EVALUATION OF MONOPODIAL ORCHIDS FOR CUT FLOWER

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Evaluation of monopodial orchids for cut flower"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
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CERTIFICATE

Certified that this thesis, entitled **"Evaluation of monopodial orchids for cut flower"** is a record of research work done independently by **Ms. Kaveriamma M.M.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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KAVERAMMA. M.M.

Dedicated to

My

Loving Family

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Introduction

INTRODUCTION

Orchids, the most exquisite of flowers, constitute an order of royalty in the world of ornamental plants. Their intricately fabricated floral structures, rich variations in hue, persistent bloom, alluring fragrance, attractive habits and spread across ecological niche have enthralled people since ages. Few plants can create such an aura of mystique and grandeur as orchids. These exotic flowers symbolize love, wealth, refinement and infinite beauty.

Orchids occupy top position as cut flowers and as potted flowering plants. Large-scale production of cuts or potted orchids exists in Japan, China, Germany, The Netherlands, Taiwan, Malaysia, Singapore, Thailand and the United States (Lopez and Runkle, 2004).They make the loveliest corsages, boutonniere, floral arrangements, cornucopia and bouquets. As ornamental crop industry is fast emerging globally as an innovative enterprise with trade in cut flowers, cut foliage, potted plants, bulbous plants and value added products; cultivation of orchids has become a lucrative venture.

Orchids which are commercially important as cut flowers belong to relatively few genera *viz.*, *Arachnis*, *Cattleya*, *Cymbidium*, *Dendrobium*, *Epidendrum*, *Oncidium*, *Phalaenopsis*, *Vanda*, a few others and their hybrids like *Ascocenda*, *Aranda*, *Aranthera*, *Mokara*, *Vascostylis* etc. Orchid plants of rare species and hybrids fetch remarkable appreciation and command excellent price in the international market. The small proportion of the total international trade of cut flowers occupied by orchids highlight its potential to take an even greater stride in flower trade. Their low perishability during transit to long distances has made orchids one of the most outstanding floricultural exportables.

In the tropics, 'orchidscaping' is popular with orchids as a choice landscape specimen (Parker, 1994). They are naturalized on trees, used as bedding plants, trained on fences, split hollow of bamboo pieces and posts and in hanging baskets. Select species of orchids make excellent indoor plants. Orchids, besides horticultural importance, serve as excellent indicators of environment degradation and play a very

useful role to balance the forest ecosystem. Few species are used as spice, food, medicine, aphrodisiac, glue, narcotics, poison etc.

Flowering potted orchids have become one of the largest segments of floriculture worldwide. The largest exporters of potted orchids include Taiwan, Thailand, the United Kingdom, Italy, Japan, New Zealand and Brazil, while the largest importer of potted orchids is the United States (Laws, 2004). In the Netherlands, *Phalaenopsis* has become the most valuable potted orchids sold; from 1983 to 2003, the number of potted orchids sold through Dutch flower auctions increased from 50,000 to 18 million pots (Laws, 2004; Wang, 2004).

In India, the orchid flora includes a variety of botanically fascinating and commercially potential genotypes (Vij, 1986). Many orchids native to this country have already proved to be important parent plants and have contributed to the production of several outstanding hybrids of the world (Bose *et al.*, 1999). Like other important orchid growing countries, India is blessed with a wealth of more than 150 genera and 1300 species of orchids scattered all over north-east Himalayas (300 species), Maharastra (130 species), Andaman and Nicobar islands (70 species) and Western Ghats (250 species). North-eastern Himalayan region and the west-coast of Kerala are the main centres of production of orchids (Rajeevan, 2003).

Commercial cultivation of orchids gathered momentum in Kerala during the early nineties. Kerala is one of the few places in the world where sophisticated infrastructure is not required for orchid cultivation. Monopodials like *Arachnis* and *Vanda* are also cultivated, greater emphasis is given to hybrids of *Dendrobium*, a shade loving sympodial orchid (Rajeevan, 1995). In view of the easiness in management and ready availability of plants from private nurseries, Dendrobiums now occupy more than 75 per cent area under orchids in the state.

Monopodials have recently gained popularity due to the availability of large number of varieties and hybrids including intergeneric ones that show a wide range of variability in floral characters. The cost of production is comparatively less as most of them grow under open conditions.

The potential of monopodial orchids for use as cut flower has so far not been exploited in the state. Research on monopodial orchids in Kerala Agricultural University has so far been sporadic in nature, conforming to a few isolated experiments. Therefore there is an imperative need to evaluate monopodial orchids for commercial exploitation and to create diversity in flori-business. With this background, a study was undertaken in the Department of Pomology and Floriculture, College of Horticulture, Kerala Agricultural University with the following objective

1. To evaluate the field performance of selected monopodial orchids.
2. To assess their qualities for use as cut flower and pot plants for commercial exploitation.

Review of Literature

2. REVIEW OF LITERATURE

Orchids represent a highly diverse and successful family of flowering plants, the Orchidaceae, which has outsmarted and outnumbered its counterparts by evolving ingenuity and higher levels of specialization in both the vegetative and reproductive traits. They culminate one of the evolutionary lines of monocots and are still in an active state of speciation (Vij, 1995).

Orchidaceae, the perennial family of monocots, includes about 800 genera and 25,000-35,000 species and has to its credit of being the largest assemblage of flowering plants. The family Orchidaceae accounts for above seven per cent of the species of flowering plants of the world (Pijl and Dodson, 1966). They are either epiphytic, terrestrial or lithophytes; a few are saprophytic, subterranean or semi-aquatic. Atwood (1986) finds that about 73 per cent of the species are epiphytes. Epiphytic orchids have showier and more flamboyant flowers than terrestrial types, and invariably these are the ones that are primarily grown indoors, as well as in greenhouses and conservatories. The flowers of terrestrial types are less dramatic but nevertheless equally captivating (Squire, 2005).

Orchids occur almost throughout the world, except perhaps in the Antarctica. Greatest diversity of orchids, including nearly all epiphytes, occurs in the tropics, especially in the tropical mountains where positive factors for orchid growth (thick vegetation and high humidity) prevail. Some species are found even in the frozen areas of Alaska, the snow covered areas of the Himalayas and the sandy deserts of Australia and Africa. New Guinea has more orchids native to the island than any other part of the world. It is closely followed by Columbia, Brazil, Costa Rica, Borneo, Java and India (Mukherjee, 2002).

The creation of new orchid hybrids is the most fascinating subject of orchidology. With the development of Lewis Knudson's (1925) asymbiotic method of orchid seedling culture, the production of hybrids received much attention and today orchid breeding stands at the forefront of ornamental horticulture. John Dominy became the first person to bloom a manmade orchid hybrid in the year 1856. This hybrid was

named as *Calanthe dominii* obtained by cross between *Calanthe masuca* and *Calanthe furcata*. Since then tremendous advances have been made in the production of hybrids throughout the world (Skelsey, 1978). The genetic plasticity inherent in Orchidaceae permits an intermingling of genomes, not only at the species level but also at the generic level (Abraham and Vatsala, 1981). There are more than 1,30,000 hybrids registered by the Royal Horticultural Society, England (Peterson, 2005).

2.1 SCENARIO OF ORCHID FLOWER PRODUCTION AND TRADE

In 1957, James Shoemaker stated "*orchid growing has not fully achieved the transition from a hobby to an industry.*" Today, orchid growing is more than just an industry; it is an international business. Orchids, which are commercially important as cut flower and potted plants belong to relatively few genera *viz.*, *Arachnis*, *Cattleya*, *Cymbidium*, *Dendrobium*, *Epidendrum*, *Oncidium*, *Phalaenopsis*, *Vanda* and a few others and their hybrids *viz.*, *Aranda*, *Aranthera*, *Mokara*, *Ascocenda* etc. Because of their long lasting, elegant floral display, enchanting and exquisite floral variations, the cut flowers and potted plants of orchids fetch a remarkable appreciation in the trade. Majority of the cultivated orchids are native of tropical countries and occur in their greatest diversity in the humid tropical forests. Brazilian Cattleyas, Mexican Laelias and Indian Dendrobiums, Cymbidiums and Vandas have played a major role in the development of modern orchid industry in the world.

2.1.1 World Scenario

Cultivation of orchids has become a very profitable occupation. The market potential for both cut flowers and potted orchids is very favourable (Laws, 1995). The small proportion of the total international trade of cut flowers occupied by orchids highlight its potential to take an even greater stride in flower trade (Hew and Yong, 1997). Development of new hybrids and commercial production of cut flowers and potted plants have expanded tremendously in Europe, U.S.A, South America, Thailand, Singapore, Malaysia, China, Japan and Sri Lanka. The largest exporters of potted orchids include Taiwan, Thailand, the United Kingdom, Italy, Japan, New Zealand and Brazil, while the largest importer of potted orchids is the United States (Laws, 2002). In

Holland, *Phalaenopsis* orchids are now the number one floral crop with a total of 18 million pots sold in 2003 (Wang, 2004).

2.1.2 Situation in India

In India, the orchid flora includes a variety of botanically fascinating and commercially potential genotypes (Vij, 1986). Like other important orchid growing countries, India is blessed with a wealth of more than 150 genera and 1300 species of orchids scattered all over north-east Himalayas (300 species), Maharastra (130 species), Andaman and Nicobar islands (70 species) and Western Ghats (250 species). North-eastern Himalayan region and the west-coast of Kerala are the main centres of production of orchids (Rajeevan, 2003).

Commercial cultivation of orchids has started and is expanding very fast for cut flower production and export. There is tremendous scope for orchid improvement and development of industry based on orchids. Many orchids native to this country have already proved to be important parent plants and have contributed to the production of several outstanding hybrids in the world. Hybrids of certain Indian orchids, like species of *Aerides*, *Ascocentrum*, *Arachnis*, *Renanthera*, *Rhyncostylis*, *and Vanda* are considered the monarchs in the orchid world (Bose *et al.*, 1999).

Fortunately, the country has all the potential for development of a successful orchid industry on scientific basis. It has varied and suitable climate and almost all the important commercial varieties of orchids including those of *Cattleya, Cymbidium, Dendrobium, Phalaenopsis, Paphiopedilum, Arachnis*, *Vanda* and their numerous intergeneric hybrids can be successfully grown. Upadhyay and Nagaraju (2001) have evaluated a collection of 390 species of orchids in 93 genera, several hybrids of *Cymbidium* (60), *Dendrobium* (5), *Aranda* (2) and *Vanda* (1) at the National Research Centre for Orchids, Pakyong. They are being maintained for further improvement through hybridization with indigenous species. Bhattacharjee *et al.* (2002) have given the passport of orchids collected and evaluated at various co-ordinating centres under floriculture in India. Botanical exploration conducted in the forest floor of Andaman

and Nicobar group of islands have led to a collection of 20 species of ornamental indigenous orchids. Further evaluation revealed suitability of *Cymbidium aloifolium, Dendrobium crumenatum, Eria andamanica, Papilionanthea teres* and *Rhynchostylis retusa* for commercial cultivation (Shiva *et al.*, 2003).

2.1.3 Scope in Kerala

The Western Ghats due to salubrious climatic conditions make a natural home of about 300 species of orchids (Jain, 1986). Kerala is one of the few places in the world, where sophisticated infrastructure is not required for orchid cultivation. Here, orchids can grow well in open and because of good rainfall, high humidity, and salubrious temperature; there is tremendous scope for the development of orchid industry in the region (Rajeevan, 1995). Thekkayan (1996) evaluated the performance of *Arachnis* Maggie Oei Red Ribbon and *Dendrobium* 'Sonia 17' under varying light regimes and nutritional levels.

Commercial cultivation of orchids gathered momentum in Kerala during the early nineties. Monopodials have recently gained popularity due to the availability of large number of varieties and hybrids including intergeneric ones that show a wide range of variability in floral characters. The genera of orchids and the varieties/hybrids, which could be commercially grown under the conditions prevailing in India, have also been described (Rajeevan *et al.*, 2002). *Vanda*, *Arachnis* and *Phalaenopsis* are the monopodial genera that flourish in Kerala. Intergeneric monopodial hybrids- *Aranda*, *Ascocenda* and *Mokara* also perform well (Rajeevan, 2003). The potential of monopodial orchids for use as cut flower and to create diversity in flori-business has not been exploited so far in the state.

2.2 GROWTH PARAMETERS AND EVALUATION OF ORCHIDS FOR CUT FLOWER

2.2.1 Vegetative characters

Ernst pfitzer in the late 19th century made primary groupings of orchids on the basis of vegetative structure of the plants. Based on the nature of growth, orchids are

classified as monopodials, sympodials and pseudomonopodials. Monopodials are characterised with stems, which lengthen indefinitely season after season and bear aerial roots almost to the top, though sometimes the roots are just at the base. The leaves may be flat, terete or intermediate. The inflorescence is lateral and produced at the leaf axils. A vast majority of orchids are characterised by the sympodial mode of growth, which includes all terrestrial orchids, both tropical and temperate. Growth of the stem eventually ceases, usually at the end of one's growth season, and lateral shoots are produced in the following season. The flower spikes may be either lateral or terminal. Plants of this group produce pseudobulbs, which are swollen stems which store water and food. Pseudomonopodials are intermediate in vegetative structure between monopodial and sympodial orchids.

So much variation is found in orchids that they can unquestionably be regarded as the most highly ecologically adapted flowering plants (Mehra and Vij, 1974). The extreme degree of morphological variability in orchids is attributed to genetic drift (Brieger *et al.,* 1975) and the final speciation in these depends on mutation, cross over rates, exchange of gene pools, environmental diversities and pressures, and reproductive isolation of new adaptive forms (Sanford, 1974). The uniqueness of the Orchidaceae is reflected in its huge amount of diversity (both floral and vegetative) coupled with peculiar pollination contrivances and wide natural hybridization. It is believed to be an active state of "evolutionary flux" (Chaterji, 1986).

Leaves

Orchid leaves, conforming to the monocotyledonous pattern, are plicate strap shaped, conduplicate or terete with sheathing bases and of variable thickness, occurring in all possible dimensions (Bose *et al.*, 1999).

There are three distinct groups of *Vanda* which are distinguished by the appearance of their leaves namely strap-leaf, the terete leaf and the semi terete *Vanda.* Hybridisation has produced other horticultural types, which are referred to as quarter-terete, and so on (Soon, 1980). When terete leaved orchids are crossed with others, with strap leaves, the offspring tend to have leaves of intermediate form, that is long and

rather succulent, but with a deep channel in the upper surface, such leaves are known as semi-terete. Similarly, further crossing with flat leaved parents dilutes the terete effect further, and one obtains broadly channeled, succulent leaves and these are known quite logically as quarter terete plants (Elliot, 1994).

In most orchids the leaves are arranged distichously or in two ranks, with the leaves alternating on opposite sides of the stem. In a few cases, by condensation of the internodes, there are two or more leaves arising at the same level as in *Codonorchis isotria.* Most orchid leaves are typical to the monocots, with many parallel veins and inconspecious cross connections between them. In many cases, the basal portion of the leaf forms a sheath around the stem, a feature without which there could be little intercalary growth, as the soft, growing portion of the internode is too soft to support itself alone (Dressler, 1993). Leaves of orchids are arranged either alternately or are basal, rarely are they opposite or whorled. Sometimes the leaves can be reduced to scales, but are generally simple and entire, frequently fleshy and attached to an enlarged or swollen stem commonly sheathing at the base (Bose *et al.*, 1999).

Leaves are generally green in colour but sometimes have silvery or golden veins providing beautiful ornamentation as in species of *Anoectochilus* (Bose *et al*, 1999) and also *Macodes sanderiana* a lithophyte (Wikipedia.org, 2007).

Roots

The aerial roots are remarkable structures being covered with a loose spongy tissue called velamen. The main function of velamen is to protect underlying tissues Velamen acts as a sponge, allowing the root to absorb moisture and minerals from the atmosphere (Khasim and Rao, 1986). Roots normally produce only roots, but "adventitious" buds that give rise to new shoots may be produced on roots, as in *Listeria, Pogonia, Psilochilus,* or *Phalaenopsis* (Dressler, 1993).

Orchids depending on their habit have different kinds of roots. However in general, the roots of most orchids are cylindrical, often thread like, branched and frequently elongated. The roots of the genera *Phalaenopsis* become considerably flat

and assist the plant to creep over the surface while those of *Aerides* and *Vanda* help the plants to climb on the tall trees (Bose *et al.*, 1999).

2.2.2 Floral characters

To quote Jacob Breynius, who wrote in his *Exoticarum Aliarumque Minus Cognitum plantarum* (1678).

"If nature ever showed her playfulness in the formation of plants this is visible in the most striking way among the orchids. The manifold shape of these flowers arouses our highest admiration. They take the form of little birds, of lizards, of insects. They look like a man, like a woman, sometimes like an austere sinister fighter, sometimes like a clown who excites our laughter. They represent the image of a lazy tortoise, a melancholy toad, an agile, ever chattering monkey. Nature has formed orchid flowers in such a way, unless they make us laugh, they surely excite our greatest admiration. The causes of their marvelous variety are hidden by nature under a sacred veil" (translated by Ames, 1948). They attract pollinators in a variety of ways including mimicry, fragrance offers of nectar, traps and other contrivances (Pijl and Dodson 1968; Arditti, 1992). Mimicry in orchids to attract pollinators is one of the marvels of nature. To entice suitable pollinating insects, some orchid flowers resemble the desired insect (Squire, 2005).

Inflorescence initiation and development

Like other flowering plants, an orchid must reach a certain stage of maturity before it can flower. The period of juvenility varies among species and among hybrids (Holtumm, 1949). *Cattleya* takes 4-7 years to reach maturity; *Dendrobium* needs 3-4 years while *Phalaenopsis* takes 24 months to bloom (Wang and Lee, 1994). Juvenility, vernalisation and photoperiodism are the three important factors that determine when the plants will flower with respect to ontogeny and season (Yong and Hew, 2004).

Development of inflorescence in *Vanda-Arachnis* tribe usually requires a period of two months. Their growth curve is typically sigmoid. During early and exponential

growth period, floral bud differentiation proceed very slowly, but becomes much faster when growth of the inflorescence stalk terminates. In *Arachnis* cv. Maggie Oei, the average growth period of an inflorescence is 70.6 days. The first flower may open on 60th day (Ede, 1963). In monopodial orchids, inflorescences will arise from axillary buds at nodes some distance (five to ten leaves counting from the apex) from the shoot apex (Hew *et al.*, 1996). In *Phalaenopsis* inflorescence arises on alternate sides between the leaves (Wikipedia.org, 2007).

Once initiated flower buds may not always develop to mature flower. In *Aranda* cv. Deborah, even among decapitated plants about 30 per cent of the buds do not develop (Goh and Seetoh, 1973). In case of ever blooming *Arachnis*, *Vanda* and *Aranda,* new inflorescence are initiated as soon as all the blooms have dropped off. Interval between successive crops of flowers can be reduced by simply removing the inflorescence when half the flowers on the stalk are open (Soon, 1980).

Flower bud initiation occurs after the reproductive stem (spike) has reached a certain length under the required environmental conditions (Lee and Lin, 1984). In *Phalaenopsis*, one large potentially reproductive bud and a small vegetative bud are produced in the axil of the subtending leaf. When all the physiological and environmental requirements are met, the large upper reproductive bud elongates which can lead to flowering (Wang, 1995). The present day *Phalaenopsis* hybrids generally bear from twelve to twenty or even more flowers, attractively spaced and the spikes have a tendency to branch, as they grow older and larger. In addition, the fact that many last for two to five months or more and that bloom succession keeps them in flower for much longer period makes them all the more desirable (Wikipedia.org, 2007).

In *Phalaenopsis*, flower spikes appear from the pockets near the base of each leaf. The first sign is a light green "mitten-like" object that protrudes from the leaf tissue. In about three months, the spike enlongates until it begins to swell fat buds. The buds will thus bloom. Usually you can tell what color the *Phalaenopsis* is by looking at the bud color. After the flowers fade, some people prefer to cut the spike above the

highest node (section). This may produce another flower spike or more rarely a keiki (a baby orchid plant that can be planted) (Wikipedia.org, 2007).

The orchid inflorescence is normally raceme or indeterminate. The flowers in the inflorescence of *Vanda-Arachnis* tribe usually open acropetally at one-day interval (Goh, 1977). The flowers are often spirally arranged on the rachis, even when the leaves are distichous, but the bracts and flowers are distichous in some groups, and the flowers are whorled in a few cases, as in *Chamaeangis* and some *Oberonia* species. The flowers are axillary on the rachis and usually flower from the base upward (Dressler, 1993).

The bract is usually inconspecious, but may be large or coloured, as in *Cyrtopodium* or *Lockharti* (Dressler, 1993).

Orchid flower

Orchids are truly flowers of superlatives. The beauty of orchids awes even a complete layman in botany. A typical orchid flower is zygomorphic (bilaterally symmetric). Notable exceptions are *Mormodes, Ludisia* and *Macodes.* (Wikipedia.org, 2007).

The orchid flowers show a great range of variations in size, colour and form. The largest flower known is that of *Sobralia macrantha,* 15 to 30 cm across, and the tiniest one is that of the *Bulbopyllum minutissimum,* the size being about the size of a pinhead (Bose *et al.*, 1999). Some of them have an appearance like ladies' slipper (*Cypripedium*). Others may assume various shapes of animals or insects. *Ophyrus apifera* looks like a bee; *Coeloglossum viride* looks like a minute frog; *Brassia* spikes suggest a small collection of colourful spiders; *Peristeria elota* or dove orchids looks like a small dove, and *Bulbophyllum purpureorhachis* simulates a lizard. Some have big flowers, whereas others have minute flowers (Mukherjee, 2002).

The details regarding the complex structure of the orchid flower were first clarified by Dr.Robert Brown (1833) and later by Charles Darwin (1862). The basic Orchid flower is composed of three sepals in the outer whorl and three petals in the

inner whorl. The medial petal is usually modified and enlarged called the labellum or lip forming a platform for pollinators. Together except the lip, they are called tepals. The reproductive organs (stamens and pistil) in the center have adapted to become a cylindrical structure called the column.

The labellum is the most prominent of all perianth parts, being endowed with arresting colours, unusual forms and peculiar markings, ridges and grooves. Except in a few instances like *Bulbophyllum*, *Eria* etc the lip is trilobed, with the central lobe much more prominent than the side lobes. The lip is attached to the base of the column. The mode of attachment may be rigid or loose (Abraham and Vatsala, 1981). The intricate detail on the lip reveals the minute decoration and rather mysterious shape that spells out a direct message to the pollinating insect (Rittershausan and Rittershausan, 1999).

The waxy structure called column or gynostemium, situated in the center of the flower, is the unique structure and primary feature distinguishing orchids from all other kinds of plants. In the evolution of orchids male and female organs fused to form a column. It is delicately coloured, attractively shaped and often is decorated with wings or a cap or a fringed bonnet. It is the most diagnostic and delightful part that is cleverly designed both outwardly and from the point of view of the functions. The column bears at the tip its anthers inside which the pollen forms compact waxy masses termed pollinia. Just below the anther the pistillate part is seen which consists of the receptive organ, stigma, a shiny depression filled with the extremely sticky fluid. The ovary is situated below the sepals, the portion which is generally recognized as stalk of flower. The partition wall between the stamen and stigma is called rostellum. The floral architecture of orchids is thus highly complex showing an extreme specialization to effect fertilization (Mukherjee, 2002).

Colour

Three types of pigments present in flowers – anthocyanins, determine colour in flowers, anthoxanthins, which are water-soluble, and plastid pigments, which are insoluble in the cell sap. The anthocyanins are responsible for scarlet, red, blue and

magenta colours. Anthoxanthins produce a colour range from pale ivory to deep yellow and the colour is intensified by a rising pH (Soon, 1980). The colour of flowers produced in spring and summer when light is brighter, will be more intense than those produced in winter. Once flowers begin to age, they lose a little of their brightness and tone down to paler shade. Individual blooms look almost transparent before falling from the stem (Rittershausan and Rittershausan, 1999).

Fragrance

Confucius wrote: "*Lan* (which means orchid in Chinese) that grows in the deep forests never withholds its fragrance even when no one appreciates it."

Fragrance plays a vital role in attracting pollinators to orchid flowers. Many of the epiphytic species are deliciously scented, a good enough reason to cultivate them. However these orchids are not fragrant for 24 hours. While the strongest fragrance persists in the species, a number of primary hybrids retain some degree of scent, but most often in the complex hybrids all traces of scent are usually lost. *Miltonopsis* and *Cattleya* are exceptional where hybrids are still sweeter (Rittershausan and Rittershausan, 1999). Main fragrance component in orchids is sesquiterpenes (C15 compounds) (Barak *et al.*, 2003). Roman Kaiser, a fragrance and flavour chemist described four basic orchid scents according to "olfactory and chemical criteria": white-floral, rosy-floral, ionone-floral, and spicy floral. Some orchids are fragrant at daytime while the others at evening or night times (Frowine, 2005).

Flower longevity

Orchid flowers vary greatly in their lifespan; some may live up to several months, whereas others are ephemeral, lasting for only a single day. The life span of blooms or inflorescences of different plants in one species or hybrid is usually the same. However, considerable differences may exist between different hybrids or species. The full bloom period of an inflorescence depends on the number of flowers and the longevity of individual flowers (Goh *et al.*, 1981). Most *Phalaenopsis* flowers are long

lasting and can stay in bloom 2-4 months under favourable conditions (Wang and Lee, 1994).

Changes in colour, shape and scent production with anthesis and age or after pollination are as common in orchids as they are spectacular. Unpollinated orchid flowers age slowly, but eventually wither and die without undergoing some of the changes, which follow pollination (Avadhani *et al.*, 1994). Porat (1994) reported a rapid acceleration of wilting process following successful pollination in several orchid genera. He also observed the wilting of flowers was accompanied by a loss of moisture from the cells of the upper layers of petals leading to their upward folding.

2.3 PRODUCTION ENVIRONMENT

Growth, development and productivity depend on the interaction between environmental factors and genetic constitution of the plants. Orchid is one such crop, which expresses a high magnitude of diversity and responds very well to the environment (Abraham and Vatsala, 1981). In recent years, several hybrids of Orchids have entered the market but the performance depends on the varying environmental conditions (Goh *et al.*, 1981).

The growth and development of Orchids is markedly influenced by the physical (temperature, light, humidity, topography), chemical (nature of substratum), and biotic (rhizosphere, associated vegetation, pollinators) factors, and their avidity to specific ecological niches varies with the species (Chadha and Bhattacharjee, 1995). Plants often respond to changes in photoperiod and temperature so that they naturally flower when environmental conditions are favorable for reproduction. Once flower buds have initiated, flower development time is dependent upon genotype and temperature (Lopez and Runkle, 2004).

2.3.1 Genetic Factors

Striking variations in growth and flowering of different genera and species have been observed are attributed to their genetic make up (Withner, 1959). Several tropical

lowland species are free flowering and produce flowers throughout the year (Goh, 1984).

Plants of the same species may flower at different times of the year in different countries or different localities in the same country. Among the tropical lowland species, many show peak flowering period even if they flower throughout the year (Goh and Arditti, 1985). Orchids growing in tropical lowlands showed greater phonological uniformity throughout the year than those at higher altitudes (Godinez, 1996).

The intricate and varied mechanisms associated with the flowering of orchids (induction, development, and gregariousness) may appear as frivolous "antics" of nature. This is not the case, however, because the underlying theme is survival of species. The "antics" are actually mechanisms that bring about flower production during appropriate periods and synchronize flowering with the attraction of pollinators, all of which ensures seed production (Goh *et al.*, 1981).

Many *Aranda* hybrids exhibit a flowering gradient. Flowering gradient has also been observed in other monopodial orchids such as *Holttumara* Maggie Mason and *Aranthea* James Storie (Goh and Seetoh, 1973). In nature the majority of orchid species flower only once a year. The flowering time may vary according to species and the climatic conditions of the area occupied by the species. Peak flowering season is August for common epiphytic orchids and June to September for terrestrial orchids (Lokesha and Vasudeva, 1993). Flowering among epiphytic orchids peaked during the dry season and early rainy season and decreased with increase in rainfall (Godinez, 1996). The occurrence of flowering gradient in monopodial orchids appears to be widespread. However, flowering gradient in monopodial orchids is not unique, as the same has been reported in other plants as well (Yong and Hew, 2004).

Triploidy invariably produces floriferousness. Triploid hybrid *Vanda* Josephine Van Brero is a continuous bloomer. Tetraploids tend to be seasonal, with the exception of Arachnis Maggie Oei, 'red ribbon' which is free flowering (Soon, 1980).

2.3.2 Growing media

A good growing media should support the plants, supply water, nutrients to the roots and provide good drainage and aeration. The type of medium will vary according to the habit of the orchids. The media suitable for growing epiphytic orchids should hold moisture but not remain soggy and wet. The media to grow epiphytic orchids like *Vanda, Dendrobium, Oncidium, Cattleya, Phalaenopsis, etc* are mainly charcoal, coconut husk, fern fibre and brick pieces, sphagnum moss can be used to hold moisture in summer months (Bose *et al.*, 1999).

2.3.3 Nutrition

Scientifically, the nutrient stress theories have little or no merit because nutrient levels do not drastically fluctuate in natural environments from one season to the other (Atherton, 1987). In nature, orchids obtain their supply of inorganic nutrients like calcium, magnesium, iron, potassium, nitrogen and traces of manganese, boron, copper, zinc etc from the tree on which they are growing and also from the atmosphere and decaying vegetables and dropping of birds.

Aerides multiflorum grew best and produced maximum number of long floral spikes when fertilized every two weeks with 1000 ppm each of nitrogen, phosphorus and potassium. This treatment also increased the flower size (Yadav and Bose, 1986). Like other plants, the growth and flowering in orchids are markedly improved by proper supply of nutrients in liquid form (Bose *et al.*, 1999).

2.3.4 Growth substances

Exogenous application of growth regulators induces or promotes, prevents or delays flowering in orchids. According Bose *et al.* (1999) lower levels of auxin generally promoted flowering while increased level inhibited it.

In *Vanda* Miss Joaquim high flower yield was directly related to the amount of sunlight received by the plants and it was invariably related to the level of auxins in the

tissues (Goh and Wan, 1973). Anti-auxins and growth retardants were found effective in stimulating flowering in *Aranda* (Goh, 1977)

2.3.5 Aeration

Most of the commonly cultivated species are epiphytic; free circulation of fresh air is essential. Many tropical orchids like *Vanda, Phalaenopsis, Aerides* etc with aerial roots were found to grow well when exposed to current of fresh air (Bose *et al.*, 1999). They do best when grown in baskets kept hanging from the beams of the greenhouse or lath house (Mukherjee, 2002).

2.3.6 Irrigation

Orchids usually are epiphytes or lithophytes and attach their roots to the surface. When it rains, water runs off freely and quickly past their roots and leaves. Therefore orchids prefer to be drenched with water that runs quickly through the pot, rather than light application of water (White, 1996). Majority of the commercial growers employ some form of overhead watering in their greenhouse. The frequency of watering depends on several factors such as climatic conditions, type of growing medium, type and size of container, growth habit of orchid etc (Bose *et al.*, 1999).

Increased watering can prevent possible dehydration and burning when temperatures reach the higher levels. According to Yoneda *et al.* (1992) various irrigation methods influenced the growth and inflorescence emergence in *Phalaenopsis* and *Doritaenopsis*.

2.3.7 Climate

Vegetative structure of an orchid plant is modified according to the diversified habit of growth, which has close relation with the climate. The majority of Orchids occurring in temperate climates are terrestrial while those in tropical regions are found frequently on trees or rocks (Bose *et al.*, 1999). Majority of the orchids under cultivation are native to the tropical countries. The area covered by the zone between

30°N and 30°S latitudes includes the home of practically all the orchids of horticultural interest (Mukherjee, 2002).

2.3.7.1 Temperature

Depending upon their preference for a particular range of temperature, the cultivated species are categorized as cool, intermediate and warm types. Low temperature requirements for flower induction have been documented in tropical orchids (Kronenberg, 1976). For many orchids, temperature variation has a decidedly more pronounced effect than day length on flowering. Chilling is necessary for the flowering of many orchids whose natural habitats are more than 500 meters above sea level. *Ascocentrum curvifolium*, *Ascocentrum ampullaceum*, *Vanda coerulae*, *Rhynchostylis gigantean, Vandopsis parishi, Phalaenopsis lindenii* and *Phalaenopsis schillerana* are examples of the beautiful monopodial orchids, which require cool night temperature to flower (Soon, 1980).

Temperature influences not only proper vegetative growth, but also production of flowers in quite a good number of species. Under natural conditions, for optimum growth and flowering, the night temperature should decidedly be lower than the day temperature, preferably by a margin of 10°F. Even though various species of orchids vary in their individual requirement of optimum temperature, generally orchids thrive in a day temperature varying between 60°F to 70°F and a night temperature of 55°F to 60°F (Abraham and Vatsala, 1981).

For many orchids, temperature has more pronounced effect than day length on flowering. In California night temperature of 13° C are employed to stimulate flowering in *Phalaenopsis* while in Florida a night temperature of 18° C is adequate. In Singapore night temperature does not fall below 20°C and even during the cool season night temperature are around 21°C. *Phalaenopsis* does flower fairly well in Singapore although admittedly not to the same degree as in Florida and California (Soon, 1980).

Phalaenopsis requires a period of exposure to relatively moderate temperature (<26°) to trigger the initiation of the inflorescence, or spiking (Sakanishi *et al.*, 1980; Lee and Lin, 1984; Yoneda *et al.*, 1992; Wang, 1995). *Phalaenopsis* orchids remain vegetative above 27°C to 29°C and can tolerate temperature as high as 32°C to 35°C for short periods before exhibiting signs of heat stress (Baker and Baker, 1991). The inhibition of flowering when the day temperature was 29°C and the night temperature was 17°C or 23°C suggests that a warm day temperature inhibits flower initiation in *Phalaenopsis* (Blanchard and Runkle, 2005).

Temperature has little or no effect on spike length or flower size (Robinson, 2002).

2.3.7.2 Rainfall

Orchids bloom throughout the year, but each species has its own season. In West Africa, Sanford (1971) finds that most orchid species flower during the rainy season, especially during the early and mid rainy season. Johannson (1974) finds a similar pattern, with two flowering peaks in the rainy season. Much of the literature gives the impression that there is no season in the tropics. Outside the tropics, seasonality is imposed primarily by cold. Within the tropics, on the other hand, seasonality is primarily due to variation in rainfall (Dressler, 1981).

2.3.7.3 Relative Humidity

Humid warm atmosphere is most essential for the growth of most of the tropical orchids, which do not have well established root system.

