type in orchids with respect to ornamental value. The postharvest longevity of spikes is considered for selecting as cut flower, while the longevity of spikes on the plant itself is counted for selecting as pot plant. In the present study, *Dendrobium ovatum* (VKA/NOR-60) recorded highest longevity of spike on plant and *Acampe praemorsa* (VKA/NOR-3) recorded highest longevity of florets on spike (Fig. 29). The florets of *Acampe praemorsa* (VKA/NOR-3) was rigid and thick compared to florets of all other accessions, and that might be the reason for highest longevity of florets in *Acampe.*

Pollen grains are important in fertilization. Hence the assessment of pollen viability is also important for conducting artificial pollination in breeding experiments (Stone *et al*., 1995). In many of the orchids the pollen grains are seen in tertad form (Shukla *et al*., 1998). The microscopic observation of pollen grains under the present study also found out similar finding.

Bellusci *et al*. (2010) stated that orchid species are one of the plant group among angiosperms with long term pollen viability. Pollen viability testing among the accessions showed above 90 percentage pollen viability for all the native orchid accessions flowered (Fig. 30). Among them maximum pollen viability was observed for *Rhynchostylis retusa* (VKA/NOR-4).

5.3.2 Qualitative floral characters

A wide range of variations could be observed in qualitative floral characteristics. Among the accessions different spike orientations such as pendulous, erect, drooping and erect to arched type were observed. Among them 34 percentage of the accession showed pendulous type and 33 percentage of the accession showed erect to arching type of inflorescence (Fig. 31). Thomas and Rani (2008) also reported erect and arching type inflorescence stalk while evaluating monopodial orchids. Erect type spikes are suitable for cut flower purpose. Amin *et al*. (2004) found that drooping type of inflorescence as in *Rhynchostylis retusa* is not suitable as cut flower, while according to De and Medhi (2015), *Rhynchostylis* plants are more suited for basket culture.

Petal curvature of the accessions showed wide variation. Forty five percentage of the accessions were having incurved petals with straight apex and 22 percentage was having deflexed curvature (Fig. 32). The present study has also investigated differences in petal shapes such as sub orbicular, elliptic, ovate, lanceolate, oblong and ovate lanceolate among the accessions. Among them 34 percentage accessions were having ovate petal shape and 22 percentage were having elliptic petal shape (Fig. 33).

Flower fragrance is another attractive feature of flowers. It was present in 56 percentage of the accessions among the nine native orchids flowered (Fig. 34). Baudino *et al*. (2007) stated that petals are the main sites of the plants, which produces natural

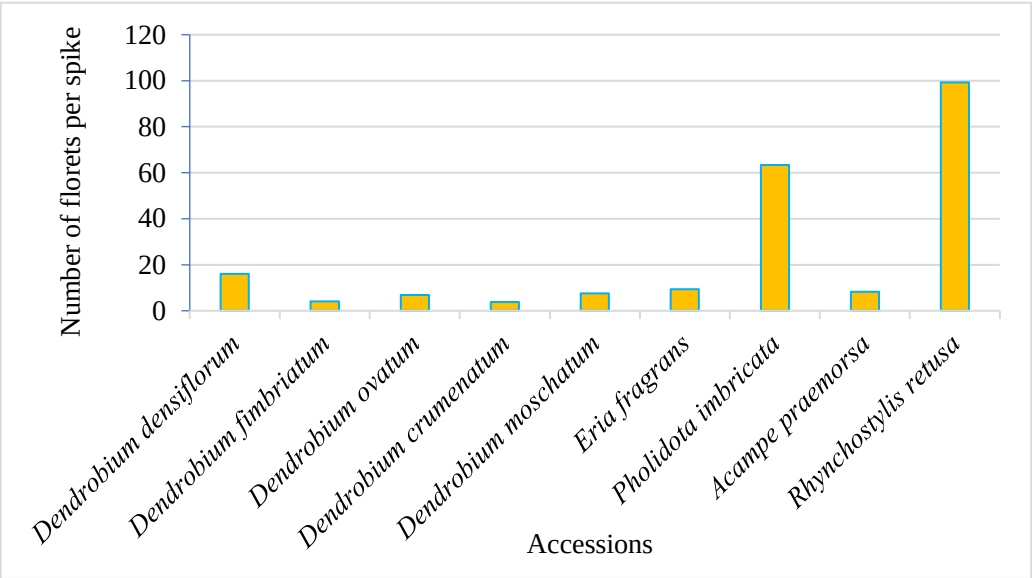


Fig. 25. Variation in number of florets per spike among native orchid accessions

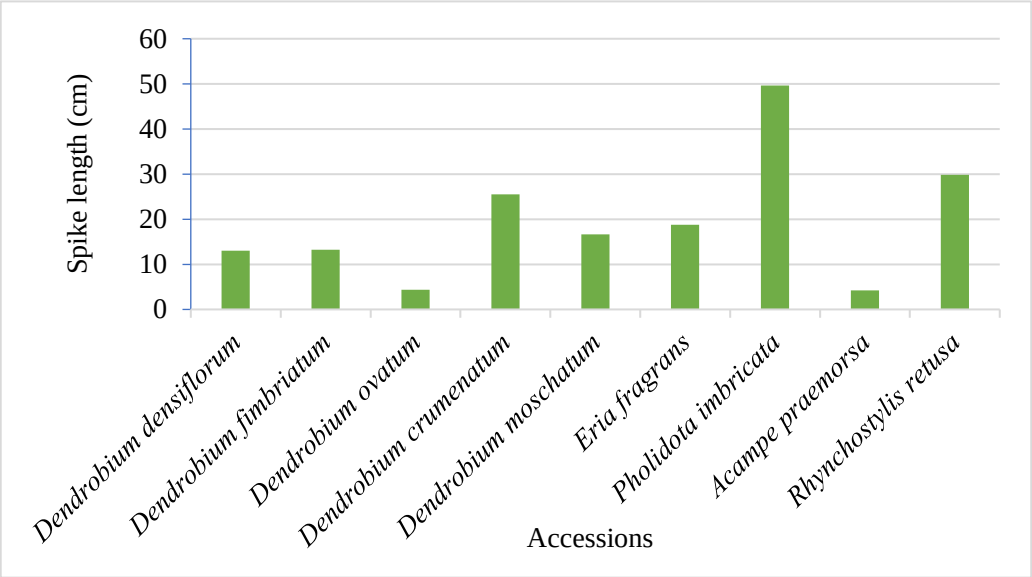


Fig. 26. Variation in spike length among native orchid accessions (cm)

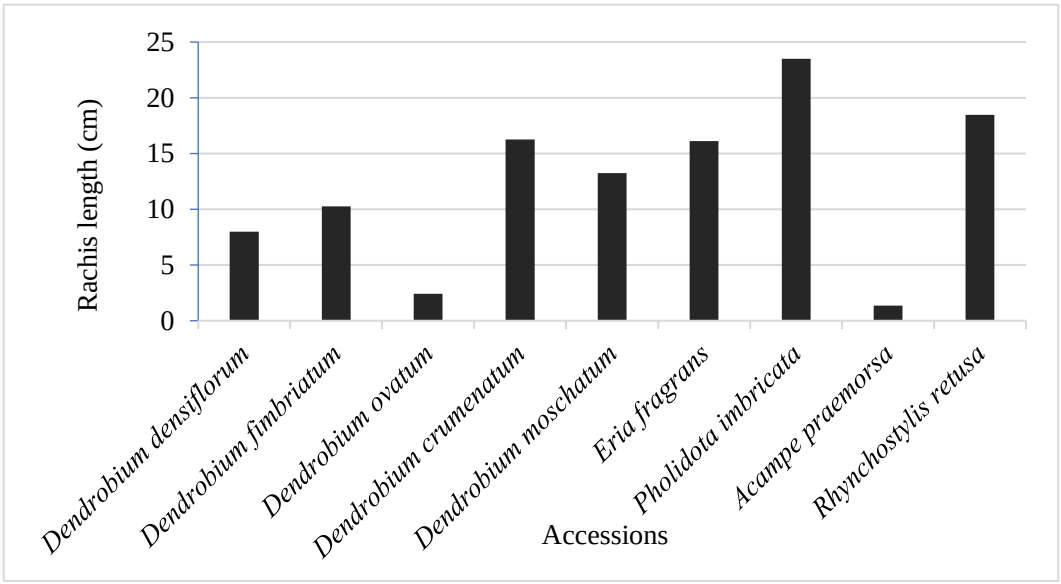


Fig. 27. Variation in rachis length among native orchid accessions (cm)

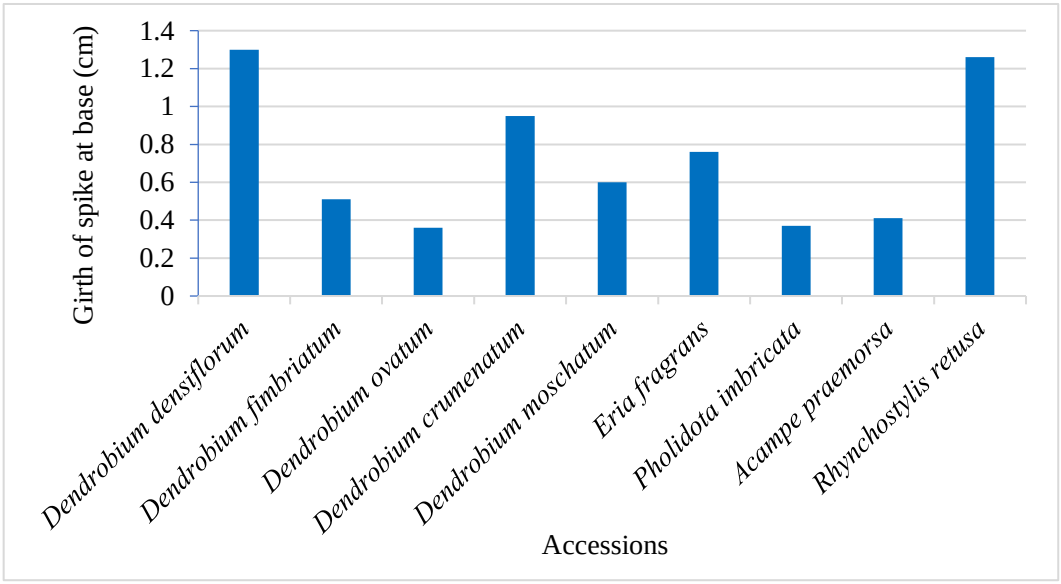


Fig. 28. Variation in girth of spike at base among native orchid accessions (cm)

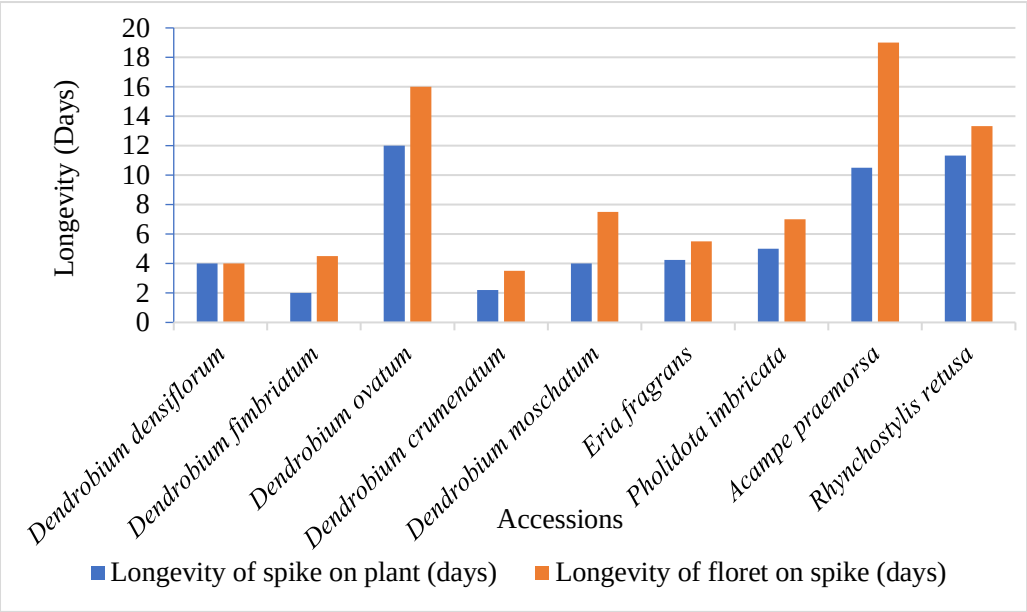


Fig. 29. Variation in longevity of spike on plant and floret on spike among native orchid accessions (days)

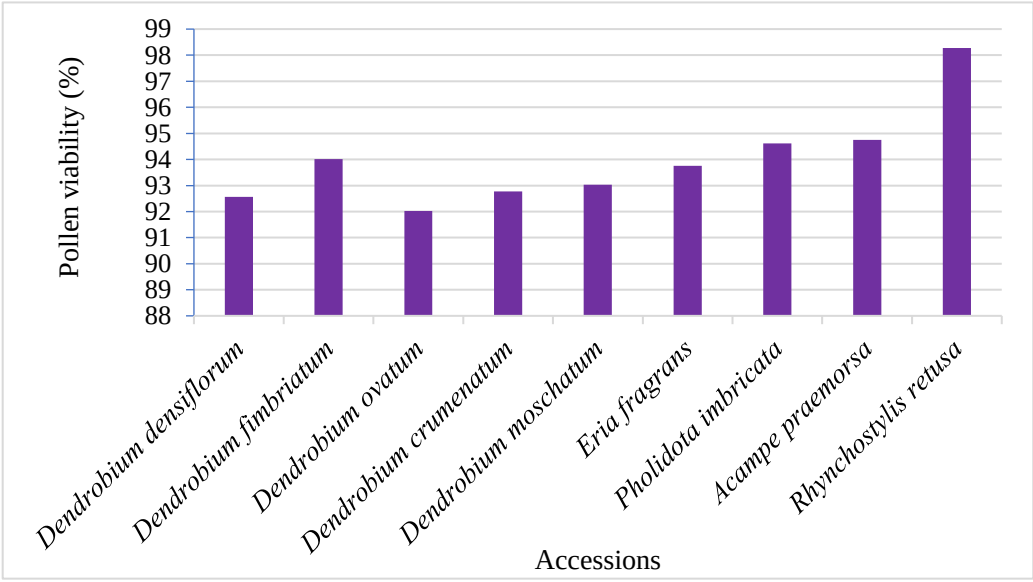


Fig. 30. Variation in pollen viability among native orchid accessions (%)

