Final Report

Pimsiri Danphitsanuparn
Thai Volunteer

Orchid Cultivation and Propagation
At
Rural Development Training Centre (RDTC)
Zhemgang, Bhutan

October 3, 2015 – September 30, 2016

Thailand International Cooperation Agency (TICA)

Acknowledgements

The success and final outcome of this module would be impossible without the support from Thailand and Bhutan agencies. As a Thai volunteer, I would like to express my gratitude to the agencies and the people who assisted in my work as follow:

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- Royal Civil Service Commission (RCSC) of the Royal Government of Bhutan for the supports in Bhutan.
- Rural Development Training Centre (RDTC), Zhemgang, Ministry of Agriculture and Forests, for helping, supports, and accommodation.
- National Biodiversity Centre (NBC), Thimphu, Ministry of Agriculture and Forests
- Regional Livestock Development Centre (RLDC), Zhemgang, Ministry of Agriculture and Forests
- Department of Forest, Ministry of Agriculture, Zhemgang, Ministry of Agriculture and Forests
- Bhutan Agriculture and Food Regulatory Authority (BAFRA), Thimphu and Zhemgang, Ministry of Agriculture and Forests
- Mr. Tshering Dorji; Officiating Director of RDTC, Mr. Karma Wangchuk; RDTC Official Counterpart.
- Mrs. Ganga Pradhan; An Assistant Chief Human Resource Officer, Ministry of Agriculture and Forests, Thimphu.
- Dr. Dhan Bahadur Gurung; the orchid professor of Faculty of Forestry, Collage of National Resources.
- RDTC staffs: Mr. Choiney Dorji, Mr. Rinchen Dorji, Mr. Pema Gyeltshen, Mrs. Dechen Dema, Mr. Dorji Wangdi, Mrs. Tshering Dema, Mrs. Menuka Rai, the drivers and farm labours.
- RLDC staffs: Dr. Bhandari, Mr. Norbula, Mrs. Sonam Wangmo.
- NBC staffs: Mrs. Sangay Dema, Mr. Nima Gyeltshen, Mr. Kezang Tobgay, Mrs. Tshering Wangmo.

Moreover, I would like to thank my family, boyfriend, Thai friends and Bhutanese friends for the encouragement and supports for any purposes while I am in Bhutan for a year.

Pimsiri Danphitsanuparn
A Thai Volunteer

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Quarter 1: October 3, 2015 – January 2, 2016

Objectives

1. To collect and identify wild orchid species, and search for the economic importance of orchids.
2. To construct the shade house for storing the collected wild orchids, cultivation, and propagation.
3. To enhance the number of orchids by sexual and asexual production.
4. To set up the orchid floriculture development and farm management curriculum for trainees.

Output/Activities

1. Gathering the information of Bhutan's orchid.
2. Greenhouse construction.
3. Collecting the orchids from the forests.
4. Orchid identification.
5. Teaching and Demonstration of orchid cultivation and propagation for the trainees.
6. Orchid sexual reproduction.
7. Ordering the equipment and chemicals for plant tissue culture.
8. Setting plant tissue culture laboratory.

Key Performance Indicators

1. The number of orchids in the shade house and the number of different identified wild orchids.
2. The species of economically important orchids.
3. Small orchid garden.
4. The proper places for sexual and asexual propagation, and laboratory for plant tissue culture.
5. The orchid floriculture development and farm management curriculum.
6. The number of participants.

Critical Success Factors

1. Cooperation of the RDTC team - members.
2. The participants' attention.
3. Output from the volunteer.

Counterpart Personnel

Mr. Karma Wangchuk, RDTC Vegetative Instructor
Mr. Tshering Dorji, RDTC Officiating Director

Discussion of job responsibility and annual work plan

The volunteer and RDTC staffs discussed the job responsibilities and planned an annual work plan. When the volunteer arrived RDTC, there had been no orchids in RDTC yet. The goal of the Thai volunteer stated in the request form was not possible given the time factors provided by contracted work. The process to produce the new hybrid orchid would take more than five years to accomplish, this resulted in changing the request originally made, thus resulting in a change in job responsibility. The summarised job responsibilities of the volunteer were re-evaluated with RDTC and confirmed as follows:

1. To collect and identify wild orchid species, and search for the economic importance of orchids.
2. To construct the shade house for storing the collected wild orchids, cultivation, and propagation.
3. To enhance the number of orchids by sexual and asexual reproduction.
4. To set up the orchid floriculture development and farm management curriculum for trainees.

Gathering the information on the orchids in Bhutan

The volunteer received the chance from RDTC officiating director, Mr. Tshering Dorji, to visit Royal Botanical Park (Lamperi, Thimphu), National Biodiversity Centre (NBC-Serbithang, Thimphu), and College of Natural Resources (CNR-Lobesa, Thimphu). This was to gather information on the orchids in Bhutan this included the orchid species, the techniques to grow orchids in both indoor and outdoor gardens, and the technology that they are using to propagate the orchid. NBC has initiated the orchid micropropagation (plant tissue culture) for a year, but they are facing the problems to grow the *in vitro* orchids and also the contamination. The volunteer received the handbook *"An Illustrated Guide to the Orchids of Bhutan"* from Dr. Dhan Bahadur Gurung, the orchid specialist and the professor of CNR. The usage of the orchids in Bhutan was recorded from the interview of the local people in Zhemgang and the staffs from NBC. In Bhutan, some orchids are consumed as the precious vegetable and also has a large market niche. Among them, *Cymbidium* species were selected as the high economic potential orchids which are worth to do the asexual reproduction by using plant tissue culture techniques.

Figure 1. Visiting the orchid gardens in Thimphu; Royal Botanical Park (left) And National Biodiversity Centre (NBC-right) .

Orchid greenhouse construction

As RDTC still did not have the proper place for orchid cultivation and propagation. At the beginning of collecting the orchids, the plastic greenhouse for tomato cultivation was used as the orchid greenhouse. The volunteer planned for the interior decoration and worked together with the farm labourers to make the shelves for growing the orchids. The request for cutting the bamboos and timbers were submitted to the Department of Forest for the permit and those were collected from the nearby Zhemgang forest. The decoration finished within one week. Then the volunteer started to collect the orchids from the forest and kept them inside the greenhouse. As this greenhouse is covered with the plastic sheet, the temperature inside increased during the daytime and low ventilation, so it was not suitable to grow the orchids. The new orchid greenhouse covered with the shading net was planned to solve this problem and it would be constructed in the quarter 2.

Figure 2. The greenhouse for growing tomato

Collecting the orchids and identification

During the quarter 1, eighteen orchid species were collected from the forest nearby Zhemgang town. Five species out of eighteen were identified into species. To identify the species , the flowers are needed, but most of them were collected without flower.

Materials for growing the orchids

In Bhutan, especially Zhemgang (one of the remote area in Bhutan), general materials to grow the orchid such as coconut husk, sphagnum mosses, charcoal, etc. are not available. The volunteer had to survey and find the local materials for growing them. The oak bark chips, Rhododendron bark chips, and mosses are plenty in that area, and were used to grow the orchid. Moreover, the volunteer found that there were sawmills in that area, so the sawdust the residual from those sawmills became one of the material to grow the orchids.

During the winter time, Zhemgang lacked water for home consumption, and also the water was not sufficient enough for plantation. Thus, the volunteer tried to do mini-research to find the material which could storage the water to decrease the watering period and save budget. The sawdust, clay, mosses, and bark chips were mixed together to make 'Clay Ball'. After drying the clay balls with the sunlight, the clay balls were used to grow the cymbidiums compared with the bark chips mixed with mosses. The character of the leaves and roots were observed every month.

Furthermore, the wooden slatted basket was designed and sent to the furniture house to make them. It was the first time for them to see the new design of the basket. However, the price of baskets was expensive, Nu.200 per piece, to reduce the cost plastic bottles and pieces of bamboos were used as a basket substitute.

Figure 3. The students were volunteering to

Figure 4. The slatted basket for growing

Orchid cultivation and propagation class

The volunteer received the opportunity to instruct the RDTC vegetable trainees for the basic ideas in orchid cultivation and propagation on October 16th, 2016. The resources for teaching was prepared by the volunteer within the first week of arrival to teach for 45 mins. As there were no orchids in RDTC at that time, so the photo in the PowerPoint presentation was an only way to demonstrate the characters of orchid flower and stem.

Figure 5. The RDTC vegetable trainees and the

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RLDC is the livestock laboratory under the Ministry of Agriculture and Forests. They have the facilities for blood tests, stool tests, diagnosing the cause of death in animals, and microbiology. The volunteer visited RLDC to see the laboratory and equipment such as laminar air flow, autoclave, and glassware. This equipment might be used in plant tissue culture, and a request was made to collaborate with RLDC for the further orchid tissue culture.

Figure 6. The laboratory at RLDC.

Orchid sexual reproduction

The hand pollination technique was used for sexual reproduction of cymbidium orchid on November 2nd, 2016. The pods (fruit) would be collected when it was 7-month old.

Figure 7. The flower of

The equipment for plant tissue culture

The list of equipment and chemicals concerned plant tissue culture technique was prepared. The volunteer and the RDTC officiating director visited the supplier in Thimphu and sent an order list on November 4th, 2015. Until the end of the first quarter, there was no response from that company.

Other Activities

Milk Processing Unit

The volunteer visited the milk processing unit, in Zhemgang town. All the milk from Zhemgang milk cooperative members would be collected and passed the process to produce the local cheese and butter. All the products would serve the community.

Figure 8. Milk processing unit, Zhemgang

Walk for health

On October 24, 2016, the volunteer participated with Zhemgang community to promote health issue, followed the campaign "Walk for health". All the participants including the government officers, the businessmen, and also the local people had to walk for 14 km in Zhemgang town within one day. This activity would like to motivate Bhutanese to do more exercise to prevent themselves from diabetics and be healthy.

Figure 9. Walk for health activity, Zhemgang

The 60th Birth Anniversary of HM the Fourth King Jigme Singye Wangchuck Celebration

During November 7-11, 2015, the volunteer attended the community activities for the 60th birth anniversary of His Majesty the Fourth King Jigme Singye Wangchuck. The first three days, everybody was gathering at the Gomphong Chorten, 8km far from the town, to pray for the 4th King for the whole day. On the last day, the activities were set up at the Zhemgang lower school. In the evening, there was the culture competition. The community members from each organisation and villages were attended in this activity. All RDTC staffs participated. The Thai volunteer played the Bhutanese music instrument 'Yang Chin', similar to Thai music instrument 'Khim', and sang Thai song 'Smiles' composed by King Bhumibol Adulyadej of Thailand. It was the great honour to be a representative of Thailand and perform in front of many who attended that event.

Figure 10. The volunteer and RDTC staffs on the 60th birth

Figure 11. The volunteer played Yang Chin, Bhutanese music

Vegetable training

The volunteer attended the practical class for tomato orchard management and also planted cauliflower, which performed for the RDTC vegetable trainees.

Figure 12. The tomato orchard management

Social Works

Before the Bhutan National Day Celebration, the volunteer and RDTC staffs went to decorate the place for celebration at Zhemgang Lower School. They used the five coloured flags and made them in order: blue, white, yellow, red, and green. Five colours represent the five elements. The colour blue symbolises the sky and space. White symbolises the air and wind. Yellow symbolises earth. Red symbolised fire. Green symbolises water. In the early morning of the Bhutan National Day, December 17, 2015, All Bhutanese people in Zhemgang were gathering at the football field of Zhemgang lower school to sing the national anthem, marching, and pay the respect to the 4th King.

Figure 13. The activities for the Bhutan National Day.

Civil Service Welfare Scheme (CSWS)

On December 1, 2015, the volunteer was invited to attend the meeting led by Royal Civil Service Commission (RCSC) at Zhemgang Dzong Meeting Hall. The change in welfare for the civil servants were stated and gave the volunteer insight in local systems in the working class.

Figure 14. The civil servants in the meeting with RCSC at

Quarter 2: January 3, 2016 – April 2, 2016

Objectives

1. To collect and identify wild orchid species, and search for the economic importance of orchids.
2. To construct the shade house for storing the collected wild orchids, cultivation, and propagation.
3. To enhance the number of orchids by sexual and asexual production.
4. To set up the orchid floriculture development and farm management curriculum for trainees.

Output/Activities

1. Gathering the information of Bhutan's orchid
2. Gathering the use of the orchids in Bhutan from the local people.
3. Greenhouse construction.
4. Setting up the small orchid garden.
5. Collecting the orchids from the forests.
6. Orchid identification.
7. Creating orchid cultivation and propagation curriculum
8. Teaching and Demonstration of orchid cultivation and propagation for the trainees.
9. Ordering the equipment and chemicals for plant tissue culture.
10. Setting plant tissue culture laboratory

Key Performance Indicators

1. The number of orchid in the shade house and the number of identified wild orchids.
2. Small orchid garden.
3. An increase in population of orchids from sexual and asexual propagation.
4. The proper places for sexual and asexual propagation, and laboratory for plant tissue culture.
5. The orchid floriculture development and farm management curriculum.
6. The number of participants.

Critical Success Factors

1. Cooperation of the RDTC team - members.
2. The participants' attention.
3. Output from the volunteer.

Counterpart Personnel

Mr. Karma Wangchuk, RDTC Vegetative Instructor
Mr. Dorji Tshering, RDTC Mushroom Instructor
Mr. Tshering Dorji, RDTC Officiating Director

Collecting the orchids and identification

The orchid collection was postponed until the new greenhouse was established, but two species were given from the RDTC farm labourers. During Febuary to April is Spring season in Bhutan, it is the best season for orchid blooming. The orchids showed the survivor sign such as producing the green leaves, white and healthy roots with the green root tips, and flower blooming. Thirteen species out of twenty were identified from their flower by comparison with the orchid database.

Orchid greenhouse construction

The new orchid greenhouse made of bamboos and shading net were constructed in the half-shade area. The volunteer designed the materials and the pattern of interior decoration. The small orchid garden was accomplished with the help of Mr. Karma Wangchuk, Mr. Dorji Tshering, and the farm labourers. Oak logs were collected from the oak trees in Zhemgange forest. All the orchids from the plastic greenhouse were shifted to the shading net greenhouse.

Figure 15. The shading net greenhouse before (left) and after (right) decoration.

Meeting with RDTC staffs

The volunteer had a meeting with RDTC staffs because the supplier in Thimphu who RDTC had ordered the equipment for plant tissue culture had no response for four months. The original plan would need to be amended. The volunteer carried out other viable options before arranging a meeting with RDTC officiating director. The volunteer contacted the orchid farms and scientific equipment suppliers in Thailand. Bhutan Agriculture and Food Regulatory Authority (BAFRA) was contacted to discuss the orchid species which are allowed to be imported to Bhutan and the process to get the permit. There are eight groups of orchids which are allowed to be imported to Bhutan (BAFRA ornamental lists, 2009) as followed:

- *Vanda* 'Miss Joaquim' hybrid
- *Phalaenopsis*
- *Oncidium*
- *Ascocentrum*
- *Cymbidium*
- *Cattleya*
- *Leptorchirs*
- Jewel orchids

The volunteer suggested two options to RDTC staffs: 1) Import the *in vitro* orchid seedlings from Thailand, 2) Ordering the equipment from Thailand. The price between two options were compared. After discussion with the officiating director, they decided the best option would be to order the equipment from Thailand.