Orchids in general prefer high humidity for their growth and flowering. Monopodial types like *Vanda*, *Phalaenopsis* etc require high humidity (70-75 per cent) than sympodial types like *Cattleya*, *Laelia* etc requiring 40-55 per cent (Quyu,1959). In the wild, the majority of orchids flourish in regions of perpetual mist (Abraham and Vatsala, 1981)

2.3.7.4 Light intensity

Light intensity affects both the growth and flowering of tropical orchids. There is a minimum light energy required not only for proper growth but also for flowering. However, many tropical monopodials, particularly members of the *Vanda –Arachnis* tribe (Sarcantheae-Vandinae) require extended periods of full sun for flowering. If this requirement is not met, plants continue vigorous vegetative growth but seldom flower (Soon, 1980). Many species of *Arachnis, Ascocentrum, Renanthera* and *Vanda* require full sun for free flowering and any shading delay or suppress the flowering process. Many of their hybrids, such as *Aranda* and *Aranthera* are known to behave in the same manner (Soon, 1980).

The optimum light requirement varies in different genera. *Arachnis*, *Cattleya*, *Oncidium*, most species of *Dendrobium* and *Vanda* grow and flower well at a light intensity ranging from 2400 to 3600 foot candle, *Cymbidium* prefers high light intensity. The optimum requirement of light for *Paphiopedilium* varies between 1800 and 2400 foot candles while *Phalaenopsis* shows satisfactory growth and flowering at 1500 foot candle light intensity (Sheehan and Sheehan, 1979).

In *Aranda* cv. Wendy Scott, plants, which received only 3 hours of direct sunlight, remained vegetative, whereas those exposed to full sun for 8 hours produced inflorescences regularly. When the former were transferred to 8 hours of direct sun, all plants produced floral buds in 7 to 10 days. These buds continued to develop to mature inflorescences (Goh *et al.*, 1981). Shade loving orchids, such as, *Dendrobium*, *Oncidium* and *Phalaenopsis* do not tolerate direct exposure to tropical full sun and they would be scorched within hours if exposed to the strong mid-day sun directly (Bose *et al.*, 1999). Plants of some species of *Vanda* and *Bulbophyllum* naturally adapted to shade conditions had smaller leaf areas, thinner leaves, cuticles and palisade layers and lower concentrations of total starch, soluble sugars, proteins, amino acids and lipids than those naturally adapted to sunny conditions (Radha *et al.*, 1994).

2.3.7.5 Photoperiodism

Changes in day length are often the cue for flowering. According to Sanford (1974) tropical plants of equatorial origin are believed to be more sensitive to small differences in day length than those from temperate regions. Such sensitivity would confer on evolutionary advantage since the day length differences are less pronounced in the tropics. However, tropical orchid hybrids like a few species of *Arachnis*, *Vanda*, *Aranda*, etc are all day neutral plants and are indifferent to day length.

Some tropical orchid hybrids like *Arachnis* cv. Maggie Oei, *Aranda* cv. Deborah, *Aranda* cv. Wendy Scott, and *Vanda* cv. Miss Joaquim as well as *Dendrobium* hybrids are indifferent to day length (Byramji and Goh, 1976). Bose and Mukhopadhyay (1977) studied the effects of day length on flowering of some tropical orchids and recorded early flowering (42-49 days earlier than plants kept in long days) in *Aerides multiflorum*, *Renanthera imschootiana*, and *Rhynchostylis retusa* by short day (9-hr light) treatment.

According to Sessler (1978), well developed, firm, long lasting flowers with strong stems indicated that the light had been adequate throughout the growing period for orchids. Most hybrid orchids, which grow in the tropical lowlands, appear to be uninfluenced by day length and thus probably day neutral plants (Soon, 1980). A number of tropical Orchid species are known to be short day (long night) plants, but other factors, such as temperature may also stimulate flowering (Dressler, 1981). A few studies reported that short days enhance spiking and spike length, and long days promote vegetative growth and development of aerial plantlets in *Phalaenopsis* (Griesbach, 1985; Yoneda *et al.*, 1991). Flowering in certain species of *Dendrobium* and *Phalaenopsis* was also hastened by 47 days to 59 days under short day (8 hr light) treatments The flower spike length and number of flowers per spike however have been observed to increase by long day (16 hr) treatments (Bhattacharjee, 1995).

Commercially important tropical orchids for cut flower production such as *Aranda, Dendrobium, Mokara, Oncidium* are all day neutral plants and are indifferent to day length (Yong and Hew, 2004).

2.4 HARVESTING AND MARKETING

In an orchid flower, visual impact is the result of the interplay of the following characteristics: brightness; intensity; clearness and contrast of colour with distinct colour patters; outstanding form, including elements such as balance, roundness or fullness, flatness, novelty; unusual texture; graceful arrangement of the florets on the stem; exceptional size, substance and floriferousness. Quality is the combination of all these desirable attributes in a single orchid (Soon, 1980)

Colour must be bright, clear and intense. Rarity is prized, e.g. albino forms and two tones. When more than one colour is present in a significant amount, the colours must harmonize. If patterns are present on the petals and sepals, such as tessellations, spotting or striping, they should be distinct.

With regard to form and shape, the key words are balance, roundness, fullness and flatness. The horn shaped *Dendrobium*, the Scorpion Orchids and the flaming *Renanthera* are admired for their peculiar shapes which are not round; balance is the important criteria here, and 'fullness' is expressed in broader sepals and petals. In *Vanda, Ascocentrum, Phalaenopsis, Dendrobium , Cymbidium*, and *Paphiopedilum* one would like to see roundness, fullness and flatness. The floral segments should overlap so that there are no gaps between the sepals and petals. The tips of the sepal and petals, or the lip as in *Oncidium papilio*, should be rounded (Soon, 1980).

The stem characteristics of importance are the habit (whether erect, arching, pendulous and if branching whether well fanned out), length, stoutness, the arrangement of the flowers on the stem and floriferousness. In the case of Orchid species, erect, arching and pendulous inflorescences are all acceptable, but in orchid hybrids, the erect and the arching inflorescence are preferred to the pendulous inflorescence. The rachis should be straight, not zigzag or twisted.

When the rachis is branched, the side branches should be held away from the main rachis so that the flowers are well displayed and not bunched together. A tall, stout

erect stem is preferred to the short stem and the slim erect stem because it will present the flowers more attractively above the growing tip of the plant.

The flowers should be well arranged, either in two rows of alternating flowers facing opposite directions or in a circular whorl around the stem, facing all directions. The flowers should not be crowded together on one side and sparse on the other. The flowers in a row should be touching or just overlapping so that there are neither wide gaps between the flowers nor overcrowding to the extent that the individual shapes of flowers canot be easily discerned. It is better to have gaps than to have flowers too bunched together (Soon, 1980).

The correct stage of harvest not only influences the keeping quality but also adds to the attraction of the spikes. If a long spike of *Dendrobium* is harvested retaining two three buds, it adds charm to the spike. This also applies to other orchids which produce long spikes like *Aranda*, *Arachnis* etc. The harvested spikes are tied in bundles of five or ten before packing in the carton. A lining with newspaper is provided inside the carton and shredded papers are used between bunch and carton ton prevent movement of spikes during transits. The flowers are generally transported by air (Rajeevan, 2006).

According to Gajanana (2006), there are two main channels for marketing orchids i.e. sale to local buyers and sale to distant markets in Mumbai, Delhi, Kolkotta, Baroda, Bangalore etc. He observed that about 69 per cent of the growers marketed orchids to local buyers and remaining 31 per cent to distant markets. The orchid cut flower business has become a highly developed trade, both for local markets and for export. However, our position in trade, both for local market and for export market is low as compared to South East Asian countries like Thailand, Singapore and Malaysia where orchid growing has become a multi-million industry.

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Evaluation of monopodial orchids for cut flower" was carried out in the orchidarium of the All India Co-ordinated Floriculture Improvement Project in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara from December 2005 to December 2006. The materials used and methodology adopted for the investigation is dealt with in this chapter.

3.1 LOCATION

Vellanikkara is situated at a latitude of 10°31' N and longitude of 76°13' E. The area lies 22.25m above MSL.

3.2 CLIMATE

The site enjoyed a humid tropical climate with maximum temperature varying from 29.5°C to 34.8°C and the minimum temperature from 22.1°C to 24.7°C during the period of investigation. The mean relative humidity varied from 31 per cent to 76 per cent. The total rainfall recorded during the period of investigation was 3463.7 mm.

The weather parameters recorded during the period are presented in Appendix 1.

3.3 FIELD EVALUATION OF MONOPODIAL VARIETIES/ HYBRIDS

3.3.1 Materials

Forty monopodial orchid varieties/hybrids of monogeneric, bigeneric and trigeneric origin were grown under appropriate conditions to evaluate their field performance. They include tall climbing orchids, intermediate climbing epiphytes and short-stemmed epiphytes. List of selected varieties/hybrids are given in Table 1.

Table 1. Monopodial orchid varieties/hybrids selected for evaluation

	Monogeneric origin
1	*Arachnis* Maggie Oei Red Ribbon
2	*Arachnis* Maggie Oei Yellow Ribbon
3	*Vanda* Prolific
4	*Vanda* John Club
5	*Vanda* Poepoe Diana
6	*Vanda* Mandai Glow
7	*Renanthera* Manila
8	*Renanthera* Cape Sabel
9	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon
10	*Phalaenopsis* Diana Pink
11	*Phalaenopsis* Hwafeng Red Jewel
12	*Phalaenopsis* Mount Lip
13	*Phalaenopsis* Taipei Gold
14	*Phalaenopsis* Ho's Happy Auckland
15	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory)
16	*Phalaenopsis* Memoria Grand Mother
	Bigeneric origin
17	*Aranda* Deborah
18	*Aranda* Majula
19	*Aranthera* Anne Black
20	*Aranthera* Lily Brook Red
21	*Aranthera* Mana Meina
22	*Renantanda* Mandai Glow
23	*Aeridachnis* Apple Blossom
24	*Ascocenda* Princess Mikasa Pink
25	*Ascocenda* Raminder Gold x Fortune East
26	*Vanda* Josephine Van Brero x *Ascocenda* Yip Sum Wah
	Trigeneric origin
27	*Vascostylis* Pine Rivers Red
28	*Vascostylis* Pine Rivers Pink
29	*Vascostylis* Pine Rivers Blue
30	*Mokara* Bangkok Gold
31	*Mokara* Sayan x *Ascocenda* Meda Arnold
32	*Mokara* Chark Kuan Pink
33	*Mokara* Calypso Pink
34	*Mokara* Walter Oumae White
35	*Mokara* Sayan x Kultana Gold
36	*Mokara* Dinah Shore
37	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai
38	*Mokara* Walter Oumae Yellow
39	*Holttumara* Bright Eye
40	*Holttumara* Emperor Hirohito

Number of Varieties/hybrids – 40

1. Monogeneric origin

Phalaenopsis –8

Arachnis -2

Vanda -4

Renanthera -2

2. Bigeneric origin

Aranda (*Arachnis* x *Vanda*) -2

Aranthera (*Arachnis* x *Renanthera*) -3

Ascocenda (*Ascocentrum* x *Vanda*) –3

Aeridachnis (*Aerides* x *Arachnis*)-1

Renantanda (*Renanthera x Vanda*) -1

3. Trigeneric origin

Mokara (*Arachnis* x *Ascocentrum* x *Vanda*)-9

Vascostylis (*Vanda* x *Ascocentrum* x *Rhyncostylis*)-3

Holttumara (*Arachnis* x *Renanthera* x *Vanda*)-2

3.3.2 Shade

Monopodial orchids were grown in shade house (21m x 6m) providing 25 per cent shade, which was found to be the best for their growth.

3.3.3 Media

The tall climbing plants like *Vanda*, *Arachnis*, *Renanthera*, *Aerides* and their hybrids were grown in beds made of coconut husk, broken tiles and brick pieces. Monopodials in the category of *Mokara*, *Vacostylis*, *Ascocenda*, etc were grown in perforated pots and arranged on benches or hung in hardwood baskets. The plants in the genus *Phalaenopsis* were grown in coconut husk or tilted pots to allow the leaves to hang.

3.3.4 General management

The tall climbing orchids were supported by horizontal wire stretched between occasional upright supports. Poles/stakes were also provided for pot grown plants, as support to a height of one meter.

The plants were watered twice a day to provide plenty of moisture, but with plenty of good drainage and aeration for the roots.

Foliar application of N: P: K 13:27:27 at 0.3 per cent (3 g/l) concentration was given at weekly interval. Need based application of plant protection chemicals was also carried out.

3.3.5 Design of the experiment

A completely randomized block design with three replications was laid out.

3.3.6 Observations

In each variety/hybrid three plants were used for recording biometric observations.

3.3.6.1 Quantitative Characters

A. PLANT CHARACTERS

1. Height

The height of the plant was measured from the base to the growing apex at monthly intervals and expressed in centimeter. The increase in height was recorded at monthly intervals.

2. Spread

The spread was measured in the north south and east west directions in short stemmed epiphytes like *Phalaenopsis*. This was expressed in centimetre as area occupied by a plant.

3. Shoot girth

Girth of shoot was measured at 20 cms below the apex for tall climbing orchids and intermediate climbing epiphytes and at base for short stemmed epiphytes and expressed in centimetre.

4. Internodal length

The internodal length was measured 20 cms below the growing tip for tall and intermediate climbing epiphytes and expressed in centimeter.

5. Number of leaves

The total number of leaves present on the plant was counted and recorded in intermediate climbing epiphytes and short-stemmed epiphytes and leaves present per metre was recorded in tall climbing epiphytes.

6. Leaf length

Length of the leaf was measured from base to the tip and expressed in centimetre.

7. Leaf breadth

The maximum width of the leaf towards the centre was measured and expressed in centimetre.

8. Leaf area

Dot method (Bleasdale, 1973) was used to measure the leaf area and the same was expressed in square centimetre.

9. Interval of leaf production

The interval between the production of two successive leaves was taken as the interval of leaf production and expressed in days.

10. Angle of orientation:

Angle of orientation of leaf with reference to the shoot was taken and recorded in degrees.

11. Leaf sheath length

The length of the sheath from the point of attachment to the shoot to the leaf lamina was measured in centimetre and recorded as sheath length.

12. Leaf sheath width

The width at the middle portion of the leaf sheath was measured in centimetre as sheath width.

13. Number of aerial roots

Number of aerial roots present per metre length was counted and recorded in tall climbing orchids and on the entire plant in intermediate climbing epiphytes and short-stemmed epiphytes.

14. Length of aerial roots

Length of the root was measured from the base to the tip and expressed in centimetre.

15. Girth of aerial roots

Girth of the root at the base was measured and expressed in centimetre.

B. FLORAL CHARACTERS

The following flower characters were observed and recorded during the period of study.

1. Days from spike emergence to opening of first floret

Time taken for the opening of first floret after spike emergence was recorded in days.

2. Days from spike emergence to harvest

Time taken for opening of fifty per cent of the flowers after spike emergence was recorded in days.

3. Days from spike emergence to complete opening of florets

Time taken for complete (100%) opening of all the florets on the spike was recorded in days.

4. *Days taken from opening of first floret to wilting of first floret*

Time taken from the opening of first flower to wilting of first flower was recorded in days.

5. Longevity of spike on the plant

Longevity was measured from the day the spike becomes suitable for use as cut flower (opening of the first floret to wilting of last floret).

6. Interval of spike production

The interval between the production of two consecutive spikes was recorded in days.

7. Number of spikes produced per year

Number of spikes produced on each plant was noted and number of spikes per plant per year in each variety/hybrid was estimated.

8. Blooming period

Flowering period/blooming time in each variety/hybrid was observed throughout the year and recorded as the blooming period for that particular variety/hybrid.

9. Length of spike

The total length of the spike in each plant was recorded in centimetre.

10. Length of rachis

The length of flowering area (rachis)/spike in each plant was recorded in centimetre and mean value was worked out.

11. Length of flower stalk

The length of flower stalk in each plant was recorded in centimetre.

12. 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.

13. Number of florets per spike

The number of florets per spike in each plant was recorded and the mean values were expressed as the number of florets per spike.

14. Internodal length (between florets)

Length between first florets at the base and last florets at the tip of the spike were recorded and average expressed in centimeter.

15. Size of floret

Size of individual floret was recorded as the product of length (vertically) and width (across) of the flower and expressed in centimetre.

16. Life of individual floret on the spike

Life of individual floret on the spike was measured for four florets per spike from the day the floret opens to the day it wilts and the mean values were expressed.

3.3.6.2 Qualitative Characters

A. PLANT CHARACTERS

1. Nature of growth	-	tall climbing epiphytes, intermediate climbing epiphytes, short stemmed epiphytes, fast/slow growing
2. Nature of shoot	-	stout, covered by persistent leaf sheath
3. Shoot colour	-	green, yellow, brown
4. Branching of shoot	-	present, absent
5. Nature of aerial roots	-	cylindrical, thread like, thick / shrivelled / creeping/ robust and flattened
6. Branching of aerial roots	-	present/ absent
7. Colour of aerial roots	-	grey, green, white

B. LEAF CHARACTERS

1. Shape	-	linear, lanceolate, elliptic, cordate, oblanceolate, obovate, ovate, terete, semi-terete, quarter-terete, falcate, conduplicate, oblanceolate, strap shaped, oblong, straight
2. Texture	-	smooth, verucose, rigid, leathery, glabrous, cereous, pubescent, fleshy
3. Margin	-	entire, wavy, serrate, coriaceous.

4. Tip	-	equally bilobed, unequally bilobed, acuminate, acute, emarginate, cuspidate, obtuse
5. Leaf base	-	cunate, truncate, acute, sheathed, keeled, sessile
6. Leaf colour	-	green, dark green, dark green with reddish purple underneath
7. Markings	-	present/absent.
8. Venation	-	single, more veined
9. Pigmentation	-	colour change during maturity
10. Arrangement	-	distichous, spiral, alternate, clustered at base
11. Nature of sheath	-	membranous, nerved or not
12. Colour of sheath	-	green, dark green
13. Other characters	-	deeply channelled, channelled at apex, channel not prominent, channelled at the base

C. FLORAL CHARACTERS

1. Inflorescence	-	simple/branched, bracteate/non bracteate, stout/slender, terminal/axillary/pendulous, straight/arching
2. Branching	-	present/absent, if branching whether well fanned out
3. Arrangement of florets on spike	-	distichous, spiral, alternate
4. Nature of rachis	-	straight, zig-zag or twisted
5. Flower	-	roundness, fullness, flatness, colour of petals, sepals, labellum
6. Nature of labellum	-	size, shape, colour- bicouloured, striped or speckled with spots
7. Pigmentation	-	colour change during maturity
8. Nature of blooming	-	seasonal, year round, with dearth periods
9. Fragrance	-	present/absent

Floral characters, both quantitative and qualitative contributed towards their use as cut flower/ potted plants. Other general characters of the plant such as branching habit, incidence of pests, diseases and disorders were also recorded.

3.3.6.3 Visual evaluation

The spikes of different monopodial orchid varieties/hybrids were visually scored for use as cut flower and their general acceptability was observed. Scoring was done based on flower colour and pigmentation, shape, size, arrangement of florets on spike and texture.

3.4 STATISTICAL ANALYSIS:

The data from the study was subjected to analysis of variance suggested by Panse and Sukhatme (1985). Treatment means were compared using DMRT wherever necessary. SPSS software was made use.

Results

4. RESULTS

Studies were conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, during 2005-2006 to evaluate the performance of forty varieties/ hybrids of monopodial orchids.

The selected varieties/ hybrids of monopodial orchids could be grouped into three based on the type of growth and are given in Table 2. The cultivation regimes also vary with the type of growth.

1. Tall climbing orchids
2. Intermediate climbing epiphytes.
3. Short stemmed epiphytes.

Tall Climbing Orchids

These orchids are tall climbing plants, which flower only at a metre or more. They retain the classic "Climbing Orchids" pattern of growth, with tall stems reaching two or more meters. They require stakes or posts as supports, or else they can be supported by horizontal bars/wire stretched between occasional upright supports.

Intermediate Climbing Epiphytes

These plants are intermediate between tall climbing and short-stemmed epiphytes, which flower below one meter. They are grown as individual pot plants in coarse brick and charcoal mixture in perforated pots on benches, or hung in hardwood baskets with little or no media.

Short Stemmed Epiphytes

These plants have a few large fleshy leaves on either sides of the short stem. These plants are shade loving and like a good deal of moisture. They are grown in tilted pots / coconut husk pieces to allow the leaves to hang down. This also allows water to drain off the crown, reducing the chances of crown rot.

Table 2. Classification of monopodial orchid varieties/ hybrids based on nature of growth

i)	**Tall climbing orchids**
1	*Arachnis* Maggie Oei Red Ribbon
2	*Arachnis* Maggie Oei Yellow Ribbon
3	*Vanda* Prolific
4	*Vanda* John Club
5	*Vanda* Poepoe Diana
6	*Vanda* Mandai Glow
7	*Renantanda* Mandai Glow
8	*Renanthera* Manila
9	*Renanthera* Cape Sabel
10	*Aranthera* Anne Black
11	*Aranthera* Lily Brook Red
12	*Aranthera* Mana Meina
13	*Aranda* Deborah
14	*Aranda* Majula
15	*Aeridachnis* Apple Blossom
16	*Holttumara* Bright Eye
17	*Holttumara* Emperor Hirohito
ii)	**Intermediate climbing epiphytes**
18	*Vanda* JVB x *Ascocenda* Yip Sum Wah
19	*Ascocenda* Princess Mikasa Pink
20	*Ascococenda* Raminder Gold x Fortune East
21	*Vascostylis* Pine Rivers Red
22	*Vascostylis* Pine Rivers Pink
23	*Vascostylis* Pine Rivers Blue
24	*Mokara* Walter Oumae Yellow
25	*Mokara* Bangkok Gold
26	*Mokara* Sayan x *Ascocenda* Meda Arnold
27	*Mokara* Chark Kuan Pink
28	*Mokara* Calypso Pink
29	*Mokara* Walter Oumae White
30	*Mokara* Sayan x Kultana Gold
31	*Mokara* Dinah Shore
32	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai
iii)	**Short-stemmed epiphytes**
33	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon
34	*Phalaenopsis* Diana Pink
35	*Phalaenopsis* Hwafeng Red Jewel
36	*Phalaenopsis* Mount Lip
37	*Phalaenopsis* Taipei gold
38	*Phalaenopsis* Ho's Happy Auckland
39	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* Miami Sunrise x Tiny Ivory)
40	*Phalaenopsis* Memoria Grand Mother

4.1 QUANTITATIVE CHARACTERS

4.1.1 Plant Characters

4.1.1.1 Plant height

Data on the plant height during the period of study (December 2005 to December 2006) are presented in Tables 3, 4 and 5.

Tall climbing orchids differed significantly with respect to increase in height throughout the period of study (Table 3). Maximum increase in height was recorded in *Arachnis* Maggie Oei Red Ribbon (164.52 cm) followed by *Arachnis* Maggie Oei Yellow Ribbon (152.93 cm) and *Renanthera* Manila (140.33 cm). *Aeridachnis* Apple Blossom recorded the minimum growth of 20.90 cm during the period of study.

Among the intermediate climbing epiphytes, *Mokara* Sayan x Kultana Gold recorded the maximum increase in height during all the months and attained a height of 36.75 cm at the end of the period of study. *Mokara* Walter Oumae White (24.20 cm) followed it. Minimum increase in plant height (1.33 cm) was observed in *Mokara* Bangkok Gold (Table 4).

Appreciable differences were observed in the plant height of short-stemmed epiphytes (Table 5). *Phalaenopsis* Memoria Grand Mother and *Phalaenopsis* Diana Pink recorded the maximum plant height (5.20 cm) and was on par with all other varieties/ hybrids except *Phalaenopsis* Ho's Happy Auckland and *Phalaenopsis* Hwafeng Red Jewel (2.90 cm). *Phalaenopsis* Diana Pink recorded the maximum increase in height (4.70 to 5.20 cm) while *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon the minimum (4.40 to 4.53 cm).

4.1.1.2 Shoot Characters

Data pertaining to shoot characters of different monopodial orchid varieties/ hybrids are presented in Tables 6 - 8.

Table 3. Increase in plant height in tall climbing monopodial orchids during the period of observation

Sl. No	Varieties/ Hybrids	Increase in plant height (cm)											
		Jan' 06	Feb '06	Mar '06	Apr' 06	May' 06	June' 06	July' 06	Aug' 06	Sept' 06	Oct' 06	Nov' 06	Dec' 06
1	*Arachnis* Maggie Oei Red Ribbon	13.00^{a}	26.80^{a}	39.80^{a}	52.87^{a}	66.27^{a}	80.10^{a}	94.10^{a}	108.63^{a}	123.60^{a}	137.17^{a}	150.81^{a}	164.52^{a}
2	*Arachnis* Maggie Oei Yellow Ribbon	12.40^{ab}	25.37^{ab}	37.70^{ab}	51.13^{ab}	63.77^{ab}	76.00^{ab}	88.40^{ab}	101.47^{ab}	114.10^{ab}	127.17^{ab}	140.27^{ab}	152.93^{ab}
3	*Vanda* Prolific	3.37^{efg}	7.30^{defg}	10.63^{efg}	14.13^{efg}	17.37^{efg}	21.37^{fg}	25.20^{efgh}	29.03^{efg}	33.13^{efg}	37.43^{efg}	41.70^{efgh}	45.70^{efgh}
4	*Vanda* John Club	8.27^{e}	16.40^{e}	25.10^{e}	33.53^{e}	42.00^{e}	50.66^{e}	59.27^{e}	68.33^{e}	77.17^{e}	85.77^{e}	94.07^{e}	102.47^{e}
5	*Vanda* Poepoe Diana	8.00^{e}	15.30^{e}	26.00^{e}	32.50^{e}	41.60^{e}	50.00^{e}	58.37^{e}	68.00^{e}	76.07^{e}	85.08^{e}	93.00^{e}	101.07^{e}
6	*Vanda* Mandai Glow	3.05^{fgh}	6.10^{efgh}	9.05^{fghi}	12.05^{efgh}	15.00^{fgh}	18.00^{fghi}	21.00^{ghi}	24.25^{fgh}	27.45^{fgh}	30.75^{fgh}	34.05^{fghi}	37.05^{fghi}
7	*Renantanda* Mandai Glow	2.20^{fg}	4.30^{gh}	6.50^{hi}	8.70^{h}	10.90^{gh}	13.10^{hi}	15.40^{hi}	17.60^{gh}	19.90^{gh}	22.2^{gh}	24.40^{hi}	26.60^{hi}
8	*Renanthera* Manila	11.27^{b}	22.63^{b}	34.40^{b}	45.67^{b}	57.63^{b}	69.67^{b}	87.03^{b}	92.40^{b}	105.00^{b}	117.53^{b}	129.03^{b}	140.33^{b}
9	*Renanthera* Cape sabel	3.73^{ef}	7.63^{def}	11.67^{defg}	15.40^{def}	19.47^{def}	23.33^{efg}	27.50^{def}	31.93^{def}	36.00^{def}	39.80^{ef}	43.70^{efg}	47.30^{efg}
10	*Aranthera* Anne Black	5.40^{d}	10.57^{d}	15.93^{d}	21.50^{d}	26.63^{d}	32.90^{d}	38.47^{d}	44.33^{d}	50.13^{d}	56.33^{d}	61.90^{d}	67.43^{d}
11	*Aranthera* Lily Brook Red	3.37^{efg}	6.7^{efg}	10.13^{fgh}	13.50^{efg}	16.87^{efg}	20.27^{fgh}	23.87^{fgh}	27.43^{fg}	30.90^{fg}	34.20^{fg}	37.53^{fgh}	41.10^{fgh}
12	*Aranthera* Mana Meina	3.00^{fgh}	5.87^{efgh}	8.87^{fghi}	11.93^{fgh}	14.97^{fgh}	18.00^{fghi}	21.00^{ghi}	24.27^{fgh}	27.37^{fgh}	30.63^{fgh}	32.83^{ghi}	35.87^{ghi}
13	*Aranda* Deborah	4.50^{de}	9.03^{de}	13.53^{def}	18.33^{de}	22.97^{de}	27.47^{fgh}	32.50^{def}	37.10^{ef}	41.73^{def}	46.33^{def}	50.97^{def}	55.70^{def}
14	*Aranda* Majula	5.20^{d}	10.40^{d}	15.40^{de}	20.50^{d}	25.60^{d}	30.80^{de}	36.00^{de}	41.40^{de}	47.00^{de}	52.40^{de}	58.00^{de}	63.10^{de}
15	*Aeridachnis* Apple Blossom	1.67^{h}	3.33^{a}	4.9^{i}	6.27^{h}	7.90^{h}	9.80^{i}	11.70^{i}	13.53^{h}	15.33^{h}	17.20^{h}	19.13^{i}	20.90^{i}
16	*Holttumara* Bright Eye	2.80^{fgh}	5.65^{fgh}	8.40^{ghi}	11.30^{fgh}	14.20^{fgh}	17.40^{ghi}	20.60^{ghi}	23.80^{fgh}	27.00^{fgh}	30.10^{fgh}	33.53^{fgh}	36.10^{ghi}
17	*Holttumara* Emperor Hirohito	4.15^{def}	8.45^{def}	11.67^{defg}	16.45^{def}	20.70^{def}	24.70^{defg}	28.80^{defg}	33.30^{def}	37.80^{def}	42.35^{def}	46.70^{defg}	50.85^{defg}

* Plants were cut at a height of 1m in December '05

Table 4. Increase in plant height in intermediate climbing monopodial orchids during the period of observation

Sl. No	Varieties/ Hybrids	Increase (cm)												
		Initial height (cm)	Jan' 06	Feb '06	Mar '06	Apr' 06	May' 06	June' 06	July' 06	Aug' 06	Sept' 06	Oct' 06	Nov' 06	Dec' 06
1	*Vanda* Josephine Van Brero x *Ascocenda* Yip Sum Wah	17.50	0.27^{e}	0.43^{e}	0.67^{d}	1.00^{fg}	1.30^{ef}	1.63^{de}	2.03^{ef}	2.50^{de}	2.93^{de}	3.40^{de}	3.80^{de}	4.17^{de}
2	*Ascocenda* Princess Mikasa Pink	31.00	0.60^{cde}	1.10^{cde}	1.70^{cd}	2.30^{defg}	3.00^{def}	3.70^{cde}	4.40^{cdef}	5.10^{cde}	5.80^{cde}	6.70^{cde}	7.40^{cde}	8.00^{cde}
3	*Ascocenda* Raminder Gold x Fortune East	17.20	0.50^{cde}	1.00^{cde}	1.50^{cd}	2.10^{defg}	2.60^{def}	3.20^{cde}	3.90^{cdef}	4.70^{cde}	5.60^{cde}	6.30^{cde}	7.10^{cde}	7.60^{cde}
4	*Vascostylis* Pine Rivers Red	30.40	0.60^{cde}	1.20^{cde}	1.90^{cd}	2.50^{defg}	3.20^{def}	3.90^{cde}	4.60^{cdef}	5.20^{cde}	6.00^{cde}	7.00^{cde}	7.90^{cde}	8.60^{cde}
5	*Vascostylis* Pine Rivers Pink	16.00	0.50^{cde}	0.90^{cde}	1.30^{cd}	1.80^{efg}	2.30^{def}	2.80^{cde}	3.40^{def}	4.00^{cde}	4.70^{cde}	5.30^{de}	5.90^{de}	6.40^{de}
6	*Vascostylis* Pine Rivers Blue	9.80	0.30^{de}	0.60^{de}	0.80^{d}	1.10^{fg}	1.50^{ef}	1.80^{de}	2.10^{ef}	2.40^{de}	2.80^{de}	3.20^{de}	3.60^{de}	3.90^{de}
7	*Mokara* Walter Oumae Yellow	22.30	0.27^{e}	0.53^{de}	0.70^{d}	0.90^{fg}	1.10^{ef}	1.33^{de}	1.53^{ef}	1.90^{de}	2.30^{de}	2.67^{de}	3.00^{de}	3.03^{de}
8	*Mokara* Bangkok Gold	23.00	0.20^{e}	0.17^{e}	0.37^{d}	0.43^{g}	0.47^{f}	0.63^{e}	0.77^{f}	0.87^{e}	1.07^{e}	1.17^{e}	1.33^{e}	1.33^{e}
9	*Mokara* Sayan x *Ascocenda* Meda Arnold	34.10	0.40^{de}	0.55^{de}	0.65^{d}	0.95^{fg}	1.05^{ef}	1.45^{de}	2.05^{ef}	2.55^{de}	2.95^{de}	3.45^{de}	4.00^{de}	4.50^{de}
10	*Mokara* Chark Kuan Pink	64.00	1.20^{bc}	2.00^{cd}	3.10^{c}	4.20^{de}	5.23^{d}	6.50^{c}	7.87^{cd}	9.33^{c}	10.93^{c}	12.63^{c}	14.23^{c}	15.57^{c}
11	*Mokara* Calypso Pink	58.00	1.13^{bc}	2.33^{b}	3.37^{c}	4.60^{cd}	5.77^{cd}	7.03^{c}	8.33^{c}	9.60^{c}	10.93^{c}	12.30^{c}	14.07^{c}	15.30^{c}
12	*Mokara* Walter Oumae White	83.00	1.80^{b}	3.50^{b}	5.30^{b}	6.80^{bc}	8.70^{bc}	10.90^{b}	13.00^{b}	15.3^{b}	17.60^{b}	19.90^{b}	22.10^{b}	24.20^{b}
13	*Mokara* Sayan x Kultana Gold	116.00	3.05^{a}	6.00^{a}	8.95^{a}	11.75^{a}	14.80^{a}	17.85^{a}	20.90^{a}	24.10^{a}	27.25^{a}	30.15^{a}	33.50^{a}	36.75^{a}
14	*Mokara* Dinah Shore	44.00	0.87^{cd}	1.67^{cde}	2.53^{cd}	3.47^{def}	4.33^{de}	5.33^{cd}	5.90^{cde}	7.20^{cd}	8.17^{cd}	9.17^{cd}	10.20^{cd}	11.10^{cd}
15	*Mokara* Khaw Phiak Suan x *Vanda* Thananchai	81.00	1.80^{b}	3.50^{b}	5.40^{b}	7.40^{b}	9.30^{b}	11.20^{b}	13.40^{b}	15.70^{b}	17.90^{b}	19.90^{b}	22.00^{b}	23.90^{b}

Table 5. Increase in plant height in short-stemmed monopodial orchids during the period of observation

Sl. No	Varieties/ Hybrids	Plant height (cm)												
		Dec'05	Jan' 06	Feb '06	Mar '06	Apr' 06	May' 06	June' 06	July' 06	Aug' 06	Sept' 06	Oct' 06	Nov' 06	Dec' 06
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	4.40^{a}	4.40^{a}	4.40^{a}	4.40^{a}	4.40^{a}	4.40^{a}	4.47^{a}	4.47^{a}	4.50^{a}	4.53^{ab}	4.53^{ab}	4.53^{ab}	4.53^{ab}
2	*Phalaenopsis* Diana Pink	4.70^{a}	4.70^{a}	4.70^{a}	4.70^{a}	4.70^{a}	4.70^{a}	4.70^{a}	4.90^{a}	4.90^{a}	4.90^{a}	5.00^{a}	5.20^{a}	5.20^{a}
3	*Phalaenopsis* Hwafeng Red Jewel	2.55^{b}	2.55^{b}	2.55^{b}	2.55^{b}	2.55^{b}	2.55^{b}	2.55^{b}	2.55^{b}	2.65^{b}	2.65^{b}	2.85^{b}	2.85^{b}	2.90^{b}
4	*Phalaenopsis* Mount Lip	4.50^{a}	4.50^{a}	4.50^{a}	4.50^{a}	4.50^{a}	4.50^{a}	4.50^{a}	4.50^{a}	4.65^{a}	4.65^{a}	4.65^{a}	4.65^{ab}	4.65^{ab}
5	*Phalaenopsis* Taipei Gold	3.10^{b}	3.10^{b}	3.10^{b}	3.10^{b}	3.25^{b}	3.25^{b}	3.25^{b}	3.40^{b}	3.45^{b}	3.55^{b}	3.55^{abc}	3.55^{ab}	3.55^{ab}
6	*Phalaenopsis* Ho's Happy Auckland	2.50^{b}	2.50^{b}	2.50^{b}	2.50^{b}	2.50^{b}	2.50^{b}	2.50^{b}	2.50^{b}	2.50^{b}	2.50^{b}	2.70^{c}	2.85^{b}	2.90^{b}
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	4.70^{a}	4.70^{a}	4.70^{a}	4.70^{a}	4.90^{a}	4.90^{a}	4.90^{a}	5.00^{a}	5.00^{a}	5.03^{a}	5.07^{a}	5.07^{a}	5.07^{a}
8	*Phalaenopsis* Memoria Grand Mother	4.90^{a}	4.90^{a}	4.90^{a}	4.90^{a}	4.90^{a}	5.00^{a}	5.00^{a}	5.10^{a}	5.15^{a}	5.15^{a}	5.15^{a}	5.20^{a}	5.20^{a}

Girth of shoot

Significant differences were observed in shoot girth of different tall growing monopodial orchids (Table 6). *Holttumara* Bright Eye recorded maximum shoot girth (5.10 cm) and was significantly superior to others followed by *Aranda* Majula (4.50 cm). Minimum shoot girth (2.07 cm) was recorded in *Vanda* John Club and was comparable with *Vanda* Poepoe Diana (2.13 cm).