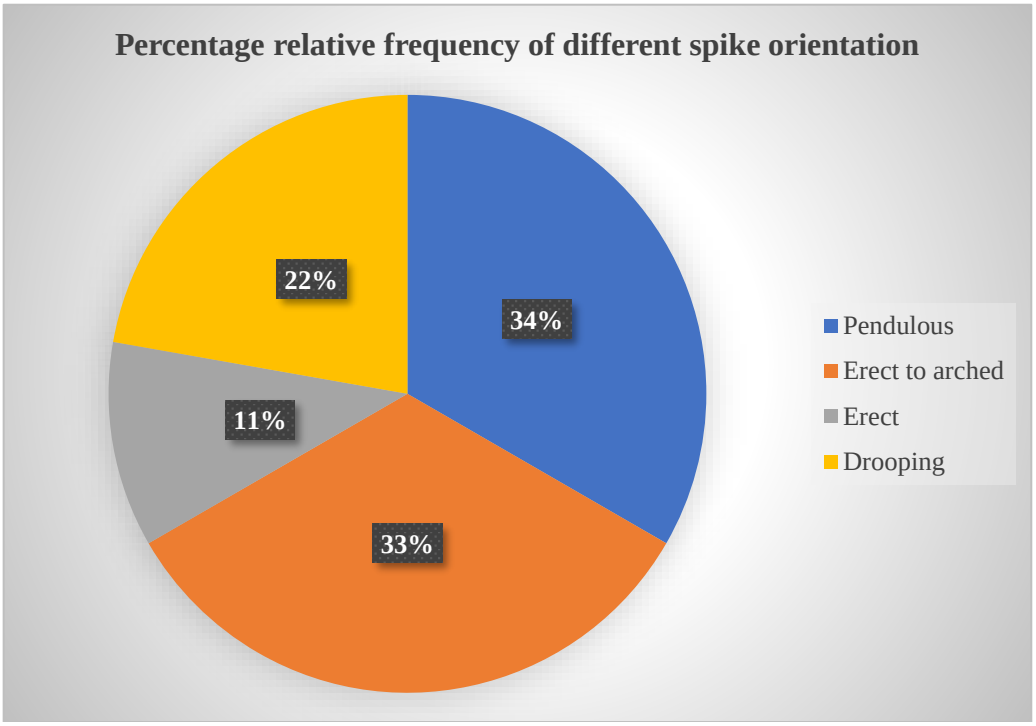


Fig. 31. Percentage relative frequency of different spike orientation of orchid accessions

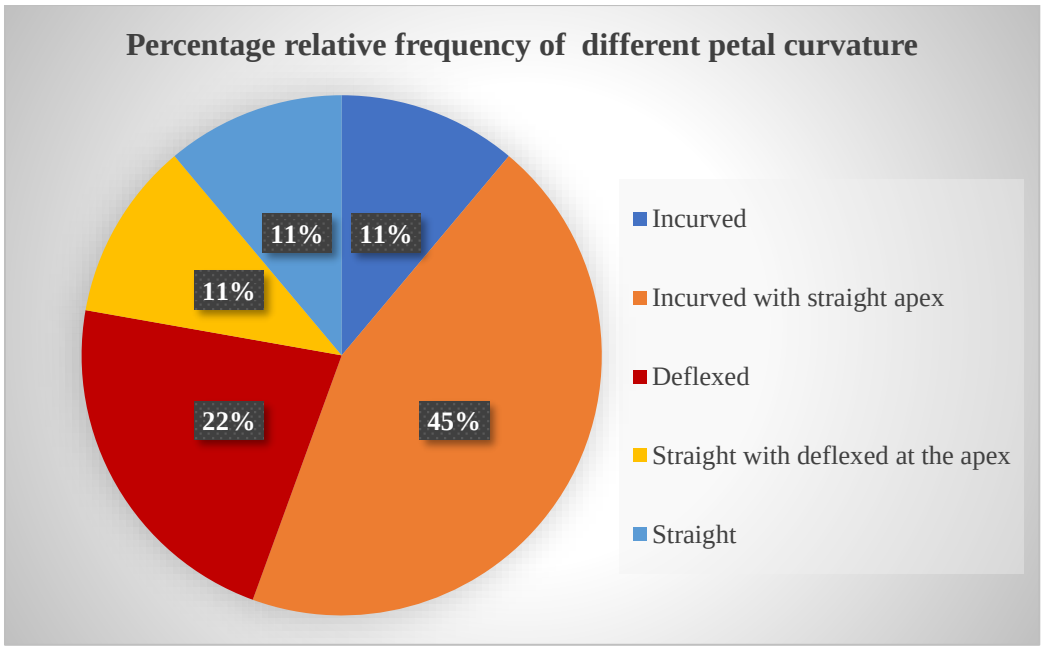


Fig. 32. Percentage relative frequency of different petal curvature of orchid accessions

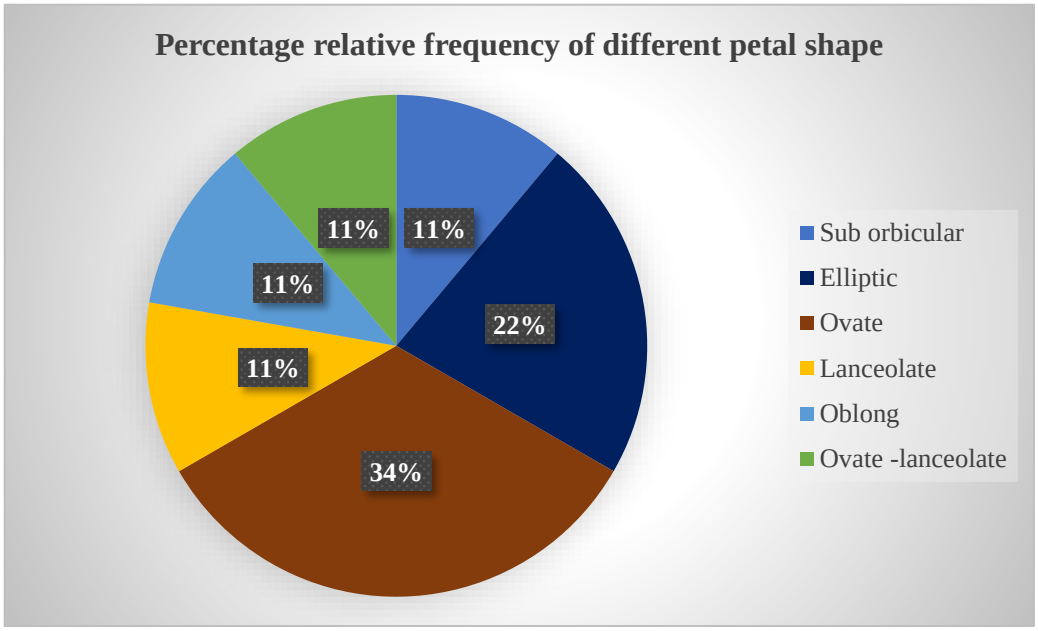


Fig. 33. Percentage relative frequency of different petal shape of orchid accessions

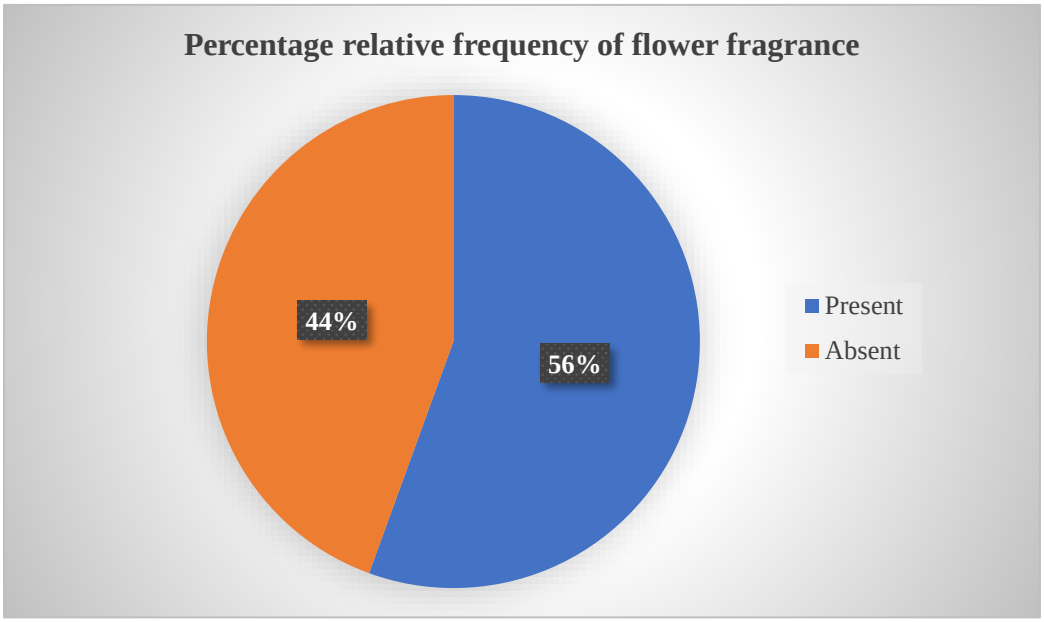


Fig. 34. Percentage relative frequency of flower fragrance of orchid accessions

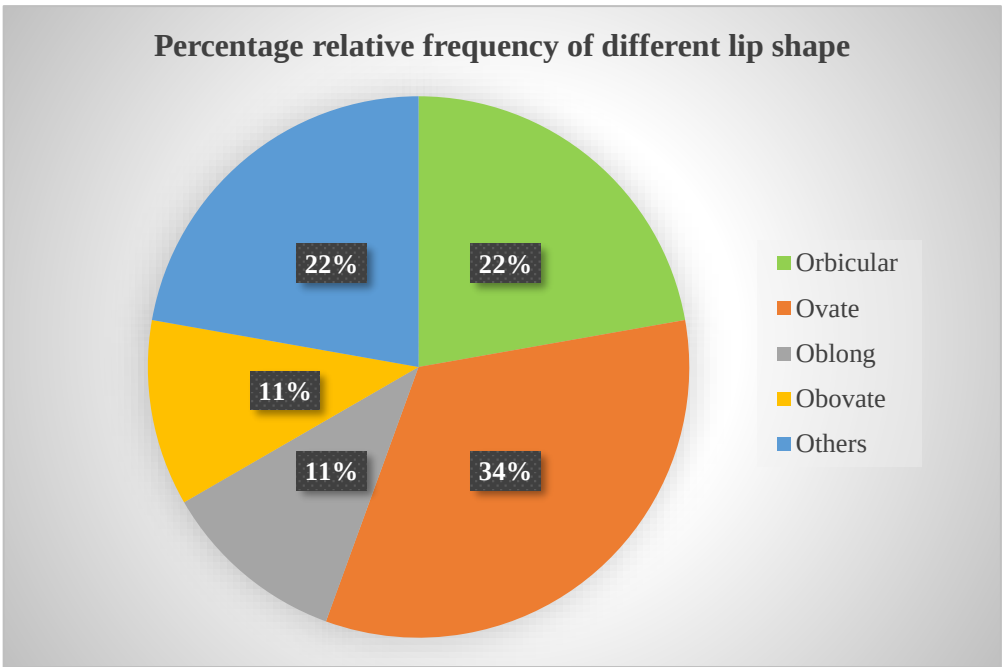


Fig. 35. Percentage relative frequency of different lip shape of orchid accessions

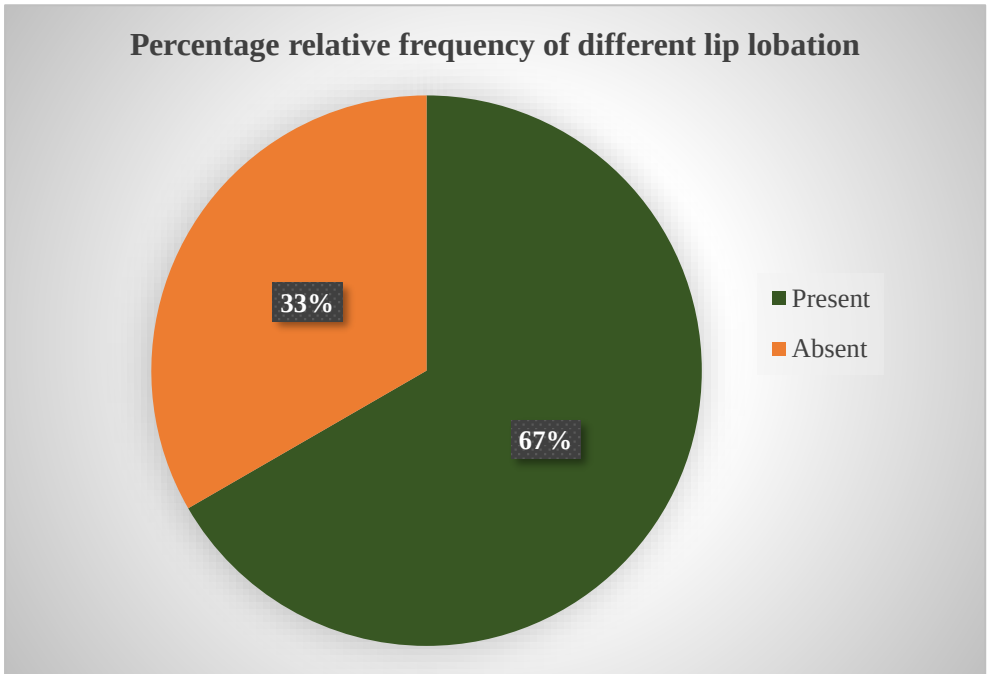


Fig. 36. Percentage relative frequency of different lip lobation of orchid accessions

fragrance. Among the accessions, flower fragrance was noted for the accessions like *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Acampe praemorsa* (VKA/NOR-3), *Rhynchostylis retusa* (VKA/NOR-4) and *Eria fragrans* (VKA/NOR-25). Among them *Dendrobium crumenatum* (VKA/NOR-34) was strongly fragrant compared to all other accessions.

Peculiar shape of floral parts especially lip (Labellum) is more important in commercial point of view. A wide diversity existed in qualitative lip characters. Orbicular, ovate, oblong, obovate were the lip shapes observed among the accessions (Fig. 35). Unique type of lip shape was exhibited by *Dendrobium moschatum* (VKA/NOR-37) and *Pholidota imbricata* (VKA/NOR-29). It was hemispherical, open mouthed pouch in *Dendrobium moschatum* (VKA/NOR-37) and sac like in *Pholidota imbricata* (VKA/NOR-29). Chen and Wood (2009) also stated sac like (saccate) lip condition in *Pholidota imbricata* while explaining floral characters of twelve *Pholidota* species. In *Dendrobium moschatum* the hemispherical, open mouthed pouch shaped lip condition was stated by Gogoi and Barah (2010) while explaining the characteristics of orchid species collected from Joypur Reserve Forest, Dibrugarh (Assam).