School Youth Agriculture Training

The hundred students from the Eastern part of Bhutan came to RDTC for the School Youth Agriculture Training Program. The students would be trained in dairy products, poultry farming, piggery, mushroom production, and vegetable production. For this year, the orchid cultivation and propagation was added as an extra course for the students during January 12-13, 2016. The volunteer prepared the materials for teaching and also games and activities. Three Zhemgang students, who were trained for orchid culture earlier, volunteered to be an assistant in the class.

Figure 16. The activities in the orchid cultivation and propagation class.

iBest training program

iBest is an training institute for the new Bhutanese generation, aimed to promote and offer the opportunity to the Bhutanese to be trained in their interested subject for their future job. RDTC was selected to be a host for sixteen trainees to train for agriculture concepts. Orchid cultivation and propagation course was included in the training program on March 3, 2016.

Figure 17. The volunteer with the RDTC trainees under iBEST project.

Visit National Biodiversity Centre (NBC), Thimphu

The volunteer and the counterpart, Mr. Karma Wangchuk, visited NBC for plant tissue culture laboratory. After meeting with Madam Sangay Dema, the director of NBC, NBC was willing to support the five packages of culture media, Vacine and Went (VW), for RDTC in the initial stage. Moreover, the volunteer and the counterpart met Mr. Stig Dalström, a Swedish orchid specialist, and Mr. Thomas Itöijer, an orchid gardener, who volunteered to help Bhutan for orchid collection, advised for orchidarium care, and summarized the number of the orchid of Bhutan. They suggested and gave lots of ideas to take care of the wild orchids of Bhutan.

Figure 18. Visiting the orchidarium and orchid tissue culture laboratory in NBC, Thimphu.

Other activities

Potluck lunch - New Year Celebration in RDTC

Potluck is the favourite meal for local Bhutanese. Each family cooked their own foods and brought them to eat together. During the New Year Celebration, RDTC staffs and their family set up this potluck lunch and celebrate together in RDTC office.

Figure 19. Potluck with RDTC family at the yard of RDTC office.

Mushroom Training

The volunteer participated the hands on mushroom training class for the students in the School Youth Agriculture Training program which conducted by Mr. Dorji Tshering. The students practiced the techniques to culture Shiitake mushroom with the oak logs and also Oyster mushroom with rice straw.

Figure 20. The mushroom training class.

The fifth king of Bhutan birthday celebration

The volunteer attended the fifth and current Druk Gyalpo ("Dragon King") of Bhutan, King Jigme Khesar Namgyel Wangchuck birthday celebration on February 21, 2016, at Zhemgang Lower School. The students, civil servants, and villagers were participated in this occasion to pay the respect to the king.

Figure 21. The fifth king of Bhutan birthday celebration at Zhemgang Lower School.

Zhemgang Tshechu

On March 16-18, 2016, Zhemgang Dzonghag had the mask dance festival called 'Tshechu'. All the people from different villages of Zhemgang came to attend this festival. The mask dance was performed in the open area near Zhemgang Dzong. Bhutanese people wore their beautiful kira and deko (Bhutanese traditional dress) for this festival. The performance started at 8 am until 5 pm of every day. The story of the mask dance based on Buddhist believe, karma, Buddha, heaven and hell, and Guru Rinpuche.

Figure 22. Tshechu festival at Zhemgang Dzong

Threma Lakhang, Zhemgang

Threma Lakhang was the latest temple in Zhemgang which opened on March 31, 2016. Zhemgang people donated their money to construct this temple as the new place for meditation and perform the ritual Puja. Before the opening ceremony, the local people from Zhemgang Trong village, including RDTC family and the volunteer came to prepare and decorate the place. Dungsey Garab Rinpoche, the main younger generation holder of the Dudjom Tersar lineage, was invited to open this lakhang. Moreover, he performed the fire Puja and blessed the participants.

Figure 23. Zhemgang people came to Threma Lakhang to prepare the place before the opening ceremony.

Figure 24. Dungsey Garab Rinpoche gave

Figure 25. Bhutanese people participated the

Quarter 3: April 3, 2016 – July 2, 2016

Objectives

1. To collect and identify wild orchid species, and search for the economic importance of orchids.
2. To construct the shade house for storing the collected wild orchids, cultivation, and propagation.
3. To enhance the number of orchids by sexual and asexual production.
4. To set up the orchid floriculture development and farm management curriculum for trainees.

Output/Activities

1. Gathering the information of Bhutan's orchid
2. Gathering the use of the orchids in Bhutan from the local people and select orchids which have economic importance.
3. Shad house construction.
4. Setting up the small orchid garden.
5. Collecting the orchids from the forests.
6. Orchid identification.
7. Creating orchid cultivation and propagation curriculum
8. Teaching and Demonstration of orchid cultivation and propagation for the trainees.
9. Ordering the equipment and chemicals for plant tissue culture.
10. Setting plant tissue culture laboratory
11. *In vitro* orchid propagation (plant tissue culture)

Key Performance Indicators

1. The number of orchid in the shade house and the number of identified wild orchids.
2. The species of economically important orchids.
3. Small orchid garden.
4. The large amount of orchids from sexual and asexual propagation.
5. The proper places for sexual and asexual propagation, and laboratory for plant tissue culture.
6. The orchid floriculture development and farm management curriculum.
7. The number of participants.

Critical Success Factors

1. Cooperation of the RDTC team - members.
2. The participants' attention.
3. Output from the volunteer.

Counterpart Personnel

Mr. Karma Wangchuk, RDTC Vegetative Instructor
Mr. Choiney Dorji, RDTC Poultry Instructor
Mr. Tshering Dorji, RDTC Officiating Director

Collecting the orchids and identification

The site survey for orchid collection was postponed because of the monsoon season. Twenty two orchid species out of twenty six were identified and labelled. The orchid garden was weeded every month to take care of the garden. The six month old pod (orchid fruit) from hand pollination was collected for orchid tissue culture.

Gathering the data of orchid utilities

The volunteer joined the site survey in Wangduephodang, Punakha, Gasa, Thimphu, and Paro Dzongkhag with Mr. Choiney Dorji to interview the Bhutanese for orchid consumption. The people in Wangduephodang, Punakha, Gasa collected the cymbidium orchid from the forest and grew them in their house for selling the orchid flower bud and home consumption. Bhutanese people eat immature orchid flower as the vegetable. The orchid flower buds are added into the national dish of Bhutanese, called “Emma Dashi”, to enhance the bitter taste. The price of the orchid flower is higher than the other local vegetable, Nu.150-200 per 3 inflorescences, but it was not sufficient for the demand. The middle man merchants would buy and collect the orchid from the farmers in those areas, Nu.50-100 per brunch, then sell them at Babesa market and Thimphu market.

In Punakha, there is one orchid community who grew the wild orchid and plan to sell the orchid as the pot plant. The price per pot would be around Nu.500-1,500. However, most of the orchids in their greenhouse were collected from the forest.

Figure 26. Interviews were held with the local Bhutanese, for orchid consumption.

Figure27. The orchid farm in Gasa Dzonghag.

Figure28. Orchid farm of the orchid community,

The Second Royal Bhutan Flower Exhibition, Paro

On June 4, 2016, the volunteer visited the Second Royal Bhutan Flower Exhibition in Paro with Mr. Choiney Dorji. Several orchid species from all over Bhutan were demonstrated in the exhibition. The Thai government presented one orchid display, many gardeners gathered to create their own exhibition to represent their local community. A competition was held to compete for the best arrangement of flowers.

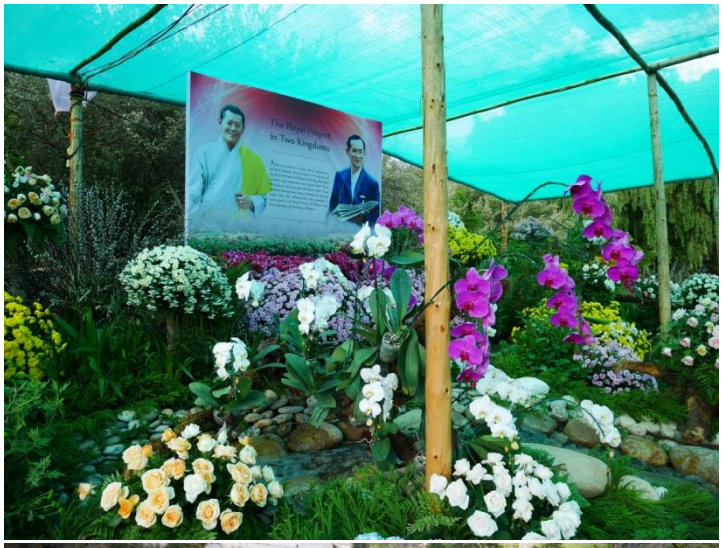

Figure 29. Thai government flower garden in the second royal Bhutan flower exhibition.

Figure 30. An example of an

Orchid tissue culture laboratory

The equipment for orchid tissue culture laboratory from Thailand and the five Hi-Media® packages of culture media from NBC were arrived at RDTC, Zhemgang. The autoclave system and the pH meter were validated by Mr. Norbula and Madam Sonam Wangmo from RLDC, Zhemgang. Thirteen culture formula including Hi-Media® were prepared and adjusted the pH 5.8. Some formula contained mashed potato, tomato, Redbull®, or Thiamine (Vitamin B1), and prepared with market agar powder.
The Thai's counterpart, Mr Karma Wangchuk, was coached for orchid *in vitro* culture. Surface sterilization and seed micropropagation were techniques that were taught to the counterpart, these are important procedures that are essential for maintaining the orchid farm in the future. All the *in vitro* orchids were kept in the dark room at RLDC, this was because of the lack of storage in RDTC.

Figure 31. The thirteen culture media formula were prepared for the orchid *in vitro* culture.

Figure 32. The Bhutanese counterpart was trained for orchid *in vitro* culture.

The shelf and cabinet for culturing *in vitro* orchid culture was rejected from the furniture house after they had asked RDTC to wait for two months. The volunteer discussed with RDTC to find the new furniture house. The new furniture house agreed to only make the shelf without polish. The fluorescent light for the shelf was not available in Bhutan, RDTC had to order them from India and it took 2 months to arrive Zhemgang (arrived in the quarter four).

Other activities

Visiting the former RDTC trainees' farm with Helvetas team

Helvetas team from Switzerland came to RDTC to evaluate the work progress. RDTC staff reported all the work that had been completed. The volunteer attended the meeting with all the staff and visited the former RDTC trainees' farm in Zhemgang with Helvetas team. Helvetas' last visit was roughly ten year ago and they were reassessing the situation to decide whether to invest more money into the organisation.

Figure 33. The Helvetas team visiting the former RDTC trainee's shiitake mushroom farm, Zhemgang.

Janajuda Ritual Puja

RDTC staff prepared the tea and snacks to serve those present to pray in Janajuda Ritual Puja at Zhemgang Dzong. This Puja was performed every year to bless all the Zhemgang people and protect from the bad spirits. The volunteer attended this event and help them to serve the tea.

Figure 34. Janajuda Ritual Puja, Zhemgang.

Quarter 4: July 3, 2016 – September 30, 2016

Objectives

1. To collect and identify wild orchid species, and search for the economic importance of orchids.
2. To construct the shade house for storing the collected wild orchids, cultivation, and propagation.
3. To enhance the number of orchids by sexual and asexual production.
4. To set up the orchid floriculture development and farm management curriculum for trainees.

Output/Activities

1. Gathering the information of Bhutan's orchid
2. Collecting the orchids from the forests.
3. Orchid identification.
4. Creating orchid cultivation and propagation curriculum
5. Teaching and Demonstration of orchid cultivation and propagation for the trainees.
6. *In vitro* orchid propagation (plant tissue culture)

Key Performance Indicators

1. The number of orchid in the shade house and the number of identified wild orchids.
2. The large amount of orchids from sexual and asexual propagation.
3. The proper places for sexual and asexual propagation, and laboratory for plant tissue culture.
4. The orchid floriculture development and farm management curriculum.

Critical Success Factors

1. Cooperation of the RDTC team - members.
2. The participants' attention.
3. Output from the volunteer.

Counterpart Personnel

Mr. Karma Wangchuk, RDTC Vegetative Instructor

Collecting the orchid and identification

The site survey for the orchid collection was postponed because of the monsoon season. Some orchids were collected from the cliffs nearby Zhemgang. Nine species were donated by NBC staff. Thirty four species out of forty one were identified and labelled.

Orchid tissue culture laboratory

Ninety percent of the *in vitro* orchids were contaminated due to the poor conditions provided by the culture room. The remaining orchids which were not contaminated were salvaged and moved to the prepared shelf with light conditions, 18/6 hrs per day, in RDTC, unfortunately none of them survived.

Figure 35. The

Figure 36. The *in vitro*

Orchid cultivation and propagation class and curriculum

The orchid cultivation and propagation curriculum was completed; this was presented to RDTC staff. A presentation allowed the Thai volunteer to adapt the curriculum and provide ample information to educate the future trainees. A general guide book and presentation resources were created in order to support teachers to guide others in the learning of this topic. The last orchid cultivation and propagation class was performed for the RDTC poultry trainees.

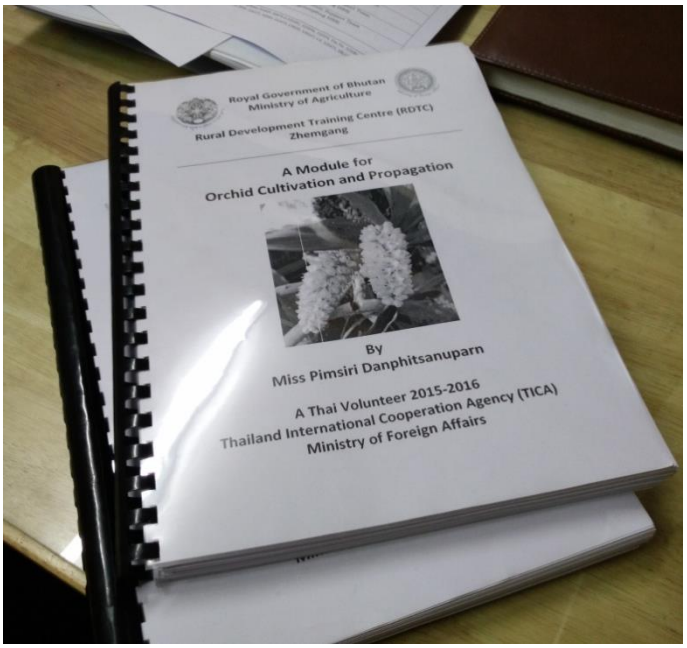

Figure 37. A

Figure 38. The orchid cultivation and propagation class

Term of References (TOR)

Rural Development Training Centre (RDTC), Zhemgang, MoAF would like to develop the floriculture course focusing on hybrid orchid cultivation and the immediate plan is to develop hybrid orchidarium and propagation. The institute submitted the request to TICA for a Thai volunteer who would help to establish and propagate the hybrid orchid, and share the cultivation and propagation techniques to staff. However, the job responsibilities of the volunteer and an annual work plan were dicussed with RDTC staffs when the volunteer arrived and this resulted in changing some points of the previous TOR. To produce the new hybrid orchids, it would take more than five years to archieved because of the duration of flowering (once a year) and the compatible of the matching orchid species. Moreover, RDTC still has no basic facility to reach the goal mentioned in the former TOR such as the orchid resources in RDTC, the appropriate greenhouse to keep the orchids, the basic knowledge to grow the orchids. Therefore, the volunteer and RDTC re-evaluated the TOR and confirmed as follows:

1. To collect and identify wild orchid species, and search for the economic importance of orchids.
2. To construct the shade house for storing the collected wild orchids, cultivation, and propagation.
3. To enhance the number of orchids by sexual and asexual reproduction.
4. To set up the orchid floriculture development and farm management curriculum for trainees.