The intermediate climbing epiphytes also showed marked differences in the girth of shoot (Table 7). Shoot girth was maximum (4.70 cm) in *Ascocenda* Princess Mikasa Pink and *Mokara* Sayan x Kultana Gold and were statistically on par with *Mokara* Chark Kuan Pink (4.67 cm) and *Mokara* Sayan x *Ascocenda* Meda Arnold (4.60cm). *Mokara* Dinah Shore recorded minimum shoot girth (2.37 cm) compared to other intermediate climbing epiphytes under study.

Noticeable differences were observed in the shoot girth of different short-stemmed epiphytes (Table 8). Maximum shoot girth (5.50 cm) was recorded in *Phalaenopsis* Diana Pink and was significantly superior to all the other short-stemmed epiphytes but closely followed *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (5.13 cm). *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) was observed to have minimum girth (3.67 cm).

Internodal length

Detectable differences could be seen in the internodal lengths of different tall climbing orchids (Table 6). It was maximum (5.60 cm) in *Vanda* Prolific and differed significantly from all other varieties. Minimum internodal length (2.00 cm) was recorded in *Aranthera* Lily Brook Red followed by *Aranda* Deborah (2.30 cm).

The intermediate climbing epiphytes also showed marked difference in the internodal length (Table 7). *Mokara* Sayan x Kultana Gold recorded maximum internodal length (2.17 cm) and was significantly superior to all the others. Minimum internodal

Table 6. Shoot characters of tall climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Shoot girth (cm)	Internodal length (cm)	Nature of shoot/ cane	Shoot colour
1	*Arachnis* Maggie Oei Red Ribbon	2.97^{h}	3.23^{d}	medium sized	greenish brown
2	*Arachnis* Maggie Oei Yellow Ribbon	3.07^{gh}	3.67^{c}	medium sized	greenish brown
3	*Vanda* Prolific	3.03^{h}	5.60^{a}	medium sized	brown
4	*Vanda* John Club	2.07^{m}	5.10^{b}	slender cane	brown
5	*Vanda* Poepoe Diana	2.13^{m}	3.27^{d}	slender cane	brown
6	*Vanda* Mandai Glow	3.60^{e}	3.57^{c}	medium sized	brown
7	*Renantanda* Mandai Glow	4.20^{d}	3.20^{d}	sturdy cane	brown
8	*Renanthera* Manila	3.03^{h}	3.10^{def}	medium sized	brown
9	*Renanthera* Cape Sabel	3.30^{f}	3.03^{ef}	medium sized	brown
10	*Aranthera* Anne Black	2.63^{j}	3.17^{de}	slender cane	brown-yellow
11	*Aranthera* Lily Brook Red	2.80^{i}	2.00^{i}	medium sized	brown
12	*Aranthera* Mana Meina	3.17^{g}	3.13^{def}	medium sized	brown
13	*Aranda* Deborah	2.50^{k}	2.30^{h}	slender cane	brown
14	*Aranda* Majula	4.50^{b}	2.50^{g}	sturdy cane	brown
15	*Aeridachnis* Apple Blossom	2.30^{l}	3.10^{def}	slender cane	dark brown
16	*Holttumara* Bright Eye	5.10^{a}	2.60^{g}	sturdy cane	brown
17	*Holttumara* Emperor Hirohito	4.37^{c}	3.00^{f}	sturdy cane	brown

Table 7. Shoot characters of intermediate climbing epiphytes

Sl. No	Varietie / Hybrids	Shoot girth (cm)	Internodal length (cm)	Nature of shoot/ cane	Shoot colour
1	*Vanda* Josephine Van Brero x Ascocenda Yip Sum Wah	4.07^{e}	1.20^{d}	medium sized	brown
2	*Ascocenda* Princess Mikasa Pink	4.70^{a}	0.70^{g}	sturdy	brown
3	*Ascocenda* Raminder Gold x Fortune East	4.50^{b}	1.00^{f}	medium sized	brown
4	*Vascostylis* Pine Rivers Red	4.50^{b}	0.70^{g}	medium sized	brown
5	*Vascostylis* Pine Rivers Pink	3.60^{e}	0.40^{i}	medium sized	brown
6	*Vascostylis* Pine Rivers Blue	3.90^{d}	0.50^{h}	medium sized	brown
7	*Mokara* Walter Oumae Yellow	4.00^{cd}	0.77^{g}	medium sized	brown
8	*Mokara* Bangkok Gold	3.17^{f}	0.97^{f}	medium sized	brown
9	*Mokara* Sayanx *Ascocenda* Meda Arnold	4.60^{ab}	1.10^{e}	medium sized	brown
10	*Mokara* Chark Kuan Pink	4.67^{a}	1.50^{b}	sturdy	brown
11	*Mokara* Calypso Pink	3.57^{e}	1.20^{d}	medium sized	brown
12	*Mokara* Walter Oumae White	3.93^{d}	1.27^{cd}	medium sized	brown
13	*Mokara* Sayan x Kultana Gold	4.70^{a}	2.17^{a}	sturdy	brown
14	*Mokara* Dinah shore	2.37^{g}	1.20^{d}	slender	brown
15	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai	3.60^{e}	1.30^{c}	medium sized	brown

Table 8. Plant spread and shoot charcters of short-stemmed epiphytes

Sl. No	Varieties/ Hybrids	Plant spread		Area (cm^2)	Shoot girth (cm)	Nature of shoot
		East-West (cm)	North-South (cm)			
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	22.00	19.50	429.00^{ab}	5.13^{b}	wrapped with leaf sheath, stout, very short stem
2	*Phalaenopsis* Diana Pink	16.90	15.00	253.50^{e}	5.50^{a}	wrapped with leaf sheath, stout, very short stem
3	*Phalaenopsis* Hwafeng Red Jewel	17.80	17.50	311.50^{cd}	4.17^{d}	wrapped with leaf sheath, very short stem
4	*Phalaenopsis* Mount Lip	19.00	25.00	475.00^{a}	4.20^{d}	wrapped with leaf sheath, very short stem
5	*Phalaenopsis* Taipei Gold	19.50	18.00	351.00^{bc}	4.07^{d}	wrapped with leaf sheath, very short stem
6	*Phalaenopsis* Ho's Happy Auckland	15.20	11.50	174.80^{f}	4.10^{d}	wrapped with leaf sheath, very short
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	13.60	9.50	129.20^{g}	3.67^{e}	wrapped with leaf sheath, very short
8	*Phalaenopsis* Memoria Grand Mother	26.30	16.00	420.80^{ab}	4.50^{c}	wrapped with leaf sheath, stout, very short stem

length (0.40 cm) was recorded in *Vascostylis* Pine Rivers Pink followed by *Vascostylis* Rivers Blue (0.50 cm).

4.1.1.3 Plant Spread

Appreciable differences were observed with regard to plant spread in short-stemmed epiphytes (Table 8). Maximum spread (475.00 cm^2) was observed in *Phalaenopsis* Mount Lip followed by *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (429.00 cm^2) and *Phalaenopsis* Memoria Grand Mother (420.80 cm^2). Minimum spread (129.20 cm^2) was observed in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) which was on par with *Phalaenopsis* Ho's Happy Auckland (174.80 cm^2).

4.1.1.4 Leaf Characters

The data regarding leaf characters of different monopodial orchids are presented in Tables 9 -11.

Leaf length

The tall climbing orchids showed detectable differences in leaf length (Table 9). *Holttumara* Bright Eye had the maximum leaf length (27.17 cm) and was on par with *Renantanda* Mandai Glow (25.87 cm). Minimum leaf length (9.57 cm) was recorded in *Vanda* Poepoe Diana and was on par with *Aranthera* Lily Brook Red (10.97 cm).

Among intermediate climbing types, *Ascocenda* Raminder Gold x Fortune East recorded maximum leaf length (26.67 cm) and was on par with *Vanda* Josephine Van Brero x *Ascocenda* Yip Sum Wah (24.43 cm) and *Vascostylis* Pine Rivers Pink (23.47 cm). Minimum leaf length (12.83 cm) was recorded in *Mokara* Walter Oumae Yellow and *Mokara* Chark Kuan Pink (Table 10).

Significant differences were observed in short-stemmed epiphytes with respect to leaf length (Table 11). *Phalaenopsis* Diana Pink recorded maximum leaf length (21.73 cm), which was on par with *Phalaenopsis* Hwafeng Red Jewel (19.63 cm).

Minimum leaf length (10.10 cm) was recorded in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) followed by *Phalaenopsis* Ho's Happy Auckland (13.53 cm) and *Phalaenopsis* Memoria Grand Mother (14.27 cm) and were comparable.

Leaf breadth

Distinguishable difference in leaf breadth was recorded in tall climbing orchids (Table 9). Maximum leaf breadth (5.17 cm) was observed in *Holttumara* Emperor Hirohito and was significantly superior to all others. Minimum leaf breadth was recorded in terete leaved orchids; *Vanda* John Club (0.40 cm) was on par with *Vanda* Poepoe Diana (0.43 cm) and *Vanda* Prolific (0.70 cm).

Intermediate climbing epiphytes varied significantly with regard to leaf breadth (Table 10). *Mokara* Sayan x Kultana Gold recorded the maximum leaf breadth (4.00 cm) and was significantly superior to others. Minimum leaf breadth (2.00 cm) was observed in *Mokara* Bangkok Gold, which was on par with *Mokara* Dinah Shore (2.17 cm).

Marked difference in leaf breadth was observed in short-stemmed epiphytes (Table 11). *Phalaenopsis* Hwafeng Red Jewel recorded the maximum leaf breadth (7.97 cm) and was on par with *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (7.13 cm). *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) recorded the minimum (3.97 cm).

Leaf Area

Wide variation was observed in the leaf area in tall climbing orchids (Table 9). *Holttumara* Bright Eye recorded maximum leaf area (100.80 cm^2) and was distinctly superior to others. The terete leaved varieties of *Vanda*, *viz.*, *Vanda* Poepoe Diana (9.56 cm^2) and *Vanda* John Club (11.47 cm^2) recorded the minimum leaf area and were on par.

With respect to the intermediate climbing epiphytes, *Ascocenda* Raminder Gold x Fortune East had the maximum leaf area (71.33 cm^2) and was significantly superior to

others except *Mokara* Sayan x Kultana Gold (64.20 cm^2). *Mokara* Bangkok Gold recorded the minimum leaf area (30.70 cm^2) and was on par with *Mokara* Walter Oumae Yellow (31.83 cm^2) and *Mokara* Dinah Shore (35.80 cm^2).

Among the short-stemmed epiphytes, leaf area was significantly high in *Phalaenopsis* Hwafeng Red Jewel (125.03 cm^2), which was superior to other varieties/ hybrids (Table 11). Minimum leaf area (25.63 cm^2) was recorded in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory).

Number of leaves

Noticeable differences could be observed in the number of leaves per meter length of shoot in tall climbing orchids (Table 9). *Aranthera* Lily Brook Red had maximum number of leaves (47.0) and was significantly superior to all others. Minimum leaf number was recorded in *Vanda* Prolific (20.0) whose sparsity was on par with *Vanda* Mandai Glow (20.7), *Vanda* John Club (21.6) and *Vanda* Poepoe Diana (23.3).

The intermediate climbing epiphytes recorded detectable differences with respect to leaf number per plant (Table 10). Maximum leaf number (45.0) was recorded in *Mokara* Walter Oumae White which was significantly superior to all others except *Mokara* Sayan x Kultana Gold (41.3) and *Mokara* Calypso Pink (40.0). Minimum leaf number (9.6) was observed in *Mokara* Dinah shore.

Among short-stemmed epiphytes, the leaf number recorded highest (5.6) in *Phalaenopsis* Memoria Grand Mother, which was superior to *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (3.0), *Phalaenopsis* Diana Pink (3.0) and *Phalaenopsis* Hwafeng Red Jewel (3.0) which recorded minimum number of leaves and were on par with each other (Table 11).

Interval of leaf production

Wide variation was recorded in the interval of leaf production among tall growing orchids (Table 9), it varied from 9.1 days (*Arachnis* Maggie Oei Yellow Ribbon) to 29.0 days (*Aranthera* Mana Meina). Interval of leaf production was maximum in *Aranthera*

Table 9. Leaf characters of tall climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	Leaves/ m (no)	Angle of orientation (degree)	Interval of production (days)	Leaf shape	Leaf texture	Leaf margin	Leaf base	Leaf tip	Leaf colour	Other characteristics
1	*Arachnis* Maggie Oei Red Ribbon	14.80^{ef}	3.33^{de}	38.30^{ef}	33.7^{ef}	60	10.9^{de}	oblong-obovate	smooth, rigid,cereous	entire, coriaceous	sheathed	bilobed	green	channelled at base
2	*Arachnis* Maggie Oei Yellow Ribbon	13.63^{f}	3.17^{e}	34.00^{fgh}	31.3^{f}	55	9.1^{e}	oblong-obovate	smooth, rigid,cereous	entire, coriaceous	sheathed	bilobed	green	channelled at base
3	*Vanda* Prolific	22.13^{d}	0.70^{j}	32.23^{gh}	20.0^{h}	35	28.5^{a}	terete	smooth, fleshy	cylindrical	sheathed	obtuse	dark green	cylindrical
4	*Vanda* John Club	12.33^{gh}	0.40^{j}	11.47^{i}	21.7^{h}	25	20.0^{cd}	terete	smooth, fleshy	cylindrical	sheathed	obtuse	green	cylindrical
5	*Vanda* Poepoe Diana	9.57^{i}	0.43^{j}	9.57^{i}	23.3^{h}	25	20.0^{cd}	terete	smooth, fleshy	cylindrical	sheathed	obtuse	green	cylindrical
6	*Vanda* Mandai Glow	24.50^{bc}	2.20^{hi}	48.27^{d}	20.7^{h}	40	28.0^{a}	semi-terete	smoth, very rigid	entire	sheathed	acute	green	channelled
7	*Renantanda* Mandai Glow	25.87^{b}	3.03^{ef}	72.00^{c}	28.0^{g}	35	22.6^{bc}	semi-terete	smooth, very rigid	entire	sheathed	acute	green	channelled
8	*Renanthera* Manila	16.03^{e}	3.53^{d}	47.27^{d}	46.0^{a}	35	15.3^{cde}	linear-oblong	leathery, rigid	entire, coriaceous	sheathed	bilobed	green	not channelled
9	*Renanthera* Cape Sabel	12.60^{gh}	3.97^{c}	40.50^{e}	42.3^{cd}	45	18.7^{cde}	linear-oblong	smooth, rigid	entire, coriaceous	sheathed	bilobed	green	channelled
10	*Aranthera* Anne Black	13.70fg	3.07^{e}	34.37^{fgh}	36.0^{e}	55	27.2^{abc}	oblong-obovate	cereous, leathery	entire, coriaceous	sheathed	bilobed	green	not channelled
11	*Aranthera* Lily Brook Red	10.97^{hi}	4.00^{c}	36.67^{efg}	47.0^{a}	60	18.3^{cde}	elliptic-oblong	smooth, leathery	entire, coriaceous	sheathed	bilobed	green	not channelled
12	*Aranthera* Mana Meina	22.77^{cd}	2.13^{i}	39.80^{e}	33.3^{ef}	35	29.0^{a}	semi-terete	leathery, fleshy, rigid	entire, incurved	sheathed	acute	green	channelled
13	*Aranda* Deborah	13.80^{fg}	2.50^{gh}	31.17^{h}	43.3^{cd}	25	13.3^{cde}	linear	smooth, rigid	entire	sheathed	bilobed	dark green	not channelled
14	*Aranda* Majula	21.47^{d}	4.00^{c}	73.83^{c}	41.0^{d}	55	20.3^{bcd}	linear	smooth, fleshy	entire, coriaceous	sheathed	bilobed	green	channelled
15	*Aeridachnis* Apple Blossom	16.37^{e}	2.73^{fg}	39.83^{e}	41.7^{cd}	50	26.7^{ab}	linear	smooth, glabrous,fleshy	entire, coriaceous	sheathed	bilobed	green	channelled at base
16	*Holttumara* Bright Eye	27.17^{a}	4.77^{b}	100.8^{a}	45.0^{bc}	40	18.3^{cde}	linear,strap shaped	smooth, rigid,fleshy	entire, coriaceous	sheathed	emarginate	green	channelled
17	*Holttumara* Emperor Hirohito	23.03^{cd}	5.17^{a}	90.23^{b}	35.0^{e}	45	21.0^{cd}	linear,strap shaped	smooth, rigid,fleshy	entire, coriaceous	sheathed	emarginate	green	channelled

Table 10. Leaf characters of intermediate climbing epiphytes

Sl. No	Varieties / Hybrids	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	Leaves/ plant (no)	Angle of orientation (degree)	Interval of production (days)	Leaf shape	Leaf texture	Leaf tip	Leaf base	Leaf margin	Leaf colour	Other characters
1	*Vanda* Josephine Van Brero x *Ascocenda* Yip Sum Wah	24.43^{ab}	2.33^{fg}	45.43^{def}	11.7^{ef}	20	63.2^{b}	quarter terete	smooth, rigid	emarginate	sheathed	entire	green	deeply channelled
2	*Ascocenda* Princess Mikasa Pink	21.57^{bcd}	2.80^{cd}	47.27^{cde}	27.0^{cd}	25	38.9^{d}	falcate, strap	leathery	emarginate	sheathed	entire	green	deeply channelled
3	*Ascocenda* Raminder Gold x Fortune East	26.67^{a}	2.83^{cd}	71.33^{a}	18.0^{def}	20	51.0^{c}	falcate, strap	smooth, rigid	emarginate	sheathed	entire, coriaceous	green	deeply channelled
4	*Vascostylis* Pine Rivers Red	22.83^{bc}	2.80^{cd}	53.00^{c}	30.0^{c}	35	43.0^{d}	falcate, strap	rigid and fleshy	emarginate	sheathed	entire	green	deeply channelled
5	*Vascostylis* Pine Rivers Pink	23.47^{ab}	2.47^{ef}	54.00^{c}	20.0^{de}	30	49.7^{c}	falcate, strap	leathery	emarginate	sheathed	entire	green	deeply channelled
6	*Vascostylis* Pine Rivers Blue	22.83^{h}	2.80^{cd}	47.67^{cde}	13.0^{ef}	25	51.3^{c}	falcate, strap	smooth, rigid	emarginate	sheathed	entire	green	deeply channelled
7	*Mokara* Walter Oumae Yellow	12.83^{h}	2.37^{fg}	31.83^{h}	12.0^{ef}	35	61.0^{b}	falcate, strap	smooth, rigid	emarginate	sheathed	entire	green	channelled
8	*Mokara* Bangkok Gold	15.60^{fgh}	2.00^{h}	30.70^{h}	12.0^{ef}	35	121.7^{a}	falcate, strap	leathery	emarginate	sheathed	entire, coriaceous	green	deeply channelled
9	*Mokara* Sayan x *Ascocenda* Meda Arnold	16.17^{fgh}	2.97^{bcd}	43.90^{def}	18.0^{def}	25	60.0^{b}	falcate, strap	smooth, rigid	emarginate	sheathed	entire, coriaceous	green	channelled
10	*Mokara* Chark Kuan Pink	12.83^{h}	3.13^{b}	50.97^{cd}	35.3^{bc}	25	24.3^{e}	falcate, strap	smooth, rigid	emarginate	sheathed	entire, coriaceous	green	deeply channelled
11	*Mokara* Calypso Pink	16.03^{fgh}	3.07^{bc}	42.37^{ef}	40.0^{ab}	35	23.2^{ef}	linear, strap	smooth, rigid	emarginate	sheathed	entire, coriaceous	green	channelled
12	*Mokara* Walter Oumae White	14.47^{gh}	3.03^{bc}	41.60^{efg}	45.0^{a}	25	17.7^{g}	oblong, strap	smooth, rigid	emarginate	sheathed	entire, coriaceous	green	channelled
13	*Mokara* Sayan x Kultana Gold	19.10^{cdef}	4.00^{a}	64.20^{b}	41.3^{ab}	35	17.3^{g}	broad-oblong	smooth, rigid	emarginate	sheathed	entire, coriaceous	green	channelled
14	*Mokara* Dinah Shore	17.13^{efg}	2.17^{gh}	35.80^{gh}	9.7^{f}	30	68.3^{a}	falcate, strap	leathery	emarginate	sheathed	entire, coriaceous	green	deeply channelled
15	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai	16.43^{fgh}	2.70^{de}	38.97^{fg}	20.0^{de}	35	19.0^{fg}	oblong, strap	leathery, smooth	emarginate	sheathed	entire, coriaceous	yellow-green	deeply channelled

able 11. Leaf characters of short-stemmed monopodial orchids

o	Varieties/Hybrids	Leaf length(cm)	Leaf breadth (cm)	Leaf area (cm^2)	Leaves/plant (no)	Angle of orientation(degree)	Interval of production (days)	Leaf shape	Leaf texture	Leaf tip	Leaf base	Leaf margin	Leaf colour	Other characters
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	17.83^{b}	7.13^{ab}	79.03^{c}	3.0^{b}	20	180.0^{cd}	elliptic-obovate	smooth, fleshy	unequally bilobed	sheathed	outcurved, entire	green	channelled at base, persistent
2	*Phalaenopsis* Diana Pink	21.73^{a}	7.00^{bc}	103.80^{b}	3.0^{b}	25	230.0^{ab}	elliptic-obovate	smooth, fleshy	unequally bilobed	sheathed	outcurved, entire	green	channelled at base, persistent
3	*Phalaenopsis* Hwafeng Red Jewel	19.63^{ab}	7.97^{a}	125.03^{a}	4.0^{ab}	20	245.0^{ab}	elliptic-obovate	smooth, fleshy	unequally bilobed	sheathed	outcurved, entire	green, purple underneath	channelled at base, persistent
4	*Phalaenopsis* Mount Lip	17.73^{b}	6.13^{cd}	81.67^{c}	3.0^{b}	25	198.0^{c}	elliptic-obovate	smooth, fleshy	Acuminate	sheathed	outcurved, entire	green, purple underneath and on margin	channelled at base, persistent
5	*Phalaenopsis* Taipei Gold	17.97^{b}	5.33^{d}	74.47^{c}	4.0^{ab}	20	160.0^{d}	elliptic-obovate	smooth, fleshy	Acuminate	sheathed	outcurved, entire	green	channelled at base, persistent
6	*Phalaenopsis* Ho's Happy Auckland	13.53^{c}	5.73^{d}	49.33^{d}	4.0^{ab}	25	285.0^{a}	elliptic-obovate	smooth, fleshy	Acuminate	sheathed	outcurved, entire	green	channelled at base, persistent
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	10.10^{d}	3.97^{e}	25.63^{e}	3.7^{ab}	35	210.0^{bc}	elliptic-obovate	smooth, fleshy	Acuminate	sheathed	outcurved, entire	green-purple	channelled at base, persistent
8	*Phalaenopsis* Memoria Grand Mother	14.27^{c}	6.73^{bc}	100.27^{b}	5.7^{a}	30	195.0^{c}	elliptic-obovate	smooth, fleshy	unequally bilobed	sheathed	outcurved, entire	green	channelled at base, persistent

Mana Meina followed by *Vanda* Prolific (28.5 days). *Arachnis* Maggie Oei Yellow Ribbon was on par with *Arachnis* Maggie Oei Red Ribbon (10.9 days) and *Aranda* Deborah (13.3 days).

The intermediate climbing epiphytes also differed significantly with respect to the interval of leaf production (Table10). *Mokara* Bangkok Gold produced leaves at maximum intervals (121.7 days). *Mokara* Sayan x Kultana Gold produced leaves at frequent intervals (17.3 days) and was on par with *Mokara* Walter Oumae White (17.7 days) and *Mokara* Khaw Phaik Suan x *Vanda* Thananchai (19.0 days).

Among short-stemmed epiphytes, leaf production interval was maximum (285.0 days) in *Phalaenopsis* Ho's Happy Auckland and minimum in *Phalaenopsis* Taipei Gold (160.0 days) (Table 11).

Angle of Orientation

The angle of orientation of leaves with respect to the shoot ranged from 60 degrees (*Aranthera* Lily Brook Red and *Arachnis* Maggie Oei Red Ribbon) to 25 degrees (*Vanda* Poepoe Diana and *Vanda* John Club) in tall climbing orchids (Table 9). The intermediate climbing and short-stemmed epiphytes recorded an angle between 20 and 35 degrees (Tables 10 and 11).

Leaf sheath characters

Data pertaining to leaf sheath characters are presented in Tables 12, 13 and 14.

Sheath length

The leaf sheath length differed significantly in tall climbing epiphytes (Table 12). The length of leaf sheath was maximum (5.60 cm) in *Vanda* Prolific and was significantly superior to all others. Minimum sheath length (2.53 cm) was recorded in *Aeridachnis* Apple Blossom and *Aranda* Deborah.

Leaf sheath length showed significant variations in the intermediate climbing epiphytes (Table 13). *Ascocenda* Princess Mikasa Pink recorded maximum sheath length (3.67 cm) and was significantly superior to others. This was followed by *Mokara* Khaw Phaik Suan x *Vanda* Thananchai (2.96 cm) and *Vascostylis* Pine Rivers Red (2.77 cm) which were on par. *Mokara* Walter Oumae White recorded the minimum (1.80 cm).

Among short-stemmed epiphytes, leaf sheath length was significantly higher in *Phalaenopsis* Hwafeng Red Jewel (2.37 cm) but on par with *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (2.30 cm), *Phalaenopsis* Diana Pink (2.30 cm) and *Phalaenopsis* Memoria Grand Mother (2.30 cm). *Phalaenopsis* Taipei Gold (1.30 cm) recorded minimum sheath length (Table 13).

Sheath breadth

The leaf sheath breadth also showed considerable variation in tall climbing orchids (Table 12). *Hottumara* Emperor Hirohito recorded the maximum sheath breadth (4.30 cm) and was on par with and *Renantanda* Mandai Glow (3.80 cm) and *Holttumara* Bright Eye (3.63 cm). Minimum sheath breadth was recorded in *Vanda* John Club (1.20 cm).

Marked differences in leaf sheath width were noticed in intermediate climbing monopodials (Table 13). Maximum sheath width (3.13 cm) was recorded in *Mokara* Sayan x Kultana Gold and was significantly superior to others. *Vascostylis* Pine Rivers Pink and *Vascostylis* Pine Rivers Red were on par with minimum width (1.80 cm and 1.90 cm, respectively).

Among short-stemmed epiphytes, *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (3.70 cm) had the maximum breadth, which was significantly superior to all others but on par with *Phalaenopsis* Diana Pink (3.67 cm) and *Phalaenopsis* Memoria Grand Mother (3.60 cm). Minimum leaf breadth (1.30 cm) was recorded in *Phalaenopsis* Taipei Gold (Table 14).

Table 12. Leaf sheath characters of tall climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Sheath length (cm)	Sheath breadth (cm)	Nature of leaf sheath	Leaf sheath colour
1	*Arachnis* Maggie Oei Red Ribbon	3.40^{d}	2.10^{d}	membranous	green
2	*Arachnis* Maggie Oei Yellow Ribbon	3.03^{ef}	2.20^{d}	membranous	green
3	*Vanda* Prolific	5.60^{a}	2.50^{cd}	membranous	dark green
4	*Vanda* John club	4.70^{b}	1.20^{e}	membranous	green
5	*Vanda* Poepoe Diana	4.27^{c}	1.30^{e}	membranous	green
6	*Vanda* Mandai Glow	4.43^{bc}	3.00^{b}	thick	green with maroon shade
7	*Renantanda* Mandai Glow	4.23^{c}	3.80^{ab}	thick	dark green
8	*Renanthera* Manila	3.27^{de}	2.67^{c}	membranous	green
9	*Renanthera* Cape sabel	2.73^{fg}	2.63^{c}	membranous	green
10	*Aranthera* Anne Black	2.87^{f}	2.10^{d}	membranous	green
11	*Aranthera* Lily Brook Red	2.47^{g}	2.13^{d}	membranous	green
12	*Aranthera* Mana Meina	3.53^{d}	2.80^{bc}	membranous	green
13	*Aranda* Deborah	2.53^{g}	2.00^{d}	membranous	dark green
14	*Aranda* Majula	3.50^{d}	2.83^{bc}	membranous	green
15	*Aeridachnis* Apple Blossom	2.53^{g}	2.10^{d}	membranous	green
16	*Holttumara* Bright Eye	3.47^{d}	3.63^{ab}	thick, membranous	green
17	*Holttumara* Emperor Hirohito	4.20^{c}	4.30^{a}	thick, membranous	green

Table 13. Leaf sheath characters of intermediate climbing epiphytes

Sl. No	Varieties / Hybrids	Sheath length (cm)	Sheath breadth (cm)	Nature of leaf sheath	Sheath colour
1	*Vanda* Josephine Van Brero x Ascocenda Yip Sum Wah	2.57^{c}	2.50^{b}	membranous, thick	green
2	*Ascocenda* Princess Mikasa Pink	3.67^{a}	1.90^{e}	thick	dark green
3	*Ascocenda* Raminder Gold x Fortune East	2.10^{d}	2.60^{b}	membranous, thick	green
4	*Vascostylis* Pine Rivers Red	2.77^{b}	1.90^{e}	membranous, thick	green
5	*Vascostylis* Pine Rivers Pink	2.20^{cd}	1.80^{e}	membranous, thick	green
6	*Vascostylis* Pine Rivers Blue	2.23^{cd}	2.17^{d}	membranous, thick	green
7	*Mokara* Walter Oumae Yellow	2.40^{c}	2.46^{bc}	membranous, thick	green
8	*Mokara* Bangkok Gold	2.10^{d}	2.10^{d}	membranous,	green
9	*Mokara* Sayanx *Ascocenda* Meda Arnold	2.13^{d}	2.73^{b}	membranous, thick	green
10	*Mokara* Chark Kuan Pink	2.80^{b}	2.70^{b}	membranous, thick	green
11	*Mokara* Calypso Pink	1.90^{e}	2.50^{b}	membranous	dark green
12	*Mokara* Walter Oumae White	1.80^{e}	2.73^{b}	membranous	green
13	*Mokara* Sayan x Kultana Gold	2.57^{c}	3.13^{a}	membranous, fleshy	green
14	*Mokara* Dinah shore	2.03^{de}	2.07^{d}	membranous	dark green
15	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai	2.96^{b}	2.40^{bc}	membranous	greenish yellow

Table 14. Leaf sheath characters of short-stemmed epiphytes

Sl. No	Varieties/ Hybrids	Sheath length (cm)	Sheath breadth (cm)	Nature of leaf sheath	Leaf sheath colour
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	2.30[a]	3.70[a]	thick, fleshy	green
2	*Phalaenopsis* Diana Pink	2.30[a]	3.67[a]	thick, fleshy	green
3	*Phalaenopsis* Hwafeng Red Jewel	2.37[a]	3.30[b]	thick, fleshy	green with purple markings
5	*Phalaenopsis* Taipei Gold	1.30[cd]	2.40[c]	thick, fleshy	green
6	*Phalaenopsis* Ho's Happy Auckland	1.97[b]	2.60[c]	thick, fleshy	green
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	1.57[c]	2.40[c]	thick, fleshy	green-purple
8	*Phalaenopsis* Memoria Grand Mother	2.30[a]	3.60[b]	thick, fleshy	green

4.1.1.5 Aerial root characters

Data pertaining to aerial root characters of monopodial orchids are presented in Tables 15, 16 and 17.

Length of aerial roots

The length of aerial roots varied significantly in tall growing orchids (Table 15). Maximum root length (122.33 cm) was recorded in *Aranthera* Mana Meina while *Vanda* Prolific recorded the minimum (50.27 cm).

Among intermediate climbing epiphytes, aerial root length was significantly high in *Vascostylis* Pine Rivers Red (98.00 cm) but on par with *Ascocenda* Princess Mikasa Pink (93.20 cm) and *Vascostylis* Pine Rivers Pink (82.67 cm). Minimum root length (30.17 cm) was recorded in *Mokara* Walter Oumae Yellow which was on par with *Mokara* Dinah Shore (30.32 cm) and *Mokara* Calypso Pink (30.87 cm) (Table 16).

In short-stemmed epiphytes, the length of aerial roots varied from 22.67 cm in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) to 34.67 cm in *Phalaenopsis* Hwafeng Red Jewel (Table 17).

Girth of aerial roots

Detectable differences were noticed in girth of aerial roots in tall growing orchids (Table 15). *Holttumara* Emperor Hirohito recorded maximum root girth (3.03 cm) and was significantly superior to others. *Vanda* John Club recorded minimum root girth (0.93 cm).