Presence of lobes on lip is also another feature observed on lip which contribute to the attractiveness of the floret. The lip can be with or without lobes. It was observed that 67 percentage of the native orchid accessions evaluated are having lip lobation (Fig. 36).

The colour of floral parts is one of the attractive features of the orchid flowers. Flower colour and colour pattern are one of the important plant characteristics used for development of varieties (Battacharjee and Das, 2008). Flowers can be single coloured or multi coloured with or without spots or streaks. Among the accessions, majority of them possess white colouration for sepal, petal, lip and column (Fig. 37-40). Single coloured sepal and petal colouration was observed in all accessions except *Acampe praemorsa* (VKA/NOR- 3) and *Rhynchostylis retusa* (VKA/NOR-4). In *Acampe praemorsa* (VKA/NOR- 3) dark red coloured transverse stripes were present on light

greenish yellow coloured sepals and petals, while in *Rhynchostylis retusa* (VKA/NOR-4) purple coloured spots were seen on the white coloured sepals and petals.

Double colouration on lip (labellum) was observed in *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium moschatum* (VKA/NOR-37), *Acampe praemorsa* (VKA/NOR- 3), *Rhynchostylis retusa* (VKA/NOR-4), *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium crumenatum* (VKA/NOR-34).

Regarding the column colour, *Eria fragrans* (VKA/NOR-25) was found to have a purple coloured thin marking on the column and *Rhynchostylis retusa* (VKA/NOR-4) was having small purple coloured spots on the column. All other accessions had only single colouration on the column.

With respect to markings present on lip, black tinge was present on *Dendrobium fimbriatum* (VKA/NOR-27), while two deep red coloured blotches were present on *Dendrobium moschatum* (VKA/NOR-37), narrow streaks of reddish purple colour on *Acampe praemorsa* (VKA/NOR- 3), strong purple colour towards lip apex in *Rhynchostylis retusa* (VKA/NOR-4), strong yellow green colour on *Dendrobium ovatum* (VKA/NOR-60) and purple marking at the edges of *Eria fragrans* (VKA/NOR-25).

5.4 CLUSTER ANALYSIS

Assessment of diversity is an essential component for germplasm conservation and characterization (Karp *et al*., 1997). Application of appropriate analysis technique is also significant in diversity assessment studies. Multivariate statistical algorithm is one of the important strategies in classification of germplasm and analysis of genetic relationships among plants (Mohammadi and Prasanna, 2003).

Awan *et al*. (2014) stated that Euclidean distance can be employed for cluster analysis of agromorphological traits to obtain the information regarding the similarity among genotypes.

Cluster analysis have used to assess the morphological diversity in flower crops such as Gladiolus (Patra and Mohanti, 2015), Chrysanthemum (Jaslam *et*

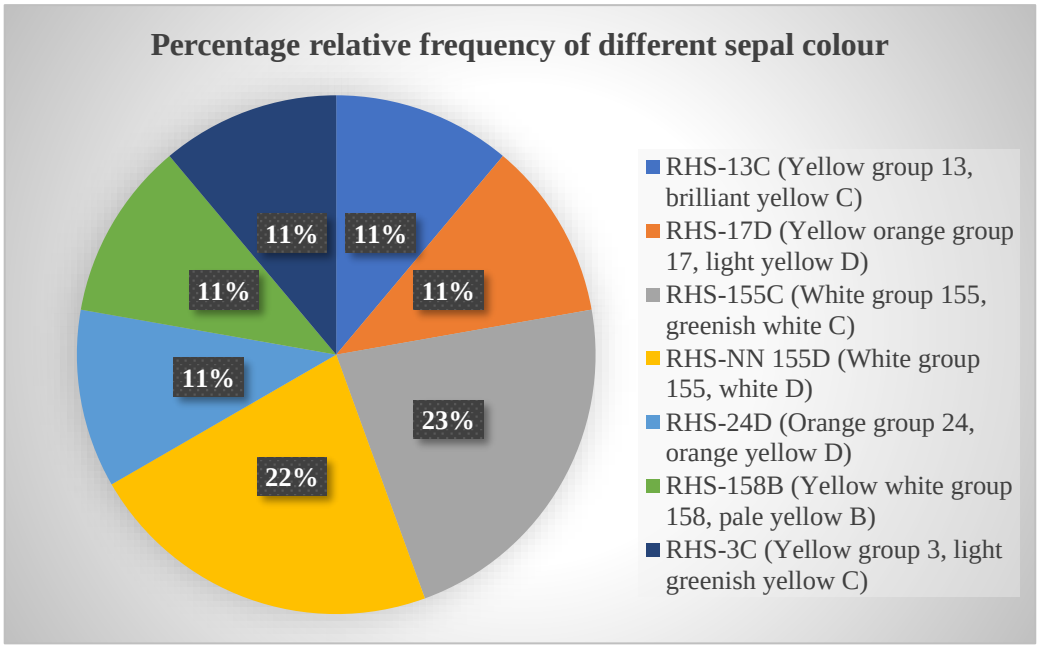


Fig. 37. Percentage relative frequency of different sepal colour

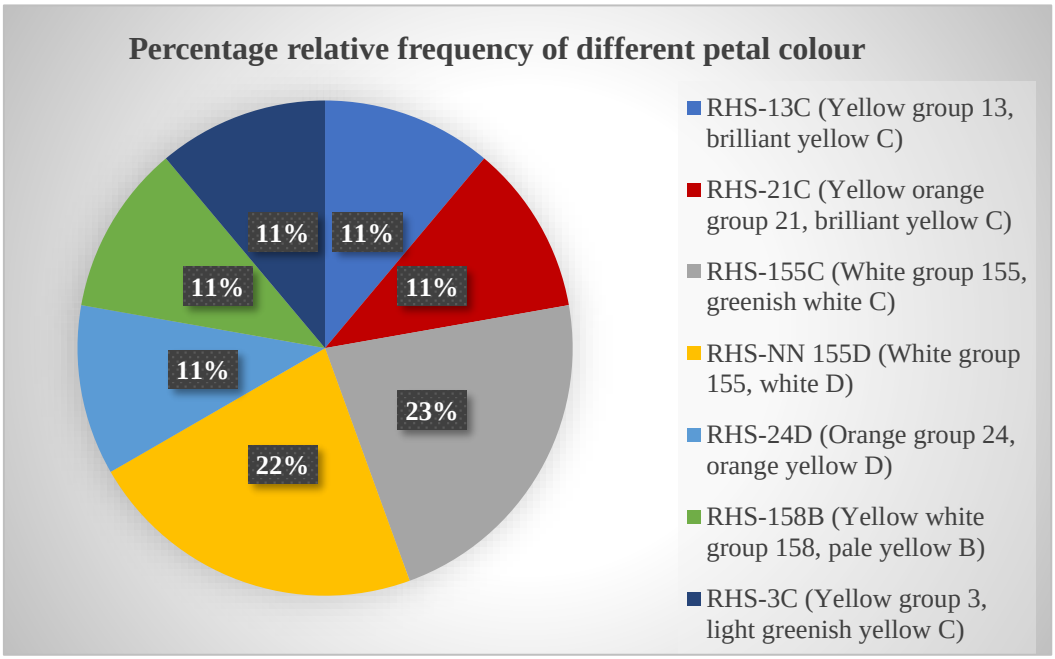


Fig. 38. Percentage relative frequency of different petal colour

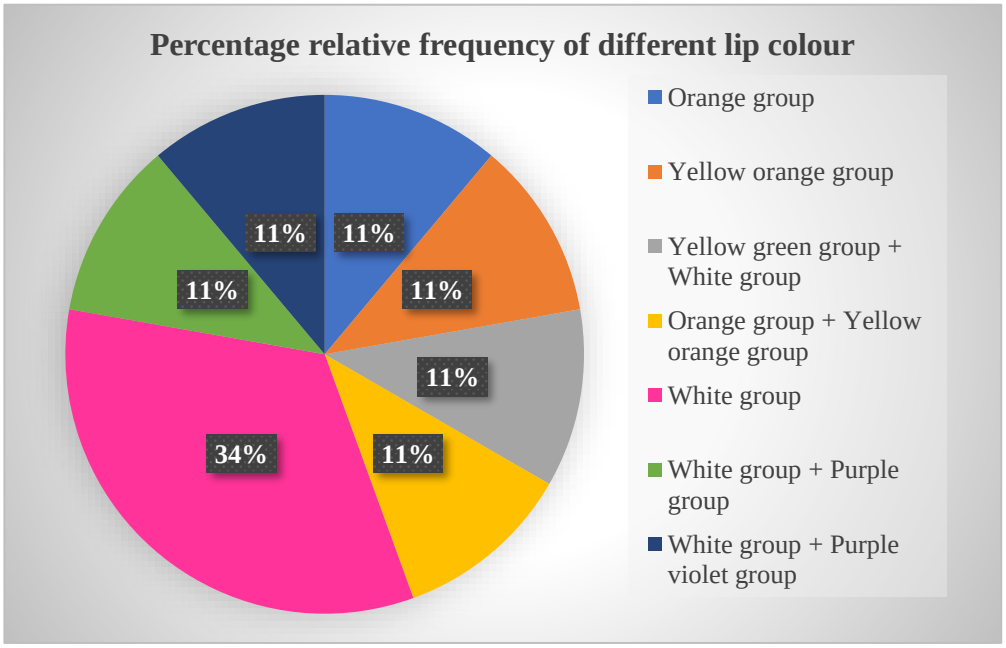


Fig. 39. Percentage relative frequency of different lip colour

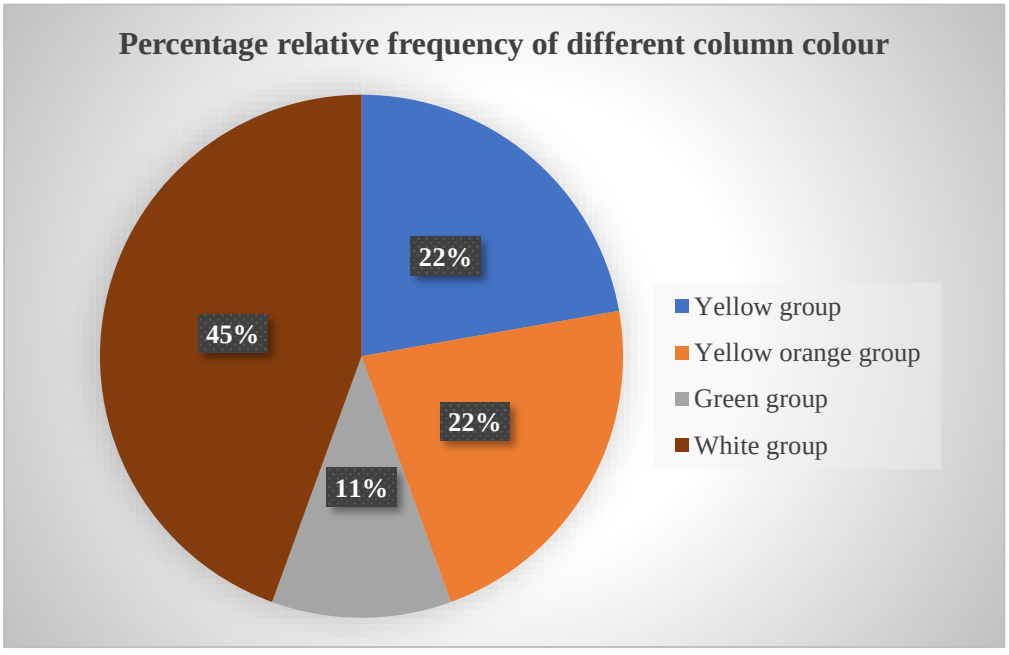


Fig. 40. Percentage relative frequency of different column colour

al., 2018), Jasmine (Nirmala and Champa, 2018), orchids (Miano *et al*., 2016) *etc*. A study conducted by Miano *et al*. (2016) in 25 orchids produced five major clusters by evaluating morphological characters. The study also found a wider inter group distance, which indicated a wider diversity among them. The results confirm that morphological characters are useful parameter for cluster analysis and which can be easily employed in orchids also.

In the present study the cluster analysis of different quantitative vegetative characters of monopodial and sympodial orchid accessions revealed 75 percent similarity. Among the three clusters formed in monopodials (Fig. 41), the Cluster C showed wider diversity with Cluster A and B. The intercluster distance between Cluster A and Cluster B was found to be less, which means they are more similar. Cluster C included the accession *Luisia* sp. (VKA/NOR-7) which was having highest plant spread, number of leaves and number of roots. *Acampe praemorsa* (VKA/NOR-3) and *Rhynchostylis retusa* (VKA/NOR-4) were grouped under Cluster A, which showed maximum plant height, leaf length, leaf width, internodal length along with minimum number of leaves and roots. Cluster C consisting the two accessions *Aerides crispa* (VKA/NOR-2) and *Vanda thwaitesii* (VKA/NOR-8) were having highest leaf sheath length and lowest plant spread and leaf length.

Cluster analysis of morphological traits was conducted by Hartati *et al*. (2019) in a sympodial orchid genera *Coelogyne*. The analysis could categorise six *Coelogyne* species into three clusters based on stem, pseudobulb, leaves, flowers and root characteristics at 73 per cent similarity.

In the present study the cluster analysis of sympodial accessions with respect to quantitative vegetative characters grouped the accessions into four clusters at 75 percent similarity. Most of the accessions were grouped under Cluster A, which include accessions belonging to the genera *Dendrobium*, *Bulbophyllum*, *Oberonia* and *Coelogyne* (Fig. 42). Cluster B containing only one accession *viz.*, *Dendrobium crumenatum* (VKA/NOR-34) was found to have maximum plant height, number of leaves and number of roots. Also, Cluster B (*Dendrobium crumenatum* VKA/NOR-34) showed maximum diversity with Cluster A mainly in characters such as plant spread,

number of leaves and number of roots. Members of Cluster C *viz., Eria fragrans* (VKA/NOR-25), *Pholidota imbricata* (VKA/NOR-29), *Flickingeria sp.* (VKA/NOR-32) and all *Cymbidium* accessions (VKA/NOR-61, VKA/NOR-43, VKA/NOR-30, VKA/NOR-35) were grouped together since they are having maximum leaf length, minimum number of leaves per plant and roots. The Cluster C showed lowest intercluster distance with Cluster A than Cluster D, which means they are more similar in quantitative characteristics. Cluster D (*Eria sp.* VKA/NOR-38) exhibited diversity with respect to leaf length, number of leaves and number of roots compared to other clusters. It showed more similarity with Cluster B (*Dendrobium crumenatum* VKA/NOR-34) with respect to plant spread.