Work Plan of Volunteer: Duration: 1 year. (Form 1 October 2015 to 30

Objectives	Detailed Output / Activities	Key Result Area (KRA)	Key Performance Indicators (KPI)	Critical Success Factor (CSF)
1. To collect and identify wild orchid species, and search for the economic importance of orchids.	1. Site survey and collect orchids from the forests 1.1 Ask for the permit to collect wild orchids from the Department of Forest and Park Service. 1.2 Discuss with RDTC staff and plan for the survey. 2. Identify the orchid species 2.1 Gather information of orchids in Bhutan. 2.2 Identify the species of wild orchids 3. Study the use of orchids from the local people and select orchids which have economic importance.	1. Outcome - Have reliable source to identify the local orchid species serve the community. 2. Outputs - Collect orchids from the forest and identify their species. - Ascertain the economic importance of orchids for cultivation and propagation.	1. The number of orchid in the shade house. 2. The number of identified wild orchids. 3. The species of economically important orchids.	1. Cooperation of the RDTC team-members. 2. The permit to collect wild orchids from the Department of Forest and Park Service. 3. The advice from orchid specialists in Bhutan and Thailand to identify the orchid species.
2. To construct the shade house for storing the collected wild orchids, cultivation, and propagation.	1. Site surveys and select the proper place for shade house construction. 2. Construct the shade house. 3. Set up the small orchid garden.	1. Outcomes - Have training place for orchid propagation and cultivation. - Have small orchid garden which exhibit and mimic their habitats. 2. Output - Have the shade house to store the wild orchids for cultivation and propagation.	1. Orchid shade house 2. Small orchid garden	1. Cooperation of the RDTC team-members.

Objectives	Detailed Output / Activities	Key Result Area (KRA)	Key Performance Indicators (KPI)	Critical Success Factor (CSF)
3. To enhance the number of orchids by sexual and asexual production.	1. Find materials for orchid cultivation. 2. Survey the places and equipment for plant tissue culture. 3. Ask for permit to use the laboratory. 4. Order the equipment and chemical for plant tissue culture techniques.	1. Outcome - Demonstrate how to cultivate and propagate the orchids to staff and trainees. **2.** Outputs - Have the proper place and equipment for orchid propagation. - Obtain the orchids from sexual and asexual propagation.	1. The large amount of orchids from sexual and asexual propagation. 2. The proper places for sexual and asexual propagation, and laboratory for plant tissue culture.	1. Cooperation of the RDTC team-members.
4. To set up the orchid floriculture development and farm management curriculum for trainees.	1. Set up the orchid floriculture development and farm management curriculum. 2. Teach the trainees	1. Outcome - Have the course for orchid floriculture development and farm management demonstrated by RDTC staff. 2. Output - Have the course for orchid floriculture development and farm management for the staffs and trainees.	1. The orchid floriculture development and farm management curriculum. 2. The number of participants.	1. Cooperation of the RDTC team-members. 2. The participants' attention

Work Plan of Volunteer: Duration: 1 year. (Form 1 October 2015 to 30 September 2016) Name: Miss Pimsiri Danphitsanuparn

Outputs/ Activities	Year 1 (2015-2016)				Counterpart Personnel	Budget	Remark
	Q1	Q2	Q3	Q4			
1. Gathering the information of Bhutan's orchid	/	/			Mr.Karma Wangchuk	-	-
2. Gathering the use of the orchids in Bhutan	/	/	/	/			
3. Shade house construction	/						
4. Setting up the small orchid garden			/	/			
5. Collecting the orchids from the forest	/	/	/	/			
6. Orchid identification	/	/	/	/			
7. Creating orchid cultivation and propagation curriculum	/	/	/	/			
8. Teaching and Demonstration of orchid cultivation and propagation for the trainees	/	/	/	/			
9. Ordering the equipment and chemicals for plant tissue culture	/	/					
10. Setting plant tissue culture laboratory	/	/					
11. *In vitro* orchid propagation (plant tissue culture)		/	/	/			

Progress Report Period of work: From 3 October

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
1. To collect and identify wild orchid species and search for the economic importance of orchids.	1. Site surveyed and collected orchids from the forests. 2. Identifed the orchid species. 2.1 Gathered information of orchids in Bhutan. 2.2 Identifed the species of wild orchids 3. Studied the use of orchids from the local people and focus on edible orchids.	1. Outcome - Having the reliable source to identify the local orchid species serve the community. 2. Outputs - The number of orchid from the site survey. - *Cymbidium* sp. was chosen for *in vitro* propagation.	1. Starting site survey and collecting the wild orchids from Zhemgang area; the degree of achievement was A. 2. Eighteen species of orchid were collected from the forest and five of them were identified; the degree of achievement was D. 3. The utilities of orchid and the food recipes contained orchid were recorded; the degree of achievement was D.	- Attachment (Figure 1, 2)	- The site survey has started in Q1 and continued to Q2, Q3, and Q4. - To identify orchids, the flower is needed, but most of the orchids that were collected only have pods, the flower might bloom during August-September. Thus, the identification cannot be completed. - The data was surveyed from Zhemgang town only.
Objectives	**Output/Actives**	**Key Result Area / Key Performance Indicators**	**Degree of Achievement (A), (D), (U)**	**Mean of Verification (for Achievement)**	**Remark**

2. To construct a shade house for storing the collected wild orchids, cultivation, and propagation.	1. Site surveyed and selected the proper place for shade house construction. 2. Constructed the shade house.	1. Outcomes - Have a training place for orchid propagation and cultivation. 2. Output - Shade houses completed.	1. An appropriate area of RDTC was chosen to construct the greenhouse; the degree of achievement was A. 2. The tomato's greenhouse was modified and bamboo shelves were installed inside for orchid cultivation. Another greenhouse was constructed using bamboo and shading net; the degree of achievement was A.	- Attachment (Figure 3-5)	- No
Objectives	**Output/Actives**	**Key Result Area / Key Performance Indicators**	**Degree of Achievement (A), (D), (U)**	**Mean of Verification (for Achievement)**	**Remark**

3. To enhance the number of orchids by sexual and asexual reproduction.	1. Found materials for orchid cultivation. 2. Surveyed the places and equipment for plant tissue culture. 3. Asked for permission to use the laboratory 4. Ordered the equipment and chemical for plant tissue culture techniques.	1. Outcome - Demonstrate how to cultivate and propagate the orchids to staff and trainees. 2. Outputs - Have correct requirements and equipment for orchid propagation. - Obtain the orchids from sexual and asexual propagation.	1. The materials locally found in Zhemgang area are used to grow the orchid; the degree of achievement was A. 2. Visiting RLDC laboratory and asking for the permission for using the equipment; the degree of achievement was A. 3. Survey the proper place in RDTC to set up *in vitro* culture laboratory; the degree of achievement was A. 4. The tools and chemicals for *in vitro* culture are not available in Bhutan; the degree of achievement was D.	- Attachment (Figure 6-10)	- The mini project has been done using the balls made of sawdust, clay, bark chips, and moss to grow the orchid. - The scientific equipment supplier has no response. - Waiting to discuss with NBC for permission to share the chemicals and equipments.
Objectives	**Output/Actives**	**Key Result Area / Key Performance Indicators**	**Degree of Achievement (A), (D), (U)**	**Mean of Verification (for Achievement)**	**Remark**
4. To set up the orchid floriculture development and	1. Set up the orchid floriculture development and	1. Outcome - Have the course for orchid	1. Instruction media were created and used for teaching the	- Attachment (Figure 11)	- Instruction media are a part of the orchid floriculture

farm management curriculum for trainees.	farm management curriculum. 2. Taught the trainees	floriculture development and farm management demonstrated by RDTC staffs. 2. Output - Have the course for orchid floriculture development and farm management for the staffs and trainees.	trainees; the degree of achievement was A. 2. The first orchid course for vegetable trainees was instructed; the degree of achievement was A.		development and farm management curriculum. This curriculum would be completed at Q4.

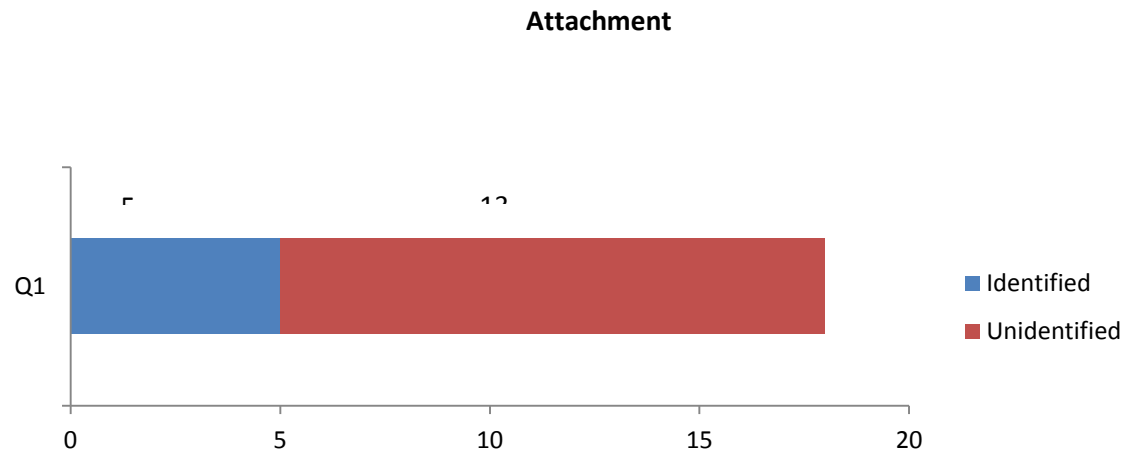

Figure 1. A Bar chart to show amount of orchids collected from November to December.

Figure 2. The wild orchids collected from Zhemgang's forest stored inside the greenhouse.

Figure 3. The first orchid greenhouse which has been growing tomato plants.

Figure 4. The first greenhouse after renovation and installation of bamboo shelves.

Figure 5. The second greenhouse is constructed with bamboo.

Figure 6. The wooden basket for orchid cultivation (Nu.200 per box)

Figure 7. The local materials used for orchid cultivation, such as bark chips, moss, and sawdust balls (made from sawdust, bark chips, mosses, and clay).

Figure 8. The orchids were propagated by division (growing in clay pot, plastic bottle, wooden basket) and mounting on oak trees.

Figure 9a.*Cymbidium* sp. flower.
Figure 9b. 2-month old of *Cymbidium* sp. pod (November-December 2015)

Figure 10a. Laboratory of Regional Livestock Development Centre (RLDC)
Figure 10b. Autoclave for culture media preparation.

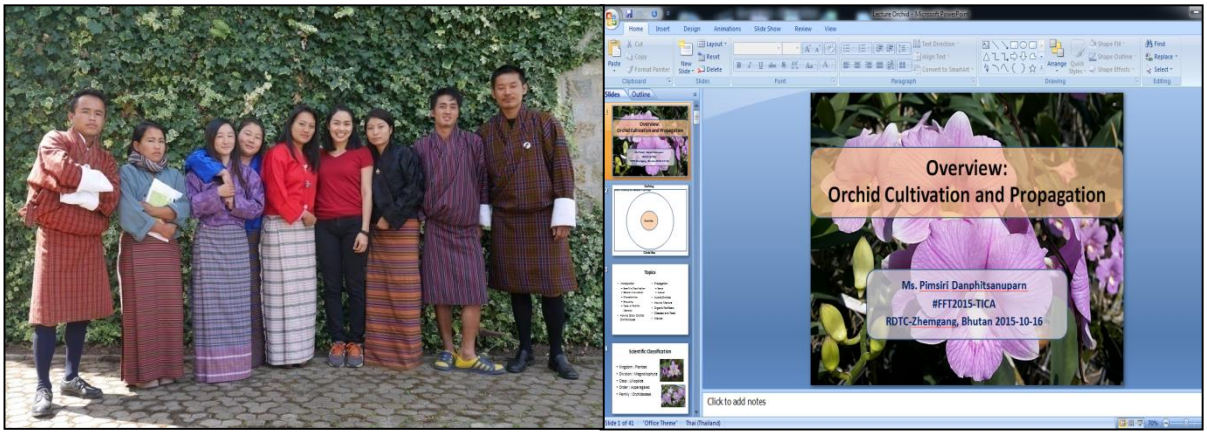

Figure 11. Teaching orchid cultivation and propagation for vegetable trainees

Figure 12. Orchid garden at Royal Botanical Park, Lamperi, Thimphu

Figure 13a. The orchidarium at the Botanical Garden - National Biodiversity Centre (NBC), Serbithang, Thimphu.
Figure 13b. Orchid In vitro cultures-NBC laboratory.

Figure 14. Gene bank, seed drying, and bio-exploration laboratory at NBC, Serbithang, Thimphu

Progress Report, Period of work: From 3 January 2016 To 2 April

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
1. To collect and identify wild orchid species and search for the economic importance of orchids.	1. Site surveyed and collected orchids from the forests. 2. Identifed the orchid species. 2.1 Gathered information of orchids in Bhutan. 2.2 Identifed the species of wild orchids 3. Studied the use of orchids from the local people and focus on edible orchids.	1. Outcome - Having the reliable source to identify the local orchid species serve the community. 2. Outputs - The number of orchid from the site survey.	1. Site survey and collecting the wild orchids from Zhemgang area; the degree of achievement was D. 2. Twenty species of orchid were in the greenhouse and thirteen of them were identified; the degree of achievement was A. 3. The utilities of orchid and the food recipes contained orchid were recorded; the degree of achievement was D.	- Attachment 1 (Figure 1)	- The site survey in Q2 was postponed because we had to finished the orchidarium before taking the new orchid from the forest. - Identify the orchids by comparison with the living specimens in NBC, Serbithang. - No updated data of orchid's utilities from the Q1.