The girth of aerial roots in intermediate climbing epiphytes varied from 1.70 cm to 3.27 cm (Table 16). *Ascocenda* Raminder Gold x Fortune East (3.27 cm) had the maximum girth followed by *Vascostylis* Pine Rivers Red (2.70 cm). *Mokara* Walter Oumae Yellow and *Mokara* Khaw Phaik Suan x *Vanda* Thananchai had minimum root girth (1.70 cm) and were on par with *Mokara* Dianah Shore (1.80 cm).

Table 15. Aerial root characters of tall climbing monopodial orchids

Sl No.	Varieties/ Hybrids	Root length (cm)	Root girth (cm)	Root/meter (no)	Nature of aerial roots	Branching of roots	Colour
1	*Arachnis* Maggie Oei Red Ribbon	87.77^{c}	1.97^{ef}	11.7^{b}	thick, fleshy	branching rare	grey
2	*Arachnis* Maggie Oei Yellow Ribbon	65.10^{d}	2.10^{cd}	12.7^{b}	thick, fleshy	branching rare	grey
3	*Vanda* Prolific	50.27^{d}	2.00^{def}	8.3^{c}	thick, fleshy,	branch when mature	grey
4	*Vanda* John club	58.00^{d}	0.93^{h}	23.3^{a}	thread like, woody, shrivelled	branch when mature	grey
5	*Vanda* Poepoe Diana	64.33^{d}	1.10^{g}	14.7^{b}	thread like, woody, shrivelled	branch when mature	grey
6	*Vanda* Mandai Glow	109.47^{ab}	2.07^{def}	8.0^{c}	thick	branch when mature	grey
7	*Renantanda* Mandai Glow	104.33^{ab}	2.10^{cd}	12.0^{b}	fleshy, thick	branch when mature	grey
8	*Renanthera* Manila	111.67^{ab}	2.00^{def}	14.0^{b}	slender	branching rare	white
9	*Renanthera* Cape Sabel	103.00^{ab}	2.90^{b}	23.3^{a}	thick	branching	grey
10	*Aranthera* Anne Black	93.40^{bc}	2.00^{def}	7.7^{c}	woody, slender	branching rare	grey
11	*Aranthera* Lily Brook Red	88.83^{bc}	2.03^{def}	12.0^{b}	woody, shrivelled and creeping	branch when mature	grey
12	*Aranthera* Mana Meina	122.33^{a}	1.93^{f}	22.0^{a}	woody and shrivelled	branch when mature	grey
13	*Aranda* Deborah	91.00^{bc}	2.03^{def}	22.3^{a}	thick, woody	branch when mature	white, tip green
14	*Aranda* Majula	100.00^{ab}	2.17^{c}	14.0^{b}	thick, fleshy	branching	white
15	*Aeridachnis* Apple Blossom	97.00^{b}	2.00^{def}	21.0^{a}	thick, fleshy	branch when mature	grey
16	*Holttumara* Bright Eye	109.00^{ab}	2.87^{b}	14.0^{b}	thick, fleshy	branch when mature	white
17	*Holttumara* Emperor Hirohito	72.17^{cd}	3.03^{a}	7.7^{c}	thick, fleshy	branch when mature	white

Table 16. Aerial root characters of intermediate climbing epiphytes

Sl. No	Varieties/ Hybrids	Root length (cm)	Root girth (cm)	Roots/ plant (no)	Root colour	Nature of aerial root	Branching
1	*Vanda* JVB x *Ascocenda* Yip Sum Wah	62.50^{cde}	2.17^{de}	21.3^{cd}	grey-white	thick,fleshy	present
2	*Ascocenda* Princess Mikasa Pink	93.20^{a}	2.20^{d}	14.0^{ef}	white	thick,woody	present
3	*Ascocenda* Raminder Gold x Fortune East	60.17^{cdef}	3.27^{a}	13.0^{ef}	white	thick,fleshy	present
4	*Vascostylis* Pine Rivers Red	98.00^{a}	2.70^{b}	17.0^{de}	white	thick,woody	present
5	*Vascostylis* Pine Rivers Pink	82.67^{ab}	1.87^{gh}	12.0^{ef}	white	slender,fleshy	present
6	*Vascostylis* Pine Rivers Blue	73.00^{bc}	2.00^{f}	9.0^{f}	white	thick,woody	present
7	*Mokara* Walter Oumae Yellow	30.17^{h}	1.70^{a}	9.7^{f}	white	thick,fleshy	present
8	*Mokara* Bangkok Gold	50.67^{defg}	1.97^{fg}	8.0^{f}	grey-white	fleshy, thick	present
9	*Mokara* Sayan x *Ascocenda* Meda Arnold	48.83^{efg}	2.07^{ef}	14.0^{ef}	white	fleshy, thick	branch when mature
10	*Mokara* Chark Kuan Pink	54.33^{defg}	2.20^{d}	17.7^{de}	white	fleshy, thick	branch when mature
11	*Mokara* Calypso Pink	30.87^{h}	2.17^{de}	26.7^{bc}	white	fleshy, thick	branch when mature
12	*Mokara* Walter Oumae White	41.17^{gh}	2.23^{d}	30.3^{b}	white	fleshy, thick	branch when mature
13	*Mokara* Sayan x Kultana Gold	66.67cd	2.57^{c}	26.0^{bc}	white with maroon tip	fleshy, thick	present
14	*Mokara* Dinah Shore	30.33^{h}	1.80^{hi}	13.0^{ef}	white	fleshy, thick	present
15	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai	45.67^{fgh}	1.70^{i}	41.0^{a}	white grey	slender, woody	branch when mature

Table 17. Aerial root characters of different short-stemmed epiphytes

Sl. No	Varieties/ Hybrids	Root length (cm)	Root girth (cm)	Roots/ plant (no)	Root colour	Nature of aerial roots	Branching of aerial roots
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	32.43^{a}	1.50^{d}	26.7^{ab}	grey	creeping,fleshy cylindrical later flattens	absent
2	*Phalaenopsis* Diana Pink	32.33^{a}	1.93^{ab}	30.0^{a}	grey	creeping, cylindrical later flattens	absent
3	*Phalaenopsis* Hwafeng Red Jewel	34.67^{a}	1.73^{c}	20.0^{bc}	grey	creeping, cylindrical later flattens	absent
4	*Phalaenopsis* Mount Lip	30.00^{a}	1.93^{ab}	28.0^{a}	grey	creeping, cylindrical later flattens	absent
5	*Phalaenopsis* Taipei Gold	31.00^{ab}	1.83^{bc}	19.3^{c}	grey	creeping, cylindrical later flattens	absent
6	*Phalaenopsis* Ho's Happy Auckland	24.83^{bc}	1.47^{d}	23.7^{abc}	grey	creeping, cylindrical later flattens	absent
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	22.67^{c}	1.57^{d}	12.7^{d}	grey	creeping, cylindrical later flattens	absent
8	*Phalaenopsis* Memoria Grand Mother	30.67^{ab}	2.00^{a}	28.3^{a}	grey	creeping, cylindrical later flattens	absent

Among short-stemmed epiphytes (Table 17), *Phalaenopsis* Memoria Grand Mother recorded maximum root girth (2.00 cm) and *Phalaenopsis* Ho's Happy Auckland, the minimum (1.47 cm).

Number of aerial roots

The number of aerial roots produced per meter showed noticeable difference in tall growing orchids (Table 15). *Vanda* John Club and *Renanthera* Cape Sabel had the maximum number of roots per metre (23.3) and were on par with *Aranda* Deborah (22.3), *Aranthera* Mana Meina (22.0) and *Aeridachnis* Apple Blossom (21.0). The number of aerial roots was minimum (7.7) in *Holttumara* Emperor Hirohito and *Aranthera* Anne Black.

Significant differences were noticed with respect to production of aerial roots/ plant in intermediate climbing epiphytes (Table 16). The number of aerial roots produced per plant varied from to 8.0 (*Mokara* Bangkok Gold) to 41.0 (*Mokara* Khaw Phaik Suan x *Vanda* Thananchai).

The short-stemmed epiphytes varied significantly with regard to the production of aerial roots (Table 17). *Phalaenopsis* Diana Pink recorded highest number of roots per plant (30.0) while *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise X Tiny Ivory) recorded significantly lesser number of roots (12.7).

4.1.2 Floral Characters

4.1.2.1 Flowering Characters

Data pertaining to the flowering characteristics of monopodial orchids such as days from spike emergence to opening of first floret, 50 per cent florets, opening of 100 per cent florets, opening of first floret to wilting of first floret, spike longevity, interval of spike production, number of flowering stems per plant, number of spikes produced per year are presented in Tables 18-20 and Figures 1-4.

Spike emergence to opening of first floret open

Tall growing orchids varied significantly with respect to the duration from the spike emergence to opening of the first floret (Table 18 and Fig. 1). The duration was maximum in *Arachnis* Maggie Oei varieties Red Ribbon and Yellow Ribbon with 59.8 and 53.0 days, respectively. *Vanda* John Club (33.1 days), *Renantanda* Mandi Glow (33.5 days), *Vanda* Poepoe Diana (34.0 days) and *Aranda* Majula (34.0 days) were statistically on par. *Holttumara* Bright Eye (18.6 days) recorded minimum duration for opening of first floret followed by *Holttumara* Emperor Hirohito (20.5 days).

Marked differences were noticed in intermediate climbing orchids with regard to the duration from spike emergence to opening of first floret (Table 19 and Fig. 2). Maximum duration was observed in *Mokara* Walter Oumae Yellow (43.8 days) followed by *Mokara* Bangkok Gold (43.0 days). *Vanda* JVB x *Ascocenda* Yip Sum Wah recorded minimum duration (23.1 days) and was significantly superior to others but on par with *Ascocenda* Raminder Gold x Fortune East (24.0 days).

Among short-stemmed epiphytes, *Phalaenopsis* Ho's Happy Auckland took maximum number of days for the first floret to open (68.7 days) and was on par with *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) (68.0 days) and *Phalaenopsis* Memoria Grand Mother (65.4 days). *Phalaenopsis* Taipei Gold recorded the minimum (52.3 days) followed by *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (57.1 days) (Table 20 and Fig.3).

Spike emergence to opening of 50 per cent florets

Duration between spike emergence to opening of 50 per cent florets differed significantly in tall growing orchids (Table 18 and Fig.1). It varied from 21.2 days (*Holttumara* Bright Eye) to 64.5 days (*Arachnis* Maggie Oei Red Ribbon). Thus, *Arachnis* Maggie Red Ribbon took maximum number of days to attain the harvestable stage followed by *Arachnis* Maggie Oei Yellow Ribbon (57.6 days), *Vanda* John Club (54.1 days) and *Aeridachnis* Apple Blossom (52.2 days). *Holttumara* Bright Eye opened florets at the earliest (21.2 days) followed by *Holttumara* Emperor Hirohito (25.7 days).

Differences were noted in intermediate climbing types with regard to the duration for the opening of 50 per cent florets (Table 19 and Fig. 2). *Mokara* Khaw Phaik Suan x *Vanda* Thananchai recorded maximum duration (47.2 days) and was on par with *Mokara* Walter Oumae Yellow (45.2 days) and *Mokara* Bangkok Gold (45.0 days). *Ascocenda* Raminder Gold x Fortune East recorded the minimum duration (25.8 days) followed by *Vanda* JVB x *Ascocenda* Yip Sum Wah (26.0 days).

Significant differences were recorded with respect to opening of 50 per cent florets in short-stemmed epiphytes (Table 20 and Fig. 3). *Phalaenopsis* Diana Pink took maximum duration (146.0 days) followed by *Phalaenopsis* Mount Lip (126.5 days) and *Phalaenopsis* Hwafeng Red Jewel (113.5 days). *Phalenopsis* Taipei Gold recorded the minimum (63.6 days) and was comparable with *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (67.3 days) and *Phalaenopsis* Ho's Happy Auckland (72.2 days).

Spike emergence opening of all florets

The tall climbing monopodials varied significantly with respect to the days taken from spike emergence to opening of all florets (Table 18 and Fig.1). The duration varied from 26.4 days (*Holttumara* Bright Eye) to 83.5 days (*Aranthera* Lily Brook Red). Of the lot, *Aranthera* Lily Brook Red recorded significantly higher duration to open completely followed by *Vanda* John Club (70.6 days), which was on par with *Arachnis* Maggie Oei Red Ribbon (69.5 days). *Holttumara* Bright Eye recorded minimum duration for all florets to open (26.4 days).

Significant differences were also observed in intermediate climbing epiphytes (Table 19 and Fig.2). *Mokara* Walter Oumae White (78.3 days) recorded significantly higher duration for opening of all the florets. *Mokara* Bangkok Gold (47.7 days), *Mokara* Chark Kuan Pink (46.9 days), *Mokara* Sayan x Kultana Gold (46.3 days), *Ascocenda* Princess Mikasa Pink (45.7 days), *Mokara* Sayan x *Ascocenda* Meda Arnold (42.7 days) and *Vascostylis* Pine Rivers Blue (42.3 days) were comparable. *Ascocenda* Raminder Gold x Fortune East recorded minimum duration (29.0 days) and was on par with *Vanda* JVB x *Ascocenda* Yip Sum Wah (31.3 days).

In short-stemmed epiphytes *Phalaenopsis* Diana Pink took maximum time for all florets to open (205.0 days) followed by *Phalaenopsis* Hwafeng Red Jewel (197.5 days) and *Phalaenopsis* Mount Lip (184.5 days). *Phalaenopsis* Memoria Grand Mother and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) were on par with 138.0 and 131.2 days respectively (Table 20 and Fig.3).

Opening to wilting of first floret

Significant differences were recorded in tall climbing orchids with respect to the duration taken from opening to wilting of first floret (Table 20). *Aranthera* Lily Brook Red recorded the maximum (42.0 days). *Renanthera* Manila (33.0 days), *Arachnis* Maggie Oei Red Ribbon (33.0 days), *Aranda* Majula (33.0 days), *Aranda* Deborah (31.2 days) and *Arachnis* Maggie Oei Yellow Ribbon (30.3 days) were on par. *Renantanda* Mandai Glow (17.5 days) recorded minimum flower life followed by *Vanda* Mandai Glow (19.0 days) and *Aranthera* Mana Meina (20.2 days).

Appreciable differences were observed in intermediate climbing epiphytes as well (Table 19). *Mokara* Walter Oumae White recorded maximum duration (40.0 days) followed by *Ascocenda* Princess Mikasa Pink (32.0 days) and *Mokara* Sayan x Kultana Gold (31.0 days). *Mokara* Walter Oumae Yellow (13.0 days), *Ascocenda* Raminder Gold x Fortune East (13.0 days) and Mokara Bangkok Gold (16.0 days) were on par with minimum life of the floret that opened first.

Short-stemmed epiphytes differed considerably with respect to the life of the first floret (Table 20). *Phalaenopsis* Taipei Gold and *Phalaenopsis* Ho's Happy Auckland recorded significantly longer flower life (45.0 days and 44.0 days respectively). *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (32.0 days), *Phalaenopsis* Hwafeng Red (31.0 days) and *Phalaenopsis* Mount Lip (31.0 days) were statistically comparable. *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) recorded the minimum life (21.0 days).

Spike longevity

Distinguishable differences were noticed with respect to the longevity of spike on the plant in monopodial orchids (Tables 18 – 20 and Fig. 4).

Among tall climbing monopodials, *Aranthera* Lily Brook Red was significantly superior to others and it retained its spike for 68.0 days on the plant (Table 18). *Aeridachins* Apple Blossom recorded the minimum longevity (24.9 days).

Of the intermediate climbing epiphytes, *Mokara* Walter Oumae White recorded maximum spike longevity (56.7 days) and was significantly superior to all others. This was followed by Mokara Calypso Pink (49.7 days). Minimum spike longevity (19.0 days) was recorded in *Mokara* Walter Oumae Yellow (Table 19).

Short-stemmed epiphytes displayed an admirable degree of longevity of spikes (Table 20). *Phalaenopsis* Hwafeng Red Jewel recorded maximum spike longevity (239.3 days) and differed significantly from the other *Phalaenopsis* types. This was followed by *Phalenopsis* Diana Pink (177.0 days) and *Phalaenopsis* Mount Lip (161.7 days). Longevity of the spike was minimum (65.0 days) in *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon.

Interval of spike production

Significant differences were recorded in tall climbing monopodials with respect to interval of production of spikes (Table 18). Interval of spike production was maximum (360.0 days) in *Renanthera* Manila and was significantly superior to all others. This was followed by *Aranthera* Lily Brook Red (194.0 days) and *Aranda* Majula (191.0 days). The interval of spike production was minimum in *Aranthera* Anne Black (60.0 days) and was on par with *Vanda* Mandai Glow (60.50), *Arachnis* Maggie Oei Red Ribbon (60.8 days), *Renanthera* Cape Sabel and *Renantanda* Mandai Glow (64.0 days each).

Considerable differences were found in the interval of spike production in intermediate climbing epiphytes (Table 19). The interval of production was significantly

more in *Mokara* Sayan x Kultana Gold (192.5 days) and was comparable with *Mokara* Walter Oumae Yellow (179.0 days) and *Ascocenda* Raminder Gold x Fortune East (173.00 days). The spike production interval was minimum (65.67 days) in *Vascostylis* Pine Rivers Red.

Among short-stemmed epiphytes, *Phalaenopsis* Diana Pink, *Phalaenopsis* Mount Lip, *Phalaenopsis* Hwafeng Red Jewel, *Phalaenopsis* Ho's Happy Auckland, *Phalaenopsis* Memoria Grand Mother, *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) produced spikes at an interval of more than 300.0 days (once a year) while *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon and *Phalaenopsis* Taipei Gold produced spikes at an interval of 175.0 days and 260.0 days respectively (Table 20).

Flowering stems/plant

Tall climbing orchids differed with respect to number of flowering branches produced by the plant (Table 18). *Aranda* Deborah recorded the maximum (2.7) followed by *Aeridachnis* Apple Blossom (2.5) and *Arachnis* Maggie Oei Red Ribbon (2.3). *Vanda* Prolific, *Vanda* Mandai glow, *Renantanda* Mandai glow, *Aranthera* Lily Brook Red, *Aranda* Majula and *Holttumara* produced a single flowering spike at a time. All the intermediate climbing epiphytes and short-stemmed epiphytes produced only single flowering stem (Tables 19 and 20 respectively).

Annual spike production

Considerable variation was observed in tall climbing orchids with regard to the number of spikes produced per annum (Table 18). *Aranda* Deborah produced maximum number of spikes (9.5) and was significantly superior to all others except *Arachnis* Maggie Oei Red Ribbon (9.0), *Aranthera* Anne Black (8.7) and *Renanthera* Cape Sabel (8.3). The number of spikes produced per year was minimum (2.0) in *Holttumara* Emperor Hirohito, *Renanthera* Manila, *Aranda* Majula and *Aranthera* Lily Brook Red.

Table 18. Flowering characters of tall climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Days from spike emergence to			Opening to wilting of 1st floret (Days)	Spike longevity (Days)	Interval of spike production (Days)	Flowering stem/plant (No.)	Annual spike production (No.)	Blooming period
		1st floret open	50 % florets open	100% florets open						
1	*Arachnis* Maggie Oei Red Ribbon	59.8^{a}	64.5^{a}	69.5^{b}	33.0^{b}	40.7^{fg}	60.8^{ef}	2.3	9.0^{a}	Year-round
2	*Arachnis* Maggie Oei Yellow Ribbon	53.0^{b}	57.6^{bc}	63.7^{c}	30.3^{bc}	41.3^{fg}	90.3^{de}	1.6	6.0^{b}	Year-round
3	*Vanda* Prolific	22.2^{i}	29.2^{ij}	42.9^{hi}	21.0^{de}	50.7^{c}	91.3^{cd}	1.0	4.0^{c}	Year-round
4	*Vanda* John club	33.1^{fg}	54.1^{c}	70.6^{b}	20.6^{e}	58.3^{b}	123.4^{e}	2.0	5.3^{bc}	Year-round
5	*Vanda* PoepoeDiana	34.0^{f}	36.9^{fg}	49.5^{gh}	22.3^{d}	42.7^{ef}	69.3^{f}	1.3	4.0^{c}	Aug-March
6	*Vanda* Mandai Glow	28.1^{h}	34.9^{gh}	47.6^{ghi}	19.0^{e}	38.0^{gh}	60.5^{ef}	1.0	5.0^{bc}	Mar-Jan
7	*Renantanda* Mandai Glow	33.5^{fg}	39.0^{f}	51.0^{ef}	17.5^{ef}	46.7^{cde}	64.0^{ef}	1.0	5.0^{bc}	Apr - Nov
8	*Renanthera* Maniia	39.0^{d}	44.0^{de}	51.0^{ef}	33.0^{b}	37.0^{gh}	once a year^{a}	2.0	2.0^{d}	Aug-Oct
9	*Renanthera* Cape Sabel	27.9^{h}	31.0^{t}	36.8^{k}	29.1^{c}	34.3^{h}	64.0^{ef}	2.5	8.3^{a}	Mar-Nov
10	*Aranthera* Anne Black	38.3^{de}	46.8^{de}	56.0^{d}	29.0^{c}	46.2^{def}	60.0^{ef}	2.0	8.7^{a}	Year-round
11	*Aranthera* Lily Brook Red	39.5^{de}	50.8^{c}	83.5^{a}	42.0^{a}	68.0^{a}	194.0^{b}	1.0	2.0^{d}	Mar-May & Sept-Dec
12	*Aranthera* Mana Meina	36.9^{f}	40.3^{f}	52.6^{de}	20.2^{e}	35.4^{h}	71.5^{def}	2.0	5.7^{bc}	March-Jan
13	*Aranda* Deborah	32.0^{g}	34.6^{gh}	44.4^{hij}	31.2^{b}	49.2^{cd}	102.4^{cd}	2.7	9.5^{a}	Oct-Dec; Feb-Apr; Jun-Aug
14	*Aranda* Majula	34.0^{f}	36.0^{g}	41.0^{ik}	33.0^{b}	37.0^{gh}	191.0^{b}	1.0	2.0^{d}	Feb-Apr & Sept-Nov
15	*Aeridachnis* Apple Blossom	49.9^{c}	52.2^{cd}	55.7^{c}	19.0^{e}	24.9^{j}	92.8^{cd}	2.0	5.7^{bc}	Dec-Jan; Mar - Apr;Aug-Sept
16	*Holttumara* Bright Eye	18.6^{k}	21.2^{l}	26.4^{l}	22.7^{d}	29.7^{i}	111.7^{cd}	1.0	4.0^{c}	Feb-Mar; Sept-Dec
17	*Holttumara* Emperor Hirohito	20.5^{j}	25.7^{k}	31.5^{l}	20.5^{e}	27.5^{ij}	207.0^{b}	1.0	2.0^{d}	Mar-May & Sept-Dec

Fig. 1. Days taken from spike emergence to opening of florets in tall climbing monopodials

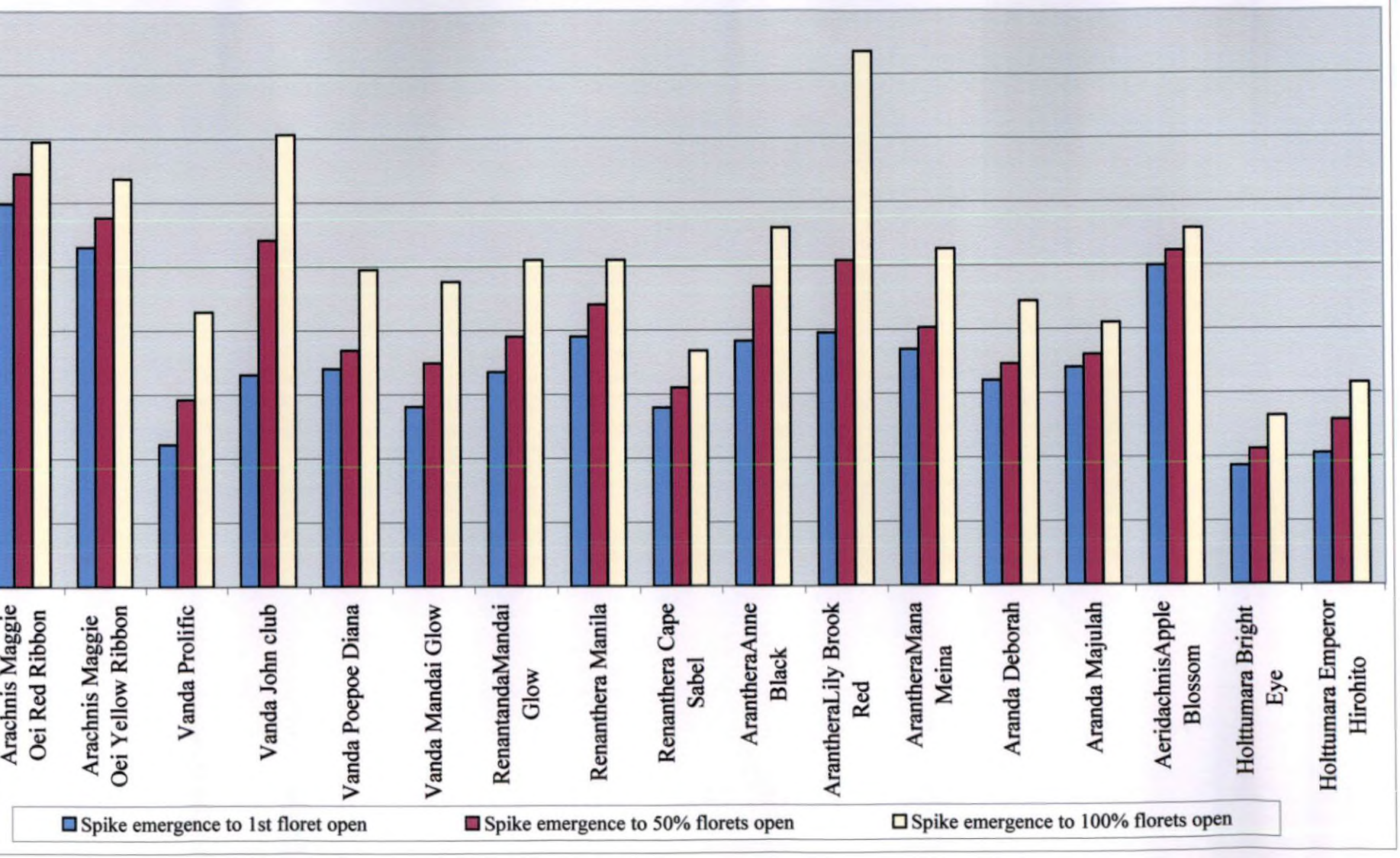


Table 19. Flowering characteristics of intermediate climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Days from spike emergence to			Opening to wilting of 1st floret (Days)	Spike longevity (Days)	Spike production interval (Days)	Flowering stem/plant (No.)	Annual spike production (No.)	Blooming period
		1st floret open	50 % florets open	100% florets open						
1	*Vanda* Josephine Van Brero x *Ascocenda* Yip Sum Wah	23.1^{i}	26.0^{f}	31.3^{f}	21.0^{cd}	32.3^{fg}	92.4^{ef}	1.0	3.3^{e}	Mar-Dec
2	*Ascocenda* Princess Mikasa Pink	29.3^{g}	33.3^{de}	45.7^{d}	32.0^{b}	44.7^{c}	89.0^{efg}	1.0	5.0^{a}	Year-round
3	*Ascocenda* Raminder Gold x Fortune East	24.0^{i}	25.8^{f}	29.0^{f}	13.0^{e}	23.0^{i}	173.0^{ab}	1.0	2.0^{d}	Mar-Apr, Sept-Oct
4	*Vascostylis* Pine Rivers Red	27.4^{h}	35.7^{d}	57.3^{bc}	26.0^{c}	39.7^{d}	65.67^{gh}	1.0	5.0^{a}	Year-round
5	*Vascostylis* Pine Rivers Pink	27.5^{h}	32.5^{e}	38.5^{e}	19.0^{d}	30.3^{fg}	82.3^{fg}	1.0	3.0^{e}	Feb-Apr, Jun-Oct
6	*Vascostylis* Pine Rivers Blue	29.3^{g}	32.5^{e}	42.3^{de}	24.0^{c}	36.0^{e}	97.5^{def}	1.0	4.0^{b}	Jun-Aug, Nov-Mar
7	*Mokara* Walter Oumae Yellow	43.8^{a}	45.2^{a}	53.7^{c}	13.0^{e}	19.0^{j}	179.0^{ab}	1.0	2.0^{d}	Feb-Apr, Sept-Nov
8	*Mokara* Bangkok Gold	43.0^{a}	45.0^{ab}	47.7^{d}	16.0^{de}	26.7^{h}	143.7^{b}	1.0	3.0^{e}	Mar-Apr, Sept-Oct
9	*Mokara* Sayanx *Ascocenda x* Meda Arnold	32.9^{e}	35.7^{d}	42.7^{de}	19.0^{d}	29.7^{gh}	98.3^{def}	1.0	3.0^{e}	Apr-May, Jul-Aug, Oct-Nov
10	*Mokara* Chark Kuan Pink	38.2^{c}	41.8^{c}	46.9^{d}	14.0^{e}	33.3^{ef}	110.3^{cde}	1.0	4.3^{b}	Mar-Dec
11	*Mokara* Calypso Pink	40.5^{b}	44.4^{b}	59.3^{b}	27.0^{bc}	49.7^{b}	81.7^{fg}	1.0	5.3^{a}	Year-round
12	*Mokara* Walter Oumae White	35.6^{d}	44.3^{b}	78.3^{a}	40.0^{a}	56.7^{a}	93.7^{def}	1.0	4.0^{b}	Year-round
13	*Mokara* Sayan x Kultana Gold	31.0^{f}	34.5^{de}	46.3^{d}	31.0^{b}	36.0^{e}	192.5^{a}	1.0	2.5^{cd}	Dec-Feb, July-Sept
14	*Mokara* Dinah shore	32.5^{e}	34.5^{de}	37.5^{e}	14.0^{e}	23.0^{i}	167.0^{b}	1.0	2.0^{d}	Mar-May, Aug-Oct
15	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai	40.5^{b}	47.2^{a}	54.2^{bc}	22.0^{cd}	31.3^{fg}	117.5^{cd}	1.0	3.0^{e}	Feb-Dec

Fig. 2. Days taken from spike emergence to opening of florets in intermediate climbing epiphytes

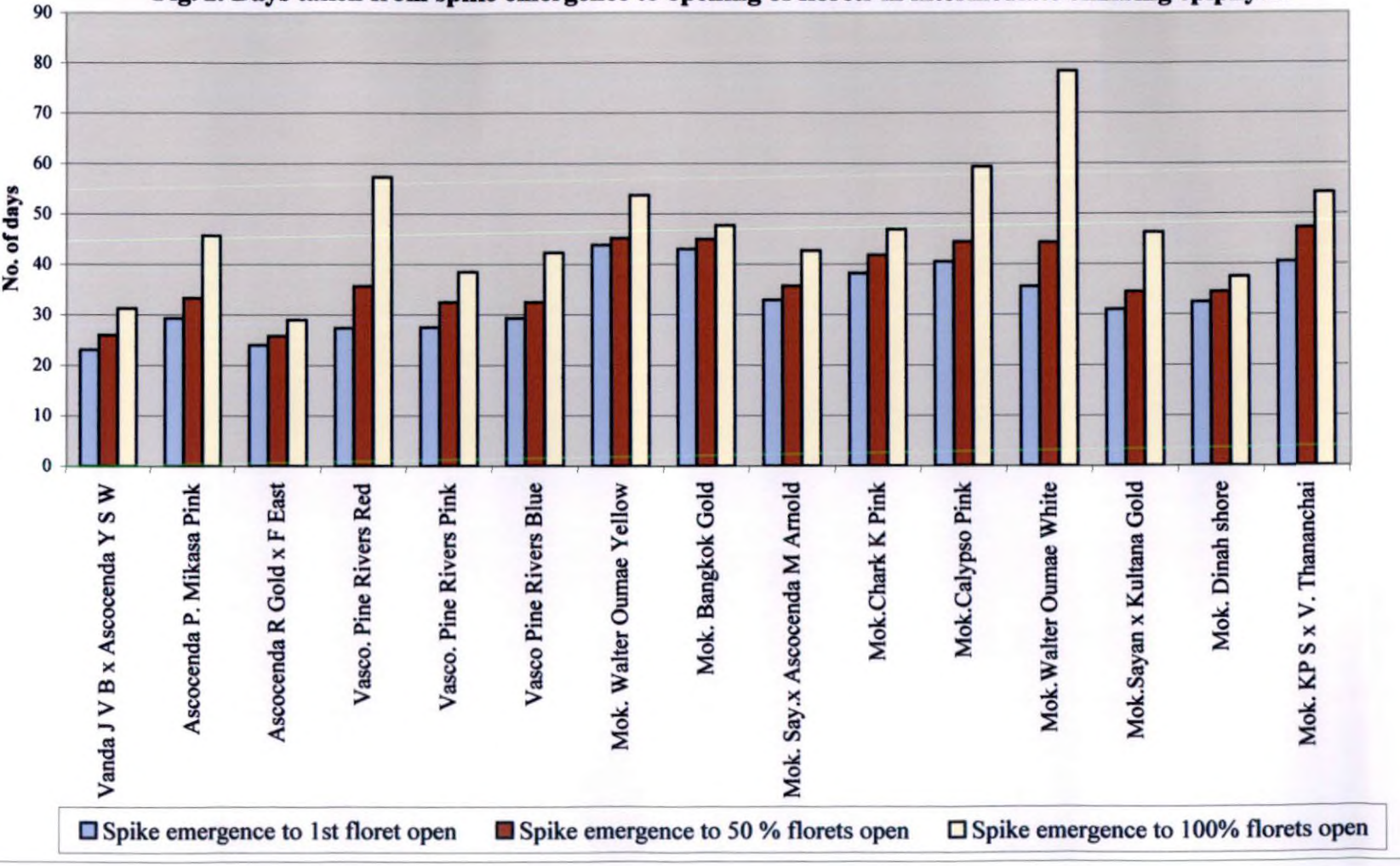


Table 20. Flowering characteristics of different short-stemmed monopodial orchids