Quantitative floral traits were also used for grouping of the accessions to determine similarity and differences in floral characteristics. Cluster analysis of 24 quantitative floral characters grouped the nine bloomed native orchid accessions into two clusters, Cluster A and Cluster B (Fig. 43). Cluster A showed maximum frequency of flowering, number of spikes, stalk length, floret characteristics such as floret size, length and width of sepal, petal and lip, sepal to sepal as well as petal to petal distance and dorsal sepal to lip distance. The two accessions clustered under Cluster B *viz., Pholidota imbricata* (VKA/NOR-29) and *Rhynchostylis retusa* (VKA/NOR-4) were found to have maximum number of florets per spike, spike length, rachis length, girth of spike at base and longevity of spike and floret. Similarly, Anuttato *et al*. (2017) used quantitative floral characteristics such as flower size, sepal and petal size for clustering of 49 wild *Rhynchostylis gigantea* accessions, and the study revealed variation with respect to flower size and dorsal sepal width within the species itself. So, the study confirms that quantitative floral characters are also useful in determining floral diversity.

Based on morphological evaluation, superior accessions were identified for commercial traits (Table 48). They are pot plant types (*Rhynchostylis retusa, Bulbophyllum* sp., *Pholidota imbricata*), fragrant flowered types (*Dendrobium fimbriatum, Dendrobium crumenatum, Dendrobium moschatum, Eria fragrans,* Rhynchostylis *retusa, Acampe praemorsa*) accessions with long spike (*Rhynchostylis*

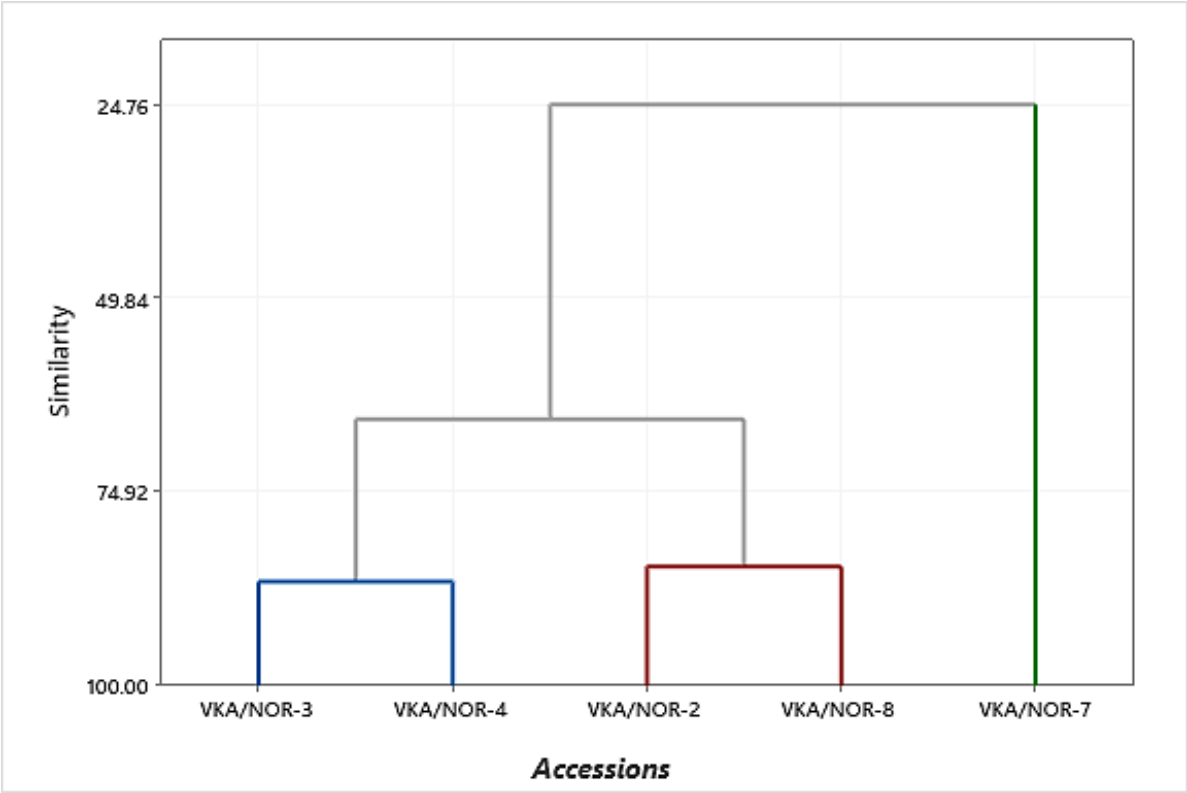


Figure 41. Dendrogram showing clustering in monopodial orchid accessions based on quantitative vegetative characters

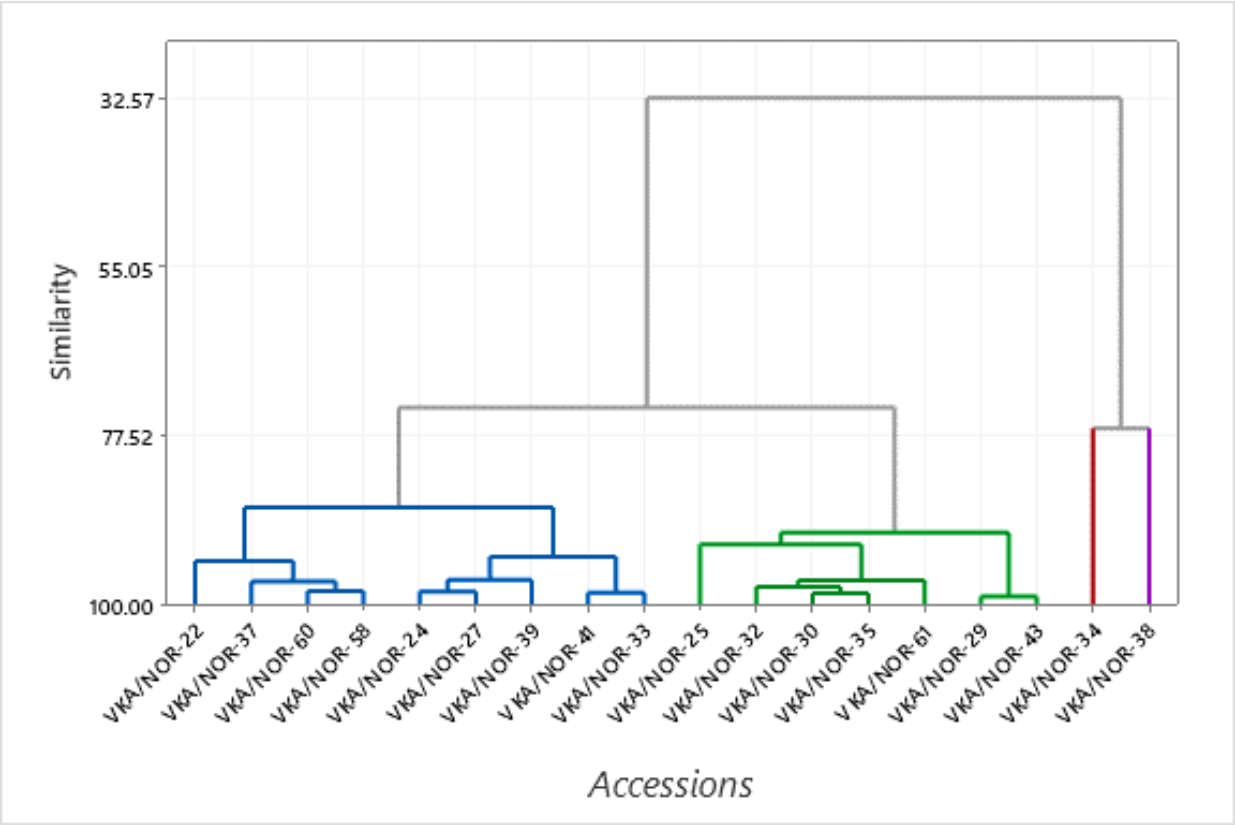


Figure 42. Dendrogram showing clustering in sympodial orchid accessions based on quantitative vegetative characters

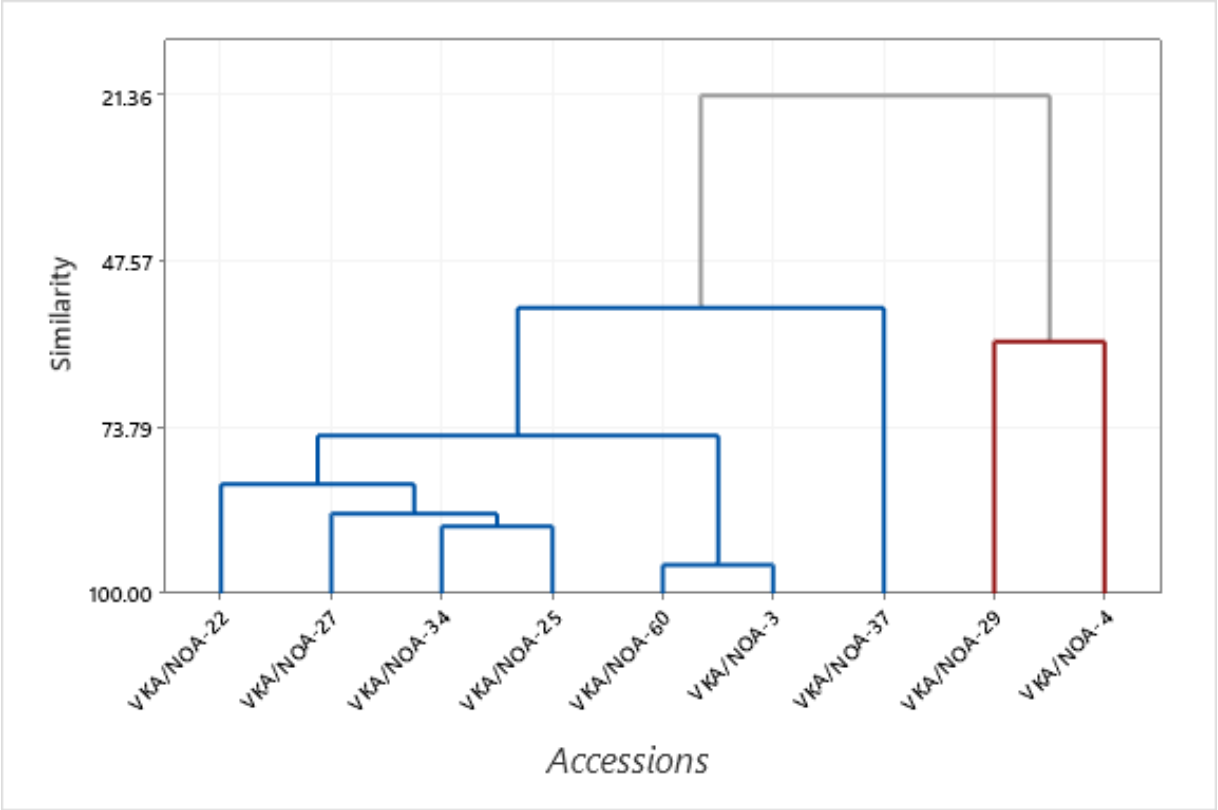


Figure 43. Dendrogram showing clustering of native orchid accessions based on quantitative floral characters

retusa, *Pholidota imbricata*), greater number of florets (*Rhynchostylis retusa*, *Pholidota imbricata*) and highest longevity (*Pholidota imbricata*, *Acampe praemorsa*).

The present study could assess noticeable variation among the native orchid accessions for vegetative and floral characteristics. The findings will be highly useful for the characterisation of different orchid species as well as useful for developing new descriptors that are helpful to distinguish different orchid flora and also for crop improvement programmes.

Table 48. Superior orchid accessions identified for commercial traits

Sl. No.	Commercial traits	Accessions
1	Pot plant types	*Rhynchostylis retusa* (VKA/NOR-4), *Bulbophyllum* sp. (VKA/NOR-39), *Pholidota imbricata* (VKA/NOR-29)
2	Fragrant flowers	*Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Eria fragrans* (VKA/NOR-25), *Acampe praemorsa* (VKA/NOR-3), *Rhynchostylis retusa* (VKA/NOR-4)
3	Long spikes (cut flower type)	*Rhynchostylis retusa* (VKA/NOR-4), *Pholidota imbricata* (VKA/NOR-29)
4	Spike longevity	*Pholidota imbricata* (VKA/NOR-29), *Acampe praemorsa* (VKA/NOR-3)
5	Number of florets per inflorescence	*Rhynchostylis retusa* (VKA/NOR-4), *Pholidota imbricata* (VKA/NOR-29)

Summary

6. SUMMARY

The study entitled 'Assessment of diversity in native orchids' was conducted at the Department of Floriculture and Landscaping, College of Agriculture, Vellanikkara, during the year 2019-20. The objective of the study was to assess the diversity among native orchid accessions by evaluating their morphological characters.

Twenty three native orchid accessions conserved under AICRP on Floriculture, Department of Floriculture and Landscaping were evaluated for vegetative and floral characters. The findings of present investigation are summarized under this chapter.

6.1 GROWTH HABITS OF ORCHIDS

- Based on the growth habits exhibited, the native orchid accessions in the germplasm were classified in to monopodial orchids and sympodial orchids.
- Monopodials are *Acampe praemorsa* (VKA/NOR-3), *Aerides crispa* (VKA/NOR-2), *Rhynchostylis retusa* (VKA/NOR-4), *Luisia* sp. (VKA/NOR-7) and *Vanda thwaitesii* (VKA/NOR-8)
- Sympodials are *Bulbophyllum sp* (VKA/NOR-39), *Coelogyne breviscapa* (VKA/NOR-33), *Cymbidium aloifolium* (VKA/NOR-61), *Cymbidium ensifolium* (VKA/NOR-43), *Cymbidium* sp. (VKA/NOR-30), *Cymbidium* sp.(VKA/NOR-35), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium haemoglossum* (VKA/NOR-41), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium ovatum* (VKA/NOR-60), *Eria fragrans* (VKA/NOR-25), *Eria* sp. (VKA/NOR-38), *Flickingeria* sp. (VKA/NOR-32), *Oberonia* sp. (VKA/NOR-58) and *Pholidota imbricata* (VKA/NOR-29).

6.2 VEGETATIVE CHARACTERS

- Significant variation was observed in plant height recorded among the native orchid accessions. Among monopodials, *Acampe praemorsa* (VKA/NOR-3)

recorded maximum plant height (43.36 cm) and *Rhynchostylis retusa* (VKA/NOR-4) recorded minimum plant height (23.64 cm).