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
2. To construct a shade house for storing the collected wild orchids, cultivation, and propagation.	1. Set up the small orchid garden.	1. Outcomes - Have small orchid garden which exhibit and mimic their habitats. 2. Output - The 5x10 m. orchid garden.	1. The small orchid garden was established; the degree of achievement was A.	- Attachment 1 (Figure 2)	- The plan to establish the orchid garden was shifted from Q3 to Q2
3. To enhance the number of orchids by sexual and asexual reproduction.	1. Do plant tissue culture laboratory. 2. Ordered the equipment and chemical for plant tissue culture techniques.	1. Outcome - Demonstrate how to cultivate and propagate the orchids to staff and trainees. **2.** Outputs - Have the proper place and equipment for orchid propagation.	1. The plant tissue culture cabinet and shelf was designed and sent to the furniture house to make them; the degree of achievement was D. 2. The tools and chemicals for *in vitro* culture were ordered	- Attachment 1 (Figure 3) - Attachment 2	- The tools and chemicals from Thailand is shifting to Bhutan. - The laboratory work was postpone because the equipment is not arrived yet.

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
		- Obtain the orchids from sexual and asexual propagation.	from Thai supplier; the degree of achievement was D. 3. Laboratory for plant tissue culture; the degree of achievement was U.		- The cabinet and shelf are under process. - Visit NBC for more information - The autoclave at RLDC is not in the good condition.
4. To set up the orchid floriculture development and farm management curriculum for trainees.	1. Set up the orchid floriculture development and farm management curriculum. 2. Taught the trainees	1. Outcome - Have the course for orchid floriculture development and farm management demonstrated by RDTC staffs. 2. Output - Have the course for orchid floriculture development and farm management for the staffs and trainees.	1. Instruction media were created and used for teaching the trainees; the degree of achievement was A. 2. The first orchid course for vegetable trainees was instructed; the degree of achievement was A.	- Attachment 1 (Figure 4)	- No

Attachment 1

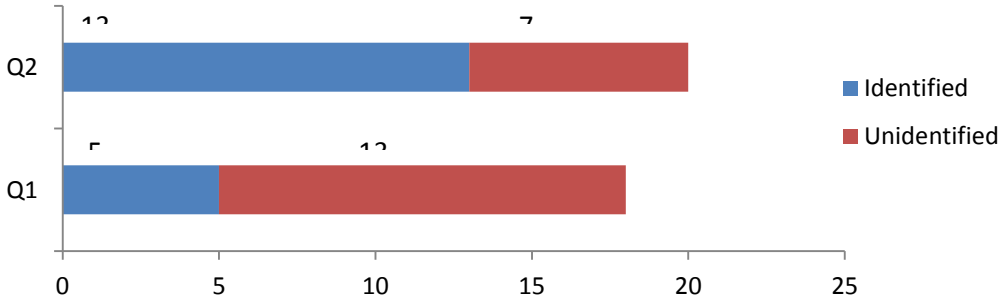

Figure 1. A Bar chart to show amount of orchids collected in Q1 (from November to December 2015) and Q2 (from January to March 2016).

Figure 2a. The small orchidarium inside the bamboo greenhouse.
Figure 2b. The shelter for terrestrial orchid outside the bamboo greenhouse.

Figure 3. Visiting the plant tissue culture laboratory and discussing with the orchid specialists from America and Sweden who collaborate with NBC, Serbithang

Figure 4. Teaching orchid cultivation and propagation for the students from School Youth Agriculture Training Program and iBest.

Attachment 2

ห้างหุ้นส่วนจำกัด ที.ซี. สถาพร กรุ๊ป
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ใบเสนอราคา

เรียน คณะเภสัชศาสตร์ มหาวิทยาลัยมหิดล เลขที่ QTO00238/59

447 ถ.ศรีอยุธยา เขตราชเทวี กรุงเทพฯ 10400

เลขประจำตัวผู้เสียภาษี 0994000158378

ห้างฯ มีความยินดีขอเสนอราคาสินค้าดังมีรายละเอียดต่อไปนี้

		จำนวน	หน่วยละ	จำนวนเงิน
1	15MR-12F200 Jansen forceps 20 cm.	4 Pcs.	200.00	800.00
2	15MR-01F200 Thumb forceps 20 cm.	1 Pcs.	125.00	125.00
3	15MR-01F160 Thumb forceps 16 cm.	2 Pcs.	80.00	160.00
4	15MR-SH3 Scalpel Handle #3(Mira)	3 Pcs.	60.00	180.00
5	15PR-SKS10 Surgicle knife stainless#10(Parabora)	1 Box	280.00	280.00
6	07HT-20SS30 Spatula stainless steel 30 cm. No.20	2 Pcs.	220.00	440.00
7	07HT-RS16-040 Rack stainless Dia.16 mm.(40)	1 Pcs.	220.00	220.00
8	05KK-RC05-R Rubber stopper No.5	100 Pcs.	5.00	500.00
9	06HT-LAMP-A Lamp stainless	3 Pcs.	65.00	195.00
10	0200-BT08C 8 onz.Glass bottle with cover	120 Pcs.	8.00	960.00

ราคารวม	3,860.00
หัก ส่วนลด	-
มูลค่าสินค้า	3,860.00
ภาษีมูลค่าเพิ่ม 7%	270.20
ราคารวมทั้งสิ้น	4,130.20

(สี่พันหกบาทยี่สิบเก้าสตางค์).

กำหนดยืนราคา 30 วัน

กำหนดส่งของ 7 วัน

จึงเรียนมาเพื่อโปรดพิจารณา

ขอแสดงความนับถือ

(นางสาวชวัลพร เฉลิมโสภณ)

ผู้จัดการ

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
1. To collect and identify wild orchid species and search for the economic importance of orchids.	1. Site surveyed and collected orchids from the forests. 2. Identifed the orchid species. 2.1 Gathered information of orchids in Bhutan. 2.2 Identifed the species of wild orchids 3. Studied the use of orchids from the local people and focus on edible orchids.	1. Outcome - Having the reliable source to identify the local orchid species serve the community. 2. Outputs - The number of orchid from the site survey.	1. Site survey and collecting the wild orchids from Zhemgang area; the degree of achievement was D. 2. Twenty six species of orchid were in the greenhouse and twenty two of them were identified; the degree of achievement was A. 3. The utilities of orchid and the food recipes contained orchid were recorded; the degree of achievement was A.	- Attachment (Figure 1-4)	- The site survey in Q3 was postponed because I did site survey for orchid consumption in Wangduephodang, Punakha, Gasa, Thimphu, and Paro Dzongkhag. - Orchid identification can do only when they have the flower. - Visited the orchid show in The Second Royal Bhutan Flower Exhibition, Paro

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
2. To construct a shade house for storing the collected wild orchids, cultivation, and propagation.	1. Set up the small orchid garden.	1. Outcomes - Have small orchid garden which exhibit and mimic their habitats. 2. Output - The 5x10 m. orchid garden.	1. The small orchid garden was established; the degree of achievement was A.	- Attachment (Figure 5)	- Orchid garden care and management.
3. To enhance the number of orchids by sexual and asexual reproduction.	1. Do plant tissue culture laboratory. 2. Ordered the equipment and chemical for plant tissue culture techniques.	1. Outcome - Demonstrate how to cultivate and propagate the orchids to staff and trainees. 2.Outputs - Have the proper place and equipment for orchid propagation.	1. The plant tissue culture cabinet and shelf was designed and sent to the furniture house to make them; the degree of achievement was D. 2. The tools and chemicals for *in vitro* culture were ordered from Thai supplier; the degree of achievement was A.	- Attachment (Figure 6-8)	- The furniture house rejected our order for plant tissue culture cabinet . For the shelf, I am waiting for RDTC staff to set up the light tubes. - The laboratory work at the first stage was

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
		- Obtain the orchids from sexual and asexual propagation.	3. Laboratory for plant tissue culture; the degree of achievement was A. 4. Orchid tissue culture training for RDTC counterpart; the degree of achievement was A.		completed. RLDC provided the autoclave, larminar airflow cabinet, and staffs to help for the whole process. - Thirteen culture media formulations were used to compare and study their effect on *Cymbidium erythraeum* 's seed.
4. To set up the orchid floriculture development and farm management curriculum for trainees.	1. Set up the orchid floriculture development and farm management curriculum. 2. Taught the trainees	1. Outcome - Have the course for orchid floriculture development and farm management demonstrated by RDTC staffs. 2. Output - Have the course for orchid floriculture development and farm management for the staffs and trainees.	1. Instruction media were created and used for teaching the trainees; the degree of achievement was D. 2. The first orchid course for vegetable trainees was instructed; the degree of achievement was U.	- The teaching material (still not completed)	- I would like to add more information into the curriculum. - No trainees in RDTC.

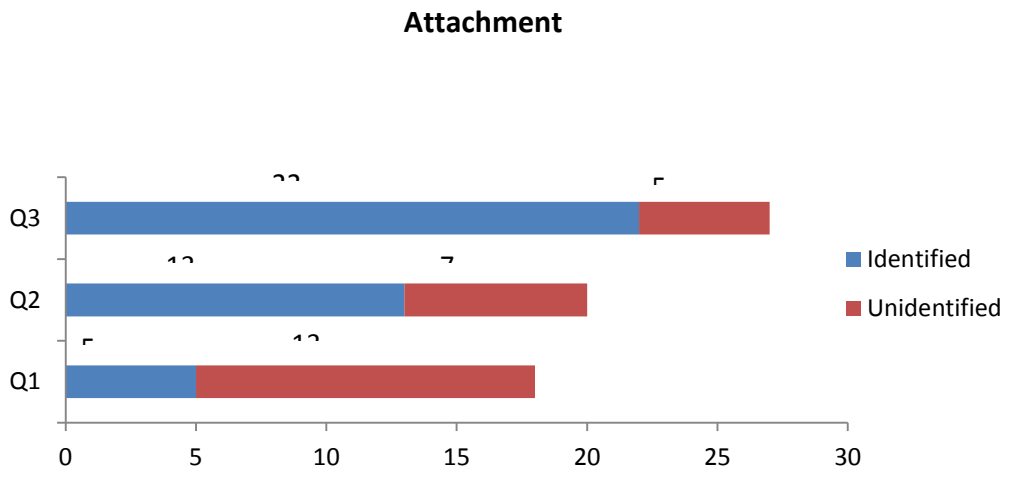

Figure 1. A Bar chart to show amount of orchids collected in Q1 (from November to December 2015), Q2 (from January to March 2016), and Q3 (from April to June 2016)

Figure 2. Site survey for orchid consumption and propagation in Wangduephodang, Punakha, Thimphu, Gasa, and Paro Dzongkhag with Mr.Choiney Dorji, RDTC.

Figure 3. *Cymbidium* sp. cultivation in the farmers' house to serve the market as the pot plant and cut flower in Wangduephodang, Punakha, Thimphu, Gasa, and Paro Dzongkhag.

Figure 4. The orchid show in The Second Royal Bhutan Flower Exhibition, Paro

Figure 5. *Cymbisium* sp. was transferred to the cultivated area using leave litter and dried cow dung.

Figure 6. Thirteen culture media formulations were prepared and used for orchid *in vitro* culture

Figure 7. Seven month-old pods of *Cymbidium erythraeum* Lindley were used for *in vitro* culture.

Figure 8. Mr.Karma Wangchuk, RDTC counterpart, was trained for orchid *in vitro* culture.

Figure 9. Attended the meeting of RDTC staffs and the Helvetas Heads from Switzerland, and visited the cultivation sites of RDTC former trainees in Zhemgang.

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
1. To collect and identify wild orchid species and search for the economic importance of orchids.	1. Site surveyed and collected orchids from the forests. 2. Identifed the orchid species. 2.1 Gathered information of orchids in Bhutan. 2.2 Identifed the species of wild orchids	1. Outcome - Having the reliable source to identify the local orchid species serve the community. 2. Outputs - The number of orchid from the site survey.	1. Site survey and collecting the wild orchids from Zhemgang area; the degree of achievement was D. 2. Forty one species of orchid were in the greenhouse and thirty four of them were identified; the degree of achievement was A.	- Attachment (Figure 1 and Table 1)	- The site survey was cancelled because of the monsoon, but I received the orchids from NBC staffs. - Orchid identification can do only when they have the flower.
2. To construct a shade house for storing the collected wild orchids, cultivation, and propagation.	1. Set up the small orchid garden.	1. Outcomes - Have small orchid garden which exhibit and mimic their habitats. 2. Output - The 5x10 m. orchid garden.	1. Taking care of the orchid garden; the degree of achievement was A.	- Orchid greenhouse at RDTC	-

Objectives	Output/Actives	Key Result Area / Key Performance Indicators	Degree of Achievement (A), (D), (U)	Mean of Verification (for Achievement)	Remark
3. To enhance the number of orchids by sexual and asexual reproduction.	1. Do plant tissue culture laboratory. 2. Ordered the equipment and chemical for plant tissue culture techniques.	1. Outcome - Demonstrate how to cultivate and propagate the orchids to staff and trainees. 2. Outputs - Have the proper place and equipment for orchid propagation.	1. *In vitro* orchid culture from the laboratory; the degree of achievement was D.	- Attachment (Figure 2)	- The *in vitro* orchid cultures were facing with the contamination because of no proper place to store them. - The tissue could not grow well because the culture medium was not suitable for growing *Cymbidium* sp.
4. To set up the orchid floriculture development and farm management curriculum for trainees.	1. Set up the orchid floriculture development and farm management curriculum. 2. Taught the trainees	1. Outcome - Have the course for orchid floriculture development and farm management demonstrated by RDTC staffs. 2. Output - Have the course for orchid floriculture development and farm management for the staffs and trainees.	1. Instruction media were created and used for teaching the trainees; the degree of achievement was A. 2. Teaching the trainees; the degree of achievement was A.	- The teaching material- Orchid Cultivation and Propagation Module	-

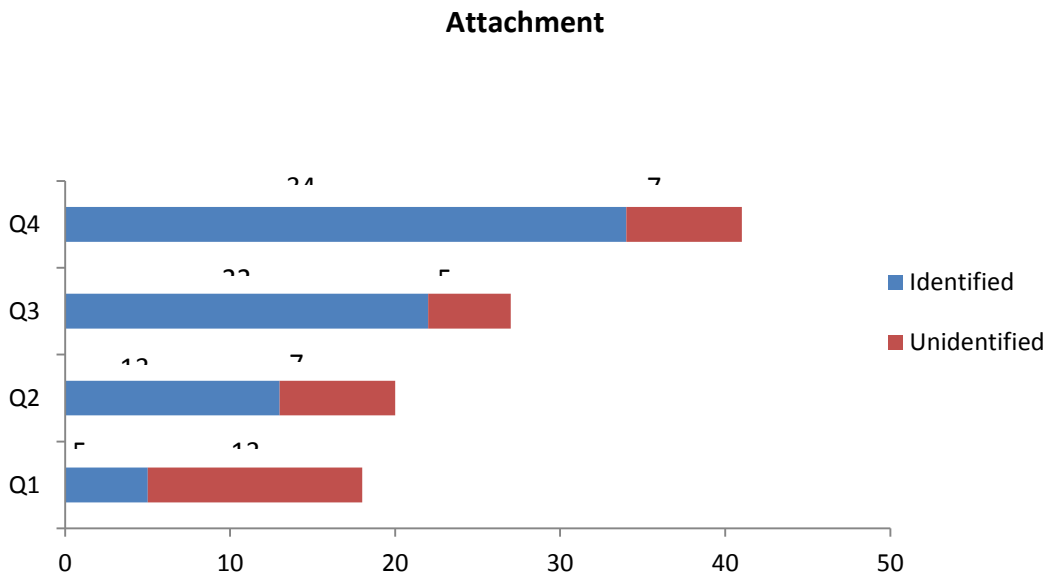

Figure 1. A Bar chart to show amount of orchids collected in Q1 (from November to December 2015), Q2 (from January to March 2016), Q3 (from April to June 2016), and Q4 (from July to September 2016).