Sl. No	Varieties/ Hybrids	Days from spike emergence to			Opening to wilting of 1st floret (Days)	Spike longevity (Days)	Spike production interval (Days)	Flowering stem/plant (No.)	Annual production of spikes (No.)	Blooming period
		1st floret open	50% florets open	100% florets open						
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	57.1^{c}	67.3^{d}	83.2^{d}	32.0^{b}	114.7^{c}	175.0	1.0	2.3^{a}	Feb-Dec
2	*Phalaenopsis* Diana Pink	63.0^{b}	146.0^{a}	205.0^{a}	28.0^{c}	177.0^{b}	once a year	1.0	1.0^{b}	Mar-Nov
3	*Phalaenopsis* Hwafeng Red Jewel	58.0^{c}	113.5^{bc}	197.5^{ab}	31.0^{b}	239.3^{a}	once a year	1.0	1.0^{b}	Dec-Nov
4	*Phalaenopsis* Mount Lip	63.5^{b}	126.5^{b}	184.5^{ab}	31.0^{b}	161.7^{b}	once a year	1.0	1.0^{b}	Apr-Nov
5	*Phalaenopsis* Taipei Gold	52.3^{d}	63.6^{d}	95.63^{d}	45.0^{a}	80.0^{cd}	260.0	1.0	1.5^{b}	Jun-Oct
6	*Phalaenopsis* Ho's Happy Auckland	68.7^{a}	72.2^{cd}	106.7^{c}	44.0^{a}	65.0^{d}	once a year	1.0	1.0^{a}	Jun-Dec
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	68.0^{a}	81.2^{c}	131.2^{bc}	21.0^{d}	81.5^{cd}	once a year	1.0	2.3^{a}	Apr-Nov
8	*Phalaenopsis* Memoria Grand Mother	65.4^{ab}	87.4^{c}	138.00^{b}	26.0^{c}	88.3^{cd}	once a year	1.0	2.0^{a}	Jun-Nov

Fig. 3. Days from spike emergence to opening of florets in short-stemmed epiphytes

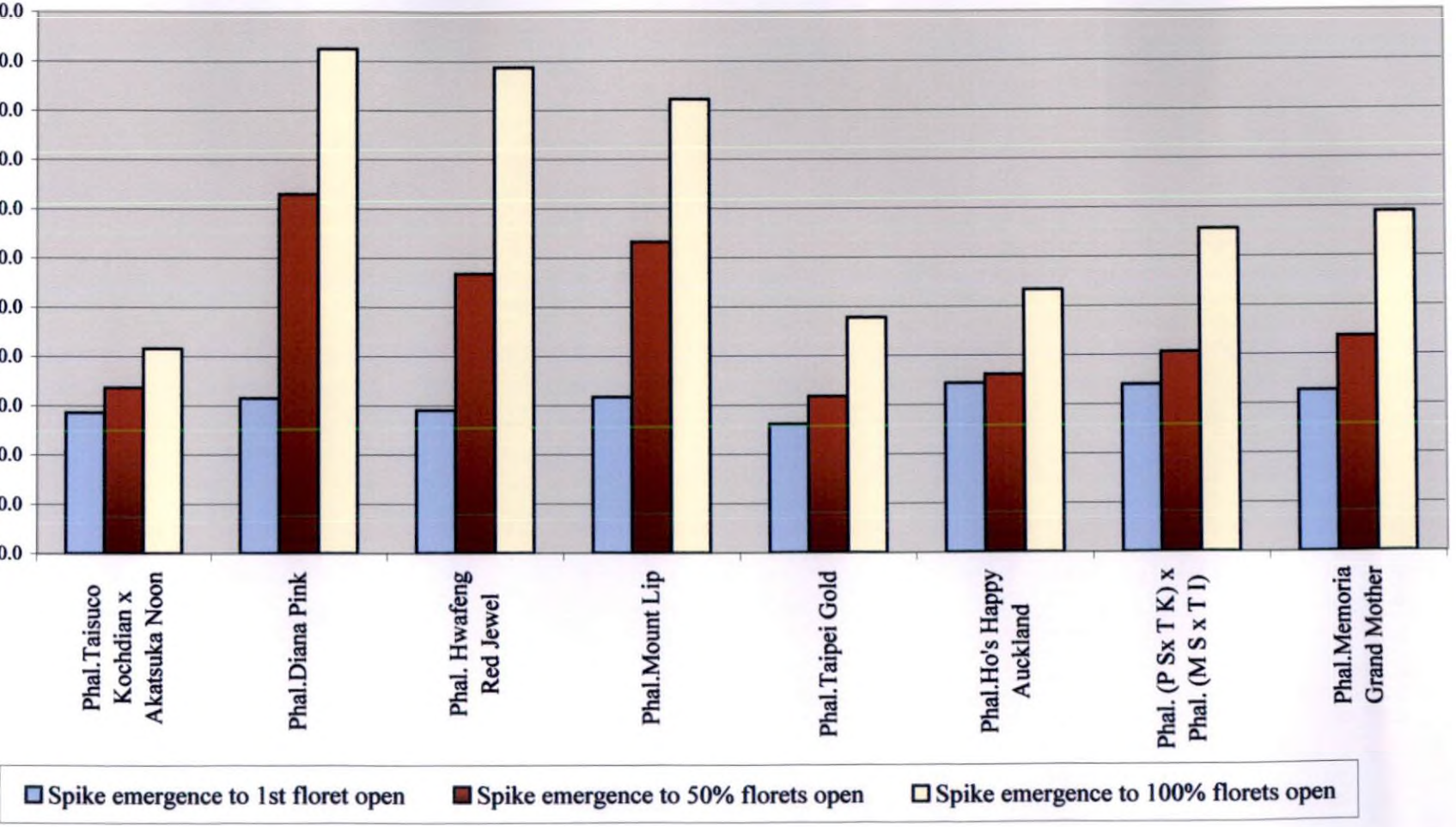


Fig. 4. Spike longevity of 40 different monopodial orchid varieties

Marked differences were also noticed among the intermediate climbing epiphytes with regard to spike production (Table 19). *Mokara* Calypso Pink produced significantly more number of spikes (5.3) closely followed by *Vascostylis* Pine Rivers Red (5.0) and *Ascocenda* Princess Mikasa Pink (5.0) and the number of spikes produced per year was minimum (2.0) in *Mokara* Walter Oumae Yellow, *Ascocenda* Raminder Gold x Fortune East and *Mokara* Dinah Shore.

In short-stemmed epiphytes, annual production of spikes did not differ significantly (Table 20). *Phalaenopsis* Taisuco Kochdian x Akatsuco Noon (2.3) and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) produced maximum number of spikes, followed by *Phalaenopsis* Memoria Grand Mother (2.0) and *Phalaenopsis* Taipei Gold (1.5). *Phalaenopsis* Diana Pink, *Phalaenopsis* Mount Lip, *Phalaenopsis* Hwafeng Red Jewel and *Phalaenopsis* Ho's Happy Auckland produced minimum number of spikes (1.0).

4.1.2.2 Spike characters

Data pertaining to spike characters of different monopodial orchids are presented in Tables 21-23.

Spike length

The tall climbing monopodial orchids differed significantly with respect to the spike length (Table 21). *Aranthera* Lily Brook Red recorded maximum spike length (75.33 cm) and was on par with *Arachnis* Maggie Oei varieties Red Ribbon (73.23 cm) and Yellow Ribbon (70.53 cm). *Vanda* Poepoe Diana recorded minimum spike length (26.53 cm) and was on par with *Renanthera* Cape Sabel (27.03 cm).

Distinguishable differences were noticed with regard to spike length in intermediate climbing epiphytes (Table 22). *Mokara* Sayan x Kultana Gold recorded the maximum spike length (60.33 cm), followed by *Mokara* Walter Oumae White (50.60 cm) which was on par with *Mokara* Calypso Pink (50.03 cm). *Vanda* JVB x *Ascocenda* Yip

Sum Wah had the shortest spike length (20.77 cm) followed by *Ascocenda* Raminder Gold x Fortune East (21.17 cm).

Among the short-stemmed epiphytes, *Phalaenopsis* Diana Pink recorded maximum spike length (95.00 cm) and was significantly superior to all others but on par with *Phalaenopsis* Mount Lip (71.00 cm). Minimum spike length (31.67 cm) was recorded in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) (Table 23).

Stalk Length

Significant variation was observed in the stalk length of tall climbing orchids (Table 21). *Aeridachnis* Apple Blossom recorded the maximum stalk length (31.03 cm) and was on par with *Vanda* John Club (30.87 cm). *Aranda* Majula recorded the minimum stalk length (10.73 cm) followed by *Aranthera* Cape Sabel (12.73 cm) and *Vanda* Prolific (14.20 cm).

Appreciable differences were observed in intermediate climbing epiphytes with respect to stalk length (Table 22). *Mokara* Sayan x Kultana Gold recorded the maximum stalk length (31.86 cm) and was significantly superior to all others. *Vascostylis* Pine Rivers Pink recorded minimum length (9.53 cm) followed by *Vascostylis* Pine Rivers Red (9.73 cm) and *Vascostylis* Pine Rivers Blue (10.30 cm) and were on par.

Among the short-stemmed epiphytes, the stalk length recorded in *Phalaenopsis* Diana Pink (64.00 cm) was significantly higher than the other *Phalaenopsis* types (Table 23). *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) and *Phalaenopsis* Memoria Grand Mother were on par with minimum stalk length (20.00 cm and 23.83 cm respectively).

Rachis length

The tall climbing monopodials showed distinct variation with regard to the length of rachis (Table 21). *Aranthera* Lily Brook Red recorded the maximum rachis length

(51.53 cm) and was significantly superior to others but on par with *Arachnis* Maggie Oei Yellow Ribbon (48.50 cm) and *Arachnis* Maggie Oei Red Ribbon (47.63 cm). The rachis length was significantly less in *Vanda* Poepoe Diana (9.83 cm) and was on par with *Aranthera* Mana Meina (13.20 cm) and *Renanthera* Cape Sabel (14.30 cm).

Considerable differences could be noticed in rachis length among the intermediate climbing epiphytes (Table 22). *Mokara* Walter Oumae White recorded the maximum (30.40 cm) and was on par with *Mokara* Sayan x Kultana Gold (28.47 cm). It was closely followed by *Vascostylis* Pine Rivers Red (22.80 cm) and *Mokara* Chark Kuan Pink (19.23 cm). *Mokara* Walter Oumae Yellow recorded the minimum rachis length (6.43 cm).

Differences were noticeable in short-stemmed epiphytes also (Table 23). *Phalenopsis* Hwafeng Red Jewel recorded the maximum rachis length (33.67 cm) and was on par with *Phalaenopsis* Mount Lip (32.83 cm), *Phalaenopsis* Diana Pink (31.00 cm) and *Phalaenopsis* Memoria Grand Mother (24.50 cm). Length was minimum (7.60 cm) in *Phalaenopsis* Ho's Happy Auckland which was on par with *Phalaenopsis* Taipei Gold (11.33 cm), *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) (11.67 cm) and *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (17.23 cm).

Girth of spike

The girth of spike varied significantly in tall climbing epiphytes (Table 21). *Aranda* Majula and *Aranthera* Lily Brook Red recorded maximum spike girth (2.20 cm) and were significantly superior to all others except *Vanda* Prolific (2.17 cm). Minimum spike girth (1.20 cm) was observed in *Renanthera* Cape Sabel which was on par with *Aranda* Deborah (1.23 cm).

Among the intermediate climbing epiphytes, *Mokara* Sayan x Kultana Gold recorded maximum spike girth (2.30 cm) and was significantly superior to all followed by *Mokara* Chark Kuan Pink (2.10 cm). Minimum spike girth (1.40 cm) was recorded in *Mokara* Bangkok Gold (Table 22).

Table 21. Spike characters of tall climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Spike length (cm)	Stalk length (cm)	Rachis length (cm)	Girth of spike (cm)	Branching habit	Nature of inflorescence
1	*Arachnis* Maggie Oei Red Ribbon	72.23^{a}	24.60^{bc}	47.63^{a}	2.07^{bc}	present	arching
2	*Arachnis* Maggie Oei Yellow Ribbon	70.53^{a}	22.03^{c}	48.50^{a}	1.87^{d}	present	arching
3	*Vanda* Prolific	37.77^{efg}	14.20^{e}	23.57^{d}	2.17^{ab}	absent	erect
4	*Vanda* John club	60.17^{b}	30.87^{a}	29.30^{c}	1.87^{d}	absent	drooping
5	*Vanda* Poepoe Diana	26.53^{h}	16.70^{d}	9.83^{g}	1.60^{e}	present	erect
6	*Vanda* Mandai Glow	35.77^{fg}	17.94^{d}	17.83^{ef}	1.80^{d}	present	erect
7	*Renantanda* Mandai Glow	45.00^{de}	23.67^{bc}	21.33^{de}	2.03^{c}	present	erect
8	*Renanthera* Manila	56.00^{bc}	26.60^{b}	29.40^{c}	2.10^{abc}	present	erect
9	*Renanthera* Cape Sabel	27.03^{h}	12.73^{e}	14.30^{fg}	1.20^{f}	present	erect
10	*Aranthera* Anne Black	58.50^{bc}	18.60^{d}	39.90^{b}	2.07^{bc}	present	erect
11	*Aranthera* Lily Brook Red	75.33^{a}	23.80^{c}	51.53^{a}	2.20^{a}	multiple branching	erect
12	*Aranthera* Mana Meina	37.17^{efg}	23.97^{b}	13.20^{fg}	1.63^{e}	absent	erect
13	*Aranda* Deborah	43.17^{ef}	18.97^{d}	24.20^{cd}	1.23^{f}	absent	erect
14	*Aranda* Majula	34.40^{g}	10.73^{e}	23.67^{d}	2.20^{a}	absent	arching
15	*Aeridachnis* Apple Blossom	51.43^{cd}	31.03^{a}	20.40^{de}	1.60^{e}	present	arching
16	*Holttumara* Bright Eye	38.67^{efg}	14.57^{de}	24.10^{cd}	2.00^{c}	absent	erect
17	*Holttumara* Emperor Hirohito	43.50^{ef}	22.60^{c}	20.90^{de}	2.10^{abc}	present	erect

Table 22. Spike characters of intermediate climbing epiphytes

Sl. No	Varieties/ Hybrids	Spike length (cm)	Stalk length (cm)	Rachis length (cm)	Girth of spike (cm)	Branching habit	Nature of inflorescence
1	*Vanda* Josephine Van Brero x *Ascocenda* Yip Sum Wah	20.77^{f}	13.17^{d}	7.60^{fg}	1.80^{e}	absent	erect
2	*Ascocenda* Princess Mikasa Pink	26.17^{e}	10.60^{de}	15.57^{cd}	1.93^{d}	absent	erect
3	*Ascocenda* Raminder Gold x Fortune East	21.17^{f}	13.34^{cd}	7.83^{gh}	1.70^{f}	absent	arching
4	*Vascostylis* Pine Rivers Red	32.53^{d}	9.73^{e}	22.80^{b}	1.70^{f}	absent	erect
5	*Vcscostylis* Pine Rivers Pink	26.10^{e}	9.53^{e}	16.57^{cd}	1.60^{g}	absent	erect
6	*Vascostylis* Pine Rivers Blue	28.47^{ef}	10.30^{de}	18.17^{c}	1.50^{h}	absent	erect
7	*Mokara* Walter Oumae Yellow	24.33^{ef}	17.90^{c}	6.43^{g}	2.00^{c}	absent	erect
8	*Mokara* Bangkok Gold	25.57^{ef}	14.40^{cd}	11.17^{ef}	1.40^{i}	absent	erect
9	*Mokara* Sayan x *Ascocenda* Meda Arnold	31.47^{de}	23.00^{b}	8.47^{fg}	2.00^{c}	absent	erect
10	*Mokara* Chark Kuan Pink	41.90^{c}	22.67^{b}	19.23^{bc}	2.10^{c}	absent	erect
11	*Mokara* Calypso Pink	50.03^{b}	21.53^{bc}	28.50^{a}	1.53^{h}	absent	erect
12	*Mokara* Walter Oumae White	50.60^{b}	20.20^{bc}	30.40^{a}	1.97^{cd}	absent	erect
13	*Mokara* Sayan x Kultana Gold	60.33^{a}	31.86^{a}	28.47^{a}	2.30^{a}	absent	erect
14	*Mokara* Dinah Shore	28.30^{de}	20.70^{bc}	7.60^{fg}	1.50^{h}	absent	erect
15	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai	40.97^{c}	27.60^{ab}	13.37^{de}	1.50^{h}	absent	erect

Table 23. Spike characters of short-stemmed epiphytes

Sl. No	Varieties/ Hybrids	Spike length (cm)	Stalk length (cm)	Rachis length (cm)	Girth of spike (cm)	Branching habit	Nature of inflorescence
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	57.23^{bc}	40.00^{b}	17.23^{b}	2.10^{b}	present	arching
2	*Phalaenopsis* Diana Pink	95.00^{a}	64.00^{a}	31.00^{a}	2.20^{ab}	present	arching
3	*Phalaenopsis* Hwafeng Red Jewel	69.00^{b}	35.33^{c}	33.67^{a}	2.17^{ab}	present	arching
4	*Phalaenopsis* Mount Lip	71.00^{ab}	38.17^{bc}	32.83^{a}	1.73^{c}	present	arching
5	*Phalaenopsis* Taipei Gold	43.93^{d}	32.6^{c}	11.33^{c}	1.37^{d}	present	arching
6	*Phalaenopsis* Ho's Happy Auckland	42.33^{d}	34.73^{c}	7.60^{c}	1.50^{d}	absent	arching
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	31.67^{e}	20.00^{d}	11.67^{c}	1.50^{d}	present	erect
8	*Phalaenopsis* Memoria Grand Mother	48.33^{cd}	23.83^{d}	24.50^{a}	2.33^{a}	multiple branching	arching

Significant differences were noticed in the spike girth of short-stemmed epiphytes (Table 23). Maximum spike girth (2.33 cm) was recorded in *Phalaenopsis* Memoria Grand Mother was significantly superior to all others and was on par with *Phalaenopsis* Diana Pink (2.20 cm) and *Phalaenopsis* Hwafeng Red Jewel (2.17 cm). Minimum spike girth was recorded in *Phalaenopsis* Taipei Gold (1.37).

4.1.2.3 Flower characters

Data pertaining to different floral characters of monopodial orchids like number of florets per spike, internodal length of spike, pedicel length, flower size and individual flower life are presented in Tables 24-26.

Number of florets/ spike

Significant differences could be noticed with regard to the number of florets per spike in tall climbing orchids and it varied from 5.2 to 116.0 (Table 24). *Aranthera* Lily Brook Red recorded maximum number of florets (116.0) compared to all others. This was followed by *Renanthera* Manila (16.0), *Holttumara* Emperor Hirohito (14.5), *Arachnis* Maggie Oei Yellow Ribbon (14.3), *Renantanda* Mandai Glow (13.7) and *Aranthera* Anne Black (13.5) and were all statistically comparable. Minimum number of florets per spike was recorded in *Aranthera* Mana Meina (5.2).

Among intermediate climbing epiphytes, *Vascostylis* Pine Rivers Red recorded the maximum number of florets/spike (29.7) and was significantly superior to all others. This was followed by *Vascostylis* Pine Rivers Blue (23.3) and *Vascostylis* Pine Rivers Pink (21.3) and were on par. The number of florets per spike (6.5) recorded was minimum in *Mokara* Dinah Shore (Table 25).

Among the short-stemmed epiphytes, appreciable differences were recorded in number of florets per spike (Table 26). *Phalaenopsis* Memoria Grand Mother recorded the maximum number of florets per spike (32.3) and was significantly superior to all *Phalaenopsis* varieties. This was followed by *Phalaenopsis* Hwafeng Red Jewel (23.3) which was on par with *Phalaenopsis* Diana Pink (19.0) and *Phalaenopsis* Mount lip

(16.3). *Phalaenopsis* Ho's Happy Auckland had minimum number of florets per spike (4.7).

Internodal length

The internodal length of the spike differed significantly among tall climbing orchids (Tale 24). *Arachnis* Maggie Oei Yello Ribbon recorded maximum internodal length (5.30 cm) and was superior to all others except *Arachnis* Maggie Oei Red Ribbon (4.87 cm). Internodal length recorded was minimum (0.94 cm) in *Vanda* Poepoe Diana.

Among the intermediate climbing epiphytes (Table 25), internodal length was significantly more in *Mokara* Sayan x Kultana Gold (2.37 cm) and was on par with *Mokara* Calypso Pink (2.33 cm). Internodal length recorded was minimum (0.80 cm) in *Vascostylis* Pine Rivers Blue (Table 25).

The short-stemmed epiphytes recorded considerable variation with regard to the internodal length of the spike (Table 26). *Phalaenopsis* Diana Pink recorded the maximum internodal length (2.28 cm) while *Phalaenopsis* (Pinlong Spring x Taisuco Kochidian) x *Phalaenopsis* (Miami Sunrise x Tiny ivory) recorded the minimum (1.02 cm).

Pedicel length

Considerable differences were observed in tall climbing orchids with regard to the pedicel length (Table 24). It varied from 2.27 cm (*Aeridachnis* Apple Blossom) to 6.03 cm (*Vanda* Mandai Glow).

Intermediate climbing epiphytes recorded noticeable differences with regard to the pedicel length (Table 25). *Vanda* JVB x *Ascocenda* Yip Sum Wah recorded the maximum pedicel length (5.43 cm) and was significantly superior to all others. *Mokara* Bangkok Gold recorded minimum pedicel length (1.37 cm).

Among the short-stemmed epiphytes, pedicel length in *Phalaenopsis* Diana Pink was significantly superior (5.27 cm) to all other varieties/hybrids (Table 26). Pedicel

length recorded in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny ivory) was significantly less (3.00 cm).

Flower size

Significant differences were noticed in tall climbing orchids with regard to the flower size (Table 24). The flower size was maximum (72.25 cm^2) in *Aranthera* Mana Meina and was significantly superior when compared to others, but on par with *Arachnis* Maggie Oei Red Ribbon (72.0 cm^2). Minimum flower size (12.50 cm^2) was recorded in *Aranthera* Lily Brook Red followed by *Aeridachnis* Apple Blossom (16.81 cm^2).

Detectable differences were also noticed with respect to individual floret size in intermediate climbing epiphytes (Tables 25). *Mokara* Walter Oumae Yellow recorded maximum size (90.25 cm^2) and was significantly superior to all others. This was followed by *Mokara* Sayn x Kultana Gold (76.50 cm^2), *Ascocenda* Princess Mikasa Pink (73.96 cm^2) and *Mokara* Sayan x *Ascocenda* Meda Arnold (72.00 cm^2). *Vascostylis* Pine Rivers Blue and *Vascostylis* Pine Rivers Pink recorded minimum floret size (11.56 cm^2).

Distinguishable differences were noticed in short-stemmed epiphytes with regard to the flower size (Table 26). Maximum flower size (99.7 cm^2) was recorded in *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon and was significantly superior to all others except *Phalaenopsis* Diana Pink (95.0 cm^2). Minimum flower size (36.0 cm^2) was observed in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny ivory) and was on par with *Phalaenopsis* Memoria Grand Mother (48.75 cm^2).

Individual flower life

Appreciable differences were found with respect to flower life within the tall growing orchids, intermediate climbing and short-stemmed epiphytes (Tables 24, 25 and 26 respectively).

Table 24. Floral characters of tall climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Florets/ spike (No.)	Internodal length (cm)	Nature of arrangement	Pedicel length (cm)	Flower size		Individual flower life (Days)	Other floral characters
						L x W (cm x cm)	Area (cm^2)		
1	*Arachnis* Maggie Oei Red Ribbon	11.3^{defg}	4.87^{a}	spiral	2.37^{j}	9.0 x 8.0	72.00^{a}	32.5^{b}	scorpion shaped, reddish brown pattern
2	*Arachnis* Maggie Oei Yellow Ribbon	14.3^{bc}	5.30^{a}	spiral	3.43^{g}	8.0 x 7.8	62.40^{b}	28.7^{bc}	scorpion shaped hay coloured with pale fawn pattern
3	*Vanda* Prolific	8.2^{h}	1.60^{ef}	spiral	4.87^{cd}	7.5 x 7.5	56.25^{bc}	20.7^{fgh}	flower soft pink, labellum pink, sweet fragrance,petals flip close to 180 degrees
4	*Vanda* John club	11.7^{cdefg}	1.80^{ef}	spiral	3.50^{g}	6.0 x 6.0	36.00^{e}	20.2^{ef}	lavender florets, labellum protruding petals flip close to 180 degrees
5	*Vanda* Poepoe Diana	8.0^{h}	0.94^{h}	spiral	4.47^{e}	8.0 x 8.0	64.00^{b}	17.6^{i}	pure white florets, petals flip close to 180 degrees
6	*Vanda* Mandai Glow	11.8^{cdefg}	1.85^{fghi}	spiral	6.03^{a}	6.4 x 6.0	38.40^{e}	19.5^{ghi}	handsome spike red violet florets with yellow markings, petals flip
7	*Renantanda* Mandai Glow	13.7^{bcde}	2.45^{de}	spiral	4.20^{f}	8.0 x 6.0	48.00^{e}	17.3^{hi}	majestic spike with orange florets, petals flip
8	*Renanthera* Manila	16.0^{b}	3.08^{c}	spiral	3.53^{g}	6.5 x 5.0	32.50^{e}	31.7^{b}	bright red flowers
9	*Renanthera* Cape Sabel	8.3^{h}	2.14^{e}	spiral	4.63^{de}	6.0 x 6.0	36.00^{e}	13.6^{j}	prominent magentha labellum
10	*Aranthera* Anne Black	13.5^{bcde}	3.84^{b}	spiral	2.8^{i}	7.0 x 6.2	43.40^{e}	26.7^{cd}	attractive crimson florets, beautiful shape
11	*Aranthera* Lily Brook Red	116.0^{a}	1.27^{g}	spiral	3.17^{h}	5.0 x 2.5	12.50^{g}	41.7^{a}	brilliant scarlet florets,numerous florets per spike
12	*Aranthera* Mana Meina	5.2^{i}	3.45^{bc}	spiral	5.07^{bc}	8.5 x 8.5	72.25^{a}	20.0^{efg}	pale orange florets
13	*Aranda* Deborah	10.3^{fgh}	2.85^{d}	spiral	3.67^{g}	5.2 x 5.0	26.00^{e}	29.6^{b}	earth matte spotted florets, shapely
14	*Aranda* Majula	9.3^{gh}	2.57^{d}	spiral	4.73^{de}	7.2 x 7.0	50.40^{c}	24.3^{cd}	prominent waxy, florets honey colour with maroon markings
15	*Aeridachnis* Apple Blossom	10.8^{efgh}	2.43^{de}	spiral	2.27^{j}	4.1 x 4.1	16.81^{g}	18.5^{hi}	ivory colour, malodorous
16	*Holttumara* Bright Eye	12.5^{cdef}	2.47^{de}	spiral	5.17^{b}	8.0x 8.0	64.00^{b}	22.1^{efg}	large spike with rose coloured attractive florets
17	*Holttumara* Emperor Hirohito	14.5^{bc}	2.02^{e}	spiral	5.3^{b}	8.0 x 7.0	56.00^{bc}	20.0^{de}	spray of coral spotted florets

Table 25. Floral characters of intermediate climbing monopodial orchids

Sl. No	Varieties/ Hybrids	Florets/spike (No.)	Internodal length (cm)	Nature of arrangement	Pedicel length (cm)	Flower size		Individual flower life (Days)	Other floral characters
						L x W (cm x cm)	Area (cm^2)		
1	*Vanda* J V B x *Ascocenda* Yip Sum Wah	7.0^{gh}	0.72^{e}	spiral	5.43^{a}	6.0 x 5.5	33.00^{ef}	21.4^{c}	salmon coloured waxy florets
2	*Ascocenda* Princess Mikasa Pink	12.6^{ef}	0.97^{de}	spiral	5.23^{b}	8.6 x 8.6	73.96^{b}	31.5^{a}	bright cerise-pink attractive florets
3	*Ascocenda* Raminder Gold x Fortune East	8.0^{gh}	1.05^{de}	spiral	5.13^{bc}	8.0 x 7.9	63.20^{c}	15.3^{f}	large, fleshy bright yellow with brown markings
4	*Vascostylis* Pine Rivers Red	29.7^{a}	1.18^{d}	spiral	3.10^{h}	3.6 x 3.6	12.96^{g}	26.0^{b}	red florets, attractively spaced
5	*Vascostylis* Pine Rivers Pink	21.3^{b}	1.2^{d}	spiral	2.50^{j}	3.4 x 3.4	11.56^{g}	20.0^{c}	pink florets, attractively spaced
6	*Vascostylis* Pine Rivers Blue	23.3^{b}	0.8^{d}	spiral	2.80^{i}	3.4 x 3.4	11.56^{g}	27.2^{b}	amethyst florets, attractively spaced
7	*Mokara* Walter Oumae Yellow	6.7^{gh}	0.87^{d}	spiral	4.67^{e}	9.5 x 9.5	90.25^{a}	10.2^{g}	large yellow florets with maroon spots
8	*Mokara* Bangkok Gold	8.0^{gh}	2.07^{b}	spiral	1.37^{k}	5.5 x 4.8	26.40^{f}	24.00^{c}	yellow flowers with burgundy blush at apex of tepals
9	*Mokara* Sayan x *Ascocenda* Meda Arnold	6.9^{gh}	1.25^{d}	spiral	4.83^{de}	9.0 x 8.0	72.00^{b}	22.0^{c}	large yellow flowers with maroon spots
10	*Mokara* Chark Kuan Pink	9.3^{fgh}	2.00^{b}	spiral	4.33^{f}	9.4 x 8.8	82.72^{ab}	22.4^{c}	pink flowers with dark pink spots
11	*Mokara* Calypso Pink	12.8^{ef}	2.33^{a}	spiral	5.00^{cd}	7.8 x 7.6	59.28^{d}	25.9^{c}	hot pink spotted florets
12	*Mokara* Walter Oumae White	14.7^{de}	1.63^{c}	spiral	5.10^{bc}	6.8 x 6.2	42.16^{e}	31.3^{a}	white florets, magentha spots
13	*Mokara* Sayan x Kultana Gold	14.6^{de}	2.37^{a}	spiral	4.80^{e}	9.0 x 8.5	76.50^{b}	28.7^{b}	large spike with deep pink florets
14	*Mokara* Dinah Shore	6.5^{h}	1.18^{d}	spiral	3.77^{g}	6.0 x 6.0	36.00^{ef}	15.5^{f}	florets venetian red, spotted
15	*Mokara* Khaw Phaik Suan x *Vanda* Thananchai	11.0^{efg}	1.83^{bc}	spiral	3.87^{g}	7.1 x 6.9	48.99^{de}	22.3^{c}	yellow florets, tepals droop down

Table 26. Floral characters of different short-stemmed monopodial orchids

Sl. No	Varieties/ Hybrids	Florets/ spike (No.)	Internodal length (cm)	Nature of arrangement	Pedicel length (cm)	Flower Size		Individual flower life (Days)	Other floral Characters
						L x W (cm x cm)	Area (cm^2)		
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	8.8^{d}	2.04^{b}	spiral	4.67^{b}	9.5 x 10.5	99.75^{a}	30.0^{c}	pure white florets with bright yellow markings at base of labellum hinged, anchor shaped, 2 ornamental process
2	*Phalaenopsis* Diana Pink	19.0^{b}	2.28^{a}	spiral	5.27^{a}	9.5 x 10.0	95.00^{a}	29.4^{c}	pink florets, wine red, labellum hinged, anchor shaped ornamental process,2 ornamental processes
3	*Phalaenopsis* Hwafeng Red Jewel	23.3^{b}	1.67^{c}	spiral	4.53^{bc}	8.5 x 10.0	85.00^{b}	28.3^{c}	persian pink florets, labellum hinged, anchor shaped, 2 ornamenal process
4	*Phalaenopsis* Mount Lip	16.3^{c}	2.05^{b}	spiral	3.63^{d}	9.0 x 9.0	81.00^{b}	31.1^{bc}	white florets, magenta blush at centre,labellum hinged, anchor shaped, 2 ornamental process
5	*Phalaenopsis* Taipei Gold	6.0^{d}	2.25^{a}	spiral	3.47^{d}	7.5 x 7.5	56.25^{d}	45.8^{a}	soft yellow florets, labellum hinged, anchor shaped, 2 ornamental process
6	*Phalaenopsis* Ho's Happy Auckland	4.7^{d}	1.55^{cd}	spiral	4.27^{c}	8.0 x 8.0	64.00^{c}	27.7^{c}	white florets, pink blush towards the centre of tepals, labellum hinged, anchor shape, 2 ornamental process
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory	7.0^{d}	1.02^{e}	spiral	3.00^{e}	6.0 x 6.0	36.00^{e}	22.6^{d}	Small pastel pink floret, labellum hinged, dark,anchor shaped, 2 ornamental tendril like process
8	*Phalaenopsis* Memoria Grand Mother	32.3^{a}	1.83^{bc}	spiral	4.20^{c}	6.5 x 7.5	48.75^{de}	26.4^{c}	Orchid pink tepals with dark veins, labellum hinged, dark, 2 ornamental tendril like process

Among tall climbing orchids, *Aranthera* Lily Brook Red recorded maximum flower life on the plant (41 .7 days) and was significantly superior to all others (Table 24). *Renanthera* Cape Sabel flowers had a very short span on plant (13.6 days).

Among the intermediate climbing epiphytes, *Ascocenda* Princess Mikasa Pink and *Mokara* Walter Oumae White were on par with maximum flower life (31.5 and 31.3 days respectively). Individual flower life recorded in *Vascostylis* Pine Rivers Blue (24.2 days), *Mokara* Sayan x Kultana Gold (28.7 days) and *Vascostylis* Pine Rivers Red (26.0 days) were all on par. Minimum flower life (10.2 days) was recorded in *Mokara* Walter Oumae Yellow (Table 25).

Among short-stemmed epiphytes, *Phalaenopsis* Taipei Gold recorded maximum individual flower life (45.8 days) and was significantly higher than all *Phalenopsis* varieties (Table 26). Minimum flower life (22.6 days) was recorded in case of *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory).

4.2 QUALITATIVE CHARACTERS

The qualitative characters of the varieties differed in all aspects and a wide range of variation cold be observed.

4.2.1 Stem characters

Data on qualitative stem and root characters are presented in Tables 6-8 and 15-17 respectively.

The different shoot types observed in tall climbing monopodial orchids were slender cane like (*Vanda* Poepoe Diana and *Vanda* John Club), medium sized (*Arachnis* Maggie Oei, *Aeridachnis* Apple Blossom, *Renanthera*, *Aranthera*, *Aranda* Deborah, *Vanda* Prolific, *Vanda* Mandai Glow) and sturdy (*Holttumara*, *Renantanda* Mandai Glow and *Aranda* Majula).The aerial roots of *Aeridachnis*, *Aranthera*, *Vanda*, *Holttumara*, *Aranda* Deborah, and *Renanthera* Manila exhibited branching when mature whereas *Arachnis* Maggie Oei roots rarely branched. In *Renanthera* Cape Sabel and *Aranda* Majula branching was observed in young roots also.