- Plant spread recorded among monopodials was highest for *Luisia* sp. (VKA/NOR-7) (1571.28 sq.cm) and lowest for *Vanda thwaitesii* (VKA/NOR-8) (133.60 sq.cm)
- In monopodial orchid accessions internodal length was maximum in *Acampe praemorsa* (VKA/NOR-3) (2.40 cm) and minimum in *Luisia* sp. (VKA/NOR-7) (1.04 cm).
- Significant differences were observed with respect to number of leaves produced by monopodial accessions. *Luisia* sp. (VKA/NOR-7) recorded the maximum number of leaves (89.20) and *Rhynchostylis retusa* recorded (VKA/NOR-4) the minimum (8.00).
- Maximum leaf length among the monopodials was for *Acampe praemorsa* (VKA/NOR-3) (23.94 cm). The minimum leaf length was recorded in *Vanda thwaitesii* (VKA/NOR-8) (14.80 cm).
- With regard to leaf width among monopodials, *Acampe praemorsa* (VKA/NOR-3) recorded maximum (2.76 cm), and which was on par with *Aerides crispa* (VKA/NOR-2) (2.36 cm) and *Rhynchostylis retusa* (VKA/NOR-4) (2.34 cm). The minimum leaf width was recorded in *Luisia* sp. (VKA/NOR-7) (1.02 cm).
- Leaf sheath is one of the most prominent features of monopodial orchids. *Acampe praemorsa* (VKA/NOR-3) recorded the maximum leaf sheath length (3.60 cm) and the lowest leaf sheath length was recorded in *Luisia* sp. (VKA/NOR-7) (0.52 cm).
- The number of roots ranged from 6.40 to 10.60. Significant variation could not be observed with respect to number of roots produced among monopodial accessions.
- Sympodial orchid accessions exhibited significant variation with respect to vegetative characters. Plant height recorded was highest for *Dendrobium moschatum* (VKA/NOR-37) (75.20 cm) and was lowest for *Bulbophyllum* sp. (VKA/NOR-39) (12.00 cm). Among the *Dendrobium* accessions *Dendrobium anceps* (VKA/NOR-24) recorded the minimum plant height (17.23 cm).

- Plant spread recorded among sympodial accessions showed distinguishable variations. *Dendrobium crumenatum* (VKA/NOR-34) recorded the maximum plant spread (3979.22 sq.cm). It was found that the plant spread (50.27 sq.cm) recorded was minimum for *Dendrobium ovatum* (VKA/NOR-60) in the final quarters of observation since the plant shed leaves towards the end of study period.
- Among the sympodial accessions, the number of leaves also exhibited significant differences. *Dendrobium crumenatum* (VKA/NOR-34) recorded maximum number of leaves (95.80), *Cymbidium aloifolium* (VKA/NOR-61) (5.80) and *Cymbidium ensifolium* (VKA/NOR-43) (5.80) recorded minimum number of leaves and which were on par. *Dendrobium ovatum* (VKA/NOR-60) was leafless at the end of the study period.
- The longest leaf among sympodials was observed in *Cymbidium* accessions compared to other accessions. Maximum leaf length was recorded by *Cymbidium ensifolium* (VKA/NOR-43) (43.50 cm), which was on par with *Cymbidium aloifolium* (VKA/NOR-61) (41.00 cm). The lowest leaf length was recorded in *Dendrobium anceps* (VKA/NOR-24) (4.50 cm).
- Compared to all other accessions *Eria* species (VKA/NOR-25 and VKA/NOR-38) recorded maximum leaf width. Among them *Eria fragrans* (VKA/NOR-25) recorded maximum leaf width (5.22 cm) and which was on par with *Eria* sp. (VKA/NOR-38) (4.96 cm) and *Pholidota imbricata* (VKA/NOR-29) (4.88 cm).
- Among the sympodial orchid accessions, maximum pseudobulb length was recorded in *Dendrobium moschatum* (VKA/NOR-37) (75.20 cm) and minimum was recorded in *Bulbophyllum sp*. (VKA/NOR-39) (4.33 cm). With respect to the pseudobulb width (girth) maximum was recorded in *Pholidota imbricata* (VKA/NOR-29) (7.06 cm) which was on par with *Eria fragrans* (VKA/NOR-25) (6.50 cm) and it was found that *Dendrobium haemoglossum* (VKA/NOR-41) is having minimum pseudobulb width (girth) (1.20 cm) throughout the entire period of study.
- Among the sympodial orchid accessions evaluated internodal length was measurable in accessions such as *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27),

Dendrobium crumenatum (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium haemoglossum* (VKA/NOR-41), *Dendrobium ovatum* (VKA/NOR-60), and *Flickingeria* sp. (VKA/NOR-32). Maximum internodal length was recorded in *Dendrobium moschatum* (VKA/NOR-37) (4.23 cm), which was on par with *Dendrobium densiflorum* (VKA/NOR-22) (4.20 cm). The minimum internodal length was observed in *Dendrobium anceps* (VKA/NOR-24) (1.40 cm).

- Number of roots among sympodials also exhibited significant variation. *Dendrobium crumenatum* (VKA/NOR-34) recorded maximum number of roots (138.60) and *Cymbidium ensifolium* (VKA/NOR-43) recorded minimum number of roots (5.75).
- Distinguishable variations were also observed with respect to the qualitative vegetative characters.
- Various types of leaf shapes were observed among the accessions. All mononpodials except *Luisia* sp. (VKA/NOR-7) and *Vanda thwaitesii* (VKA/NOR-8) were having strap shaped leaves. The leaves of *Luisia* sp. (VKA/NOR-7) was terete and that of *Vanda thwaitesii* (VKA/NOR-8) was channelled.
- Among sympodials various leaf shapes observed were lanceolate, narrow elliptic, narrow lanceolate, narrow oblong, linear -oblong and linear. Lanceolate leaves were observed in *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium ovatum* (VKA/NOR-60), *Eria* sp. (VKA/NOR-25, VKA/NOR-38), *Pholidota imbricata* (VKA/NOR-29 and *Oberonia* sp. (VKA/NOR-58).
- *Dendrobium haemoglossum* (VKA/NOR-41), *Coelogyne breviscapa* (VKA/NOR-33) and *Cymbidium ensifolium* (VKA/NOR-43) recorded linear leaves, while *Cymbidium aloifolium* (VKA/NOR-61) and *Cymbidium* sp. VKA/NOR-35 and VKA/NOR-30 recorded linear oblong leaves.
- *Dendrobium crumenatum* (VKA/NOR-34) was found to have narrow elliptic leaves and *Flickingeria* sp. (VKA/NOR-32) was having narrow oblong leaves. Narrow lanceolate leaf was recorded in *Bulbophyllum* sp. (VKA/NOR-39).

- With respect to leaf texture all monopodial accessions were having smooth and rigid textured leaves. In sympodial accessions *Pholidota imbricata* (VKA/NOR-24), *Cymbidium aloifolium* (VKA/NOR-61) and *Cymbidium* species (VKA/NOR-35 and VKA/NOR-30) were found to have smooth and leathery texture, while *Dendrobium anceps* (VKA/NOR-24) and *Oberonia* sp. (VKA/NOR-58) were having fleshy leaves. All other sympodial accessions had smooth textured leaves.
- Among the accessions leaf colour belonging to yellow green group was recorded in *Vanda thwaitesii* (VKA/NOR-8), *Dendrobium anceps* (VKA/NOR-24) *Bulbophyllum* sp. (VKA/NOR-39), *Flickingeria* sp. (VKA/NOR-32), *Eria* sp. (VKA/NOR-25 and VKA/NOR-38) and *Oberonia* sp. (VKA/NOR-58).
- Leaf orientation observed in monopodial accessions was arching type except in *Luisia* sp. (VKA/NOR-7). *Luisia* sp. (VKA/NOR-7) was found to have straight and arching type of leaves.
- Among sympodial orchid accessions except *Dendrobium anceps* (VKA/NOR-24) all other *Dendrobium* accessions were found to have horizontal leaf orientation. *Dendrobium anceps* (VKA/NOR-24), *Flickingeria* sp. (VKA/NOR-32) and *Oberonia* sp. (VKA/NOR-58) had erect leaves.
- Semi erect leaf orientation was observed in *Eria* sp. (VKA/NOR-25 and VKA/NOR-38), *Bulbophyllum* sp. (VKA/NOR-39), *Coelogyne breviscapa* (VKA/NOR-33) and in all *Cymbidium* accessions except in *Cymbidium ensifolium* (VKA/NOR-43). *Cymbidium ensifolium* (VKA/NOR-43) and *Pholidota imbricata* (VKA/NOR-29) had arching type of leaf.
- With respect to leaf arrangement most of the monopodial accessions were having alternate distichous type of leaf arrangement, except in *Luisia* sp. (VKA/NOR-7) which was having alternate spiral arrangement of leaves.
- Among sympodial accessions, *Eria* species (VKA/NOR-25 and VKA/NOR-38), *Pholidota imbricata* (VKA/NOR-29), *Bulbophyllum* sp. (VKA/NOR-39), *Flickingeria* sp. (VKA/NOR-32) and *Coelogyne breviscapa* (VKA/NOR-33) were found to have leaf arrangement on the apex of the pseudobulb.
- In *Dendrobium densiflorum* (VKA/NOR-22), leaf arrangement was near the apex of pseudobulb i.e. subterminally in alternate distichous manner. In all other

Dendrobium accessions leaf arrangement was alternate distichous along the stem. Among the *Cymbidium* accessions leaves were found to be arranged as basal cluster. *Oberonia* sp. (VKA/NOR-58) had leaf arrangement of alternate equitant type.

- Root colour observed among the native orchid accessions showed considerable variation. All monopodials were found to have greenish grey coloured roots except in *Luisia* sp. (VKA/NOR-7), whereas *Luisia* sp. (VKA/NOR-7) was found to have greyish brown coloured roots.
- Among sympodials, root colour showed different shades of grey, green, white and brown. *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium crumenatum* (VKA/NOR-34), *Flickingeria* sp. (VKA/NOR-32) and all *Cymbidium* accessions were found to have white coloured roots. *Dendrobium moschatum* (VKA/NOR-37) and *Dendrobium haemoglossum* (VKA/NOR-41) showed greenish grey coloured roots, whereas *Dendrobium ovatum* (VKA/NOR-56) and *Eria* sp. (VKA/NOR-25 and VKA/NOR-38) had brown coloured roots. *Bulbophyllum* sp. (VKA/NOR-39) and *Coelogyne breviscapa* (VKA/NOR-33) was having root colour of greyish brown colour.
- Root branching was observed in all the monopodial orchids, whereas in sympodial accessions, except in accessions *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium moschatum* (VKA/NOR-37) and *Dendrobium ovatum* (VKA/NOR-60), all others accession had branching of roots.
- Cluster analysis of monopodial orchid accessions based on ten quantitative vegetative characters grouped them in to three clusters at 75 percentage similarity. Cluster A consists of *Acampe praemorsa* (VKA/NOR-3) and *Rhynchostylis retusa* (VKA/NOR-4). *Aerides crispa* (VKA/NOR-2) and *Vanda thwaitesii* VKA/NOR-8) belongs to Cluster B, while Cluster C has *Luisia* sp. (VKA/NOR-7).
- Cluster A exhibited the highest cluster mean with respect to plant height, leaf length, leaf width and internodal length. Cluster B showed maximum value of cluster mean for leaf sheath length, while Cluster C showed maximum cluster

mean for plant spread, number of leaves and number of roots. It was found that cluster A and B are showing wider inter cluster distance with cluster C.

- Cluster analysis of eight quantitative vegetative characters of sympodial orchid accessions revealed four clusters at 75 per cent similarity.
- Cluster A includes accessions *viz*., *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium anceps* (VKA/NOR-24), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Dendrobium haemoglossum* (VKA/NOR-41), *Dendrobium ovatum* (VKA/NOR-60), *Bulbophyllum sp.* (VKA/NOR-39), *Oberonia sp*. (VKA/NOR-58) and *Coelogyne breviscapa* (VKA/NOR-33).
- Cluster B includes *Dendobium crumenatum* (VKA/NOR-34), Cluster C includes *Eria fragrans* (VKA/NOR-25), *Pholidota imbricata* (VKA/NOR-29), *Flickingeria sp*. (VKA/NOR-32), *Cymbidium aloifolium* (VKA/NOR-61), *Cymbidium ensifolium* (VKA/NOR-43), *Cymbidium sp.* (VKA/NOR-30) and *Cymbidium sp.* (VKA/NOR-35). While *Eria sp.* (VKA/NOR-38) was grouped under Cluster D.
- More inter cluster distance was between Cluster A and Cluster B, while minimum inter cluster distance was between Cluster B and Cluster D.
- The mean value of clusters showed highest value for characters such as plant height, plant spread, number of leaves and number of roots in Cluster B, while Cluster A showed least value for plant spread and leaf width. Cluster C was showing maximum cluster mean for leaf length and Cluster D showed maximum cluster mean for leaf width.

6.3 FLORAL CHARACTERS

- Floral characters of nine native orchid accessions *viz.*, *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Eria fragrans* (VKA/NOR-25), *Pholidota imbricata* (VKA/NOR-29), *Acampe praemorsa* (VKA/NOR-3) and *Rhynchostylis retusa* (VKA/NOR-4) were recorded.

- Accessions such as *Dendrobium densiflorum* (VKA/NOR-22) (February), *Dendrobium fimbriatum* (VKA/NOR-27) (April), *Dendrobium moschatum* (VKA/NOR-37) (April), *Acampe praemorsa* (VKA/NOR-3) (April), *Pholidota imbricata* (VKA/NOR-29) (June- July), *Rhynchostylis retusa* (VKA/NOR-4) (May-June) and *Dendrobium ovatum* (VKA/NOR-60) (Jan- February) exhibited single flowering season.

- *Dendrobium crumenatum* (VKA/NOR-34) exhibited three flowering seasons (April-May, October, Dec-Jan) as well as more frequency of flowering (5.00). *Eria fragrans* (VKA/NOR-25) was having long flowering season (May- Oct) compared to other accessions.

- Among the accessions *Dendrobium crumenatum* (VKA/NOR-34) recorded significantly higher number of spikes per plant (5.76), whereas *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium densiflorum* (VKA/NOR-22) produced minimum number of spikes (1.00) per plant.

- Number of florets per spike produced was maximum in *Rhynchostylis retusa* (VKA/NOR-4) (99.33) which was followed by *Pholidota imbricata* (VKA/NOR-29) (63.33). The minimum number of florets per spike was recorded in *Dendrobium crumenatum* (VKA/NOR-34) (3.75).

- *Pholidota imbricata* (VKA/NOR-29) recorded maximum spike length (49.66cm) and rachis length (23.50 cm) respectively, while *Acampe praemorsa* (VKA/NOR-3) recorded minimum spike and rachis length (4.21 cm and 1.37 cm).