Figure 2. Orchid tissue culture. a) The shelf with the light fluorescence lamp. b) The contaminated experiment. c) Three-month-old callus of *Cymbidium* sp.

Table 1. Name list of the orchid in RDTC greenhouse.

Identified Orchid Species	Unidentified Orchid Species
1. *Arundina graminifolia* (D.Don) Hochreutiner 2. *Bulbophyllum gymnopus* J.D. Hooker 3. *Bulbophyllum odoratissimum* (J.E. Smith) Lindley 4. *Bulbophyllum reptans* (Lindley) Lindley 5. *Bulbophyllum secundum* J.D. Hooker 6. *Bulbophyllum striatum* (Griffith) 7. *Calanthe plantaginea* Lindley 8. *Cleisostoma williamsonii* (H.G. Reichenbach) Garay 9. *Coelogyne schultesii* S.K. Jain&S.Das 10. *Coelogyne stricta* (D.Don) Schlechter 11. *Cryptochilus lutea* Lindley 12. *Cryptochilus sanguine* Wallich 13. *Cymbidium erythraeum* Lindley 14. *Dendrobium chrysanthum* Lindley 15. *Dendrobium devonianum* Paxton 16. *Dendrobium falconeri* Hooker 17. *Dendrobium heterocarpum* Lindley 18. *Dendrobium longicornu* Lindley 19. *Eria amica* H.G. Reichenbach 20. *Eria graminiflorea* Lindley 21. *Eria spicata* (D.Don) Handel-Mazzetti 22. *Esmeralda clarkei* H.G. Reichenbach 23. *Gastrochilus acutifolius* (Lindley) Kuntze 24. *Goodyera schlechtendaliana* H.G. Reichenbach 25. *Malaxis purpurea* (Lindley) Kuntze 26. *Oberonia falcate* King & Pantling 27. *Otochilus fuscus* Lindley 28. *Otochilus lancilabius* Seidenfaden 29. *Papilionanthe vandarum* (H.G. Reichenbanch) Garay 30. *Phalaenopsis taenialis* (Lindley) E.A. Christenson&Pradhan 31. *Pholidota pallida* Lindley 32. *Pholidota protracta* J.D. Hooker 33. *Pleione praecox* (J.E. Smith) D.Don 34. *Vanda cristata* Lindley	1. *Chiloschista* sp. 2. *Coelogyne* sp. 3. *Cymbidium* sp.1 4. *Cymbidium* sp.2 5. *Liparis* sp. 6. *Phaius* sp. 7. *Platanthera* sp.

ปัญหาและอุปสรรค/ข้อเสนอแนะ

ปัญหาและอุปสรรค

ความเข้าใจด้านการผลิตกล้วยไม้ลูกผสม

ปัญหาและอุปสรรค:

- ผู้อำนวยการสถาบันผู้ซึ่งเขียนจดหมายขออาสาสมัครจากประเทศไทยนั้นลาพัก แบบ extraordinary leave เป็นระยะเวลา 1 ปี และเจ้าหน้าที่ที่ปฏิบัติงานอยู่ ณ ขณะนั้น ยังไม่มีแนวทางแน่ชัดถึงการมาปฏิบัติงานของอาสาสมัครและไม่มีความรู้เกี่ยวกับการปลูกเลี้ยงกล้วยไม้มาก่อน รวมถึงกระบวนการผลิตกล้วยไม้ลูกผสม
- เนื่องจากพื้นฐานความรู้ที่ต่างกัน เจ้าหน้าที่ที่ RDTC ส่วนใหญ่ทำทางสัตว์ และการเพาะปลูกผักและไม้ผล เลยไม่เข้าใจกระบวนการและภาพรวมการเพาะเลี้ยงกล้วยไม้ รวมทั้งระยะเวลาที่จะต้องใช้ในแต่ละขั้นตอนของการเพาะเลี้ยงกล้วยไม้โดยวิธีเพาะเลี้ยงเนื้อเยื่อ

การแก้ไข:

- ในช่วงแรกที่อาสาสมัคร และ RDTC พูดคุยถึงรูปแบบการทำงาน ความเป็นไปได้ของการปฏิบัติงานของอาสาสมัครในระยะเวลา 1 ปี บนพื้นฐานของทรัพยากรที่เอื้ออำนวย อาสาสมัครอธิบายถึงขั้นตอนการผลิตกล้วยไม้ลูกผสมให้กับเจ้าหน้าที่ RDTC รับทราบ และจึงเขียน annual work plan ร่วมกัน
- อธิบายและแจกแจงรายละเอียดการปฏิบัติงานให้ละเอียดมากขึ้น เพื่อความเข้าใจที่ตรงกัน ของอาสาสมัคร และเจ้าหน้าที่ RDTC ในกรอบระยะเวลาที่เหลืออยู่ในการปฏิบัติงาน

เครื่องมือ สารเคมี และทรัพยากร

ปัญหาและอุปสรรค:

- เมื่ออาสาสมัครเดินทางไปถึง RDTC พบว่า ทาง RDTC ยังไม่มีการปลูกกล้วยไม้ใดๆ กล้วยไม้ทั้งหมดยังอยู่ในป่า และช่วงที่ อาสาสมัครเดินทางไปถึง (เดือนตุลาคม 2558) พ้นช่วงที่กล้วยไม้ออกดอก ซึ่งปกติกล้วยไม้จะบานปีละหนึ่งครั้ง และเข้าสู่ฤดูหนาว ทำให้ไม่สามารถระบุชนิดของกล้วยไม้ได้ในทันที และไม่สามารถทำกล้วยไม้ลูกผสมได้ในทันทีเมื่ออาสาสมัครเดินทางไปถึง
- ขาดโรงเรือนเพาะเลี้ยงกล้วยไม้ที่เหมาะสม
- ไม่สามารถหาอุปกรณ์ สำหรับทำแลปเพาะเลี้ยงเนื้อเยื่อในประเทศภูฏานได้
- ขาดทุนทรัพย์ในการจัดซื้อสารเคมีเดี่ยวๆ สำหรับทำอาหารเลี้ยงเนื้อเยื่อกล้วยไม้
- ไม่มีสถานที่สำหรับเพาะเลี้ยง และเก็บรักษากล้วยไม้ในขวดทดลองอย่างเหมาะสม ทำให้ประสบภาวะติดเชื้อ และไม่สามารถดำเนินการต่อในด้านการเพาะเลี้ยงเนื้อเยื่อได้ในระยะเวลาที่อาสาสมัครปฏิบัติงาน

การแก้ไข:

- อาสาสมัครและเจ้าหน้าที่ RDTC ออกสำรวจกล้วยไม้จากป่าบริเวณ Zhemgang และเก็บมาดูแลที่โรงเรือนกล้วยไม้ชั่วคราว และรอจนกระทั่งกล้วยไม้ออกดอก จึงระบุชื่อชนิดกล้วยไม้ เนื่องจากกล้วยไม้แต่ละสายพันธุ์มีช่วงเวลาการบานของดอกต่างกัน ดังนั้นจึงไม่สามารถทำกล้วยไม้ลูกผสมได้หากไม่มีกล้วยไม้อยู่ในโรงเรือน และสังเกตช่วงเวลาการบานของดอก อาสาสมัครจึงอธิบายเหตุผลให้ทางเจ้าหน้าที่ RDTC รับทราบ

- สร้างโรงเรือนเพาะเลี้ยงกล้วยไม้ใหม่ โดยใช้ตาข่ายสแลนพรางแสงคลุมโดยรอบ เพื่อลดปริมาณแสงที่จะตกลงสู่กล้วยไม้โดยตรง และเพิ่มการระบายความร้อนและการหมุนเวียนอากาศในโรงเรือน
- สั่งซื้อเครื่องมือและอุปกรณ์ทำแลปจากประเทศไทย
- เนื่องจากสารเคมีที่ใช้ในการทำอาหารเพาะเลี้ยงเนื้อเยื่อนั้นมีหลายชนิด แต่ละชนิดมีราคาค่อนข้างสูง อาสาสมัครและ RDTC จึงติดต่อ NBC เพื่อขอการสนับสนุนด้านอาหารเพาะเลี้ยงกล้วยไม้ ที่ทางสวนพฤกษศาสตร์มีอยู่แล้ว ทาง NBC ให้อาหารเพาะเลี้ยงสำเร็จรูปสูตร Vacine and Went (VW) แก่ทาง RDTC นอกจากนี้อาสาสมัครได้ทดลองใช้มันฝรั่ง มะเขือเทศ และไทอามีน (วิตามินบี 1 จากสถานีอนามัย) มาทดลองทำอาหารเพาะเลี้ยงกล้วยไม้
- RDTC ขอใช้สถานที่ และอุปกรณ์ทำแลป อาทิเช่น Autoclave pH meter และ Laminar airflow จาก RLDC และได้รับการสนับสนุนเป็นอย่างดี จากเจ้าหน้าที่ของทาง RLDC แต่เนื่องจากห้องที่ใช้ในการเก็บรักษากล้วยไม้ในขวดทดลองมีความชื้นสูง จึงทำให้กล้วยไม้ในขวดทดลองติดเชื้อรา และไม่สามารถใช้งานได้ ทั้งนี้อาสาสมัครหมดระยะเวลาปฏิบัติงาน จึงไม่สามารถดำเนินการแก้ไขได้

การดำเนินงาน

ปัญหาและอุปสรรค

- เนื่องจาก RDTC อยู่ในเมือง Zhemgang และกระบวนการดำเนินงานต่างๆ ภายใต้ MoAF ต้องส่งเอกสารเข้า Head office ในเมือง Thimphu หรือการเดินเอกสารใดๆ ที่ต้องส่งเข้า Thimphu ต้องใช้เวลาในการดำเนินเอกสาร อย่างน้อย 2-3 วัน

การแก้ไข

- วางแผนการทำงาน โดยเผื่อระยะเวลาสำหรับเดินเอกสารไว้อย่างน้อย 1 สัปดาห์

ความเป็นอยู่ในเมือง Zhemgang

ปัญหาและอุปสรรค

- การเดินทางออกนอกพื้นที่ไม่สะดวก เนื่องจากมีรถโดยสารจากเมือง Zhemgang ไป Thimphu มีเพียงหนึ่งคัน และมีรถแท็กซี่เพียงหนึ่งคัน ซึ่งมีคิวการใช้รถตลอดเวลา
- ช่วงหนึ่งของการอยู่ที่เมือง Zhemgang รถยนต์ของ RDTC ไม่มีน้ำมัน เนื่องจากหมดเงินงบประมาณ ทำให้ออกพื้นที่ไม่ได้
- เมือง Zhemgang ไม่มี immigration office ทำให้ต้องเดินทางไปเมือง Gelephu ซึ่งใช้เวลาเดินทาง 4 ชั่วโมง เพื่อทำ Route permit
- เมือง Zhemgang ไม่มีโรงพยาบาล มีเพียงสถานีอนามัยที่จ่ายยาที่รักษาอาการของโรคทั่วไป และไม่มีร้านขายยา

การแก้ไข

- เดินทางพร้อมรถยนต์ของออฟฟิศ หรือของเจ้าหน้าที่ RDTC กรณีเดินทางด้วยตนเอง ต้องสืบหาวัน และเวลาที่รถบัสให้บริการ แต่ในช่วงมรสุม รถบัสจะหยุดการเดินทางเป็นเวลา 3-4 เดือน
- ใช้รถของเจ้าหน้าที่ RDTC แทนรถของออฟฟิศ และเปลี่ยนแผนการดำเนินงาน
- วางแผนการเดินทางล่วงหน้า อย่างน้อย 1-2 สัปดาห์ เนื่องจากต้องนัดหมายการเดินทางกับรถของออฟฟิศ กรณีมีเจ้าหน้าที่เดินทาง ไป Gelephu หรือ Thimphu จะได้ฝากเอกสารให้เจ้าหน้าที่ RDTC ดำเนินการให้ หรือเดินทางไปพร้อมกับรถของออฟฟิศ เพื่อทำ route permit ที่ Gelephu แล้วจึงเดินทางต่อไปยังเมืองเป้าหมาย

- อาสาสมัครใช้ยาที่นำติดตัวไปจากประเทศไทย สำหรับชาวบ้าน กรณีเจ็บป่วยรุนแรงจะถูกส่งต่อไปที่โรงพยาบาลที่ Tingtibi ซึ่งห่างออกไปประมาณ 1.30 ชั่วโมง หรือส่งไปที่ Gelephu หรือ Thimphu

ข้อเสนอแนะ

โครงการส่งเสริมการผลิตกล้วยไม้ (Orchid cultivation and propagation) แต่เดิมได้รับการสนับสนุนจาก National Biodiversity Centre (NBC), Serbithang, Thimphu และกรมป่าไม้ในแต่ละพื้นที่ ในการให้ความรู้แก่ชาวบ้านที่รวมตัวกันปลูกกล้วยไม้ และดำเนินกิจกรรมเป็น Orchid community ซึ่งเก็บรวบรวมกล้วยไม้จากบริเวณป่าโดยรอบหมู่บ้านมารวบรวมไว้ในพื้นที่ส่วนกลาง และช่วยกันดูแล รวมทั้งแบ่งรายได้เมื่อขายดอกกล้วยไม้ได้ จากที่อาสาสมัครได้ทราบข้อมูล Orchid community มีทั้งที่ Wanghuephrodang Punakha และ Trongsa แต่บางกลุ่มได้ปล่อยทิ้งกล้วยไม้ให้ตายลง และยุติการปลูกกล้วยไม้ในลักษณะ Orchid community เนื่องจากผลผลิตที่ได้นั้นลดลงเรื่อยๆ ทำให้ชาวบ้านไม่สนใจจะดูแลต่อ ส่งผลให้กล้วยไม้ที่ถูกเก็บมาจากป่าได้ถูกทำลายเป็นจำนวนมาก โดยเฉพาะกล้วยไม้ที่มีมูลค่าทางการตลาดในตระกูลซิมบิเดียม (Cymbidiums) ทั้งนี้ยังมีชาวบ้านอีกจำนวนหนึ่งที่เก็บกล้วยไม้ตระกูลซิมบิเดียมมาปลูกไว้บริเวณสวนของตน เพื่อเป็นรายได้เสริม หากแต่ยังมีความเข้าใจผิดในการปลูกเลี้ยง จึงทำให้ผลผลิตลดลง และหันไปเก็บกล้วยไม้จากป่าเพิ่มเติม รวมทั้งกฎหมายการเก็บกล้วยไม้จากป่าของประเทศภูฏานนั้นยังไม่แข็งแรงพอ ทำให้ชาวบ้านสามารถเก็บกล้วยไม้ออกจากป่าได้ในจำนวนไม่จำกัด จึงอาจส่งผลต่อประชากรกล้วยไม้ตระกูลซิมบิเดียมในป่าได้