Among intermediate climbing epiphytes, *Mokara* Dinah Shore had slender shoot. *Mokara* Khaw Phaik Suan x *Vanda* Thananchai, *Mokara* Walter Oumae White, *Mokara* Calypso Pink, *Mokara* Bangkok Gold and *Vascostylis* hybrids had medium thick shoot; *Ascocenda* hybrids, *Vanda* JVB x *Asc.* YSW, *Mokara* Walter Oumae Yellow, *Mokara* Sayan x *Asc.* Meda Arnold, *Mokara* Chark Kuan Pink and *Mokara* Sayan x Kultana Gold had sturdy stem. Roots of *Ascocenda*, *Vascostylis*, *Mokara* Walter Oumae Yellow, *Mokara* Bangkok Gold, *Mokara* Sayan x Kultana Gold branched. *Mokara* Sayan x *Ascocenda* Meda Arnold, *Mokara* Chark Kuan Pink, *Mokara* Calypso Pink, *Mokara* Walter Oumae White and *Mokara* Khaw Phaik Suan x *Vanda* Thananchai branch when very mature.

The stem of short-stemmed epiphytes was wrapped with overlapping leaf sheath thus appearing stout. Roots never exhibited branching but flattened and clasped the pot as they matured.

4.2.2 Leaf characters

Data regarding leaf and leaf sheath characters are presented in Tables 9-11 and 12-14, respectively.

Different leaf characters were observed in tall climbing orchids. Leaf shapes recorded were terete (*Vanda* John Club, *Vanda* Poepoe Diana and *Vanda* Prolific), semi-terete (*Vanda* Mandai Glow, *Renantanda* Mandai Glow and *Aranthera* Mana Meina), linear (*Aranda* and *Aeridachnis*), linear, strap shaped (*Holttumara* and *Aranda* Majula), linear-oblong (*Renanthera*), oblong-obovate (*Arachnis* Maggie Oei and *Aranthera* Anne Black) and elliptic-oblong (*Aranthera* Lily Brook Red). All had parallel venation.Entire, coriaceous leaf margin was recorded in all tall growing monopodials except in *Aranthera* Mana Meina, which had entire incurved leaves and in *Aranda* Deborah, where margin was entire. *Vanda* John Club, *Vanda* Poepoe Diana and *Vanda* Prolific being terete leaved exhibited no leaf margin. Leaves of *Aranthera* Mana Meina, *Vanda* Mandai Glow and *Renantanda* Mandai Glow were deeply channeled. *Renanthera* Cape Sabel, *Holttumara*, *Aranda* Majula were channeled. *Arachnis* Maggie Oei and *Aeridachnis*

Apple Blossom were channeled at base. In *Aranthera* Lily Brook Red, *Aranthera* Anne Black and in *Aranda* Deborah channel was absent or not conspicuous. All had green sheath and leaves except for *Vanda* Prolific (dark green leaves & sheath) and *Vanda* Mandai Glow (leaf sheath green with maroon shade).

All the intermediate climbing epiphytes had strap shaped leaves and were with parallel venation. In addition *Vascostylis* and *Ascocenda* hybrids were falcate. Leaves of *Vanda* JVB x *Ascocenda* Yip Sum Wah were quarter terete and falcate and those of *Mokara* were oblong but *Mokara* Walter Oumae Yellow, linear. Leaf margin of *Mokara* and *Ascocenda* hybrids was entire and coriaceous while that of *Vascostylis*, *Mokara* Walter Oumae Yellow and *Vanda* JVB x *Ascocenda* Yip Sum Wah was entire. They had green leaves and leaf sheath, were deeply channeled throughout the central vein.

Leaves of short-stemmed epiphytes were elliptic-oblong, had smooth and fleshy leaves and recorded parallel venation. They were all channeled at the base. All recorded sheathed leaf base, as well as entire and outcurved leaf margin. With respect to colour, *Phal.* (Pinlong Spring x Taisuco Kochdian) x *Phal.* (Miami Sunrise x Tiny Ivory) had green-purple leaves, *Phalaenopsis* Hwafeng Red Jewel and *Phalaenopsis* Mount Lip had purple markings at the base, all other *Phalaenopsis* plants had green leaves.

4.2.3 Floral characters

Data regarding floral characters are presented in Tables 18 - 23. Among tall growing orchids; *Arachnis* Maggie Oei, *Vanda* John Club and *Vanda* Prolific were free flowering. Short dearth periods were observed in *Aeridachnis* Apple Blossom (May), *Vanda* Mandai Glow (Feb), *Aranthera* Anne Black (June), *Aranda* Deborah (May-June), *Aranthera* Mana Meina (Jan-Feb), *Renantanda* and *Renanthera* Cape Sabel (Dec-Feb). Seasonal flowering was observed in *Vanda* Poepoe Diana (Aug-Mar), *Renanthera* Manila (Aug-Oct), *Holttumara* Bright Eye (Aug-Apr), *Holttumara* Emperor Hirohito (Oct-Dec and Mar- May), *Aranthera* Lily Brook Red (Mar- May and Sept- Dec) and *Aranda* Majula (Sept-Nov and Feb- Apr). In all the plants inflorescence arose from lateral position and florets displayed spiral arrangement. Spikes of *Vanda* Prolific, *Vanda*

Poepoe Diana, *Vanda* Mandai Glow, *Holttumara* Bright Eye, *Holttumara* Emperor Hirohito, *Renantanda* Mandai Glow, *Aranda* Deborah, *Renanthera* Cape Sabel, *Renanthera* Manila, *Aranthera* Lily Brook Red, and *Aranthera* Mana Meina were erect while those of *Arachnis* Maggie Oei, *Aranthera* Anne Black, *Aeridachnis* Apple Blossom and *Aranda* Majula were arching. *Vanda* John Club was drooping. *Aranthera* Lily Brook Red recorded multiple branching. Branching was absent in case of *Aranda* Deborah, *Holttumara* Bright Eye and *Aranda* Majula and *Aranthera* Mana Meina. All the others recorded branching. Florets displayed a wide range of size, patterns and shades (scarlet, red, crimson, coral, orange, red-violet, brown, hay, lavender, rose, pink, ivory and white). Few were fragrance and others not. *Aeridachnis* Apple Blossom had nauseating odour. *Vanda* Prolific and *Aranda* Deborah recorded very sweet fragrance.

Of the intermediate climbing epiphytes, *Vascostyls* Pine Rivers Red, *Mokara* Calypso Pink and *Mokara* Walter Oumae White were free flowering. Short dearth periods were observed in *Ascocenda* Princess Mikasa Pink (Apr), *Mokara* Khaw Phaik Suan x *Vanda* Thananchai (Jan), *Vanda* JVB x *Asc*ocenda YSW, and *Mokara* Chark Kuan Pink (Jan- Feb), *Mokara* Bangkok Gold (May- July), *Vascostylis* Pine Rivers Blue (Apr-May and Sept–Oct) and *Vascostylis* Pine Rivers Pink (May & Nov-Jan). Seasonal blooming was observed in *Mokara* Walter Oumae Yellow (Feb-Apr and Aug-Oct), *Ascocenda* Raminder Gold x Fortune East (Mar-Apr and Aug-Oct), *Mokara* Sayan x Kultana Gold (Dec–Feb and Jul–Sept), *Mokara* Sayan x *Ascocenda* Meda Arnold (Apr-May, Oct-Nov and Jul-Aug) and *Mokara* Dinah Shore (Mar-May and Aug-Oct). Spikes were generally erect except in *Ascocenda* Raminder Gold x Fortune East, which was arching. None of the intermediate climbing epiphytes branched. Florets were spirally arranged and varied in their shape, size, pattern and hue (red, salmon, bright cerise pink, amethyst and other shades of pink and yellow).

In short-stemmed epiphytes, *Phalaenopsis* Hwafeng Red Jewel recorded longest blooming period (Dec-Nov) among short-stemmed epiphytes. Comparatively shorter seasons were observed in *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon and *Phalaenopsis* Diana Pink (Mar-Dec), *Phalaenopsis* Mount Lip and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory)

Arachnis Maggie Oei Yellow Ribbon

Plant tall climbing; shoot medium thick; leaves oblong-obovate, smooth, rigid, cereous, green, tip bilobed, margin entire, coriaceous; leaf sheath membranous; roots fleshy, thick, grey, branching rare. Spike arching, 11 to 16 florets, tepals spatulate, buff with fawn yellow patches, appearance scorpion like-dorsal sepal raised, lateral sepals incurved, petals spreading; labellum trilobed, midlobe swollen, fleshy, yellow, lateral lobes fawn - brown streaks.

Flowering branch: 1.6
Average yield/year: 6.0 spikes

Arachnis Maggie Oei Red Ribbon

Plant tall climbing; shoot medium thick; leaves oblong-obovate, smooth, cereous, rigid, green, tip bilobed, margin entire, coriaceous; leaf sheath membranous; roots fleshy, thick, grey, branching rare. Spike arching, 8 to 14 florets, tepals spatulate, cream with reddish brown markings, scorpion like, dorsal sepal raised and lateral sepals incurved, petals spreading; labellum trilobed, midlobe fleshy, swollen, deep pink, lateral lobes cream reddish brown streaks.

Flowering branch: 2.3
Average yield/year: 9.0 spikes

Vanda Prolific

Plant tall climbing; shoot medium thick; leaves terete, smooth, fleshy, tip obtuse, green; leaf sheath membranous, dark green; roots grey, thick, fleshy, branch when mature. Spike erect, 7 to 11 soft pink florets, fragrant, tepals obovate, petals flip; labellum trilobed, midlobe prominent, base hay colour, apex, rose-purple, spotted, lateral lobes pink-caramel shades.

Flowering branch: 1.0
Average yield/year: 4.0 spikes

Vanda *John Club*

Plant tall climbing; shoot slender cane; leaves terete, smooth, fleshy, dark green, tip obtuse; leaf sheath membranous; roots grey, thread like, woody, shrivelled, branch when mature. Spike drooping, 9 to 15 florets, tepals obovate, lavender, sepals lighter hue, petals intense shade, fringed, petals flip; labellum trilobed, midlobe prominent, base caramel, spotted and deep lavender shade towards the apex, lateral lobes large, burnt sienna-lavender shades.

Flowering branch: 2.0
Average yield/year: 5.3 spikes

Vanda Poepoe Diana

Plant tall climbing; shoot slender cane; leaves terete, smooth, fleshy, tip obtuse, green; leaf sheath membranous, green; roots thread like, woody, grey, shrivelled, branch when mature. Spike erect, 4 to 12 florets, pure white, tepals obovate, fringed, petals flip; labellum trilobed, midlobe prominent, base green, apex fringed, white, lateral lobes greenish within.

Flowering branch: 1.3
Average yield/year: 4.0 spikes

Vanda Mandai Glow

Plant tall climbing; shoot medium thick; leaves semi - terete, smooth, very rigid, green; leaf sheath thick, green, maroon shade; roots grey, thick, branch when mature; Spike erect, 11 to 15 florets, red-violet, tepals linear - obovate, wavy, petals flip; labellum trilobed, midlobe base yellow, apex red, lateral lobes yellow.

Flowering branch: 1.0
Average yield/year: 5.0 spikes

Renanthera Manila

Plant tall climbing; shoot sturdy; leaves linear-oblong, leathery, rigid, green, tip bilobed, margin entire, coriaceous; leaf sheath membranous; roots white, slender, branching rare. Spike erect, 15 to 17 florets, mottled red, tepals unequal, lanceolate, spur red; labellum trilobed, midlobe pale yellow, dark maroon spots, lateral lobes red streaks.

Flowering branch: 2.0
Average yield/year: 2.0 spikes

Renanthera Cape Sabel

Plant tall climbing; shoot medium thick; phyllotaxy fish bone like; leaves linear oblong, smooth, rigid, green, tip bilobed, margin entire, coriaceous; leaf sheath membranous; roots grey, thick, branch young. Spike drooping, 8 to 9 florets, tepals colour auburn, spotted, curl back, labellum trilobed, midlobe deep magenta streaks, lateral lobes magenta streaks.

Flowering branch: 2.5
Average yield/year: 8.3 spikes

Aranthera Anne Black

Plant tall climbing; shoot medium thick; leaves oblong-obovate, smooth, leathery, cereous, green, tip bilobed, margin entire, coriaceous; leaf sheath membranous; roots grey, woody, slender, branching rare. Spike arching, 11 to 16 florets, irregular crimson transverse streaks with yellow-orange markings, appearance spider like, tepals linear-ovate, laterals slightly fringed; labellum trilobed, midlobe short, triangular, fleshy, mid and lateral lobes cream-crimson streaks.

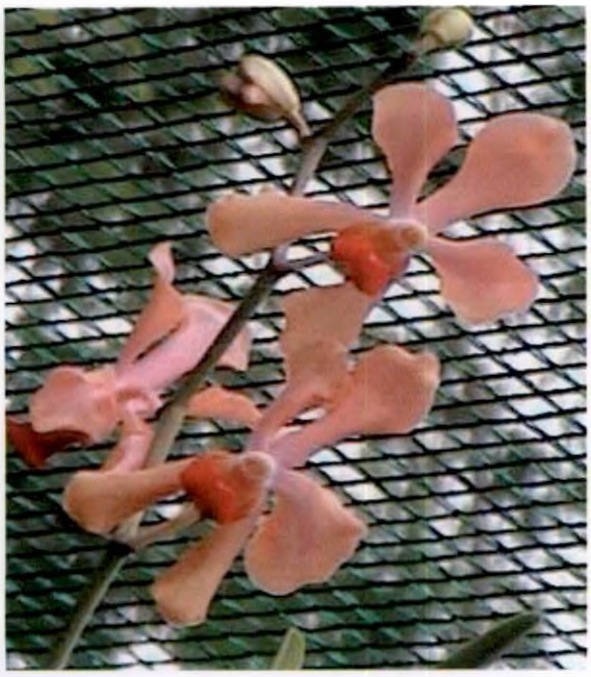
Flowering branch: 2.0
Average yield/year: 8.7 spikes

Aranthera Lily Brook Red

Plant tall climbing; shoot medium thick; leaves elliptic - obovate, smooth, leathery, green, tip bilobed, not channeled, margin entire; leaf sheath membranous; roots shrivelled, woody, creeping. Spike erect, multiple branching, 112 to120 small scarlet florets, dorsal sepal linear, laterals obovate, fringed, petals linear, spreading, spur red, labellum trilobed, tiny, midlobe triangular, fleshy, scarlet, lateral scarlet - yellow streaks.

Flowering branch: 1.0
Average yield/year: 2.0 spikes

Aranthera Mana Meina



Plant tall climbing; shoot sturdy; leaves semi-terete, fleshy, leathery, rigid, green margin incurve, tip acute; leaf sheath membranous; roots woody, shrivelled, branch when mature. Spike erect, 5 to 6 florets, tepals pinkish orange, base pink streaks, curl back, apex wavy, petals and dorsal sepal linear-obovate, lateral sepals obovate; labellum trilobed, midlobe fleshy, apex rust brown, base pink-orange, lateral lobes rust shade.

Flowering branch: 2.0
Average yield/year: 5.0 spikes

Renantanda Mandai Glow

Plant tall climbing; shoot sturdy; leaves semi-terete, smooth, very rigid, green; leaf sheath thick; roots grey, thick, fleshy, branch when mature. Spike erect, at times branch, 9 to 22 florets, tepals orange, linear-obovate, wavy, petals flip, sepals large; labellum trilobed, midlobe base deep yellow, rust spots, rough, deep rust towards apex, lateral lobes yellow - deep rust streaks.

Flowering branch: 1.0
Average yield/year: 5.0 spikes

Aranda Deborah

Plant tall climbing; shoot slender cane; leaves dark green, linear, smooth, rigid, cereous, tip emarginate, margin entire; leaf sheath membranous; roots white/grey, tip green, thick, woody, branch when mature. Spike erect 9 to 12 florets, spreading, colour earth matte, spotted, fragrant, tepals spatulate; labellum trilobed, midlobe elongate, ridged, yellowish, lateral lobes matte-yellow shades.

Flowering branch: 2.7
Average yield/year: 9.5 spikes

Aranda Majula

Plant tall climbing; shoot sturdy; leaves linear, smooth, fleshy, green, tip bilobed, margin entire, coriaceous; leaf sheath membranous; roots white, thick, fleshy, branching. Spike arching, 8 to 9 waxy florets, honey colour with maroon markings, tepals linear-obovate; labellum midlobe fleshy, pink, lateral lobes yellow-pink shades, column prominent, white.

Flowering branch: 2.0
Average yield/year: 2.0 spikes

Holttumara Bright Eye

Plant tall climbing; shoot sturdy; leaves linear, strap shaped, smooth, rigid, fleshy, tip emarginate, margin entire, coriaceous; leaf sheath thick, membranous; roots white, thick, fleshy, branch when mature. Spike erect, rose coloured spray, tepals rose with dark spots, petals spreading, dorsal sepal linear-obovate, lateral sepals obovate; labellum midlobe, base cream, apex rose hue, ridged, lateral lobes white-rose shades.

Flowering branch: 1.0
Average yield/year: 4.0 spikes

Holttumara Emperor Hirohito

Plant tall climbing; shoot sturdy; leaves linear, strap shaped, smooth, rigid, fleshy, tip emarginate, margin entire, coriaceous; leaf sheath thick, membranous; roots white, thick, fleshy, branch when mature. Spike erect, branching, coral spray, tepals coral with dark spots, petals spreading, dorsal sepal linear-obovate, lateral sepals obovate; labellum midlobe, pale yellow with maroon streaks, ridged, lateral lobes coral-cream shades.

Flowering branch: 1.0
Average yield/year: 2.0 spikes

Aeridachnis Apple Blossom

Plant tall climbing; shoot medium thick; leaves green, linear, smooth, rigid, tip bilobed, channel not prominent, margin coriaceous, entire; leaf sheath membranous; roots grey, thick, fleshy. Spike arching, branching, 9 to 16 florets, colour ivory, fragrant, spreading, tepals linear-obovate, sepals larger than petals; labellum trilobed, cream with green/pink tinge, shape prominent, midlobe along with deep spur-high heel like appearance, laterals lobes green/pink.

Flowering branch: 2.0
Average yield/year: 5.7 spikes

Vanda JVB *x Ascocenda* Yip Sum Wah

Plant intermediate climbing epiphyte; shoot medium thick; leaves quarter terete, rigid, green, tip acute, margin entire; leaf sheath thick; roots white, thick, fleshy, branching. Spike erect, 6 to 9 florets salmon colour, tepals obovate, sepals larger than petals; labellum trilobed, midlobe prominent, broad, rust shade, ridged, shape fishtail, lateral lobes pale salmon.

Flowering branch: 1.0
Average yield/year: 3.3 spikes

Ascocenda Princess Mikasa Pink

Plant intermediate climbing epiphyte; shoot sturdy; leaves falcate, strap shaped, leathery, rough, green, tip emarginate, margin entire; leaf sheath thick; roots white, thick, woody, branching. Spike erect, 9 to 13 florets, bright cerise-pink, tepals obovate, net veined; labellum trilobed, midlobe violet, ridged, lateral lobes cerise pink.

Flowering branch: 1.0
Average yield/year: 5.0 spikes

Ascocenda Raminder Gold x Fortune East

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, leathery, smooth, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous, thick; roots branching, white, thick, woody. Spike arching, 8 florets, waxy, fleshy, ochre yellow with brown markings, tepals obovate, petals incurved, lateral sepals outcurved; labellum trilobed, midlobe yellow, prominent, lateral lobes yellow.

Flowering branch: 1.0
Average yield/year: 2.0 spikes

Vascostylis Pine Rivers Red

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, leathery, rigid, fleshy, green, tip emarginate, margin entire; leaf sheath membranous, thick; roots white, thick, woody, branching. Spike erect, 22 to 37 florets, small, red, tepals obovate; labellum trilobed, midlobe deep red, ridged, lateral lobes red, spur narrow, deep.

Flowering branch: 1.0
Average yield/year: 5.0 spikes

Vascostylis Pine Rivers Pink

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, rigid, green, tip emarginate, margin entire; leaf sheath membranous, thick; roots white, slender, fleshy, branching. Spike erect, 21 to 22 florets, small, pink, tepals obovate; labellum trilobed, midlobe deep pink, ridged, lateral lobes pink, spur narrow.

Flowering branch: 1.0
Average yield/year: 3.0 spikes

Vascostylis Pine Rivers Blue

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, rigid, smooth, fleshy, green, tip emarginate, margin entire; leaf sheath membranous, thick; roots white, thick, woody, branching. Spike erect, 20 to 28 florets small, amethyst, obovate; labellum trilobed, midlobe dark, ridged, lateral lobes amethyst, spur narrow.

Flowering branch: 1.0
Average yield/year: 4.0 spikes

Mokara Walter Ouma Yellow

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, smooth, rigid, green, tip emarginate, margin entire; leaf sheath membranous, thick; roots branching, white, thick, fleshy. Spike erect, 5 to 7 florets, spreading, large, yellow with prominent tangerine spots, tepals obovate; labellum midlobe ridged, tangerine streaks, lateral lobes yellow-orange shades.

Flowering branch: 1.0
Average yield/year: 2.0 spikes

Mokara Sayan x *Ascocenda* Meda Arnold

Plant intermediate climbing epiphyte; shoot sturdy; leaves falcate, strap shaped, rigid, fleshy, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous, thick; roots white, fleshy, thick, branching. Spike erect, 6 to 7 florets, well shaped, large, yellow with orange spots, tepals obovate; labellum trilobed, midlobe ridged, apex orange, lateral lobes yellow, margin orange.

Flowering branch: 1.0
Average yield/year: 3.0 spikes.

Mokara Bangkok Gold

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, leathery, green-yellow, tip emarginate, margin entire, leaf sheath membranous, thick; roots grey-white, fleshy, thick, branching. Spike erect, 8 florets, tepals obovate, yellow with burgundy spots and blush towards tip, labellum trilobed midlobe burgundy lateral lobes yellow-burgundy steaks.

Flowering branch: 1.0
Average yield/year: 3.0 spikes

Mokara Chark Kuan Pink

Plant intermediate climbing epiphyte; shoot sturdy; leaves falcate, strap shaped, smooth, rigid, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous, thick; roots white, thick, fleshy, mature branch. Spike erect, 7 to 10 florets, large, spreading, pink with dark spots, spreading, tepals obovate; labellum trilobed, midlobe pink, ridged, lateral lobes pink-straw streaks.

Flowering branch: 1.0
Average yield/year: 4.3 spikes

Mokara Calypso Pink

Plant intermediate climbing epiphyte; shoot medium thick; leaves short, falcate, strap shaped, smooth, rigid, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous; roots white, fleshy, thick, mature branch. Spike erect, 8 to 15 florets, spreading, hot pink, spotted, tepals obovate; labellum, trilobed, midlobe hot pink, ridged, lateral lobes pink streaks.

Flowering branch: 1.0
Average yield/year: 5.3 spikes

Mokara Walter Oumae White

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, short, smooth, rigid, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous; roots white, thick, fleshy, mature branch. Spike erect, 16 to 19 florets, white, rose spots; sepals broadly obovate, petals obovate, curl towards apex; labellum trilobed, midlobe base white, apex rose, ridged, laterals white-rose streaks.

Flowering branch: 1.0
Average yield/year: 4.0 spikes

Mokara Dinah Shore

Plant intermediate climbing epiphyte; shoot slender cane; leaves falcate, strap shaped, smooth, leathery, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous; roots white, thick, fleshy, branching. Spike erect, 6 to 7 florets, venetian red, dark spots, spreading, tepals obovate; labellum trilobed, midlobe red, ridged, lateral lobes buff colour streaks.

Flowering branch: 1.0
Average yield/year: 2.0 spikes

Mokara Sayan x Kultana Gold

Plant intermediate climbing epiphyte; shoot sturdy; leaves large, falcate, strap shaped, smooth, rigid, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous, fleshy; roots white, thick, fleshy, branching. Spike erect, 11 to 16 florets, spreading, bright pink, tepals obovate; labellum trilobed, midlobe ridged, dark pink, lateral lobes dark pink shade

Flowering branch: 1.0
Average yield/year: 2.5 spikes

Mokara Khaw Phaik Suan x *Vanda* Thananchai

Plant intermediate climbing epiphyte; shoot medium thick; leaves falcate, strap shaped, smooth, rigid, green, tip emarginate, margin entire, coriaceous; leaf sheath membranous, thick; roots white, thick, fleshy, mature branch. Spike erect, 10 to 11 florets, tepals obovate, lateral sepals droop, yellow, orange spots; labellum trilobed, midlobe ridged, apex orange, laterals yellow-orange streaks.

Flowering branch: 1.0
Average yield/year: 3.0 spikes

Phalaenopsis Taisuco Kochdian x Akatsuka Noon

Plant short-stemmed epiphyte; leaves elliptic -obovate, green, tip bilobed, margin outcurved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey, branching absent. Spike arching, branched, 7 to 12 florets, pure white, tepals base pink spots, sepals elliptic, petals obovate; labellum trilobed, anchor shaped, hinged, bright yellow markings, bifid, cushion like centre, rust hue, midlobe with 2 ornamental processes, lateral lobes erect, spur absent.

Flowering branch: 1.0
Average yield/year: 3.0 spikes

Phalaenopsis Diana Pink

Plant short-stemmed epiphyte; leaves elliptic -obovate, green, tip acuminate, margin outcurved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey, branching absent. Spike arching, branch, 19 florets, pink, sepals elliptic, petals obovate; labellum trilobed, anchor shaped, hinged midlobe wine red, base swollen, bifid, yellow, wine red spots, 2 ornamental process, lateral lobes pink, wine red shade, lateral lobes erect, spur absent.

Flowering branch: 1.0
Average yield/year: 1.0 spike

Phalaenopsis Hwafeng Red Jewel

Plant short-stemmed epiphyte; leaves elliptic -obovate, green, purple markings, tip bilobed, margin outcurved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey, branching absent. Spike arching, branched, 12 to 21 florets persian pink, uniform, sepals elliptic, petals obovate; labellum hinged, anchor shaped, dark pink, centre bifid, cushion like swell, yellow orange, midlobe 2 ornamental process, lateral lobes erect, spur absent.

Flowering branch: 1.0
Average yield/year: 1.0 spike

Phalaenopsis Mount Lip

Plant short-stemmed epiphyte; leaves elliptic -obovate, green, purple markings, tip acuminate, margin out curved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey, branching absent. Spike arching, branched, 16 to 17 florets, white with magenta blush towards centre, sepals elliptic, petals obovate; labellum trilobed, hinged, anchor shaped, magenta, centre bifid, cushion like swell, rust markings, midlobe magenta, 2 ornamental process, lateral lobes erect, spur absent.

Flowering branch: 1.0
Average yield/year: 1.0 spike

Phalaenopsis Taipei Gold

Plant short-stemmed epiphyte; leaves elliptic -obovate, green, tip acuminate, margin outcurved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey, branching absent. Spike arching, branched, 6 to 9 soft yellow florets, uniform size, sepals elliptic, petals obovate, labellum trilobed, anchor shaped, hinged, yellow, pale towards apex, base bifid, swollen, rust markings, midlobe 2 ornamental process, lateral lobes erect, spur absent.

Flowering branch: 1.0
Average yield/year: 1.5 spikes

Phalaenopsis Ho's Happy Auckland

Plant short-stemmed epiphyte; leaves elliptic-obovate, green, tip acuminate, margin outcurved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey. Spike arching, 4 to 5 florets, tepals white, pink blush towards the centre and lower margin of lateral sepals; sepals elliptic, petals obovate; labellum trilobed, reddish, anchor shaped, hinged, centre bifid, cushion like swell, midlobe 2 ornamental process, lateral lobes erect, spur absent.

Flowering branch: 1.0
Average yield/year: 1.0 spike

Phal. (Pinlong Spring x Taisuco Kochdian) x *Phal.* (Miami Sunrise x Tiny Ivory)

Plant short-stemmed epiphyte; leaves small, elliptic-obovate, purple-green, tip acuminate, margin outcurved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey, branching absent. Spike erect, branched; florets 5-10, small, pastel pink, sepals elliptic, petals obovate; labellum trilobed, anchor shaped, hinged, fleshy, centre bifid, cushion like swell, cream-orange, mahagony spots, midlobe dark pink, rust markings, 2 ornamental process, lateral lobes erect, spur absent.

Flowering branch: 1.0 spikes
Average yield/ year: 2.0 spikes

Phalaenopsis Memoria Grand Mother

Plant short-stemmed epiphyte; leaves elliptic -obovate, green, tip acuminate, margin outcurved; leaf sheath thick, fleshy, wrap around shoot; roots young cylindrical, flatten when mature, clasping, grey, branching absent. Spike arching, multiple branch, upto 38 florets, orchid pink, dark veins, sepals elliptic, petals obovate; labellum trilobed, anchor shaped, hinged, fleshy, centre bifid, cushion like swell, reddish, midlobe magenta spots, 2 ornamental process, lateral lobes erect, spur absent.

Flowering branch: 1.0
Average yield/year: 2.0 spikes

(Apr-Nov), *Phalaenopsis* Taipei Gold (Jun-Nov), *Phalaenopsis* Memoria Grand Mother (May-Nov) and *Phalaenopsis* Ho's Happy Auckland (Jun-Dec). Spikes of short-stemmed epiphytes were arching except *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) which was erect. All the short-stemmed epiphytes showed branching of inflorescence and florets were arranged spirally. In *Phalaenopsis* orchids, colours recorded ranged from pure white, pastel pink, pink, persian pink, soft pink to soft yellow and lips had darker shades of yellow, wine red, magenta and *Phalaenopsis* Mount Lip and *Phaaenopsisl.* Ho's Happy Auckland had white florets with beautiful blush at the centre.

Visual Scoring/Evaluation

Data pertaining to the scores obtained for forty monopodial orchids are presented in Table 29. The highest mean total score was recorded for *Aranthera* Lily Book Red (43.6), which was followed by *Aranthera* Anne Black (43.5), *Aeridachnis* Apple Blossom and *Aranda* Deborah (43.2 each). The highest score for four characters, *viz.*, colour and pigmentation (9.0), texture (8.9), shape and pattern (9.0) and arrangement of florets on spike (8.8) was recorded in *Aranthera* Lily Brook Red. The lowest mean total was recorded for *Renanthera* Cape Sabel (40.7).

Ascocenda Princess Mikasa Pink recorded the highest mean total score (44.3) and topped the visual scoring in intermediate climbing epiphytes. *Mokara* Chark Kuan Pink, *Mokara* Walter Oumae White, *Mokara* Sayan x Kultana Gold were on par with an excellent mean total score of 44.1. The total mean score in *Ascocenda* Raminder Gold x Fortune East (43.4), *Vanda* JVB x *Ascocenda* Yip Sum Wah (43.3), *Vascostylis* Pine Rivers Red (43.2), *Mokara* Sayan x *Ascocenda* Meda Arnold (43.0), *Vascostylis* Pine Rivers Blue and *Vascostylis* Pine Rivers Pink (42.9 each) was good. The lowest mean score (41.3) was recorded for *Mokara* Khaw Phaik Suan x *Vanda* Thananchai.

In short stemmed epiphytes, *Phalaenopsis* Hwafeng Red Jewel recorded the maximum total mean score (44.9) and was followed by *Phalaenopsis* Mount Lip (44.8), *Phalaenopsis* Taipei Gold (44.6), *Phalaenopsis* Diana Pink (44.5) *Phalaenopsis* Ho's Happy Auckland and *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (44.4). The total

mean score was minimum (42.3) in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory).

The results generated from the present study indicate that there were consistent differences in the growth performance of different orchid varieties. Considering the quantitative and qualitative characters tall climbing orchids *viz.*, *Aranthera* Anne Black, *Aranthera* Lily Book Red, *Aranda* Deborah, *Arachnis* Maggie Oei Red Ribbon, *Vanda* Prolific and *Aeridachnis* Apple Blossom have immense potential for use as cut flower together with the intermediate climbing types *viz.*, *Mokara* Chark Kuan Pink, *Mokara* Walter Oumae White and *Mokara* Calypso Pink. The *Holttumara* hybrids *viz.*, Bright Eye and Emperor Hirohito, *Renantanda* Mandai Glow, *Vanda* Mandai Glow, *Mokara* Sayan x Kultana Gold, *Mokara* Bangkok Gold, *Mokara* Sayan x *Ascocenda* Meda Arnold and *Mokara* Dinah Shore could be considered. Short-stemmed epiphyte *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon would also be an excellent choice as cut flower.

The performance projected the short-stemmed *Phalaenopsis* varieties the best as pot plants. Intermediate climbing epiphytes *viz.*, *Ascocenda* Princess Mikasa Pink, *Vascostylis* Pine Rivers Red, *Vascostylis* Pine Rivers Pink, *Vanda* JVB x *Ascocenda* Yip Sum Wah and *Vascostylis* Pine Rivers Blue would also make excellent pot plants.

Table 27. Visual scoring of forty monopodial orchid flowers

Sl. No	Orchid Varieties/ Hybrids	Score					
	Tall climbing epiphytes	Colour and pigmentation (out of 10)	Texture (out of 10)	Shape and pattern (out of 10)	Size of florets (out of 10)	Arrangement of florets on spike (out of 10)	Total
1	*Arachnis* Maggie Oei Red Ribbon	8.7	9.0	8.8	8.6	8.0	43.1
2	*Arachnis* MaggieOei Yellow Ribbon	7.8	9.0	8.7	8.4	8.0	41.9
3	*Vanda* Prolific	9.0	8.4	8.8	8.2	8.6	43.0
4	*Vanda* John Club	8.8	7.7	8.8	8.1	8.4	41.8
5	*Vanda* Poepoe Diana	8.7	7.7	8.5	8.5	8.2	41.6
6	*Vanda* Mandai Glow	8.7	8.2	8.5	7.9	8.6	41.9
7	*Renantanda* Mandai Glow	8.7	8.2	8.5	8.2	8.7	42.3
8	*Renanthera* Manila	8.8	8.3	8.6	7.6	8.4	41.7
9	*Renanthera* Cape Sabel	7.7	8.4	8.2	7.9	8.5	40.7
10	*Aranthera* Anne Black	8.9	8.8	9.0	8.0	8.8	43.5
11	*Aranthera* Lily Brook Red	9.0	8.9	9.0	7.9	8.8	43.6
12	*Aranthera* Mana Meina	7.8	8.7	8.4	8.7	8.5	42.1
13	*Aranda* Deborah	8.7	9.0	9.0	7.7	8.8	43.2
14	*Aranda* Majula	8.8	8.8	9.0	8.1	7.7	42.4
15	*Aeridachnis* Apple Blossom	8.8	8.9	8.9	7.8	8.8	43.2
16	*Holttumara* Bright Eye	8.7	8.8	8.6	8.5	8.5	43.1
17	*Holttumara* Emperor Hirohito	8.7	8.8	8.6	8.4	8.6	43.1
	Intermediate climbing epiphytes						
1	*Mokara* Walter Oumae Yellow	8.5	8.5	8.8	8.7	8.6	43.1
2	*Vanda* JVB x *Ascocenda* Yip Sum Wah	8.8	8.9	8.8	8.0	8.8	43.3
3	*Ascocenda* Princess Mikasa Pink	9.0	8.9	9.0	8.5	8.9	44.3
4	*Ascococenda* Raminder Gold x Fortune East	8.7	8.8	8.8	8.4	8.7	43.4

Sl. No	Orchid Varieties/ Hybrids	Score					
	Tall climbing epiphytes	Colour and pigmentation (out of 10)	Texture (out of 10)	Shape and pattern (out of 10)	Size of florets (out of 10)	Arrangement of florets on spike (out of 10)	Total
5	*Vascostylis* Pine Rivers Red	8.9	8.8	8.8	7.3	9.4	43.2
6	*Vascostylis* Pine Rivers Pink	8.9	8.8	8.8	7.1	9.3	42.9
7	*Vascostylis* Pine Rivers Blue	9.0	8.8	8.8	7.1	9.2	42.9
8	*Mokara* Bangkok Gold	8.7	8.6	8.8	7.3	8.7	42.1
9	*Mokara* Sayan x *Ascocenda* Meda Arnold	8.4	8.4	8.7	8.7	8.8	43.0
10	*Mokara* Chark Kuan Pink	8.8	8.7	9.0	8.7	8.9	44.1
11	*Mokara* Calypso Pink	8.9	8.7	8.9	8.6	8.8	43.9
12	*Mokara* Walter Oumae White	9.0	8.9	9.0	8.4	8.8	44.1
13	*Mokara* Sayan x Kultana Gold	9.0	8.6	8.9	8.8	8.8	44.1
14	*Mokara* Dinah Shore	8.9	8.6	8.9	7.8	8.7	42.9
15	*Mokara* Khaw Phiak Suan x *Vanda* Thananchai	8.0	8.4	8.6	8.1	8.2	41.3
	Short stemmed epiphytes						
1	*Phalaenopsis* Taisuco Kochdian x Akatsuka Noon	8.8	8.8	8.9	9.0	8.9	44.4
2	*Phalaenopsis* Diana Pink	8.9	8.8	8.9	9.0	8.9	44.5
3	*Phalaenopsis* Hwafeng Red Jewel	9.0	9.0	9.0	8.9	9.0	44.9
4	*Phalaenopsis* Mount Lip	9.0	9.0	9.0	8.9	8.9	44.8
5	*Phalaenopsis* Taipei gold	8.9	9.0	9.0	8.8	8.9	44.6
6	*Phalaenopsis* Ho's Happy Auckland	8.9	8.8	9.0	8.8	8.9	44.4
7	*Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory)	8.7	8.7	8.5	7.9	8.7	42.5
8	*Phalaenopsis* Memoria Grand Mother	8.6	8.7	8.6	8.0	8.8	42.7

Discussion

5. DISCUSSION

The results on the evaluation of monopodial orchid varieties/ hybrids for use as cut flower are discussed briefly.