- Girth of spike at base recorded was highest in *Dendrobium densiflorum* (VKA/NOR-22) (1.30 cm), which was on par with *Rhynchostylis retusa* (VKA/NOR-4) (1.26 cm). It was found that the girth of spike at the base recorded in *Pholidota imbricata* (VKA/NOR-29) (0.37 cm) was on par with the minimum spike girth of *Dendrobium ovatum* (VKA/NOR-60) (0.36 cm).

- *Dendrobium densiflorum* (VKA/NOR-22) recorded maximum stalk length of individual floret (5.04 cm), while *Pholidota imbricata* (VKA/NOR-29) recorded minimum stalk length (0.66 cm) for individual floret.

- Significant variation could be observed with respect to the size of florets, length and width of different floral parts recorded among native orchid accessions flowered. *Dendrobium moschatum* (VKA/NOR-37) recorded the maximum flower size (54.37 sq.cm) and highest petal length (3.98 cm), petal width (2.94 cm), petal to petal distance (6.89 cm), length of dorsal sepal (3.49 cm), width of dorsal sepal (1.63 cm), and length of lateral sepal (3.01 cm). Maximum width of lateral sepal was recorded in *Dendrobium fimbriatum* (VKA/NOR-27) (1.98 cm).

- *Dendrobium crumenatum* (VKA/NOR-34) showed maximum sepal to sepal distance (4.70 cm), while *Dendrobium moschatum* (VKA/NOR-37) recorded maximum dorsal sepal to lip distance (3.96 cm), which was on par with *Dendrobium fimbriatum* (VKA/NOR-27) (3.66 cm), *Dendrobium crumenatum* (VKA/NOR-34) (3.35 cm) and *Eria fragrans* (VKA/NOR-25) (3.23 cm).

- Lip (labellum) length and width recorded among the accessions also showed significant variation. Maximum lip (labellum) length was recorded in *Dendrobium crumenatum* (VKA/NOR-34) (2.75 cm) and minimum was recorded in *Pholidota imbricata* (VKA/NOR-29) (0.55 cm), whereas lip (labellum) width recorded was maximum in *Dendrobium moschatum* (VKA/NOR-37) (2.28 cm) and minimum in *Eria fragrans* (VKA/NOR-25) (0.39 cm).

- Among the nine native orchid accessions evaluated, the floral parameters such as flower size (0.31 sq.cm), petal length (0.46 cm), petal width (0.12 cm), petal to petal distance (0.25 cm), length of dorsal sepal (0.55 cm), width of dorsal sepal (0.39 cm), length of lateral sepal (0.49 cm), width of lateral sepal (0.25 cm), sepal to sepal distance (0.48 cm), dorsal sepal to lip distance (0.78 cm) and Lip (labellum) length (0.55 cm) recorded were minimum in *Pholidota imbricata* (VKA/NOR-29).

- Noticeable variation was observed with respect to column length and width recorded among the accessions. *Dendrobium crumenatum* (VKA/NOR-34) recorded the maximum (1.78 cm) and *Dendrobium ovatum* (VKA/NOR-60) recorded the minimum (0.22 cm) column length.

- *Dendrobium moschatum* (VKA/NOR-37) recorded the maximum column width (0.58 cm). It was found that the column width of *Dendrobium fimbriatum* (VKA/NOR-27) (0.15 cm) was on par with that of *Dendrobium densiflorum* (VKA/NOR-22) (0.12 cm), which was the minimum column width recorded among the accessions flowered.

- The longevity of spike on plant (days) recorded was found maximum for *Dendrobium ovatum* (VKA/NOR-60) (12.00) and minimum for *Dendrobium crumenatum* (VKA/NOR-34) (1.00). With respect to the longevity of florets on spike, *Acampe praemorsa* (VKA/NOR-3) (19.00 days) recorded the maximum number of days and *Dendrobium crumenatum* (VKA/NOR-34) recorded the minimum number of days (1.93).

- The pollen viability (%) recorded was found to exhibit more than 90 percentage viability for all the accessions flowered. Among them maximum pollen viability was recorded for *Rhynchostylis retusa* (VKA/NOR-4) (98.27 percentage) and minimum pollen viability was recorded for *Dendrobium ovatum* (VKA/NOR-60) (92.03 percentage).

- The qualitative floral characters of nine native orchid accessions bloomed during the study period were evaluated and wide variations was observed.

- Pendulous, drooping and erect or arching type of spike orientation was observed among the accessions. *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium moschatum* (VKA/NOR-37) were having pendulous type of spikes, while drooping type of spike was observed in *Pholidota imbricata* (VKA/NOR-29) and *Rhynchostylis retusa* (VKA/NOR-4).

- The spikes of *Dendrobium crumenatum* (VKA/NOR-34), *Eria fragrans* (VKA/NOR-25) and *Dendrobium ovatum* (VKA/NOR-60) was oriented in erect to arching manner, while erect spike opposed by leaf was observed in *Acampe praemorsa* (VKA/NOR-3).

- The different petal shapes observed among the accessions are sub orbicular, elliptic, ovate, lanceolate, oblong and ovate to lanceolate. *Acampe praemorsa*

(VKA/NOR-3) was found to have ovate to lanceolate petal shape. *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium crumenatum* (VKA/NOR-34) recorded elliptic petal shape. Ovate petal shape was observed in *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium moschatum* (VKA/NOR-37) and *Rhynchostylis retusa* (VKA/NOR-4), while sub orbicular petal shape was found in *Dendrobium densiflorum* (VKA/NOR-22). *Eria fragrans* (VKA/NOR-25) was found to have lanceolate petal shape and *Pholidota imbricata* (VKA/NOR-29) was having oblong shaped petals.

- Petal curvature among the accessions also showed variations. The different petal curvatures observed are deflexed, incurved with straight apex, straight with deflexed apex, incurved and straight.

- *Eria fragrans* (VKA/NOR-25) and *Dendrobium ovatum* (VKA/NOR-60) were found to have deflexed petal curvature, whereas *Dendrobium crumenatum* (VKA/NOR-34) was having a curvature of straight with slightly deflexed apex.

- Incurved petals with straight apex were noticed in *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Acampe praemorsa* (VKA/NOR-3) and *Pholidota imbricata* (VKA/NOR-29).

- *Dendrobium densiflorum* (VKA/NOR-22) showed incurved petals and *Rhynchostylis retusa* (VKA/NOR-4) showed straight petals.

- Differences in lip shapes were also noticed among the native orchid accessions. Unique lip shape of hemispherical open-mouthed pouch was observed in *Dendrobium moschatum* (VKA/NOR-37). *Pholidota imbricata* (VKA/NOR-29) showed another unique lip shape of sac like (saccate) appearance.

- *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium densiflorum* (VKA/NOR-22) was having orbicular lip shape, while *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium crumenatum* (VKA/NOR-34) and *Acampe praemorsa* (VKA/NOR-3) was found to have ovate lip shape.

- Oblong lip shape was recorded in *Eria fragrans* (VKA/NOR-25) and obovate lip shape was recorded in *Rhynchostylis retusa* (VKA/NOR-4).

- Six accessions except *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium moschatum* (VKA/NOR-37) were having lobed lips.

- Flower fragrance is one of the attractive features of orchids. It was found that *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Acampe praemorsa* (VKA/NOR-3), *Rhynchostylis retusa* (VKA/NOR-4) and *Eria fragrans* (VKA/NOR-25) were having flower fragrance. Among them *Dendrobium crumenatum* (VKA/NOR-34) produced strongly fragrant flowers.

- The colours of different floral parts like, sepal, petal, lip and column were evaluated by using RHS colour chart, and distinguishable variations were observed.

- Colour of sepal and petal belonging to the white group of RHS colour chart was observed in *Dendrobium crumenatum* (VKA/NOR-34) (RHS-NN 155D), *Rhynchostylis retusa* (VKA/NOR-4) (RHS-NN 155C), *Eria fragrans* (VKA/NOR-25) (RHS-155C) and *Dendrobium ovatum* (VKA/NOR-60) (RHS-155C).

- Brilliant yellow (RHS-13C), light yellow (RHS-17D) and orange yellow (RHS-24D) coloured sepals were observed in *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27) and *Dendrobium moschatum* (VKA/NOR-37) respectively. *Pholidota imbricata* (VKA/NOR-29) was found to have pale yellow (RHS-158B) coloured sepals and petals.

- Single colouration of sepal and petal was observed in all accessions except *Acampe praemorsa* (VKA/NOR- 3) and *Rhynchostylis retusa* (VKA/NOR-4).

- *Acampe praemorsa* (VKA/NOR- 3) had dark red (RHS-187B) coloured transverse stripes present on light greenish yellow (RHS-3C) coloured sepals and petals. *Rhynchostylis retusa* (VKA/NOR-4) was having purple (RHS-N 80A) coloured spots present on the white (RHS-NN 155C) coloured sepals and petals.

- Lip colour and markings present on lip observed among the accessions also showed noticeable difference.

- In *Dendrobium ovatum* (VKA/NOR-60) strong yellow green colour (RHS-N144C) was present towards the inner side of greenish white (RHS-155C) coloured lip. In *Dendrobium moschatum* (VKA/NOR-37) two deep red (RHS-53A) coloured blotches were present on strong orange (RHS-22B) coloured lip. In *Dendrobium crumenatum* (VKA/NOR-34) brilliant yellow (RHS-7A) coloured marking was present on white (RHS-NN 155D) coloured lip. In *Dendrobium fimbriatum* (VKA/NOR-27) a black (RHS-203B) tinge was present on vivid orange yellow (RHS-23A) coloured lip. In *Acampe praemorsa* (VKA/NOR- 3) narrow streaks of reddish purple (RHS-N 78A) colour was present on white (RHS-NN 155D) coloured lip. In *Rhynchostylis retusa* (VKA/NOR-4) strong purple colour (RHS-N 80A) was present towards the apex of white (RHS-NN 155C) coloured lip. In *Eria fragrans* (VKA/NOR-25) a thin purple coloured marking was present at the edges of white (RHS-155C) coloured lip.

- With respect to the column colour, except *Eria fragrans* (VKA/NOR-25) and *Rhynchostylis retusa* (VKA/NOR-4) All other accessions had single coloured column without any markings.

- In *Eria fragrans* (VKA/NOR-25) a purple coloured (RHS-N 80A) thin marking was present on the column, while in *Rhynchostylis retusa* (VKA/NOR-4) small purple coloured spots (RHS-N 80A) were observed on the column.

- Cluster analysis of flora characters revealed two clusters with 54.88 percentage similarity in Cluster A and 60.22 percentage similarity in Cluster B.

- Cluster A includes accessions such as *Dendrobium densiflorum* (VKA/NOR-22), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium ovatum* (VKA/NOR-60), *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium moschatum* (VKA/NOR-37), *Eria fragrans* (VKA/NOR-25) and *Acampe praemorsa* (VKA/NOR-3). Cluster B includes accessions like *Pholidota imbricata* (VKA/NOR-29) and *Rhynchostylis retusa* (VKA/NOR-4).

- Cluster A exhibited highest cluster mean in the floral characters such as frequency of flowering, number of spikes per plant, stalk length, flower size, petal length, petal width, petal to petal distance, length of dorsal sepal, width of dorsal sepal, length of lateral sepal, width of lateral sepal, sepal to sepal distance, dorsal sepal to lip, lip length, lip width, column length and column width.

- Cluster B exhibited highest cluster mean for number of florets per spike, spike length, rachis length, girth of spike at base, longevity of spike on plant, longevity of floret on spike and pollen viability.

- Based on the evaluation of morphological traits, superior accessions were identified for different commercial traits and accordingly they were grouped as pot plant types (*Rhynchostylis retusa*, *Bulbophyllum* sp., *Pholidota imbricata*), fragrant flowered types (*Dendrobium fimbriatum*, *Dendrobium crumenatum*, *Dendrobium moschatum*, *Eria fragrans*, *Rhynchostylis retusa*, *Acampe praemorsa*) accessions with long spike (*Rhynchostylis retusa*, *Pholidota imbricata*), greater number of florets (*Rhynchostylis retusa*, *Pholidota imbricata*) and highest longevity (*Pholidota imbricata*, *Acampe praemorsa*)

The overall study on 'Assessment of diversity in native orchids' evaluated the vegetative and floral characters of twenty three native orchid accessions and could assess the wide morphological variability existed among them.

References

7. REFERENCES

Abbas, A. 2016. Characterisation and conservation of promising genotypes of orchids from central Western Ghats. M.Sc (Ag) thesis, Kerala Agricultural University, Thrissur, 171p.

Abraham, A. and Valsala, P. 1981. *Introduction to orchids with illustrations and descriptions of 150 South Indian orchids*, Tropical Botanic Garden and Research Institute, Trivandrum, 533p.

Ajithkumar, K., Rajendran, P., and Aswini, A. 2017. Conservation of orchids in the Western Ghats Region of Kerala, India. *Acta Hortic.* 57–62.

Akshata, S., Nataraj, S. K., Jadeyegowda, M., Sujatha, A., Nair., and Kantharaj, Y. 2018. Morphological characterization of wild orchids of Western Ghats. *J. Farm Sci*. *Spl.* 31(5): 618-619.

Ames, O. and Correll, D. S. 1985. *Orchids of Guatemala and Belize.* Dover Publications Inc, New York, USA, 800p.

Amin, M. M. U., Mollah, M. S., Tania, S. A., Ahmad, M. R., and Khan, F. N. 2004. Performance study of six indigenous epiphytic monopodial orchids of Bangladesh. *J. Biol. Sci*. 4(2): 87-89.

Anuttato, S., Boonruangrod, R., Kongsamai, B., and Chanprame, S. 2017. Morphological characterization of wild *Rhynchostylis gigantea* in Thailand. *J. Int. Soc. Southeast Asian Agric. Sci*. 23(2): 20-32.

Arditti, J. 1992. *Fundamentals of Orchid Biology*, John Wiley and Sons, New York, 704p.

Awan, F. K., Khurshid, M. H., Afzal, O., Ahmed, M., and Chaudhry, A. N. 2014. Agro-morphological evaluation of some exotic common bean (*Phaseolus Vulgaris* L.) genotypes under rainfed conditions of Islamabad, Pakistan. *Pakistan. J. Bot*. 46(1): 259-264.

Baudino, S., Caissard, J. C., Bergougnoux, V., Jullien, F., Magnard, J. L., Scalliet, G., and Hugueney, P. 2007. Production and emission of volatile compounds by petal cells. *Plant Signaling and Behavior* 2 (6): 525–526.