Rural development training centre (RDTC) เป็นองค์กรหนึ่งที่มีหน้าที่ส่งเสริม และให้ความรู้ผู้สนใจ ในการทำการเกษตร การริเริ่มตั้งหลักสูตรการปลูกเลี้ยงกล้วยไม้ โดยให้อาสาสมัครจากประเทศไทย เป็นหลักในการเริ่มต้นในระยะแรก ถือเป็นการเริ่มต้นที่ดี เนื่องจากในประเทศภูฏานยังไม่มีหลักสูตร Floriculture มาก่อน แต่ทั้งนี้เป้าหมายในการปฏิบัติงานที่ระบุใน Request form for service of Thai volunteer กับเครื่องมือ และทรัพยากรที่มีนั้นยังไม่สัมพันธ์กัน จึงทำให้ต้องปรับเป้าหมายการปฏิบัติงานใหม่ การผลิตกล้วยไม้ลูกผสม (Hybrid orchids) นั้นใช้เวลานาน บางชนิดใช้เวลาหลายสิบปีกว่าจะผลิตลูกผสมที่ตรงความต้องการของตลาดได้ และมักจะใช้เทคนิคเพาะเลี้ยงเนื่อเยื่อเข้ามาช่วยร่นเวลาการผลิต ดังนั้นอาสาสมัครจึงเสนอให้ RDTC เริ่มจากจุดเริ่มต้น คือ ทำโรงเรือนกล้วยไม้ เพื่อเป็นสถานที่เก็บรวบรวมพันธุ์กล้วยไม้ป่าจากป่าในบริเวณเมือง Zhemgang ระบุชื่อชนิดกล้วยไม้ (Identification) การดูแลกล้วยไม้และการบำรุงรักษา การขยายพันธุ์กล้วยไม้โดยใช้เทคนิคพื้นฐาน เช่น การแยกกอ (division) การใช้ยอดอ่อน (keiki) การตัดลำต้น (stem cutting) การยึดกล้วยไม้ไว้กับต้นไม้ (mounting) รวมทั้งทดลองเพาะเลี้ยงกล้วยไม้ด้วยเทคนิคเพาะเลี้ยงเนื้อเยื่อ (plant tissue culture)

กล้วยไม้ตระกูลซิมบิเดียม เป็นกลุ่มที่อาสาสมัครเสนอให้เป็นกล้วยไม้กลุ่มแรก ที่ควรนำมาขยายพันธุ์โดยเทคนิคเพาะเลี้ยงเนื้อเยื่อ เนื่องจากเป็นกล้วยไม้ที่ชาวภูฏานนิยมบริโภคดอกอ่อน และมีคุณค่าทางเศรษฐกิจ ราคาสูงเมื่อเทียบกับผักท้องถิ่นทั่วไป ในบางพื้นที่ราคาสูงถึง 150-200 นูลตรัม ต่อ 3 ช่อดอก ซึ่งหากทาง RDTC สามารถขยายพันธุ์กล้วยไม้ชนิดนี้ได้ และส่งเสริมให้ชาวบ้านปลูกกล้วยไม้ชนิดนี้ โดยใช้ RDTC เป็นแหล่งผลิตกล้วยไม้ จะทำให้ลดปัญหาการเก็บกล้วยไม้จากป่าได้ และเป็นการเพิ่มรายได้ให้กับชาวบ้านในอีกทางหนึ่ง

อาสาสมัครได้สอนเทคนิคการปลูกเลี้ยงกล้วยไม้ทั้งขั้นตอนพื้นฐาน และเทคนิคเพาะเลี้ยงเนื้อเยื่อให้กับเจ้าหน้าที่ของ RDTC แต่ทั้งนี้เนื่องจากเครื่องมือและสถานที่ของทาง RDTC นั้นยังไม่เหมาะสมต่อการเพาะเลี้ยงเนื้อเยื่อ หากทาง RDTC ต้องการพัฒนาการปลูกเลี้ยงกล้วยไม้ด้วยวิธีเพาะเลี้ยงเนื้อเยื่อ RDTC ควรสร้างห้องขนาดเล็กสำหรับเพาะเลี้ยงกล้วยไม้ใน

หลอดทดลองในระยะเริ่มต้น ห้องควรปิดมิดชิด สามารถควบคุมอุณหภูมิ ความชื้น และแสงได้ รวมทั้งส่งเจ้าหน้าที่ของสถาบันเข้าอบรมการเพาะเลี้ยงเนื้อเยื่อกล้วยไม้เพิ่มเติม

อาหารปลูกเลี้ยงกล้วยไม้ในหลอดทดลองที่ได้รับการสนับสนุนจาก NBC เป็นอาหารสูตร Vacien and Went (VW) แบบสำเร็จ ซึ่งจากการทบทวนเอกสาร อาหารที่เหมาะสำหรับการปลูกกล้วยไม้ตระกูลซิมบิเดียม ควรเป็น Murashige and Skoog (MS) ดังนั้นอาหารเพาะเลี้ยงจึงยังไม่เหมาะสมต่อการเพาะเลี้ยงกล้วยไม้เป้าหมาย ในอนาคต หากทาง RDTC สามารถสร้างห้องที่ และมีสารเคมีที่เหมาะสมในการเตรียมอาหารเพาะเลี้ยงกล้วยไม้ตระกูลซิมบิเดียม จะทำให้มีโอกาสในการประสบความสำเร็จในการเพาะเลี้ยงเนื้อเยื่อมากยิ่งขึ้น

ในการปลูกเลี้ยงกล้วยไม้ให้ได้ผลผลิตดี นอกจากความเหมาะสมของโรงเรือน วัสดุปลูก สภาพอากาศ และสภาพแวดล้อมแล้ว อาหารเสริมหรือปุ๋ยก็เป็นปัจจัยสำคัญที่จะช่วยให้กล้วยไม้มีผลผลิตต่อเนื่อง แต่เนื่องด้วยประเทศภูฏานมุ่งเน้นการทำเกษตรอินทรีย์ จึงไม่มีปุ๋ยกล้วยไม้สำเร็จวางจำหน่ายในประเทศ หากแต่มีปุ๋ยเคมีที่ใช้ในทางการเกษตรทั่วไป คือ Suphala NPK fertilizer สูตร 15-15-15 ซึ่งยังไม่มีหลักฐานการใช้ปุ๋ยชนิดนี้ในกล้วยไม้มาก่อน ทาง RDTC ควรทดลองปรับขนาดการใช้ปุ๋ยชนิดนี้กับกล้วยไม้ เพื่อแนะนำต่อชาวบ้านผู้ปลูกเลี้ยงกล้วยไม้ในโอกาสต่อไป

เมือง Zhemgang เป็นเมืองขนาดไม่ใหญ่ และนับเป็นหนึ่งในเขตกันดาร (Remote area) ของประเทศภูฏาน อยู่ทางภาคกลางค่อนมาทางใต้ของประเทศภูฏาน อยู่ห่างจากเมืองหลวงประมาณ 1-2 วันเดินทาง (350-400 กิโลเมตร) ชาวบ้านในแถบนี้จะพูดภาษา Kengpa (เนื่องจากเดิมเป็นชุมชนของชาว Keng) ภาษา Shachop ภาษา Dzongka และภาษา Nepali เมืองนี้ไม่มีโรงพยาบาล มีแต่สถานีอนามัยขนาด 5 เตียง มีโรงพยาบาลหลักที่เมือง Tingtibi ซึ่งห่างออกไปประมาณ 1 ชั่วโมง มีรถโดยสารประจำทางเพียงหนึ่งคัน ซึ่งจะหยุดการเดินทางในช่วงมรสุม และมีรถแท็กซี่หนึ่งคัน ในฤดูร้อนประมาณช่วงเดือนเมษายน-กันยายน เป็นช่วงที่มีฝนตกหนักต่อเนื่องทำให้เกิดน้ำท่วม แผ่นดินถล่ม ตัดขาดเส้นทางสัญจร ทั้งจากทางเมือง Gelephu ซึ่งอยู่ทางชายแดนอินเดีย และทางเมือง Trongsa ทำให้การเดินทางเป็นไปด้วยความยากลำบาก และค่อนข้างอันตราย รวมทั้งขาดอาหารสดรวมทั้งเนื้อสัตว์ที่ขนส่งมาจากอินเดีย ชาวบ้านปรับตัวโดยการวางแผนปลูกผักไว้รอสำหรับหน้ามรสุม แต่สำหรับอาสาสมัครค่อนข้างได้รับผลกระทบ จึงแก้ปัญหาโดยการขอซื้อผักสดจากชาวบ้านในละแวกใกล้เคียง และวางแผนซื้ออาหารกระป๋องตุนไว้สำหรับช่วงเวลาดังกล่าว แต่จากการที่ได้อาศัยอยู่ที่เมืองนี้เป็นระยะเวลา 1 ปี ทำให้อาสาสมัครได้เรียนรู้ความเป็นอยู่ และวิถีของชาวภูฏานโดยแท้จริง ได้เรียนรู้การพึ่งพาอาศัยซึ่งกันและกัน และการใช้ชีวิตแบบพอเพียง ชีวิตของชาวบ้านนั้นผูกเชื่อมกับเรื่องของศาสนา และจิตวิญญาณเป็นหลัก มีการทำพิธีกรรมทางศาสนาบ่อยครั้ง ซึ่งอาสาสมัครมักจะถูกเชิญให้เข้าร่วมทั้งในพิธีบูชาสำคัญๆ หรือแม้กระทั่งพิธีปัดเป่าสิ่งชั่วร้าย เนื่องจากเมือง Zhemgang เป็นเมืองเล็ก ผู้คนจึงคุ้นหน้าคุ้นตา และคุ้นเคยกันเป็นอย่างดี และเมื่ออาสาสมัครได้เข้าเป็นส่วนหนึ่งของชุมชนแล้ว ก็ได้รับการต้อนรับ และเชื้อชวนให้เข้าร่วมกิจกรรมต่างๆ กับเพื่อนบ้าน รวมทั้งได้รู้จักผู้คนในฝ่ายงานต่างๆ ของรัฐบาล และเอกชน ทำให้ได้รับความช่วยเหลือตลอดระยะเวลาที่อาศัยอยู่ที่นั่น แม้ความเป็นอยู่จะไม่ได้สะดวกสบายเหมือนอยู่ในเมืองหลวง แต่ประสบการต่างๆ ก็ได้สอนให้อาสาสมัครได้รู้จักการปรับตัว เรียนรู้ และรู้จักการแก้ปัญหา ระยะเวลา 1 ปี ในเมือง Zhemgang จะเป็นความทรงจำที่ดีสำหรับอาสาสมัครตลอดไป

Royal Government of Bhutan
Ministry of Agriculture

Rural Development Training Centre (RDTC)
Zhemgang

A Module for Orchid Cultivation and Propagation

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Introduction

Orchids are the high value flower in the global trade. Imports and exports of orchids are increasing year by year. In 2012, the total size of orchid trade was US$504 million from more than 40 exporting and 60 importing orchid countries around the world (De et al., 2014). These monocot plants from the Orchidaceae family have the astonishing beautiful flowers which generally grow as an ornamental plant and used for interior decoration. Many countries have become the major exporter for orchids. The top orchid exporting country is the Netherlands (39.67%) followed by Thailand (28.41%), Taiwan (10%), Singapore (10%) and New Zealand (6%) (De et al., 2014). Most of the commercial orchids are hybrid typing and have been traded under the regulation of the Convention on International Trade in Endangered Species (CITES) of wild fauna and flora. However, the illegal trading of wild orchids is majority found belong the border area in Southeast Asia, which has been almost completely overlooked (Phelps et al., 2015).

In Bhutan, the orchids are widely found in the forest. Collecting the orchids from the forest is controlled under the framework for the collection and management of non-wood forest products (Social Forestry Division, 2009). However, there is no restricting law and regulation for taking the orchids from the forest, except if the whole community would like to collect large amounts of orchids for community business purpose. Bhutanese generally take the orchids from the forest and grow in their own home garden for the use of home decorations and consumption in meals. With the lack of the knowledge of orchid care, this may affect the numbers in nature in the future.

Rural Development Training Centre (RDTC) is an institute under the Ministry of Agriculture and Forests (MoAF) which provide the agriculture knowledge and skills for the farmers, youths, including school leavers, to gain employment opportunities. Agricultural skill training programs in RDTC are focused on crops/horticulture and livestock, but not yet concerned with floriculture, especially orchids. Edible orchids, especially *Cymbidium* species, could be a side income for the farmers. In Thimphu, Punakha, and Wangdue, orchid flowers are sold as an expensive vegetable in the market and never sufficient for the demand. The challenging of growing orchids is how to keep them alive and continuously produce the flowers every year.

This module has been purposely made to provide the basic knowledge of the orchids including their characteristics, identification, nomenclature, cultivation, propagation, orchid market, and orchid utilization, which may benefit to the new orchid grower and the farmers.

Lesson 1

General Information

A Brief History

At the beginning of the 18th century, Europeans began exploring Asia and New World. The orchid hunter looked for the exotic orchid varieties to take home for an auction. The newly discovered species meant for the highest price. However, because of the difficulties during the long journey in the ocean, large number of orchids died. During the mid 18th to 19th century, the orchid enthusiast began to understand what the orchids need and started to culture the orchid in England, including orchid hybridization.

“Orchids” belong to Orchidaceae family. An orchid means orchis or testicle in Greek word. Theophratus, a Geeek philosopher and a father of botany, name these plants as their ostensibly shape of roots (Figure 1.1) in about 350 B.C. However, the first written about the orchids was found in China in 551 B.C. by Chinese Confucius who mentioned the fragrance of orchid as the virtue of the woman.

Nowadays, there are more than 25,000 orchid species are recorded and each year more than 10,000 hybrids are published around the world. Orchids are cosmopolitan in distribution, except Antarctica and deserts. In the different climates and continents, there are different genus and species of the orchid (Figure 1.2). For example, dendrobiums, one of the largest orchid genera (1,400 species), thrive in tropical zones, especially tropical forest of Southeast Asia; cymbidiums are originally found at high altitude in temperate zones.