Orchids are the most spectacular among flowers and are unique with their manifold and perplexing range of floral structures, mesmerizing hue and a longer span of the plant and flower. They enjoy a cosmopolitan habit and are epiphytic, terrestrial lithophytes, saprophytic; a few are semi-aquatic or subterranean. Based on their growth habit orchids are grouped as monopodials and sympodials.

Monopodial orchids are generally epiphytes with an unlimited apical growth. Their stems enclosed within the leaf sheath lengthen indefinitely season after season and bear aerial roots often along the whole length. The leaves may be flat, terete or intermediate. The inflorescence is produced at the leaf axils, piercing the leaf sheaths as they emerge.

The performance of any plant depends upon its inherent genetic character as influenced by the growing environment. Each plant has its inherent characters, which ultimately makes it suitable for commercial exploitation. However, the environment under which it is grown largely determines the realization of its genetic potential. Thus, it becomes a primary requisite to evaluate the plant types based on their growth and other characters.

In the present study, forty monopodial orchid varieties/hybrids belonging to monogeneic, bigeneric and trigeneric origin having varying growth patterns *viz.*, tall climbing orchids, intermediate climbing epiphytes and short-stemmed epiphytes were evaluated.

5.1 QUANTITATIVE CHARACTERS

The quantitative characters under study were plant characters like increase in height, girth of shoot, internodal length, plant spread; leaf characters like length, breadth,

leaf area, number of leaves and interval of production, angle of orientation, length and breadth of leaf sheath together with characters like aerial root length, girth and number of aerial roots were recorded. Floral characters like days taken from spike emergence to opening of first floret, fifty per cent florets and opening of all florets, opening to wilting of first floret, spike longevity, interval and annual spike production, spike length, rachis length, stalk length, spike girth, number of florets per spike, internodal length of spike, flower size and individual flower life were also observed to compare the varieties.

In general, tropical orchids enjoy humid, warm atmosphere and burst into activity in the rainy season. During the period of study, majority of the monopodials performed better during rainy season (June to October) both in terms of vegetative growth and flower production. It is a fact that good vegetative growth is a pre-requisite for better flower production. Growth, development and productivity depend on the interaction between environmental factors and genetic constitution of the plants. Orchid is one such crop, which expresses a high magnitude of diversity and responds very well to the environment (Abraham and Vatsala, 1981).

5.1.1 Plant characters

Height is an inherent genetic character of plants which can be influenced by growing conditions. The height differences are largely due to differences in internodal length. Since the monopodials exhibited different nature of growth *viz.*, tall climbing orchids, intermediate climbing epiphytes and short-stemmed epiphytes, the basic morphological difference among them was height. All the Tall growing orchids of monogeneric origin *viz.*, *Arachnis* Maggie Oei Red Ribbon, *Arachnis* Maggie Oei Yellow Ribbon, *Renanthera* Manila followed by *Vanda* John Club and *Vanda* Poepoe Diana recorded faster growth as indicated by height throughout the period of study. Monogeneric orchids in general had longer internodes and hence grew faster but there were exceptions (*Vanda* Mandai Glow, *Vanda* Prolific and *Renanthera* Cape Sabel). *Aeridachnis* Apple Blossom showed the minimum growth. Among the intermediate climbing epiphytes, *Mokara* Sayan x Kultana Gold showed significant increase in height compared to others which could very much be correlated with large internodes. *Mokara*

Bangkok Gold recorded the minimum increase in plant height. Short-stemmed epiphytes recorded a slow rate of growth. Zotz (1998) studied slow growing epiphytic orchid *Dimerandra emarginata* and recorded that growth was highly seasonal with little variation between the years. Generally, tall climbing orchids and majority of the intermediate climbing epiphytes grew throughout the year and expressed better growth during the rainy season.

The girth of pseudostem gives an indication about the strength of stem. Shoot girth recorded in different varieties varied considerably. Among tall climbing orchids, *Holttumara* Bright Eye had maximum girth and thus the plant maintained an erect growth. *Vanda* John Club and *Vanda* Poepoe Diana recorded the least girth and thus the plants were lanky and demanded support. In case of intermediate climbing epiphytes, *Ascocenda* Princess Mikasa Pink and *Mokara* Sayan x Kultana Gold recorded the maximum girth while *Mokara* Dinah Shore, the minimum. However in short-stemmed epiphytes, shoot girth had lesser relevance as compared to the others which had a vertical growth.

Spread of the plant gives the area occupied by the plant under growing environmental conditions as this determines the number of plants that could be accommodated in a given area (plant density). In monopodial orchids that are characterised by non branching nature, the spread is largely determined by the leaf characteristics such as length, breadth and orientation or phyllotaxy. It was calculated by multiplying the N-S and E-W dimensions. However, short-stemmed epiphytes which grew close to the medium/container were having rosette nature and broad leaves, thus better spread. The spread was again indicative of the slightly creeping nature of *Phalaenopsis* when they grow old. Of the eight *Phalaenopsis* orchids, maximum spread was observed in *Phalaenopsis* Mount Lip while *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) recorded the minimum spread. It may further be noted that the long and arching nature of the spikes has better role in deciding the spacing. In tall climbing and intermediate climbing types which had an upright growth, plant spread had lesser relevance as compared to short-stemmed epiphytes.

Leaf characters both quantitative and qualitative; contribute to the selection of plants for commercial exploitation. Quantitative characters include leaf length and width indicative of the leaf size, leaf number, interval of leaf production, angle of orientation together with leaf sheath characters like length and width which directly contribute to the photosynthetic efficiency.

In tall climbing orchids, leaf length was maximum in *Holttumara* Bright Eye, followed by *Renantanda* Mandai Glow. It was minimum for *Vanda* Poepoe Diana. The width was maximum in *Holttumara* varieties Emperor Hirohito. *Holttumara* Bright Eye recorded the maximum leaf area, closely followed by *Holttumara* Emperor Hirohito. Minimum leaf area was recorded in terete leaved varieties *viz.*, *Vanda* Poepoe Diana and *Vanda* John Club which also had minimum leaf breadth. Among intermediate climbing epiphytes, *Ascocenda* Raminder Gold x Fortune East recorded maximum leaf length and *Mokara* Walter Oumae Yellow the minimum; *Mokara* Sayan x Kultana Gold recorded maximum leaf breadth while *Mokara* Dinah Shore the minimum. *Ascocenda* Raminder Gold x Fortune East recorded maximum leaf area and *Mokara* Dinah Shore the minimum. Short-stemmed epiphytes in general had large leaves. Such wide differences were also indicated in the descriptions of Bose *et al.* (1999) and Bhattacharjee *et al.* (2002) of different cultivars of orchids.

Interval of leaf production is an indicative of leaf yield. Tall growing orchids produced leaves at frequent intervals compared to intermediate and short-stemmed epiphytes. Among tall growing orchids minimum interval of leaf production was observed in *Arachnis* Maggie Oei varieties Red Ribbon and Yellow Ribbon and maximum in *Aranthera* Mana Meina. However the leaf count was maximum in *Aranthera* Lily Brook Red which recorded the minimum internodal length. Of the intermediate climbing epiphytes, *Mokara* Sayan x Kultana Gold and *Mokara* Walter Oumae White produced leaves frequently and recorded maximum leaf count. Leaf count was minimum in *Mokara* Dinah Shore and took a longer span of time to produce the consecutive leaf. Short-stemmed epiphytes did not record significant differences with respect to number of leaves per plant.

Angle of orientation of leaves benefit the plants by proper interception of light. Appreciable differences were recorded with respect to the angle of orientation of leaves. In tall growing orchids, it ranged from 60 degrees (*Arachnis* Maggie Oei Red Ribbon and *Aranthera* Lily Brook Red) to 25 degrees in others. Intermediate climbing and short-stemmed epiphytes recorded angles between 20 and 35 degrees. Where sickle shaped (falcate) leaves are produced in most of the intermediate climbing orchids and faccid leaves in *Phalaenopsis*, angle of orientation of leaves attains importance in tall climbing orchids.

In monopodial orchids unlike the sympodial ones, the aerial stem is the true stem on which aerial roots are also located. In view of the epiphytic character, main function of these roots is to help the climbing orchids to cling on to the support. It was observed that in tall climbing orchids; roots were lengthier and hung freely thus indicating the need to cling to a support and climb reaching a height of several metres in the wild. In short-stemmed epiphytes which usually perch on tree top or in crevices in its natural habitat, the roots flatten and creep around the support. Besides, these roots have velamen tissues which help in easy absorption of moisture and nutrients through the entire length.

5.1.2 Floral characters

Different flowering patterns were observed in orchids. Few flowered year-round whereas a few were seasonal. Soon (1980) opined that most hybrid orchids, which grow in the tropical lowlands, appear to be uninfluenced by day length and thus probably are day neutral plants. While Dressler (1981) stated that within the tropics, seasonality is primarily due to variation in rainfall. Majority of the orchid hybrids were prolific. Drastic differences were observed with regard to floral characters between varieties. Yong and Hew (2004) stated that juvenility, vernalisation and photoperiodism are the three important factors that determine when the plants will flower with respect to ontogeny and season. Plants often respond to changes in photoperiod and temperature so that they naturally flower when environmental conditions are favorable for reproduction (Lopez and Runkle, 2004).

Different genera of orchids differ in the growth requirements. Many species of *Arachnis, Ascocentrum, Renanthera* and *Vanda* require full sun for free flowering and any shading delays or suppresses the flowering process. Many of their hybrids, such as *Aranda* and *Aranthera* are known to behave in the same manner whereas *Phalaenopsis*, *Dendrobium* etc require shading for flower production (Soon, 1980).

Lee and Lin (1984) opined that flower bud initiation occurred after the reproductive stem (spike) has reached a certain length under the required environmental conditions. Lopez and Runkle (2005) stated that once flower buds have initiated, flower development time is dependent upon genotype and temperature. Among tall climbing monopodials, *Holttumara* Bright Eye opened the first floret early, closely followed by *Holttumara* Emperor Hirohito. *Arachnis* Maggie Oei bloomed late, var. Red Ribbon took a little longer time. Ede (1963) observed that in *Arachnis* cv. Maggie Oei, the average growth period of an inflorescence is 70.6 days and the first flower may open on 60th day. Of the intermediate climbing orchids *Vanda* JVB x *Ascocenda* Yip Sum Wah and *Ascocenda* Raminder Gold behaved similarly in the opening of first floret. *Mokara* Walter Oumae Yellow opened the first floret late and was on par with *Mokara* Bangkok Gold. In case of short-stemmed epiphytes, *Phalaenopsis* Taipei Gold recorded the minimum time for opening of the first floret while *Phalaenopsis* Ho's Happy Auckland opened late. It was observed during study that monopodial orchids in general open florets acropetally at a day's interval. Goh (1977) stated that flowers in the inflorescence of *Vanda-Arachnis* tribe usually open acropetally at one-day interval.

In monopodials, harvestable stage is calculated based on the opening of fifty per cent of the florets. Of the tall monopodials, *Holttumara* Bright Eye could be harvested first followed by *Holttumara* Emperor Hirohito. *Arachnis* Maggie Oei var. Red Ribbon and Yellow Ribbon attained harvestable stage late. It was observed that in intermediate climbing epiphytes, *Ascocenda* Raminder Gold x Fortune East and *Vanda* JVB x *Ascocenda* Yip Sum Wah could be harvested first. Among short-stemmed epiphytes (*Phalaenopsis*), stage of harvest was not a criterion as the spike stays on plant for long and opening of flowers showed no synchrony.

Among tall climbing orchids, *Holttumara* Bright Eye took minimum time for all florets to open completely, followed by *Holttumara* Emperor Hirohito. *Aranthera* Lily Brook Red recorded significantly longer period. The duration between spike emergence to opening of all florets showed significant difference in intermediate climbing epiphytes. *Ascocenda* Raminder Gold x Fortune East recorded minimum number of days followed by *Vanda* JVB x *Ascocenda* Yip Sum Wah. *Mokara* Walter Oumae White recorded significantly longer period for all the florets to open. Among short-stemmed epiphytes, complete opening of florets ranged from a few days to months and this was the criterion observed for choosing an orchid as pot plant or as corsage (where individual florets are valued).

Orchids with good spike length find a place in the cut flower trade while this is not a criterion for pot plants. In case of tall climbing orchids, *Aranthera* Lily Brook Red recorded maximum spike length and was on par with *Arachnis* Maggie Oei varieties. *Vanda* Poepoe Diana and *Renanthera* Cape Sabel were on par having the shortest spikes. In intermediate climbing epiphytes, spike length was significantly higher in *Mokara* Sayan x Kultana Gold followed by *Mokara* Walter Oumae White. *Vanda* JVB x *Ascocenda* Yip Sum Wah had minimum spike length. In short-stemmed epiphytes, chance of breakage is more especially if the spike is very long. *Phalaenopsis* Diana Pink recorded significantly superior spike length. *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) recorded the minimum spike length. Robinson (2002) opined that temperature has little or no effect on spike length.

Rachis area is given prime importance as it attracts attention being the flower bearing area. Among tall climbing monopodials, *Aranthera* Lily Brook Red recorded the maximum rachis (flowering area) length followed by *Arachnis* Maggie Oei. *Vanda* Popoe Diana recorded the shortest rachis length. Among the intermediate climbing epiphytes; *Mokara* Walter Oumae White was on par with *Mokara* Sayan x Kultana Gold with maximum rachis length while *Mokara* Walter Oumae Yellow recorded the shortest. Among the short-stemmed epiphytes, *Phalenopsis* Hwafeng Red Jewel had the maximum rachis length while *Phalaenopsis* Ho's Happy Auckland, the minimum. The rachis length

among the three different classes of orchids also varied considerably. From the point of view of customer, rachis length has to be seen together with number and size of florets.

For arranging flowers in long necked vase; lengthier stalks are preferred but for potted orchids it may not always be graceful. Among tall growing orchids, *Aeridachnis* Apple Blossom and *Vanda* John Club were on par with maximum stalk length while *Aranda* Majula recorded the minimum. Among intermediate climbing epiphytes, *Mokara* hybrids (popular as cut flower) usually recorded lengthy stalks. *Mokara* Sayan x Kultana Gold recorded the maximum stalk length while *Vascostylis* Pine Rivers Pink (pot orchid), the minimum. The stalk lengths in short-stemmed epiphytes (*Phalaenopsis* varieties) varied significantly. *Phalaenopsis* Diana Pink recorded the longest stalk while *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) and *Phalaenopsis* Memoria Grand Mother the shortest.

Spikes with good girth are preferred as they would be sturdy. It decides the space a spike occupies in arrangement and thus the probability of inclusion of different types in the arrangement. Variations were observed with regard to the girth. In tall climbing orchids, *Aranda* Majula and *Aranthera* Lily Brook Red recorded the maximum spike girth while *Renanthera* Cape Sabel had the minimum. In intermediate climbing epiphytes *Mokara* Sayan x Kultana Gold recorded maximum spike girth while *Mokara* Bangkok Gold the minimum. Among short-stemmed epiphytes, *Phalaenopsis* Memoria Grand Mother recorded maximum and *Phalaenopsis* Taipei Gold the minimum spike girth.

A vital tool for evaluating a plant in terms of its economic feasibility more importantly as cut flower and at times as pot plant (single spike stays for a very long time) is by the number of spikes produced by the plant per annum. During the period of study, tall growing monopodials *viz.*, *Aranda* Deborah, *Arachnis* Maggie Oei Red Ribbon and *Aranthera* Anne Black produced maximum number of spikes per plant. Their interval of spike production was less except in *Aranda* Deborah which recorded multiple spikes production often. Though *Aranthera* Lily Brook Red produced lesser number of spikes, it being multiple branched, individual branches could be marketed as a spike. Thekkayan (1996) observed that in *Arachnis* Maggie Oei Red Ribbon inflorescence production was

greater under 100 and 75 per cent light. Among the intermediate climbing orchids, *Mokara* Calypso Pink produced maximum number of spikes (at times recorded multiple spikes), though interval of production was not the minimum. It was closely followed by *Vascostylis* Pine Rivers Red and *Ascocenda* Princess Mikasa Pink. In short-stemmed epiphytes (*Phalaenopsis* varieties), the number of spikes produced by the plant per year was less but the spike longevity on the plant was more in *Phalaenopsis* Hwafeng Red Jewel, *Phalaenopsis* Diana Pink and *Phal.* Mount Lip and this criterion was observed for choosing an orchid as pot plant.

Soon (1980) reported that in the case of ever blooming *Arachnis*, *Vanda* and *Aranda,* new inflorescence are initiated as soon as all the blooms have dropped off. He also reported that the interval between successive crops of flowers can be reduced by simply removing the inflorescence when half the flowers on the stalk are open; a common horticultural practice.

Significant differences could be spotted among monopodial orchids with respect to the number of florets produced per spike. Spikes of *Aranthera* Lily Brook Red did flaunt an exorbitant average of 116 florets while the other tall growing orchids recorded an average of less than 15 florets per spike. Number of florets per spike in *Oncidium goldiana*, a sympodial orchid might be upto 70. Among the intermediate climbing epiphytes, *Vascostylis* hybrids recorded maximum number of florets with *Vascostylis* Pine Rivers Red having an upper hand. *Mokara* Dinah Shore recorded minimum number of florets per spike. In short-stemmed epiphytes, the number of florets per spike ranged from 4.5 (*Phalaenopsis* Ho's Happy Auckland) to 32.3 (*Phalaenopsis* Memoria Grand Mother). Bose *et al.* (1999) had quoted that the majority of *Phalaenopsis* orchids produced 15 to 30 flowers per spray.

Longevity of spike on the plant is generally an indicative of the longevity after harvest. It depends on the environmental conditions, genetic factor and incidence of pests and diseases. Under normal conditions of growth, among tall climbing orchids, spikes of *Aranthera* Lily Brook Red was found to have maximum longevity; *Aranda* Deborah, *Aranthera* Anne Black, *Arachnis* Maggie Oei varieties and *Vanda* Prolific as well

recorded high longevity on plant. Among intermediate climbing epiphytes, *Mokara* Walter Oumae White recorded maximum longevity and this was followed by *Mokara* Calypso Pink and *Ascocenda* Princess Mikasa Pink. In short-stemmed epiphytes, the spike lasted for 2-8 months on the plant and this is an important factor for choosing *Phalaenopsis* varieties as pot plants.

Large showy flowers always attract attention and a good floret size would be an added advantage. Lokesha and Vasudeva (1994) analysed 746 Indian orchids and reported that those with large showy flowers were the most vulnerable to commercial exploitation and the most likely to be endangered species. Among tall growing monopodials, *Aranthera* Mana Meina and *Arachnis* Maggie Oei Red Ribbon had larger flowers. *Aranthera* Lily Brook Red had tiny but very attractive florets. In intermediate epiphytes, *Mokara* Walter Oumae Yellow recorded the maximum while *Vascostylis* had the minimum floret size. Among short-stemmed epiphytes, *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon and *Phalaenopsis* Diana Pink recorded the maximum flower size while *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny ivory) had smaller floret size.

Florets with a good pedicel length are useful as corsages. *Cattleya* species are popularly termed 'corsage orchids'. Other orchids are also used as corsages especially Dendrobiums and Phalaenopsis. Considerable variations were recorded among different monopodial orchids with respect to the pedicel length. It varied from 2.27 cm (*Aerdachnis* Apple Blossom) to 6.03 cm (*Vanda* Mandai Glow) in tall climbing types. In intermediate climbing epiphytes, it ranged from 1.37 cm (*Mokara* Bangkok Gold) to 5.43 cm (*Vanda* JVB x *Ascocenda* Yip Sum Wah) while in short-stemmed epiphytes, it varied between 3.0 cm in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny ivory) and 5.2 cm (*Phalaenopsis* Diana Pink).

5.2 QUALITATIVE CHARACTERS

These characters help mainly in identifying the different genera/species/varieties. They also have economic relevance.

The different shoot types observed in monopodial orchids were slender cane like, medium thick and sturdy. But short-stemmed epiphytes had very short stem and were wrapped with overlapping leaf sheath thus appearing stout. In tall climbing and intermediate climbing epiphytes, some aerial roots branched early; a few exhibited branching when mature whereas a few rarely branched. In short-stemmed epiphytes, roots never exhibited branching but flattened and crawled around the pot as they matured.

The different leaf characters recorded among monopodials varied widely; shapes were terete, semi-terete, quarter-terete, linear, strap shaped, falcate, linear-oblong, oblong-obovate and elliptic-oblong. Leaf margin being entire, coriaceous, incurved, outcurved or absent (terete leaved). Leaves were parallel veined, deeply channeled through central vein, channeled, channeled at base or not conspicuous. All recorded sheathed leaf base. Sheath was dark green, green or green with maroon shade. Colour varied from green, green-purple to green with purple markings at the base.

Flowering habit of different monopodial orchids did record a considerable variation. Some were free flowering types while the others were with short-dearth periods and a few seasonal. Yong and Hew (2004) stated that the occurrence of flowering gradient in monopodial orchids appeared to be widespread. However, flowering gradient in monopodial orchids was not unique, as the same has been reported in other plants as well. The flowering season of orchids and its duration are both determined genetically (Goh and Arditti, 1985).During the period of study, plants performed considerably well throughout. Goh (1984) recorded that several tropical lowland species were free flowering and produced flowers throughout the year and this freedom of flowering is said to be a genetic character. During the period of study, it was observed that flowering peaked from June to October and also during February-March. May and November received maximum rainfall and flowering showed a steep decline. Godinez (1996) stated that flowering among epiphytic orchids peaked during the dry season and early rainy season and decreased with increase in rainfall. Decline in flowering from November-January could be attributed to shorter day lengths.

Among tall growing orchids *Arachnis* Maggie Oei, *Vanda* John Club and *Vanda* Prolific were free flowering. *Aeridachnis* Apple Blossom, *Vanda* Mandai Glow, *Aranthera* Anne Black, *Aranda* Deborah, *Aranthera* Mana Meina, *Renantanda* and *Renanthera* Cape Sabel were with short dearth periods while *Vanda* Poepoe Diana, *Renanthera* Manila, *Holttumara* Bright Eye, *Holttumara* Emperor Hirohito, *Aranthera* Lily Brook Red and *Aranda* Majula were seasonal. Intermediate climbing epiphytes were also free flowering (*Vascostyls* Pine Rivers Red, *Mokara* Calypso Pink and *Mokara* Walter Oumae White), with short dearth periods (*Ascocenda* Princess Mikasa Pink, *Mokara* Khaw Phaik Suan x *Vanda* Thananchai, *Vanda* JVB x *Asc*ocenda YSW, *Mokara* Chark Kuan Pink, *Mokara* Bangkok Gold, *Vascostylis* Pine Rivers Blue and *Vascostylis* Pine Rivers Pink) or seasonal blooming (*Mokara* Walter Oumae Yellow, *Ascocenda* Raminder Gold x Fortune East, *Mokara* Sayan x Kultana Gold, *Mokara* Sayan x *Ascocenda* Meda Arnold, *Mokara* Dinah Shore). Short-stemmed *Phalaenopsis* varieties in general flowered once a year but remained for several months.

During the period of study, in a few monopodials flowering intensified from June-September and they produced more number of spikes than usual. This may be attributed to long day conditions, rainfall, abundant relative humidity, optimal sunlight hours and temperature conditions. Soon (1980) reported that in day neutral orchids, flowering intensified in certain months of the year than is its custom. Each plant then produces one or two more spikes than in its custom. Because continuous flower production depends on photosynthesis going in top gear, it is likely that the amount of light and energy received by the plant is the decisive factor causing the peaks of flowering. Thus long days with clear skies encourage flower production. But flowering reduced considerably from November to January and this may be due to short-day conditions prevalent. Sanford (1971) based on observations of West African orchids indicated that the blooming time response of some orchids is genetically controlled.

In all the plants, inflorescence arose from lateral position and florets displayed spiral arrangement. Litwin (1989) opined that the inflorescence development in *Phalaenopsis* species and cultivars is influenced by the direction of light source. Some spikes were erect while others arched. Straight spike may be an advantage as cut flower

but arching spike may as well be graceful. Goh (1977) stated that the orchid inflorescence is normally raceme or indeterminate. The flowering nature often indicates how plants are best grown; those with single and upright stems are usually grown in pots, whereas those with cascading and arching stems are ideal for planting towards the edge of a shelf (Squire, 2005).

Florets displayed a wide range of size (*Arachnis* resembles a scorpion, *Mokara* a 'Smiling face' while *Phalaenopsis* the 'flight of moths'), patterns (*Arachnis* viz. 'cobweb', *Phalaenopsis* with amazing blush) and shades (scarlet, red, crimson, coral, orange, ochre yellow, magenta, cerise pink, amethyst, red-violet, brown, hay, lavender, rose, pink, ivory and white). Griesbach (2005) opined that blue flower colour is rare in plants, including orchids, and a few orchids are naturally sky blue as in *Vanda* Coerula. Meanwhile orchids which attract moths at night are usually white in colour. Because of the rarity of this colour, blue flowered orchids are highly sought after. Fragrance was observed at different times of the day in different varieties. *Aeridachnis* Apple Blossom had nauseating odour. *Vanda* Prolific and *Aranda* Deborah recorded very sweet fragrance. Majority of the hybrids were non-fragrant. While the strongest fragrance persists in the species, a number of primary hybrids retain some degree of scent, but most often in the complex hybrids all traces of scent are usually lost. *Miltonopsis* and *Cattleya* are exceptional where hybrids are still sweeter (Rittershausan and Rittershausan, 1999).

The qualitative characters are important for selection of monopodial orchid varieties for commercial exploitation. These characters give visual effect for use as cut flower and pot plants.

The foregoing discussion on the present study suggests that there were consistent difference in the growth performance of different monopodial varieties. Considering the quantitative and qualitative characters tall climbing orchids *viz.*, *Aranthera* Anne Black, *Aranthera* Lily Book Red, *Aranda* Deborah, *Aeridachnis* Apple Blossom, *Vanda* Prolific and *Arachnis* Maggie Oei Red Ribbon have immense potential for use as cut flower together with the intermediate climbing types *viz.*, *Mokara* Chark Kuan Pink, *Mokara* Walter Oumae White and *Mokara* Calypso Pink. Short-stemmed epiphyte, *Phalaenopsis*

Taisuco Kochdian x Akatsuka Noon would be an excellent choice as cut flower. Tall climbing *Holttumara* hybrids *viz.*, Bright Eye and Emperor Hirohito, *Renantanda* Mandai Glow, *Vanda* Mandai Glow; intermediate climbing epiphytes *viz.*, *Mokara* Sayan x Kultana Gold, *Mokara* Bangkok Gold, *Mokara* Sayan x *Ascocenda* Meda Arnold and *Mokara* Dinah Shore may well be considered as cut flower.

Short-stemmed *Phalaenopsis* hybrids performed very well and could be recommended as pot plants. Intermediate climbing epiphytes *viz.*, *Asococenda* Princess Mikasa Pink, *Vascostylis* Pine Rivers Red, *Vascostylis* Pine Rivers Pink, *Vanda* JVB x *Ascocenda* Yip Sum Wah and *Vascostylis* Pine Rivers Blue would make excellent pot plants.

The present investigation on evaluation of forty monopodial varieties for commercial exploitation was conducted under uniform growing conditions. Useful information has been obtained on growth differences and behaviour. It is necessary to conduct further studies to improve the yield and quality of cut flower by critically studying the requirements of light, nutrients, plant bio-regulators, water etc in order to fully exploit the commercial feasibility. Post harvest handling techniques should also be standardised to maintain keeping quality for commercial exploitation as cut flower.

Summary

6. SUMMARY

Evaluation of monopodial orchids for use as cut flower was carried out at the orchidarium of the AICFIP, Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during 2005-2006. The main objective was to evaluate their field performance for commercial exploitation.

Forty monopodial orchids belonging to monogeneric, bigeneric and trigeneric origin were used for the study. The salient findings of the study are summarized here. They were grouped as tall climbing orchids, intermediate climbing epiphytes and short-stemmed epiphytes. Under field conditions, the vegetative characters and floral characters showed significant differences, which was mainly due to the inherent genetic characters and environmental conditions.

- Maximum increase in plant height (164.52 cm) was recorded in *Arachnis* Maggie Oei Red Ribbon while *Aeridachnis* Apple Blossom recorded the minimum (20.90 cm). Among the intermediate climbing epiphytes, *Mokara* Sayan x Kultana Gold recorded the maximum increase in height (36.75 cm) while it was minimum (1.33 cm) in *Mokara* Bangkok Gold. The short-stemmed epiphytes recorded a slow rate of growth.
- Shoot girth recorded maximum (5.10 cm) in *Holttumara* Bright Eye, a tall climbing orchid and among the intermediate climbing epiphytes, *Ascocenda* Princess Mikasa Pink and *Mokara* Sayan x Kultana Gold recorded the maximum (4.70 cm). In short-stemmed epiphytes, shoot girth had lesser relevance as compared to others.
- Internodal length among tall climbing orchids was maximum (5.60 cm) in *Vanda* Prolific and minimum (2.00 cm) in *Aranthera* Lily Brook Red. Among the intermediate climbing epiphytes, *Mokara* Sayan x Kultana Gold recorded maximum internodal length (2.17 cm) and *Vascostylis* Pine Rivers Pink the minimum (0.40 cm).
- Appreciable differences were observed with regard to plant spread in short-stemmed epiphytes alone. Maximum spread (475.00 cm^2) was observed in *Phalaenopsis* Mount Lip and minimum (129.20 cm^2) in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory).

- In tall climbing orchids, leaf length was maximum (27.17 cm) in *Holttumara* Bright Eye, leaf breadth in *Holttumara* Emperor Hirohito (5.17 cm). *Holttumara* Bright Eye recorded maximum leaf area (100.80 cm^2). Among intermediate climbing epiphytes, *Ascocenda* Raminder Gold x Fortune East recorded maximum leaf length (26.67 cm) and leaf area (71.33 cm^2). *Mokara* Sayan x Kultana Gold had maximum leaf breadth (4.00 cm). In short-stemmed epiphytes, *Phalaenopsis* Diana Pink recorded the maximum leaf length (21.73 cm), *Phalaenopsis* Hwafeng Red Jewel the maximum leaf breadth (7.97 cm) and leaf area (125.03 cm^2).

- Number of leaves per metre was maximum (47.0) in *Aranthera* Lily Brook Red, a tall climbing orchid; maximum leaves per plant were recorded in *Mokara* Walter Oumae White (45.0) an intermediate climbing epiphyte, and *Phalaenopsis* Memoria Grand Mother (5.6) a short-stemmed epiphyte.

- Leaf production interval was minimum in *Arachnis* Maggie Oei Yellow Ribbon (9.1 days), a tall growing orchid, *Mokara* Sayan x Kultana Gold (17.33 days), an intermediate climbing epiphyte and *Phalaenopsis* Taipei Gold (160.0 days) among short stemmed epiphytes.

- In tall climbing orchids, the angle of orientation of leaves ranged from 60 degrees in *Aranthera* Lily Brook Red and *Arachnis* Maggie Oei Red Ribbon to 25 degrees in *Vanda* Poepoe Diana. Intermediate climbing and short-stemmed epiphytes recorded an angle between 20 and 35 degrees.

- Leaf sheath length recorded was maximum in *Vanda* Prolific (5.60 cm) and sheath breadth in *Renantanda* Mandai Glow (4.43 cm). Among intermediate climbing epiphytes, *Ascocenda* Princess Mikasa Pink recorded maximum sheath length (3.67 cm) and *Mokara* Sayan x Kultana Gold the maximum sheath breadth (3.13 cm). In *Phalaenopsis* varieties, sheath length was maximum (2.37 cm) in *Phalaenopsis* Hwafeng Red Jewel and sheath breadth in *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (3.70 cm).

- Monopodial varieties differed in their length, girth and number of aerial roots. Among tall climbing orchids, *Aranthera* Mana Meina recorded maximum root length

(122.33 cm) and *Holttumara* Emperor Hirohito the maximum root girth (3.03 cm). Number of aerial roots/metre was maximum (23.3) in *Vanda* John Club and *Renanthera* Cape Sabel. In intermediate climbing epiphytes; *Vascostylis* Pine Rivers Red had the maximum root length (98.0 cm), *Ascocenda* Raminder Gold x Fortune East, the maximum girth (3.27 cm) and maximum number of roots per plant (40.0) was recorded in *Mokara* Khaw Phaik Suan x *Vanda* Thananchai. In short-stemmed epiphytes, *Phalaenopsis* Hwafeng Red Jewel recorded the maximum root length (34.67 cm), *Phalaenopsis* Memoria Grand Mother the maximum girth (2.0 cm) and maximum roots/plant (30.0) in *Phalaenopsis* Diana Pink.