Bellusci, F., Musacchio, A., Stabile, R., and Pellegrino, G. 2010. Differences in pollen viability in relation to different deceptive pollination strategies in Mediterranean orchids. *Ann. Bot.* 106: 769–774.

Bhattacharjee, S. K. and Das, S. P. 2008. *Orchids: Botany, Breeding, Cultivation, Uses and Post-Harvest Management.* Aavishkar Publishers, Jaipur, Rajasthan, India, 396p.

Biswas, S. S. and Singh, D. R. 2019. *A Manual on Orchid Education* [e -book]. ICAR-National Research Centre for Orchids, East Sikkim, India. Available: https: //nrcorchids.nic.in/images/e-Book-A-manual-on-orchid-education.pdf [30 January 2020].

Bose, T.K., Bhattacharjee, S. K., Das, P., and Basak, U. C. 1999. In: *Orchids of India* (2nd Ed.). Naya Prakash, Kolkata, India.

Bose, T. K. and Bhattacharjee, S. K. 1980. *Orchids of India*. Naya Prakash Publishers, Calcutta, West Bengal, India, 538p.

Correll, D. S. 1950. *Native orchids of North America*. Chronica Botanica, Waltham, 415p.

Chen, S. C., Ormerod, P., and Wood, J. J. 2009. *Oberonia* Lindl. In: Wu, Z. Y., Raven, P. H. and Hong, D. Y. (Eds) *Flora of China.* 25: 236–245.

Chen, S. C. and Wood, J. J. 2009. *Pholidota* Lindl. In: Wu, Z. Y., Raven, P. H. and Hong, D. Y. (Eds) *Flora of China* 25: 335–339.

Connel, J. Mc. and Kamemoto, H. 1983. Characteristics of four sets of reciprocal crosses in *Dendrobium* (Orchidaceae). *J. American. Soc. Hortic. Sci*. 108: 1003-1006.

Deepa, T. 2017. Evaluation of fragrant vandaceous orchids for ornamental traits. M. Sc (Hort.) thesis, Kerala Agricultural University, Thrissur. 123p.

De, L. C. and Bhattacharjee, S. K. 2011. *Ornamental Crop Breeding.* Aavishkar Publishers and Distributors, Jaipur, Rajasthan, 438p.

De, L. C. and Medhi, R. P. 2014. Diversity and conservation of rare and endemic orchids of North East India - A review. *Indian J. Hill Farm.* 27(1):81- 89.

De, L. C. and Medhi, R. P. 2015. Orchid- a diversified component of farming systems for profitability and livelihood security of small and marginal farmers. *J. Global BioSci*. 4: 1393 -1406.

De, L. C. and Pathak, P. 2015. Value addition in orchids. *J. Orchid Soc. India* 29: 31-37.

De, L. C., Pathak, P., Rao, A. N., and Rajeevan, P. K. 2014. *Commercial Orchids*. De Gruyter Open Ltd., Berlin, 322p.

De, L. C., Rao, A. N., Rajeevan, P. K., Pathak, P., and Singh, D. R. 2015. Medicinal and aromatic orchids - an overview. *Int. J. Curr. Res.* 7(9):19931-19935.

De, L. C., Rao, A. N., Rajeevan, P. K., Sood, S. K., and Rawat, G. S. 2011. Guidelines for the conduct of test for distinctiveness, uniformity and sta bility on Orchid *Cymbidium*, *Dendrobium* and *Vanda* orchids. *Plant Variety J. India* 5(10): 5-83.

Donald, G. J. Mc. 1991. Disa Hybridization- Part II: Breeding characteristics. *American Orchid Soc. Bull*. 60: 748-753.

Dressler, R. L. 1993. *Phylogeny and Classification of the Orchid Family*. Cambridge University Press, USA, 314p.

Freudenstein, J. V. and Chase, M. W. 2015. Phylogenetic relationships in Epidendroideae (Orchidaceae), one of the great flowering plant radiations: progressive specialization and diversification. *Ann. Bot.* 115:665-681.

Frowine, S. A. 2005. *Fragrant Orchids.* Timber press, USA. 200p.

Gangaprasad, A. 2014. In: Nainan, J. (ed.), Orchids of Western Ghats and its Conservation. *Proceedings of golden jubilee seminar series Emerging trends in pure and applied disciplines*. St. George College, Kottarakkara, pp. 1-10.

Godinez, S. E. 1996. Trends in the phenology of flowering in the Orchidaceae of Western Mexico. *Biotropica* 130-136.

Gogoi, K and Borah, R. L. 2010. Orchids in Joypur Reserve Forest, Dibrugarh (Assam), India: The genus *Dendrobium. J. Orchid Soc. India* 24 (1-2): 21-28.

Gutierrez, 2010. Orchids: A review of uses in traditional medicine, its phytochemistry and pharmacology. *J. Med. Plant. Res*. 4(8): 592-638.

Hartati, S., Endang, S., Muliawati, Pardono, P., Cahyono., and Yuliyanto, P. 2019. Morphological characterization of *Coelogyne* spp for germplasm conservation of orchid. *Rev. Ceres* 66(4): 265-270.

Hedge, S. N. 1997. Orchid wealth of India. *Proc. Indian Natl. Sci. Acad*. 63: 229-244.

Hegland, S. J., Nielsen, A., Lazaro, A., Bjerknes, A-L., and Totland, O. 2009. How does climate warming affect plant-pollinator interactions. *Ecol Lett*. 12:184-195

Hew, C. S. and Yong, J. W. H. 2004. The Physiology of Tropical Orchids in Relation to the Industry. World Scientific Publishing Company, USA, 388p.

Jalal, J. S. and Jayanthi, J. 2012. Endemic orchids of peninsular India: a review. *J. Threatened Taxa* 4(15): 3415-3425.

Janakiram, T. and Baskaran, V. 2018. Commercialisation and conservation aspects of orchids. *Orchid Soc. India* 32: 55-61.

Jaslam, P. K. M., Deepankar., and Kumar, A. 2018. Multivariate analysis of genetic diversity in *Chrysanthemum* germplasm. *Int. J. Pure App. BioSci*. 6 (3): 572-577.

Karp, A., Kresovich, S., Bhat, K. V., Ayad, W. G., and Hodgkin, T. 1997. *Molecular Tools in Plant Genetic Resources Conservation: A Guide to the Technologies*. IPGRI Technical Bulletin No. 2, International Plant Genetic Resources Institute (IPGRI), 42p.

Karthigeyan, K., Jayanthi, J., Sumathi, R., and Jalal, J. S. 2014. A review of the orchid diversity of Andaman and Nicobar Islands, India. *Richardiana* 15: 7-85.

KAU (Kerala Agricultural University) 2016. *Package of Practices Recommendations*: *Crops* (15th Ed.), Kerala Agricultural University, Thrissur, 360p.

Kaushik, P. 2013. Therapeutic value of Indian orchids. *J. Orchid Soc. India* 27(1-2): 37-45.

Kaveriamma, M. M. 2007. Evaluation of monopodial orchids for cut flower. M.Sc (Hort.) thesis, Kerala Agricultural University, Thrissur, 167p.

Khuraijam, J. S., Sharma, S. C., and Roy, R. K. 2017. Orchids: potential ornamental crop in North India. *Intl. J. Hort. Crop Sci. Res.* 7(1):1-8.

Lee, N. and Lin, G. M. 1984. Effect of temperature on growth and flowering of *Phalaenopsis* white hybrid. *J. Chinese Soc. Hortic. Sci*. 30:223-231.

Medhi, R. P. and Chakrabarti, S. 2009. Traditional knowledge of NE people on conservation of wild orchids. *Indian J. Tradit. Knowl.* 8: 11-16.

Meesawat, U. and Kanchanapoom, K. 2007. Understanding the Flowering Behavior of Pigeon Orchid (*Dendrobium crumenatum* Swartz). *Orchid Sci. Biotechnol*. 1(1): 6-14.

Memmott, J., Craze, P. G., Waser, N. M., and Price, M. V. 2007. Global warming and the disruption of plant-pollinator interactions. *Ecol Lett*. 10: 710-717. doi:10.1111/j.1461-0248.2007.01061.x

Miano, T. F., Rabbani, M. G., and Memon, N. U. N. 2016. Assessment of genetic diversity among orchids. *Bangladesh J. Bot.* 45(5): 987-993.

Misra, S. and Misra, S. 2007. *Orchids of India - A Glimpse*. Bishen Singh Mahendra Pal Singh, Dehradun, 402p.

Mohammadi, S. A. and Prasanna, B. M. 2003. Review and interpretation analysis of genetic diversity in crop plants-salient statistical tools. *Crop Sci*. 43: 1235-1248.

Moles, A. T., Warton, D. L., Warman, L., Swenson, N. G., Laffan, S. W., Zanne, A. E., Pitman, A., Hemmings, F. A., and Leishman, M. R. 2009. Global patterns in plant height. *J. Ecol*. 97: 923–932.

Moniruzzaman, M. and Ara, K. A. 2012. Evaluation and characterization of physio-morphological and yield performance of native *Dendrobium* orchids. *Acta Hortic.* 953: 61-70.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., and Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.

Ninawe, A. S. and Swapna, T. S. 2017. Orchid diversity of North East India-traditional knowledge and strategic plan for conservation. *J. Orchid Soc. India* 31:41-56.

Nirmala, K. S. and Champa, B. V. 2018. Diversity evaluation of floral morphological traits of *Jasminum* spp. in relation to flower trade. *Bull. Env. Pharmacol. Life Sci*. 7(10):75-81.

NRCO and PPV & FRA. 2012. Orchid Descriptors. Available: http://164.100.238. 77/Downloads.

html [18 October 2019].

Pande, S. A., Sant, N., Vishwasrao, V., and Datar, M. N. 2010. Wild Orchids of Northern Western Ghats. Available: https://www. researchgate.net/profile/ MandarDatar4/publication/262063805_Wild_Orchids_of_Northern_Western _Ghats/links/55bb59d208ae092e965f1d05/Wild-Orchids-of-NorthernWestern -Ghats.pdf [17 December 2020].

Patra, S. K. and Mohanty, C. R. 2015. Genetic divergence study in Gladiolus. *J. Recent Adv. Agric.* 3(2): 356- 360.

Rao, A. N. 2004. Medicinal orchid wealth of Arunachal Pradesh. Indian Medicinal Plants of Conservation Concern. Newsletter of ENVIS Node on Indian Medicianal plants. 1(2):1-5.

Rasmussen, H. N. 1986. The Vegetative Architecture of Orchids. *Lindleyana* 1(1): 42-50.

Rathcke, B. and Lacey, E. P 1985. Phenological patterns of terrestrial plants. *Annu. Rev. Ecol. Syst*. 16: 179-214

Roychowdhury, N., Mandal, T., and Munsi, P. S. 2004. Evaluation of different *Dendrobium* spp. under polyhouse in North-East Indian hills. *Acta Hortic*. 658: 315.

Sebastian, M. 2015. Evaluation of *Vanda* orchids for commercial traits. M.Sc (Hort.) thesis, Kerala Agricultural University, Thrissur, 108p.

Sharmao, K. R. 2019. Morpho-molecular characterization of intergeneric hybrids of *Ascocentrum*. Ph.D (Hort) thesis, Kerala Agricultural University, Thrissur, 182p.

Shukla, A. K, Vijayaraghavan, M. R., and Chaudhry. B. 1998. *Biology of Pollen*. APH Publishing corporation, 133p.

Singh, F. 1990. Indian orchids. *Indian hortic.* 35(1): 14-15.

Singh, F. 1986. Orchids. In: Chadha, K. L. and Choudhary, B. (eds), *Ornamental Horticulture in India*, Publications and Information Division, ICAR, New Delhi, India, pp. 127.

Stone, J. L., Thomson, J. D., and Dent-Acosta, S. J. 1995. Assessment of pollen viability in hand-pollination experiments: a review. *American J. of Bot*. 82 (9): 1186 -1197.

Sugapriya, S. 2009. Evaluation of *Dendrobium* orchids under green house condition. MSc. (Hort.) thesis. College of Agriculture, Dharwad University of Agricultural Science. 67p.

Sugapriya, S., Mathad, J. C., Patil, A. A., Hegde, R. V., Lingaraju, S., and Birdar, M. S. 2012. Evaluation of *Dendrobium* orchids for growth and yield grown under greenhouse. *Karnataka J. Agric. Sci*. 25(1): 104-107.

Thomas, B. and Rani, L. C. 2008. Assessment of floral characters in commercial varieties of monopodial orchids. *J. Ornam. Hortic*. 11 (1): 15-20.

Tsai, W. C., Hsiao, Y. Y., Pan, Z. J., Hsu, C. C., Yang, Y. P., and Chen, W. H. 2008. Molecular biology of orchid flower - with emphasis on Phalaenopsis. *Adv. Bot. Res.* 47: 99-145.

U. S. Department of Agriculture (USDA). 2010. Floriculture crops 2009 summary. United States Department of Agriculture, National Agricultural Statistics Service, Washington, D. C. Available: https://www.nass.usda.gov/Publications /Todays_Reports/reports/floran10.pdf

U. S. Department of Agriculture (USDA). 2016. Floriculture Crops 2015 Summary. United States Department of Agriculture, National Agricultural Statistics Service, Washington, D. C. Available: https://downloads.usda.library.cornell. edu/usdaesmis/files/0p0966899/ pz50gz655/ 8910jx 14p/FlorCrop-04-26-2016.pdf

U. S. Department of Agriculture (USDA). 2019. Floriculture crops 2018 summary. United States Department of Agriculture, National Agricultural Statistics Service, Washington, D. C. Available: https://www.nass.usda.gov/Publications/ Todays_Reports/reports/floran19.pdf

Vij, S. P. and Pathak, P. 2001. Orchid diversity in India and its conservation. In: *Integrated rural development: Science and Technology*. Proceedings of 93 rd Indian science congress. Indian science congress Association. Kolkata, India, pp 28-32.

Wang, S. L., Viswanath, K. K., Tong, C. G., An, H. R., Jang, S., and Chen, F. C. 2019. Floral Induction and Flower Development of Orchids. *Front. Plant Sci*. 10:1258.

Withner, C. L. 1959. *The Orchids: A Scientific Survey*. Ronald Press, New York, 604p.

Withner, C. L. 2001. What is an orchid. Available: https://staugorchidsociety.org/PDF /WhatIs AnOrchid-Withner.pdf [01 July 2020].

Yi, Y., Xing, F., Huang, X., Chen, H., and Wand, F. 2005. Medicinal plants of *Bulbophyllum* species in China. *J. Trop. Subtrop. Bot.* 13: 65-69.

Zhang, S., Yang, Y., Li, J., Qin, J., Zhang, W., Huang, W., and Hu, H. 2018. Physiological diversity of orchids. *Plant Diversity* 40 (4): 196-208.