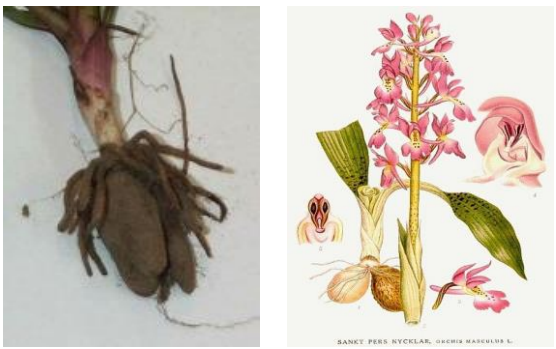


Figure 1.1. Orchid root shape as tuberoids at the base of the stem.

Hence, the orchid enthusiasts should find some information how to grow their orchid because there are varieties of their habitats and needs. In Thailand, 177 genera, 1,125 species are recorded (A.D.2000). High varieties of orchids found in Thailand as there is the tropical area. While Bhutan, temperate zone, has around 370-400 species up to date.

In the global market, orchids have a high value and the market size is increasing year by year. However, all orchid species are protected for the purposes of international commerce under CITES (Convention on International Trade in Endangered Species) as potentially threatened or endangered in their natural habitat except hybrids (CITES, 2011).

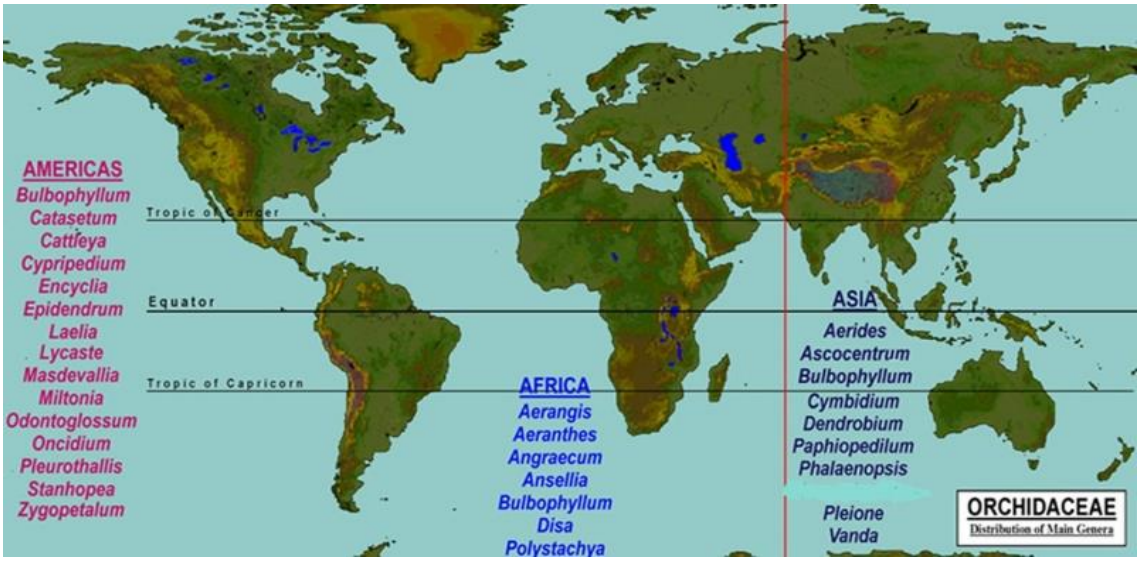


Figure 1.2. The distribution of main Orchidaceae genera.

Orchid Flower Structure

Orchids fascinate the growers with their unique and beautiful in size, shape, and colorful flowers. Comparison between orchids and the other flowers, orchids have particular structures which not found in the other flowers; labellum (or lip), bottom petal is differentiated to be a platform for pollinators; column, the fuse of sexual organs (anther and stigma) (Figure 1.3). Moreover, resupination, the upside-down flower against with the inflorescence axis, is the majority character of the orchid flower (Figure 1.4).

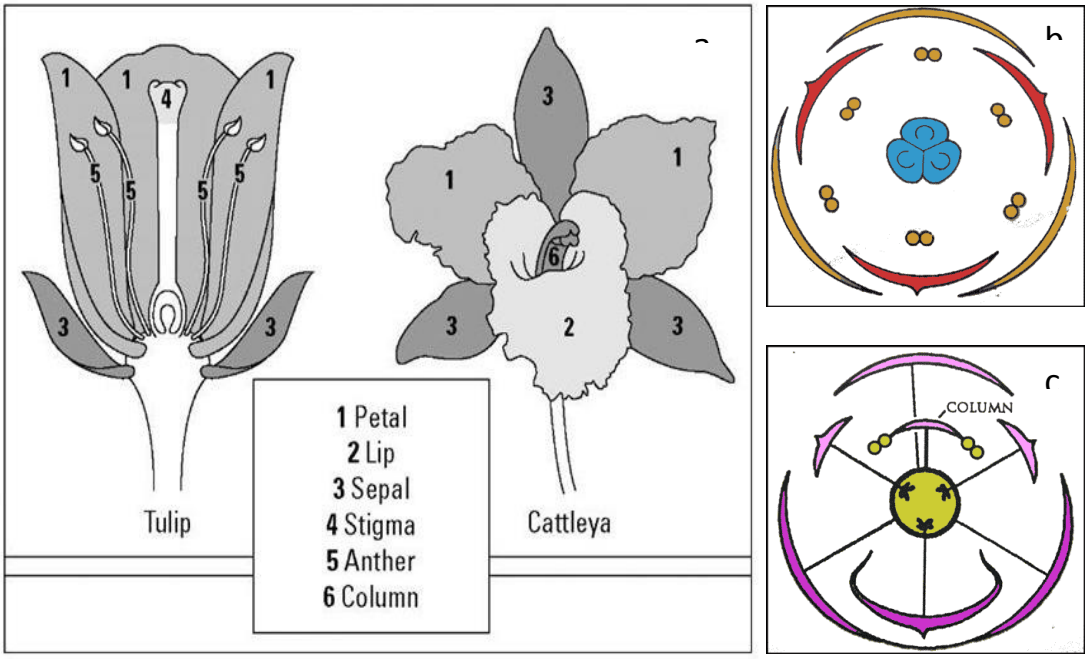


Figure 1.3. Diagrams of orchids and other flower type. a) Comparison between the common flower (tulip) and the orchid (*Cattleya*) structure. b) Flower diagram of the common flower. c) Flower diagram of orchid flower.

Figure 1.4. The resupination of the orchid flower. a) resupinate, labellum below column. b) non-resupinate, labellum above column.

Sepals - Sepals are in the outer whorl of orchid flower, less showy compares to petals and labellum. Three sepals, one dorsal (uppermost) and two lateral (lowermost) sepals, are generally found in triangle form; however, in some orchid genera such as *Paphiopedilum*, *Bubophyllum*, and *Pleutothallis*, their two lateral sepals are fused into one. Sometimes sepals have similar color and size as petals; in some species dorsal sepal has a larger size and prominent than the others.

Petals - Petals are in the inner whorl. Orchids has two upper petals, while one lateral petal modified into a labellum (lip). Petals form a triangle with the labellum. In some species, the size of the petals has reduced and droop.

Labellum (lip) - The labellum, or lip, has evolved from the lowermost petal of the orchid. The labellum of some species is enlarged and showy with frills. While in some species, their size is reduced or unnoticeable compare to the other part of the flower. 'Concolor' is used to call the labellum which has the same color as the flower. In *Paphiopedilum* and *Phragmipedium*, slipper orchids, the labellum forms a pouch-shaped (Figure 1.5) to guide the insects to pollen. Several species forms a tube or spur at the back of the lip filled with nectar to attract their pollinators.

Column – One of the unique characteristic of the orchid is the fusion of reproductive organ into a tubular structure called 'column'; male organ, the stamen which contain waxy masses pollen grains (pollinia); female organ, the pistil with a stigma to trap the pollen grains. Pollen grains are at the top of the column and protected by an anther-cap. The number of pollen grains, between two to eight, is different depends on the species. The stigma is located behind the anther near the ovary. The placement has generally helped to avoid self-pollination (Figure 1.6).

Orchid flower is the most important part for orchidologists to identify and classify the orchid into genera, species, and varieties. The character of labellum, flower shape, color, even the position of pollinia and stigma on the column are used to group the orchids. Generally, the orchid will bloom once a year at the same time every year, and last for 1-2 weeks up to 1 months for wild species. Some orchids have strongly fragrant while they bloom, but the flowers fade quickly within 1-2 days because they consume lots of energy for that purpose. In the environment which has the active pollinators, the flower may fade quickly. At the higher and cooler elevation with a few potential pollinators, the orchids

grow in this harsh environment have a last long flowering time to allow the pollinators enough time to find them. However, most of the hybrids provide a longer blooming period than the wild species.

Figure 1.5. The flowers in genus *Paphiopedilum*. a) *Paphiopedilum fairrieanum,* b) *Paphiopedilum bellatulum,* and c) *Paphiopedilum malipoense.*

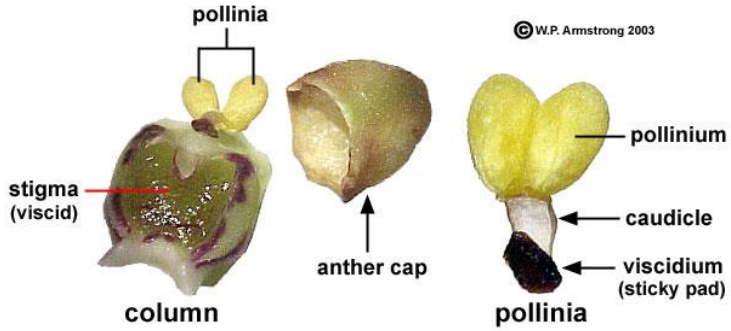


Figure 1.6. The column of *Brassia* species.

Parts of an Orchid Plant

Pseudobulb

Pseudobulb is an organ for storing food which generally found in epiphytic and terrestrial orchids which have a sympodial growth habit. Normally, ‘bulb’ is a botany technical term used for the underground storage organ, ‘pseudo-‘ is a Greek word means ‘false’, so ‘pseudobulb’ is used to call the superficially

resemble bulb. Since orchid bulb is obviously found above the ground that is the reason why we usually call this organ as a ‘pseudobulb’.

Pseudobulbs which store moisture and nutrients for the plant, and grow along a fibrous part of rootstock called the rhizome. A rhizome is a long, creeping stem connected each pseudobulb, the new pseudubulb called growth-sprout (Figure 1.7). Leave, flower stems and flowers all develop out of the new growth from the pseudobulb. The new pseudobulb exploit the energy and nutrients from the older one. After supporting the new growth, the existing pseudobulb would generally go dormant and becomes what is called a back bulb. When all the energy is transferred to the new pseudobulb, back bulb will become shrivels and dies (Tibb, M., 2008).

Orchid pseudobulbs are found with a smooth surface with lengthwise grooves, green, and variable in shape and size; cymbidium pseudobulbs are mostly oval-shaped and may grow to over 15cm; some dendrobium species has the long cane-like pseudobulbs covered with leaves over the whole length and may grow up to 2m; some bulbophyllum species has round or disc-like pseudobulb; *Grammatophyllum speciosum* (giant orchid) has the stem-like pseudobulbs, leafy in the apical part and may up to 3m (Figure 1.8).

Figure 1.7. The orchid rhizome with pseudobulbs.

Figure 1.8. The variable characteristics of sympodial orchid pseudobulb. a) The parts of orchid plants with labeling. b) Oval-shape pseudobulb. c) Round or disc-shape pseudobulb. d) Stem-like pseudobulb. e) Cane-like pseudobulb. f) Oblong pseudobulb.

Leaves

Orchids are monocots. Their leaves are like most of the monocots which have simple leaves with parallel veins, though some Vanilloideae have reliculate venation. Leaves may be ovate, obovate, lanceolate, linear, elliptic (Figure 1.9), and vary in size of the individual plant. Normally, orchid leaves alternate on the stem, often folded longitudinally along the main stem, and have no stipules. The orchids in the dry climate are found with the thick leaves with waxy coated.

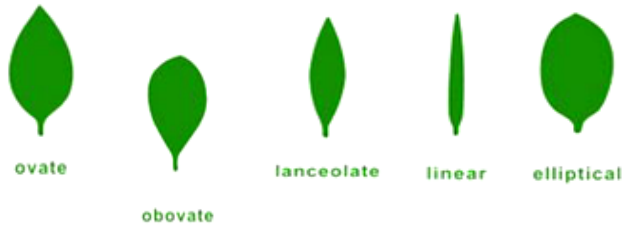


Figure 1.9. The diagram of leaf shape.

Orchid Fruits and Seeds

After the orchid flowers are pollinated with their pollinators for a few days, the fruit will develop into a capsule (or pod) (Figure 1.10). Each orchid species has a different time of ripening after pollination: 210-270 days for cymbidiums; 120-140 days for dendrobiums; and 180-440 days for paphiopedilums. Generally, when the fruit matures, it will dehiscent by 3 to 6 longitudinal slits, while remaining closed at both ends. The numerous seeds in microscopic size, dust-like seeds, will be blown off by the wind (Figure 1.11). Orchid seeds lack of endosperm and depend upon the symbiotic relationships with a specific fungi to provide them nutrient during germination.

Figure 1.10. Cymbidium pod after 7 month-pollination.

Carbon (C) and nitrogen (N) are assimilated by the the fungus, mycorrhiza, and transfer into the root and shoot of the orchids (Cameron et. al., 2006). The

mutualistic relationship between orchids and mycorrhiza is called mycoheterotrophic (Leak, 1994).

Figure 1.11. Orchid pod dehiscent and seeds under 40x magnification.

Growth Conditions

Orchids are divided into four types according to growing condition (Figure 1.12):

Epiphytes – Epiphytic orchids grow on trees, obtain the nutrients from the moisture in the air and any debris which has collected in the axils of the branch. Their roots attach the tree branch and penetrate beneath the mosses. Moreover, the velamen, the white cover, is found on the old roots to protect the roots from the damage and dehydration.

Saprophytes – The word 'saprophyte' is used for any plant that does not synthesize its own food by photosynthesis, but use the organic materials in its substrate for their growth. They are generally found with no leaves and no noticeable green part. They grow in mulch, often on the forest floor or living upon the decaying trees.

Terrestrials – These orchids grow in or on the ground – humus rich soil. The plants are found solitary or in colonies. Most have the symbiotic relationship with the microorganism in the native soil. The vegetative part can be found only in the spring; only the underground parts can survive during winter. However, some are everygreen, such as *Phaius* and *Calanthe*.

Lithophytes – The orchids that thrive on the surfaces of rocks. The organic matter and the water in the area they grow are poor, so they develop the hard waxy leaves and pseudobulbs to help them to survive from the dryness and strong solar radiation, and penetrate their water-absorbing roots to survive.

Figure 1.12. The growth habits of orchid: a) Epiphytes. b) Saprophytes. c) Terrestrials. d) Lithophytes.

Growth Habits

In the orchid family, two types of growth habit are recorded, sympodial and monopodial (Figure 1.13). Understanding the orchids growth habits must help the growers to do potting.