- Duration from spike emergence to opening of first floret and 50 per cent florets in tall climbing orchids was maximum in *Arachnis* Maggie Oei Red Ribbon (59.8 days and 64.5 days, respectively) and minimum in *Holttumara* Bright Eye (18.6 days and 21.2 days, respectively). For all florets to open, *Aranthera* Lily Brook Red recorded maximum duration (83.5 days) and *Holttumara* Bright Eye, the minimum (26.4 days).

In intermediate climbing epiphytes, *Mokara* Walter Oumae Yellow recorded the maximum duration from spike emergence to opening of first floret (43.8 days) and *Vanda* JVB x *Ascocenda* Yip Sum Wah, the minimum (23.1 days); *Mokara* Khaw Phaik Suan x *Vanda* Thananchai recorded maximum duration (47.2 days) for opening of 50 per cent of florets and *Ascocenda* Raminder Gold x Fortune East, the minimum (25.8 days). For all florets to open, *Mokara* Walter Oumae White recorded the maximum (78.1 days) and *Ascocenda* Raminder Gold x Fortune East, the minimum (29.0 days).

Among short-stemmed epiphytes, *Phalaenopsis* Ho's Happy Auckland took maximum duration for opening of first floret (68.7 days) and *Phalaenopsis* Diana Pink for opening of 50 per cent of florets (146.0 days) while *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon took the minimum duration for opening of first floret (57.1 days) and *Phalenopsis* Taipei Gold for opening of 50 per cent of florets (63.6 days). *Phalaenopsis* Diana Pink recorded maximum duration for all florets to open (205.0 days) while *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon took the minimum (83.2 days).

- Distinguishable differences were noticed with respect to the longevity of spike on the plant. In tall climbing monopodials, *Aranthera* Lily Brook Red (68.0 days) recorded maximum spike longevity on the plant while spikes of *Aeridachins* Apple Blossom had the minimum longevity (24.9 days). Of the intermediate climbing epiphytes, spikes of *Mokara* Walter Oumae White had the maximum (56.7 days) and *Mokara* Walter Oumae Yellow, the minimum longevity (19.0 days). Short-stemmed epiphytes displayed an admirable degree of longevity of spikes with *Phalaenopsis* Hwafeng Red Jewel recording the maximum longevity (239.3 days) and *Phalaenopsis* Ho's Happy Auckland, the minimum (65.0 days).

- *Renanthera* Manila among tall climbing monopodials produced spikes once a year while *Aranthera* Anne Black produced spikes at minimum intervals (60.0 days). In intermediate climbing epiphytes, it was maximum in *Mokara* Sayan x Kultana Gold (192.5 days) and minimum in *Vascostylis* Pine Rivers Red (65.7 days). Among short-stemmed epiphytes, majority of them produced spikes once a year with an exception of *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon (145.0 days).

- *Aranda* Deborah, a tall climbing orchid produced maximum number of spikes (9.5) followed by *Arachnis* Maggie Oei Red Ribbon (9.0), *Aranthera* Anne Black (8.7). Minimum number of spikes (2.0) was recorded in *Aranda* Majula, *Holttumara* Emperor Hirohito, *Renanthera* Manila and *Aranthera* Lily Brook Red. Among intermediate climbing epiphytes, annual spike production was maximum (5.3) in *Mokara* Calypso Pink, closely followed by *Vascostylis* Pine Rivers Red (5.0) and *Ascocenda* Princess Mikasa Pink (5.0). Minimum number of spikes (2.0) recorded in *Ascocenda* Raminder Gold x Fortune East, *Mokara* Walter Oumae Yellow and *Mokara* Dinah Shore. Short-stemmed epiphytes *Phalaenopsis* Taisuco Kochdian x Akatsuco Noon and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) produced maximum number of spikes (2.3).

- *Aranthera* Lily Brook Red, a tall climbing orchid had maximum spike length (75.33 cm) and *Vanda* Poepoe Diana, the minimum (26.53 cm). Intermediate climbing epiphytes like *Mokara* Sayan x Kultana Gold (60.33 cm), *Mokara* Walter

Oumae White (50.60 cm) and *Mokara* Calypso Pink (50.03) recorded the maximum spike length and *Vanda* JVB x *Ascocenda* Yip Sum Wah, the minimum (20.77 cm). In short-stemmed epiphytes, maximum spike length (95.00 cm) was in *Phalaenopsis* Diana Pink and minimum (31.67 cm) in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory).

- Among tall climbing orchids, *Aranthera* Lily Brook Red had the maximum rachis length (51.53 cm) while *Vanda* Poepoe Diana, the minimum (9.83 cm). *Mokara* Walter Oumae White recorded the maximum (30.40 cm) and *Mokara* Walter Oumae Yellow, the minimum (6.43 cm) among intermediate climbing epiphytes. *Phalenopsis* Hwafeng Red Jewel (33.67 cm), a short-stemmed epiphyte had maximum rachis length and *Phalenopsis* Ho's Happy Auckland, the minimum (7.60 cm).

- *Aeridachnis* Apple Blossom (31.03 cm), *Mokara* Sayan x Kultana Gold (31.86 cm) and *Phalaenopsis* Diana Pink (64.00 cm) had the maximum stalk length while *Aranda* Majula (10.73 cm), *Vascostylis* Pine Rivers Pink (9.53 cm) and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) (20.00 cm) recorded the minimum as tall climbing, intermediate and short-stemmed epiphytes, respectively. Spike girth in tall climbing orchids was maximum in *Aranda* Majula and *Aranthera* Lily Brook Red (2.20 cm) and minimum in *Renanthera* Cape Sabel (1.20 cm). *Mokara* Sayan x Kultana Gold recorded the maximum (2.30 cm) and *Mokara* Bangkok Gold, the minimum girth (1.40 cm) among intermediate climbing epiphytes. In short stemmed epiphytes, *Phalaenopsis* Memoria Grand Mother recorded the maximum girth (2.33 cm) and *Phalaenopsis* Taipei Gold, the minimum (1.37 cm).

- Number of florets per spike in tall climbing orchids was maximum in *Aranthera* Lily Brook Red (116.0) and minimum in *Aranthera* Mana Meina (5.2). *Vascostylis* Pine Rivers Red (29.7), an intermediate climbing epiphyte and *Phalaenopsis* Memoria Grand Mother (32.3), a short-stemmed epiphyte had maximum number of florets. *Mokara* Dinah Shore and *Phalaenopsis* Ho's Happy Auckland recorded the minimum (6.5 and 4.7 respectively).

- Tall climbing orchids *viz.*, *Aranthera* Mana Meina (72.25 cm^2) and *Arachnis* Maggie Oei Red Ribbon (72.0 cm^2) recorded maximum flower size while *Aranthera* Lily Brook Red, the minimum (12.50 cm^2). In intermediate climbing epiphytes, *Mokara* Walter Oumae Yellow recorded the maximum (90.25 cm^2) while *Vascostylis* Pine Rivers Blue and Pink recorded the minimum floret size (11.56 cm^2). Among *Phalaenopsis* varieties, Taisuco Kochdian x Akatsuka Noon recorded the maximum (99.75 cm^2) and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phl.* (Miami Sunrise x Tiny Ivory), the minimum flower size (48.75 cm^2).

- The pedicel length in tall climbing orchids varied from 2.27 cm (*Aeridachnis* Apple Blossom) to 6.03 cm (*Vanda* Mandai Glow). Flowers of *Vanda* JVB x *Ascocenda* Yip Sum Wah recorded the maximum pedicel length (5.43 cm) and *Mokara* Bangkok Gold, the minimum (1.37 cm). In short-stemmed epiphytes, the flowers of *Phalaenopsis* Diana Pink had the maximum (5.2 cm) while *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny ivory), the minimum pedicel length (3.0 cm).

- Individual flower life recorded in monopodial orchids varied significantly. In tall climbing orchids, it was maximum in *Aranthera* Lily Brook Red (42.0 days) and minimum in *Renanthera* Cape Sabel (13.6 days). *Mokara* Walter Oumae White recorded the maximum (40.0) while *Mokara* Walter Oumae Yellow, the minimum (10.2 cm) among the intermediate climbing epiphytes. *Phalaenopsis* Taipei Gold, a short-stemmed epiphyte recorded the maximum flower life (45.0 days) while *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny ivory), the minimum (22.6 days).

- Different shoot types observed in tall climbing and intermediate climbing orchids were slender cane like, medium thick and sturdy. Roots either branched early or when mature. Short-stemmed epiphytes had very short stem and were wrapped with overlapping leaf sheath thus appearing stout; roots never exhibited branching but flattened and crawled around the pot as they matured.

- Leaf characters varied enormously in tall climbing orchids. Shapes recorded were terete, semi-terete, linear, linear-strap shaped, linear-oblong, oblong-obovate, and

elliptic-oblong. Leaf margin recorded were entire, coriaceous, incurved or absent in terete leaved plants. Either deeply channeled, channeled, channeled at base or not conspicuous. Intermediate climbing epiphytes had strap shaped, falcate, quarter terete leaves. Leaf margin entire or coriaceous or both. Short-stemmed epiphytes were elliptic-oblong, had smooth and fleshy leaves. They were all channeled at the base, had sheathed leaf base, entire and outcurved leaf margin. Colour of leaf varied from green, green-purple or had purple markings at the base.

- Monopodial orchids varied with regard to flowering being free flowering, with short dearth periods or seasonal flowering. Among tall climbing orchids, *Arachnis* Maggie Oei, *Vanda* John Club and *Vanda* Prolific were free flowering. *Aeridachnis* Apple Blossom, *Vanda* Mandai Glow, *Aranthera* Anne Black, *Aranda* Deborah, *Aranthera* Mana Meina, *Renantanda* and *Renanthera* Cape Sabel were with short dearth period. Seasonal flowering was observed in *Vanda* Poepoe Diana, *Renanthera* Manila, *Holttumara* Bright Eye, *Holttumara* Emperor Hirohito, *Aranthera* Lily Brook Red and *Aranda* Majula.

- Among intermediate climbing epiphytes, *Vascostyls* Pine Rivers Red, *Mokara* Calypso Pink and *Mokara* Walter Oumae White were free flowering. Short dearth periods were in *Ascocenda* Princess Mikasa Pink, *Mokara* Khaw Phaik Suan x *Vanda* Thananchai, *Vanda* JVB x *Asc*ocenda YSW, *Mokara* Chark Kuan Pink, *Mokara* Bangkok Gold, *Vascostylis* Pine Rivers Blue and *Vascostylis* Pine Rivers Pink. Seasonal blooming was observed in *Mokara* Walter Oumae Yellow, *Ascocenda* Raminder Gold x Fortune East, *Mokara* Sayan x Kultana Gold, *Mokara* Sayan x *Ascocenda* Meda Arnold and *Mokara* Dinah Shore. Short-stemmed epiphytes usually bloomed once a year.

- In all monopodials, inflorescence arose from lateral position and florets displayed spiral arrangement. Spikes were either erect or arching and many exhibited branching. Florets displayed a wide range of size, patterns and shades. Fragrance was observed in some varieties.

- The highest visual score for the characters *viz.*, colour and pigmentation, texture, shape and pattern, size of florets and arrangement of florets on spike among tall

climbing orchids was recorded in *Aranthera* Lily Brook Red (43.3) followed by *Aranthera* Anne Black (43.5), *Aeridachnis* Apple Blossom and *Aranda* Deborah (43.2 each), while *Renanthera* Cape Sabel recorded the minimum (40.7). *Ascocenda* Princess Mikasa Pink, an intermediate climbing epiphyte recorded maximum (44.3) and *Mokara* Khaw Phaik Suan x *Vanda* Thanarichai, the minimum score (41.3). *Phalaenopsis* Hwafeng Red Jewel and *Phalaenopsis* Mount Lip recorded maximum (44.9 and 44.8, respectively) among short-stemmed epiphyte and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phal.* (Miami Sunrise x Tiny Ivory), the minimum visual score (42.5).

- Considering the quantitative and qualitative characters, tall climbing types *viz.*, *Aranthera* Anne Black, *Aranthera* Lily Book Red, *Aranda* Deborah, *Aeridachnis* Apple Blossom, *Vanda* Prolific and *Arachnis* Maggie Oei Red Ribbon together with intermediate climbing types *viz.*, *Mokara* Chark Kuan Pink, *Mokara* Walter Oumae White and *Mokara* Calypso Pink has an immense potential for use as cut flower. The varieties *Holttumara* hybrids *viz.*, Bright Eye and Emperor Hirohito, *Renantanda* Mandai Glow, *Vanda* Mandai Glow, *Mokara* Sayan x Kultana Gold, *Mokara* Bangkok Gold, *Mokara* Sayan x *Ascocenda* Meda Arnold and *Mokara* Dinah Shore could be considered. *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon, a short-stemmed epiphyte, would also be an excellent choice as cut flower.

- The performance projected short-stemmed *Phalaenopsis* varieties the best as pot plants. Intermediate climbing epiphytes *viz.*, *Ascocenda* Princess Mikasa Pink, *Vascostylis* Pine Rivers Red, *Vascostylis* Pine Rivers Pink, *Vanda* JVB x *Ascocenda* Yip Sum Wah and *Vascostylis* Pine Rivers Blue would also make excellent pot plants.

References

REFERENCES

Abraham, A and Vatsala, P. 1981. *Introduction to Orchids*. Tropical Botanical Garden and Research Institute, Trivandrum.533p.

Ames, O.1948. Notes on resupination in the Orchidaceae. *Amer. Orchid Soc.Bull.*15:18-19.

Arditti, J. 1992. *Fundamentals of Orchid Biology*. John Wiley and Sons, Inc., New York.691p.

*Atherton, J.G. 1987. *Manipulation of Flowering*. Butterworths, London. 438p.

Atwood, J.T. Jr. 1986. The size of the orchidaceae and the systematic distribution of epiphytic orchids. *Selbyana*. 9:171-186.

Avadhani, P.N., Nair, H., Arditti, J. and Hew, C.S. 1994. Physiology of orchid flowers. In: Arditti, J. (ed.), *Orchid Biology, Reviews and Perspectives*. Wiley – Interscience, New York, pp.189-362.

Baker, M.L. and Baker, C.O. 1991. *Orchid species culture*: *Pescatorea, Phaius, Pholidota, Phragmepedium, Pleione*. Timber Press, Portland, Ore.

Barak, P., Bednar, P., Cap., Ondrakova, L. and Stransky, Z. 2003. SPME - A valuable tool for investigation of flower scent. *J. Separation Sci.* 26(8):715-721.

Bhattacharjee, S.K. 1995. Cultural Requirements of Orchids. In: Chadha, K.L. and Bhattacharjee, S.K. (eds.), *Advances in Horticulture Vol. 12 - Ornamental Plants* (eds.). Malhotra Publishing House, New Delhi, pp.673-701.

Bhattacharjee, S.K., Pushkar, S. and Kumar, P.N. 2002. *Passport Data of Flower Crops Germplasm*. AICRP on Floriculture. Technical Bulletin No. 23. ICAR, New Delhi. 210p.

Blanchard, M.G. and Runkle, E. 2005. Temperature effects on flower induction of two *Phalaenopsis* orchid hybrids. *HortScience*. 39:882.

Bleasdale, J.K.A.1973. *Plant Physiology in Relation to Horticulture*. English language book Society and Mac Millan Press Ltd, London.139p.

Bose T.K. and Mukhopadhyay, T.P.1977. Effects of day length on growth and flowering of some tropical orchids. *Orchid Rev*. 85:245-47.

Bose, T.K., Bhattacharjee, S.K., Das, P. and Basak, U.C. 1999.*Orchids of India*. Naya Prokash, Kolkotta.487p.

*Breiger, F.G., R.Maatsch, and K. Senghas (eds.). 1974. Schlechter, *Die Orchideen*, 3d ed. Paul Parey, Berlin.

Byramji, H. and Goh, C.J. 1976. Photoperiodic responses of some local orchid hybrids, *J. Singapore Nat. acad. Sci.*, 5: 15-17.

Chadha, K.L., and Bhatacharjee, S.K.1995. *Advances in Horticulture Vol. 12 - Ornamental Plants.* Malhotra Publishing House, New Delhi.

Chaterji, A.K.1986. Chromosomes in Orchid Phylogeny and Classification. In: Vij, S.P. (ed.), *Biology, Conservation and Culture of Orchids.* The Orchid Society of India, pp. 181-188.

Dressler, R.L.1981. *The Orchids, Natural History and Classification*- Harvard University Press, Cambridge, USA.171p.

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

Ede, J. 1963. Some observations on the flowering characteristics of *Arachnis* Maggie Oei. *Malayan Orchid Rev.*7:76-78.

Elliot, J 1994. *Orchid growing in the tropics* (ed.). Orchid Society of South East Asia. Time Editions Pte Ltd, Singapore. 207p.

Frowine, S.A.2005. *Fragrant Orchids: A Guide to Selecting, Growing, and Enjoying.* Timber Press. 200p [book on-line].
Available: http://www.google.com/books?id=nzxs0Jx4ml8C&dq

Gajanana, T.M. 2006. Marketing of traditional and modern cut flowers. In: Rajeevan, P.K, Valsalakumari, P.K, Geetha, C.K., Sudhadevi, P.K, (eds), *Reflections on Indian Floribusiness.* Kerala Agricultural University, Thrissur. pp.69-87.

Godinez, E.S. 1996.Trends in the phenology of flowering in the Orchidaceae of Western Mexico. *Biotropica* 28:1, 130-136; 33ref.

Goh, C.J. 1977. Regulation of floral initiation and development in orchid hybrid *Aranda* Deborah. *Ann. Bot.* 41: 763-769.

*Goh, C.J. 1984. Physiology of flowering in orchids. Proceedings of the 11th World Orchid Conference, Florida. pp.166-73.

Goh, C.J. and Arditti, J. 1985. Orchidaceae, In: A.H. Halevy (ed.), *Handbook of flowering.* Volume 1, CRC Press. pp.309-336.

*Goh, C.J and Seetoh, H.C. 1973. Apical control of flowering in an orchid hybrid, *Aranda* cv. Deborah. *Ann. Bot.* 37:113-119.

*Goh, C.J. and Wan, H.Y. 1973. The role of auxins in the flowering of a tropical orchid hybrid Vanda Miss Joaquim. In: Sumiki, Y. (ed), *Plant Growth Substances.* Hirotaka Publishing Company. pp.945-953.

Goh, C.J., Strauss, M.S. and Arditti, J. 1981. Flower induction and physiology of orchids. In: Arditti, J. (ed), *Orchid Biology*: Reviews *and Perspectives*. Cornell University Press, New York.2: 213-241.

Griesbach, R.J. 1985. An orchid in every pot. *Florists' Rev.*176 (4548):26-30.

Griesbach, R.J. 2005. A Scientific approach to breeding blue orchids: exploring new frontiers in search of elusive flower colours. *Orchids*. 74(5): 378-379.

Hew, C.S., Clifford, P.E., and Yong, J.W.H. 1996.Aspects of Carbon partitioning in tropical orchids. *J. Orchid Soc. India*, 10(1-2): 53-81.

Hew, C.S. and Yong, J.W.H. 1997. *The Physiology of Tropical Orchids in Relation to the Industry.* World scientific. 331p [book on-line].
Available :http://www.google.co.in/books?vid=ISBN0395677262

Holttum, R.E. 1949. Freedom of flowering in orchids in Singapore. *Malay Orchid Rev.* 4: 15-17.

Jain, S.K. 1986. Orchid Wealth of India. In: Vij, S.P. (ed.), *Biology, Conservation and Culture of Orchids.* The Orchid Society of India. pp.319-322.

Johannson, D.R.1974. Ecology of vascular epiphytes in West African rain forest. *Acta Phytogeographica Suecica* 50:1-129.

Khasim, S.M. and Rao, P.R.M. 1986. Anatomical studies in relation to habitat tolerance in some epiphytic orchids. In: Vij, S.P. (ed.), *Biology, Conservation and Culture of Orchids.* The Orchid Soc. of India. p.49-57.

Kronenberg, H.G. 1976. Flowering in *Dendrobium crumenatum* Sw. *Am. Orchid Soc. Bull.* 45:513.

Laws, N. 1995. Cut orchids in the world market. *FloraCultura Intl.* 5(12): 12-15.

Laws, N. 2002. Orchid commerce around the world. *FloraCultura Intl.* 12(10):28-29.

Laws, N. 2004. The world's fascination with potted orchids. *FloraCultura Intl.* 14 (12) 26-27.

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

Litwin, L.M. 1989. Fine tuning hybrid care. *The Orchid Digest.* 53(4):175-177.

Lokesha, R. and Vasudeva, R. 1993. Do the endangered orchids differ from the common ones in their habit distribution, and phonological patterns? *J. orchid. Soc. India.*7 (1-2) 53-60.

Lokesha, R. and Vasudeva, R. 1994. Do floral features determine the endangered status of Indian Orchids. *J. Orchid Soc. India.* 8(1-2): 53-54.

Lopez, R.G. and Runkle, E.S. 2004. The flowering of orchids [on-line] Available:http://www.hrt.msu.edu/faculty/Runkle/Orchid/Articles/AOS%20Lopez%20and%20Runkle.pdf [26 Mar 2007]

Lopez, R.G. and Runkle, E.S.2005. Environmental physiology of growth and flowering of orchids. *HortScience.* 40(7): 1969-1973.

Mehra, P.N. and Vij, S.P. 1974. Some observations on the ecological adaptations and distribution pattern of the East Himalayan Orchids. *Amer. Orchid Soc. Bull.* 43(4):301-315.

Mukherjee, S.K.2002. *Orchids.* Indian Council of Agricultural Research, New Delhi.102p.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers.* I.C.A.R., New Delhi. 4:97-123.

Parker, J. 1994. Tropical orchidsacapes. *American orchid Soc. Bulletin.* 63(3): 256-265.

Peterson, C. 2005. In the Garden: World of Orchids [on-line]. *The Daily Astorian* Sept 29. Available:http://www.dailyastorian.info/main.asp?SectionID=15&SubSectionID=789&ArticleID=27942&TM.

*Pijl, L.V.D, and Dodson, C.H.1966. *Orchid Flowers: Their Pollination and Evolution.* Univ. Miami Press, Coral Gables, FL.

*Porat, R.1994. Comparison of emasculation and pollination of *Phalaenopsis* flowers and their effects on flower longevity, ethylene production and sensitivity to ethylene. *Lindleyana* 9: 85-92.

Quyu, B.S.H. 1959. Cited by Bose, T.K., Bhattacharjee, S.K., Das, P. and Basak, U.C. 1999. Orchids of India, Naya Prokash, Kolkotta. 487p.

Radha, R.K, Menon, V.S. and Seeni, S. 1994. Physiological analysis of sun and shade plants of selected orchids from the Western Ghats. *J. Orchid Soc. India.* , 8(1-2): 55-59

Rajeevan, P.K. 1995. The scenario of orchid industry in Kerala: Retrospective of a decade. *J. Orchid Soc. India*, 9(1-2):1-5

Rajeevan, P.K. 2003. Orchids.In: Chadha, K.L. (ed.), *Handbook of Horticulture.* I.C.A.R., New Delhi. pp. 573-577

Rajeevan, P.K. 2006. Production technology of orchids. In: Rajeevan PK, Valsalakumari, P.K., Geetha, C.K., Sudhadevi, P.K. (eds), *Reflections on Indian Floribusiness.* Kerala Agricultural University, Thrissur. pp.107-119.

Rajeevan, P.K., Sobhana, A., Bhaskar, J., Swapna, S. and Bhattacharjee, S.K. 2002. *Orchids.* All India Co-ordinated Research Project on Floriculture, IARI, New Delhi. 62p.

Rittershausen, W. and Rittershausan, B. 1999. *Orchids.* Quadrille Publishing Ltd, Great Britain. 224p.

*Robinson, K.A. 2002. Effects of temperature on the flower development rate and morphology of *Phalaenopsis* orchid. MS thesis. Mich. State Univ., East lansing.

Sakanishi, Y., Imanishi, H. and Ishida, G. 1980. Effect of temperature on growth and flowering of *Phalaenopsis amibilis. Bulletin.* Univ. Osaka, Series B.Agri.Biol. - Osaka (Prefecture) Daigaku 32:1-9.

Sanford, W.W. 1971. The flowering time of West African orchids. *Bot. J. Linnear Soc.* 64: 163-181.

Sanford, W.W. 1974. The ecology of orchids. *The Orchids.* Scientific Studies, Withner, C.L., Ed., Wiley-Interscience, N.Y. pp.1-100.

Sessler, G.J. 1978. Orchids and How to grow them. Englewood Cliffs, N.J. Prentice-Hall. 370p.

Sheehan, T.J. and Sheehan, M. 1979. *Orchid Genera Illustrated.* Van Nostrand Reinhold Co., New Delhi.

Shiva, K.N., Nair, S.A. and Medhi, R.P. 2003.Orchid diversity and its conservation in Bay islands. *J. Orchid Soc. India.* 17:57-62.

Skelsey, A. 1978. *Orchids.* Time –Life Books, Alexandria, Virginia. 160p.

Soon, T.E. 1980. *Asian Orchids.* Times Books International, Singapore. 287p.

Squire, D. 2005. *The Orchid Specialist.* New Holland Publishers. 80p.

Thekkayan, S.G. 1996. Performance of selected orchids under varying light regimes, culture methods and nutrition. Ph.D. Thesis. Kerala Agricultural University. Thrissur. 346 p.

Upadhyay, R.C. and Nagaraju, V. 2001. An overview of National Research Centre for Orchid. In: Vij, S.P., Pathak, P., Nayyar, H, Sembi, J.K. and Gupta, A., (eds), *Orchid Diversity in India: Science and Commerce.* National Seminar on Orchid diversity in India: Science and Commerce. The Orchid Society of India, Chandigarh. *Souvenier and Abstracts.* p.77.

Vij, S.P. 1986. (ed.). *Biology, Conservation and Culture of Orchids.* The Orchid Society of India. 492p.

Vij, S.P. 1995. In: Chadha, K.L. and Bhattacharjee, S.K. (eds.), Genetic Resources of Orchids. *Advances in Horticulture* Vol. 12 - Ornamental Plants. Malhotra Publishing House, New Delhi. pp.153-181.

Wang, Y.T. 1995. *Phalaenopsis* Orchid light requirement during the induction of spiking. *HortScience* 30:59-61.

Wang, Y.T. 2004. Flourishing market for potted orchids. *FlowerTech.*7 (5):14-17.

Wang, Y.T. and Lee, N. 1994.A new look for an old crop: Potted blooming Orchids [on-line]. Available:http://primera.tamu.edu/orchids/paper1.htm [20 Jan.2007].

White, J. 1996. *Taylor's Guide to Orchids.* Houghton Mifflin Gardening. 400p.

Wikipedia. 2007. Phalaenopsis. [On-line free encyclopedia] Available: http://en.wikipedia.org/wiki/Phalaenopsis. [24 Jan 2007]

Withner, C.L. 1959. *The Orchids: A Scientific Survey.* Ronald Press, New York.648p.

Yadav, L.P. and Bose, T.K, 1986.Physiology of Flowering in Orchids. In: Vij, S.P. (ed.), *Biology, Conservation and Culture of Orchids.* The Orchid Society of India. pp 79-84.

Yoneda, K., Momose, H. and Kubota. 1991. Effects of day length and temperature on flowering in juvenile and adult *Phalaenopsis* plants. *J. Jpn. Soc. Hort. Sci.* 60:651-657.

Yoneda, K., Momose. H. and Kubota. 1992. Comparison of flowering behaviour between mature and premature plants of *Phalaenopsis* under different temperature conditions. *Trop. Agr.*36:207-210.

Yong, J.W.H and Hew, C. S. 2004. *The Physiology of Tropical Orchids in Relation to the Industry* .World scientific. 370p [on-line]
Available : http ://www.google.com/books?vid=ISBN981238801X

Zotz, G. 1998. Demography of the epiphytic orchid, *Dimerandra emarginata. J. Trop. Ecology.* [on-line] Available:http://journals.cambridge.org/action/ display Abstract? fromPage=online&aid=35383 [6 March 2007]

*Originals not seen

Appendix

APPENDIX-I

Monthly distribution of weather parameters during the experiment December 2005 to December 2006

Period	Temperature		Mean RH (%)	Rainfall	Sunshine hours	No of rainy days	Daylength (hrs)
	Maximum	Minimum					
Dec '05	31.5	22.1	66.0	3.2	226.1	0	11:45
Jan '06	32.5	22.6	57.5	0.0	277.7	0	11:45
Feb '06	34.3	22.3	51.0	0.0	267.8	0	11:50
Mar '06	34.8	23.8	67.5	95.2	236.5	4	12:10
Apr '06	33.4	24.7	74.5	86.2	211.3	3	12:20
May '06	31.8	24.3	78.5	675.5	179.9	14	12:30
Jun '06	29.9	23.6	84.0	608.6	113.1	17	12:30
Jul '06	29.5	23.3	85.5	519.0	69.4	29	12:30
Aug '06	29.8	23.1	83.0	550.6	131.8	15	12:15
Sept '06	29.6	23.0	84.0	522.2	116.4	17	12:15
Oct '06	31.0	23.0	78.5	323.7	147.3	11	12:10
Nov '06	31.7	23.7	71.5	795.0	195.0	5	11:45
Dec '06	31.5	23.6	56.5	0.0	242.0	0	11:45

EVALUATION OF MONOPODIAL ORCHIDS FOR CUT FLOWER

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the
requirement for the degree of

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ABSTRACT

The investigation on the evaluation of monopodial orchids was conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during 2005-2006 with the main objective of evaluating their field performance for commercial exploitation.

Forty monopodial orchids belonging to monogeneric, bigeneric and trigeneric origin were selected for the study. They were evaluated for their height, spread, shoot characters (length, girth), leaf characters (length, breadth, area, interval of production, leaf sheath length, breadth), aerial root characters (number, length, breadth), floral characters (spike emergence to opening of florets, length, girth and longevity of spike, interval of production, annual production of spikes, number of florets/ spike, individual flower life, flower size, blooming period under field conditions.

They exhibited wide variation in both vegetative and floral characters. The orchid varieties were grouped as tall climbing, intermediate climbing and short-stemmed epiphytes. Among the tall climbing orchids, maximum increase in height was observed in *Arachnis* Maggie Oei Red Ribbon and minimum in *Aeridachnis* Apple Blossom. Shoot girth, leaf length and leaf area were maximum in *Holttumara* Bright Eye while minimum girth was recorded in *Vanda* John Club. *Vanda* Prolific had the maximum internodal length. Maximum numbers of leaves was recorded in *Renanthera* Manila and roots in *Vanda* John Club and *Renanthera* Cape Sabel. Interval of leaf production and root length were maximum in *Aranthera* Mana Meina while interval of leaf production was minimum in *Arachnis* Maggie Oei Yellow Ribbon.

Duration from spike emergence to opening of florets was maximum in *Arachnis* Maggie Oei Red Ribbon (first and fifty per cent florets) and *Aranthera* Lily Brook Red (complete opening of florets) and minimum in *Holttumara* Bright Eye. Spike characters like spike length, rachis length, stalk length, spike girth, days taken from opening to wilting of first floret and spike longevity were maximum in *Aranthera* Lily Brook Red, while stalk length and internodal length was maximum *Aeridachnis* Apple Blossom and

Arachnis Maggie Yellow Ribbon respectively. Floral characters like number of florets per spike and individual flower life were maximum in *Aranthera* Lily Brook Red, pedicel length in *Vanda* Mandai Glow and individual flower size in *Aranthera* Mana Meina and *Arachnis* Maggie Oei Red Ribbon. Interval of spike production was minimum in *Aranthera* Anne Black and maximum in *Renanthera* Manila. *Aranda* Deborah produced maximum number of spikes per year followed by *Arachnis* Maggie Oei Red Ribbon, and *Aranthera* Anne Black.

Among intermediate climbing epiphytes, *Mokara* Sayan x Kultana Gold recorded maximum increase in height, shoot girth, leaf width and internodal length whereas it recorded the least interval of leaf production. *Ascocenda* Raminder Gold x Fortune East recorded the maximum leaf area and *Mokara* Bangkok Gold, the minimum. The internodal length recorded in *Vascostylis* Pine Rivers Pink was minimum followed by *Vascostylis* Pine Rivers Blue and Red.

Mokara Walter Oumae Yellow recorded maximum and *Vanda* JVB x *Ascocenda* YSW, the minimum duration from spike emergence to opening of first floret while *Mokara* Walter Oumae White, the maximum for opening of all florets and *Ascocenda* Raminder Gold x Fortune East, the minimum. Spike characters like spike length, stalk length, spike girth and internodal length were maximum in *Mokara* Sayan x Kultana Gold while duration from opening to wilting of first floret, rachis length and spike longevity were maximum in *Mokara* Walter Oumae White. Interval of spike production was maximum in *Mokara* Sayan x Kultana Gold and minimum in *Vascostylis* Pine Rivers Red. Annual spike production was maximum in *Mokara* Calypso Pink closely followed by *Vascostylis* Pine Rivers Red and *Ascocenda* Princess Mikasa Pink.

Short-stemmed varieties exhibited a slow rate of growth. *Phalaenopsis* Hwafeng Red Jewel recorded maximum leaf area, *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory), the minimum. Duration from spike emergence to opening of all florets and spike characters like length, stalk length, internodal length were maximum in *Phalaenopsis* Diana Pink and rachis length and spike longevity in *Phalaenopsis* Hwafeng Red Jewel. *Phalaenopsis* Memoria Grand Mother

had maximum number of florets per spike. Flower size was maximum in *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon, pedicel length in *Phalaenopsis* Diana Pink and individual flower life in *Phalaenopsis* Taipei Gold. All the *Phalaenopsis* hybrids produced spikes at an interval close to a year except *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon.

The qualitative characters of the monopodial orchid varieties differed in all aspects and a wide range of vegetative and floral characters could be observed. They also differed with regard to flowering; being free flowering, with short dearth periods or seasonal flowering.

Considering the qualitative and quantitative characters, among tall climbing orchids, *Aranthera* Anne Black, *Aranthera* Lily Brook Red, *Aranda* Deborah, *Aeridachnis* Apple Blossom and *Arachnis* Maggie Oei Red Ribbon has immense potential for use as cut flower together with the intermediate climbing types, *viz.*, *Mokara* Chark Kuan Pink, *Mokara* Walter Oumae White and *Mokara* Calypso Pink. *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon, a short stemmed epiphyte would be an excellent choice.

The performance projected short-stemmed *Phalaenopsis* hybrids the best as pot plants. Intermediate climbing epiphyte, *viz.*, *Ascocenda* Princess Mikasa Pink, *Vascostylis* varieties and *Vanda* JVB x *Ascocenda* Yip Sum Wah would also make excellent pot plants.