Appendices

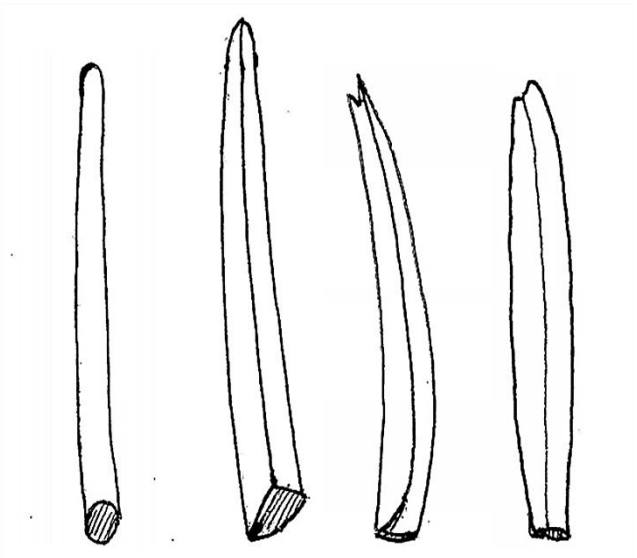
APPENDICES

Appendix I. Meteorological data during the period of observation from July 2019 to June 2020

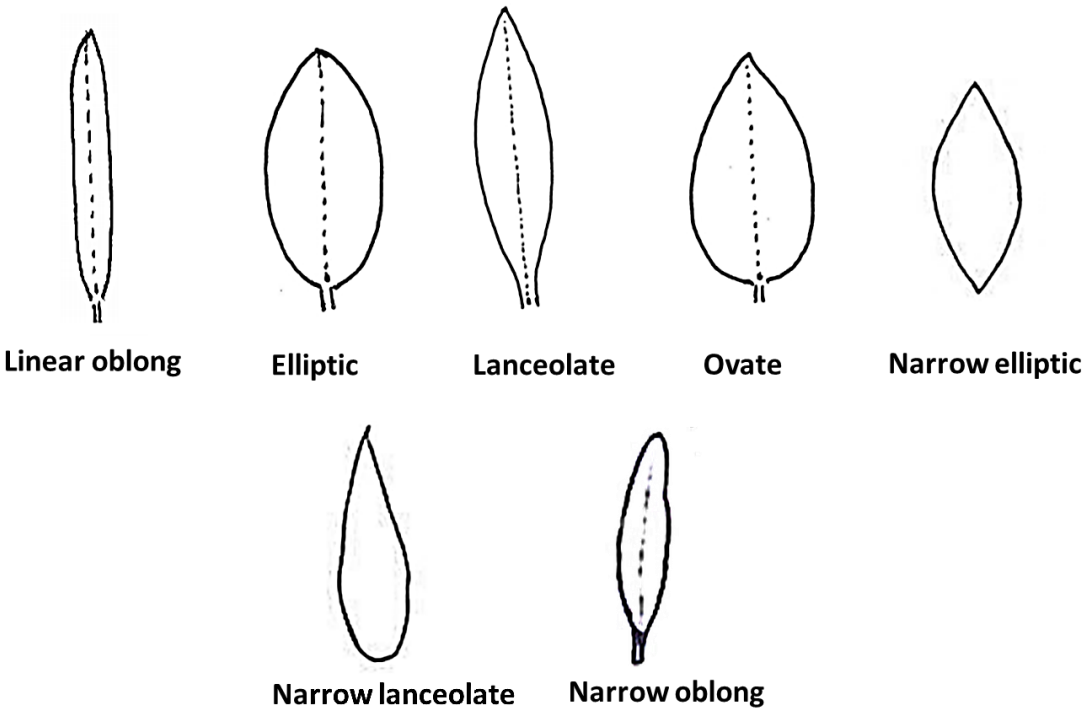
Months	Temperature (°C)		Mean RH (%)	Rainfall (mm)
	Max	Min		
July 2019	30.4	22.8	85	654.4
Aug 2019	29.5	21.9	89	977.5
Sep 2019	31.2	22.0	85	419.0
Oct 2019	32.4	21.4	79	418.4
Nov 2019	32.9	21.7	71	205.0
Dec 2019	32.3	22.1	63	4.4
Jan 2020	34.1	22.4	60	0.0
Feb 2020	35.5	23.2	54	0.0
Mar 2020	36.4	24.4	65	33.4
Apr 2020	36.4	24.7	71	44.7
May 2020	35.0	25.2	77	59.6
June 2020	31.1	23.7	85	427.2

Appendix II. Descriptors for leaf characters (NRCO and PPV &FRA)

Leaf shape descriptors for monopodials

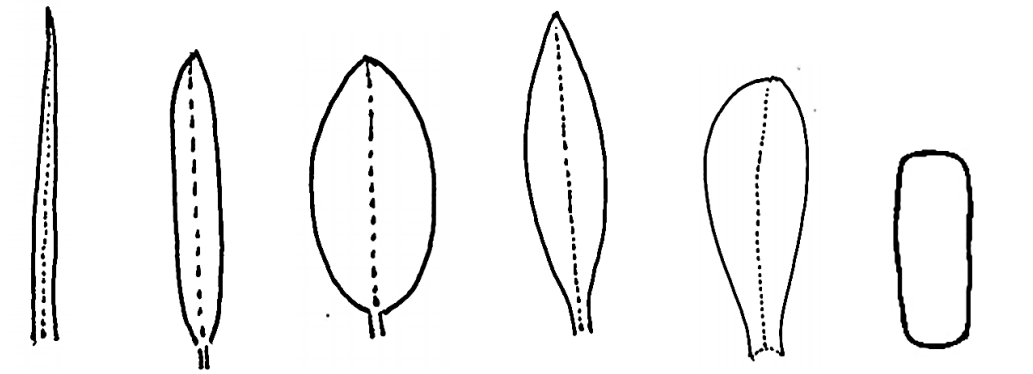


Leaf shape descriptors for sympodials

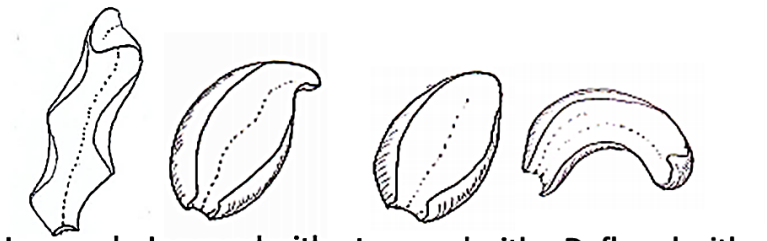


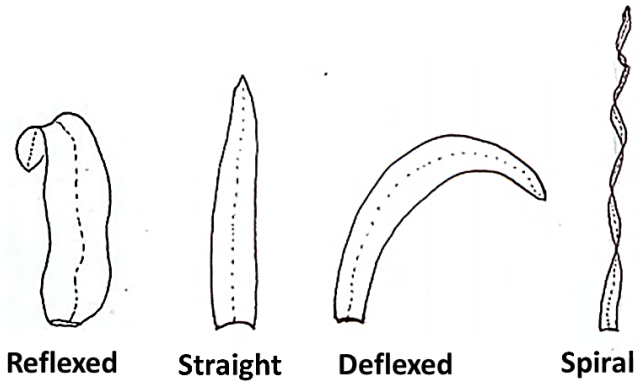
Appendix III. Descriptors for floral characters (NRCO and PPV &FRA)

Descriptors for petal shape

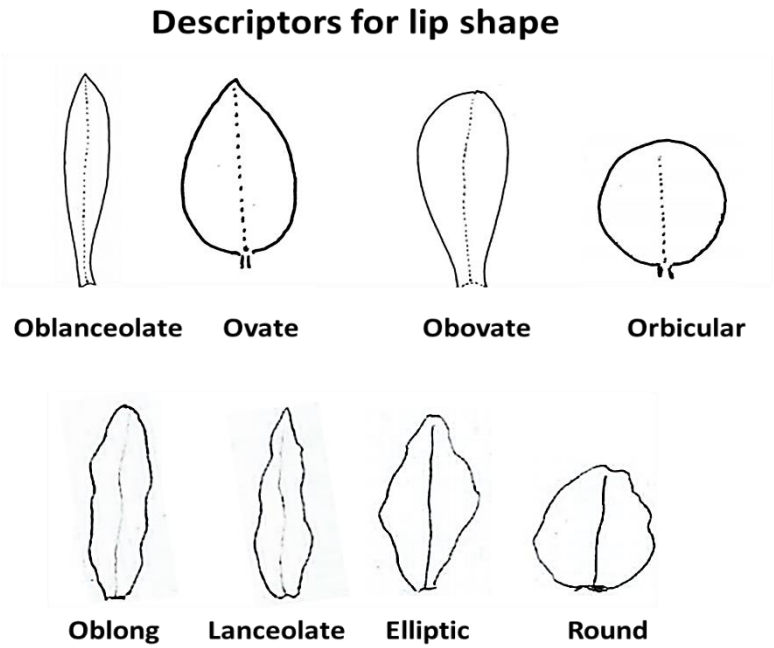


Descriptors for petal curvature





Appendix IV. Descriptors for floral characters (NRCO and PPV &FRA) contd…



ASSESSMENT OF DIVERSITY IN NATIVE ORCHIDS

By

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(2018-12-029)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture
(FLORICULTURE AND LANDSCAPING)

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ABSTRACT

A study entitled 'Assessment of diversity in native orchids' was conducted in the Department of Floriculture and Landscaping, College of Agriculture, Vellanikkara, from July 2019 to June 2020. The objective of the study was to assess the diversity among the native orchid accessions by evaluating their morphological characters. The morphological characters of twenty three native orchid accessions conserved under the Department of Floriculture and Landscaping were studied.

Based on the growth habit, five accessions were classified as monopodial orchids and 18 accessions were classified as sympodial orchids. The accessions *viz*; *Acampe praemorsa, Aerides crispa, Rhynchostylis retusa, Vanda thwaitesii* and *Luisia* sp. were grouped under monopodials, and the accessions belonging to genera *viz*; *Dendrobium, Eria, Pholidota, Bulbophyllum, Flickingeria, Coelogyne, Cymbidium* and *Oberonia* were grouped under sympodials. The quantitative vegetative characters varied significantly among the accessions. Among the monopodial accessions, *Acampe praemorsa* (VKA/NOR-3) recorded maximum plant height (43.36 cm), internodal length (2.40 cm), leaf length (23.94 cm), leaf width (2.76 cm) and leaf sheath length (3.60 cm). In sympodial orchid accessions, plant height recorded was highest for *Dendrobium moschatum* (VKA/NOR-37) (75.20 cm). The highest plant spread was observed in *Luisia* sp. (VKA/NOR-7) (1571.28 sq.cm) among monopodials, whereas *Dendrobium crumenatum* (VKA/NOR-34) (3979.22 sq.cm) was superior in terms of this parameter among the sympodials. These two species also recorded maximum number of leaves compared to other accessions (89.20 and 95.80). Among sympodials, *Cymbidium* accessions were observed to be superior in terms of the parameter leaf length, and maximum leaf length was recorded in *Cymbidium ensifolium* (VKA/NOR-43) (43.50 cm). Variability was also noted among the accessions with regard to qualitative vegetative characters *viz*; leaf shape, leaf orientation, leaf arrangement and root colour.

Nine native orchid accessions bloomed during the study period were evaluated for their floral characters. Among them *Dendrobium crumenatum* (VKA/NOR-34) exhibited three flowering seasons (April-May, October, Dec-Jan). The accession

Pholidota imbricata (VKA/NOR-29) recorded highest spike length as well as rachis length (49.66 cm and 23.50 cm). The number of florets per spike recorded was maximum in *Rhynchostylis retusa* (VKA/NOR-4) (99.33). Largest showy flower among the accessions was observed in *Dendrobium moschatum* (VKA/NOR-37) with maximum flower size of 54.37 sq.cm, highest petal length (3.98 cm), petal width (2.94 cm), petal to petal distance (6.89 cm), length of dorsal sepal (3.49 cm), width of dorsal sepal (1.63 cm), and length of lateral sepal (3.01 cm). Lip (labellum) is the most attractive feature of an orchid flower and is found to have variations. The accession *Dendrobium crumenatum* (VKA/NOR-34) (2.75 cm) was found to have maximum lip (labellum) length and *Dendrobium moschatum* (VKA/NOR-37) (2.28 cm) was found to have maximum lip (labellum) width. The longevity of spike on plant recorded was maximum for *Dendrobium ovatum* (VKA/NOR-60) (12.00 days), and the longevity of florets on spike recorded was maximum in *Acampe praemorsa* (VKA/NOR-3) (19.00 days). The pollen viability (%) was found to be more than 90 percentage for all the accessions flowered and it was noted maximum for *Rhynchostylis retusa* (VKA/NOR-4) (98.27 percentage).

Cluster analysis at 75 percentage similarity among the accessions done based on their quantitative characters resulted in different clusters containing accessions with similar morphological traits. Among sympodials most of the accessions were grouped under Cluster A with common characters for plant spread as well as leaf width. With respect to quantitative floral characters most of the accessions were grouped under Cluster A and they showed similarity for characters such as number of spikes, flower size, petal length and width, petal to petal distance, dorsal sepal to lip distance, length and width of lateral sepal and dorsal sepal, and also length and width of lip and column.

Wide variation was observed in spike orientation, petal shape, petal curvature and lip shape. The accessions were also noted for the presence of flower fragrance, and it was recorded in *Dendrobium crumenatum* (VKA/NOR-34), *Dendrobium fimbriatum* (VKA/NOR-27), *Dendrobium moschatum* (VKA/NOR-37), *Acampe praemorsa* (VKA/NOR-3), *Rhynchostylis retusa* (VKA/NOR-4) and *Eria fragrans* (VKA/NOR-25). The floral parts of the accessions also exhibited different sepal, petal, lip and column colouration.

Based on morphological evaluation, superior accessions were identified for commercial traits and accordingly they were grouped as pot plant types (VKA/NOR-4, VKA/NOR-39, VKA/NOR-29), fragrant flowered types (VKA/NOR-27, VKA/NOR-34, VKA/NOR-37, VKA/NOR-4, VKA/NOR-3) accessions with long spike (VKA/NOR-4, VKA/NOR-29), greater number of florets (VKA/NOR-4, VKA/NOR-29) and highest longevity (VKA/NOR-29, VKA/NOR-3). Diversity assessment using cluster analysis has revealed the variability as well as similarity existed among native orchid accessions on the basis of their morphological characters. The findings are highly useful for identification of superior accessions which can be utilized for crop improvement programmes and also for commercial floriculture.