Sympodial - Sympodial means 'many footed'. Orchids with sympodial growth habit can creep on the top of media surface with their rhizome - horizontal stems. The new growth is produced at the base of old one. Each new growth develops its own roots, not only at the central point as in monopodial, and emerged the new rhizomes. The orchids which have sympodial growth such as *Cattleya*, *Cymbidium, Dendrobium* and *Oncidium*.

Monopodial – Monopodial means 'one footed'. The growth originates from one point and has one upright stem. The inflorescences arise from the axils of the leaves. Vandas and phalaenopsis have this growth habit.

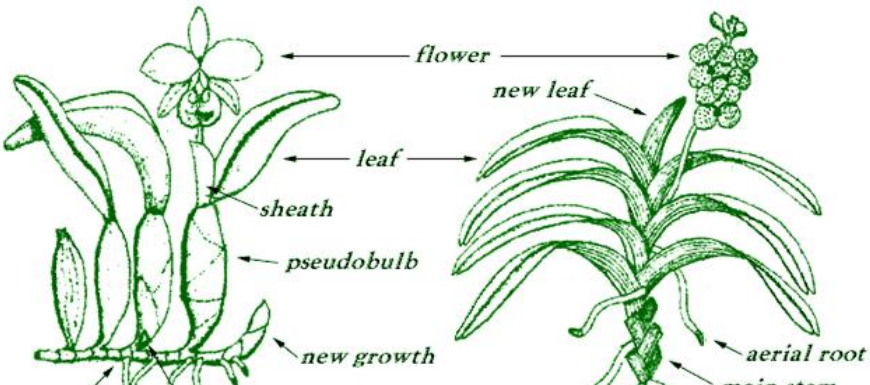


Figure 1.13. Diagram shows growth habits of the orchid. Left) Sympodial. Right) Monopodial.

Orchid Habitats

Orchids are extremely adaptable. They have cosmopolitan in distribution except the frigid (Antarctica) and arid (dessert) extremes. Habitat grouping depends on the world climate zone are as follows: tropical, sub-tropical, temperate, and cold climate (Table 1.1).

Table 1.1. The orchids habitat divided by the climate zone.

Habitats	Temperature	Orchids
Tropical	Day temp ≥21°C Night temp ≥18°C	*Dendrobium,Mokara, Vanda*, etc.
Sub-tropical	Day temp 18-21°C Night temp 15.5-18°C	*Cattleya,Oncidium, Paphiopedilum, Bulbophyllum, Phalaenopsis*, etc.
Temperate	Day temp 14.5-15.5°C Night temp 12.5-14.5°C	*Miltonia, Odontoglossum*, etc.
Cold climate	Day temp 12.5-14.5°C Night temp 10-12.5°C	*Cymbidium*, Jewel Orchid (*Goodyera* and *Ludisia*), etc.

Orchids in the ecosystem

Most of the orchids are the producer in the ecosystem. The stems, leaves, and roots of epiphytic orchids can produce the food by themselves through

photosynthesis. Orchids have the relationship with the other organisms to support them during seed germination and pollination.

Mycoheterotrophic is a term used to call the completely fungus-dependent relationship between orchids and mycorrhiza (Leak, 1994). This kind of relationship may exist for the whole life of some nongreen terrestrial orchids. This is generally found during the germination stage of the green-leaved orchids.

Insects play an important role in orchid pollination. After they land on an orchid flower, the orchid pollen may attach on their body hair. When the insects fly to the new flower, the pollen would be taken and stick on the stigma of the new one. The insects usually fly into the pouch-shaped labellum orchids, Lady's slippers, and seeking for the nectar and may be temporarily trapped. Some orchids develop their lips similar to the female pollinator to attract the males, called 'mimicry' (Figure 1.14). When the male pollinators cling with the flowers, they will carry the pollen to pollinate with another flower.

Figure 1.14. Mimicry of the orchid lips.

Lesson 2

Classification and Nomenclature

Orchid classification

The taxonomy of the orchids started with Carl Linnaeus, a Swedish naturalist, during the 18th century. The taxonomist classified orchids to Orchidaceae family with five subfamilies, confirmed by molecular, embryological, and morphological analyses: Apostasioideae, Cypripedioideae, Vanilloideae, Orchidoideae, and Epidendroideae (Pridgeon et al., 1999-2005), and then subdivided into tribes and subtribes. Moreover, the key to subfamilies is mentioned in the Table 2.1 (Chen et al., Flora of China).

1. Subfamily Apostasioideae

The orchids in this group have 2-3 fertile anthers (Figure 2.1). All the flower is monophyletic, descended from a common evolutionary ancestor or ancestral group. Base on the molecular and morphological data, the orchids in the subfamily has the basal lineage, primitive orchid (Kocyan et al, 2004), they do not share the same common ancestor to the other subfamilies. However, only two genera, Neuwiedia and Apostasia, and 15 species are in this subfamily.

Figure 2.1. The flower of *Neuwiedia veratrifolia* Blume.

2. Subfamily Cypriperdioideae

The orchids in this subfamily are well-known as the ladyslippers orchids because of their pouch-shaped labellum. The pouch is developed to trap the

insect. When the insects struggle to leave the pouch, they will past the staminode and collect the pollinia (stick on their body) from one flower to the other flowers (fertilization). Generally, the flowers have 2 fertile anthers with 1 shield-like staminode (Figure 2.2), style free and no rostellum, monophyletic. There are five genera of ladyslippers, *Cypridium, Paphiopedilum, Mexipedium, Phragmipedium* and *Selenipedium*, with nearly 115 types of terrestrial orchids.

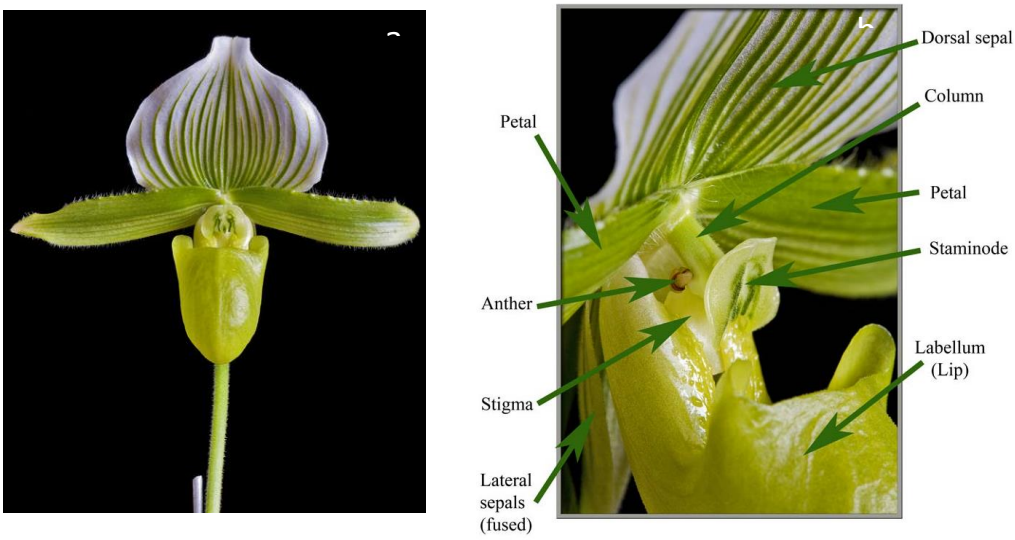


Figure 2.2. *Paphiopedilum* species. a) Overall flower. b) Flower structure with the labels.

3. Subfamily Ochidoideae

The flowers have 1 fertile erect anther with mealy pollen, monoplyletic. An anther closes to the rostellum. The operculum cover the end of the column. Stems are cluster and have fleshy or tuberoid roots. Leaves are rosette and have alternate arrangement (Figure 2.3). Plants are usually terrestrial. Subfamily Orchidoideae has 4 tribes; Orchideae, Diseae, Cranichideae, and Diurideae. The former subfamily Spiranthoideae is now embedded in the tribe Cranichideae.

Figure 2.3. *Goodyera repens* (L.) R. Br. a) Flower. b) Leave and stem.

4. Subfamily Vanilloideae

The flowers have 1 fertile incumbent anther, not basifixed (attach at or near the base), monophyletic. The pollinia are mearly or hard, attach by a stalk to a sticky viscidium. The labellum has no spur. The stem is a long, thick, succulent vines (Figure 2.4) or terrestrial herbs. This subfamily consists of 2 tribes, Pogonieae and Vanilleae, and 24 genera (about 185 species) (Flora of China).

Figure 2.4. *Vanilla planifolia* Jacks. Ex Andrews. a) Flower. b) Leaf arrangement.

5. Subfamily Epidendroideae

The epidendroid orchids and the largest group of epiphytes or lithophytes. Most of the showy genera; *Cattleya, Oncidium, Phalaenopsis, Vanda, Cymbidium, Dendrobium* and *Grammatophyllum* (largest orchid), are included within this subfamily (Figure 2.5). There are more than 10,000 orchid species in this group. Both sympodial and monopodial growth habits are found. Plants are epiphytic, lithophytic, or less terrestrial. Stems are cylindric to pseudobulbs. Most have hard pollinia with variable number, 2, 4, 6, or 8. In nonvandoid epidendroids, the column show an elongation and tipping of the mature anther (Stern, 2014). Anther arises and there is the operculum cover the end of the column. Most or the orchids in this subfamily are monophyletic and

partly are polyphyletic (not inherit from common ancestors), tribe Arethuseae and Epidendreae.

Figure 2.5. Flowers of the epidendroideae orchid. a) *Cymbidium* sp. b) *Grammatophyllum* sp. c) *Cattleya* sp. d) *Vanda* sp. e) *Phalaenopsis* sp. f) *Dendrobium* sp.

Table 2.1. Key to orchid subfamilies from Flora of China (Chen et al.).

1	>	Stamens 2 or 3…….	(2)
	>	Stamen solitary……	(3)
2 (2)	>	Flower rotate or subregular; lateral sepals free; lip petal-like, sometimes rather broad; column fused only at base of filaments; anthers 2 or 3, erect above lip; stigma terminal……	1. Subfam. Apostasioideae
	>	Flower zygomorphic (bilaterally symmetrical); lateral sepals usually fused almost to apex; lip usually saccate or urceolate; column with 2 lateral anthers and a terminal usually shield-shaped staminode; stigma ventral, stalked……	2. Subfam. Cypripedioideae

3 (3)	>	Plants usually terrestrial, growing from tubers or a horizontal fleshy rhizome; anther basifixed or not; pollinia segmented, comprising massulae, or mealy……	3. Subfam. Orchidoideae
	>	Plants usually epiphytic or lithophytic, rarely terrestrial or lianalike, growing from cylindric stems or pseudobulbs, borne on woody or tough rhizomes; anther not basifixed; pollinia mealy or hard, often attached by a stalk to a sticky viscidium……	(4)
4 (4)	>	Plants lianalike or terrestrial, often heteromycotrophic and lacking green leaves; stems cylindric, never pseudobulbous; pollinia 2, powdery, as monads or tetrads, lacking a stipe and a distinct viscidium……	4 Subfam. Vanilloideae
	>	Plants epiphytic, lithophytic, or less commonly terrestrial, rarely heteromycotrophic; stems cylindric to pseudobulbous; pollinia 2, 4, 6, or 8, usually hard, rarely sectile, often attached by 1 or 2 stipes to 1 or 2 distinct viscidia…….	5 Subfam. Epidendroideae

Orchid Nomenclature

The system of naming plant and animal began in the 18th century by Linnaeus. He proposed the binomial system, genus and species name, using Latinized names, and that system is still used for wild orchid nomenclature. Nowadays, there are two systems for naming orchids: The International Code of Botanical Nomenclature (ICBN) and The International Code of Nomenclature for Cultivated Plants (ICNCP).

The International Code of Botanical Nomenclature (ICBN) has been used to name the wild orchid and natural hybrid orchid as in Table 2.2 and has the ending such as –aceae for family name; -eae for tribe; and –inae for subtribe. The accepted name and synonyms for wild and natural hybrid orchids are in this following website; http://apps.kew.org/wcsp/prepareChecklist.do?checklist=selectedfamilies%40%40100090420121954649. While the

International Code of Nomenclature for Cultivated Plants (ICNCP) has been used to name the man-made hybrid orchids as in Table 2.3. The database for hybrid names is belonged to the Royal Horticultural Society (RHS) which available in this website: http://apps.rhs.org.uk/horticulturaldatabase/orchidregister/orchidregister.asp.

Table 2.2. The basic nomenclature of the wild and natural hybrid orchids.

Orchid names	Rules	Example
Wild orchid name	- Binomial nomenclature - The first letter of the genus name is capitalized. - The species name is lowercase. - Both names are always in italics.	**Genus name + sp** *Cattleya triande* *Paphiopedilum bellatulum*
Natural Hybrid Names	- Include an 'x' between the genus and the species name.	*Cattleya dowiana var. aurea* x *Cattleya warscewiczii*

Table 2.3. The basic nomenclature of the hybrid orchids.

Orchid names	Rules	Example
Hybrid name (Grex name)	- Use for man-made hybrid orchid - The genus name is italicized - The hybrid name is not italicized and the first letter of each word is capitalized.	• **Primary hybrid** - The hybrid made up of two wild orchid species. *Calanthe triplicata* x *Calanthe sylvatica* *Calanthe* Dominyii Originator: John Dominy • **Complex hybrid** - A hybrid made up two hybrids or a hybrid and a species. *Dendrobium* Benikujyaku x *Dendrobium* New Comet

Orchid names	Rules	Example
Cultivar names	- Give to individual plant. - Hybrid name has no italics - Cultivar name has single quote.	*Dendrobium* Red Emperor 'Prince'
Trade names	- Unique to the company and it is not the official registered name of the hybrid. - Italicize the genus name and to place the trade name in all caps with no quotation marks. The first letter of each word in the trade name should have a slightly larger font than the remaining capital letters.	*Phalaenopsis* GREEN PIXIE

American Orchid Society (AOS) award

Moreover, some orchids receive the grant from American Orchid Society (AOS) award. To notice that these orchids got the award, some of the more common AOS awards would put at the end of their names (Mellard, 2013) as follow:

- **HCC (Highly Commended Certificate): Awarded to orchid species or** hybrids scoring 75 to 79 points inclusive on a 100-point scale.
- **AM (Award of Merit): Awarded to orchid species or hybrids scoring 80 to 89** points inclusive on a 100-point scale.
- **FCC (First Class Certificate): The highest flower-quality award, awarded** to orchid species or hybrids scoring 90 points or more on a 100-point scale.
- **JC (Judges' Commendation):** Given for distinctive characteristics that the judges unanimously feel should be recognized but cannot be scored in the customary ways.
- **CBR (Certificate of Botanical Recognition):** Awarded to rare and unusual species with educational interest that has received no previous awards. The entire plant must be exhibited. This award is granted provisionally

and filed with the judging center Chair pending taxonomic verification supplied by the exhibitor.

- **CHM (Certificate of Horticultural Merit):** Awarded to a well-grown and well-flowered species or natural hybrid with characteristics that contributes to the horticultural aspects of orchidology, such as aesthetic appeal. This award is granted provisionally and filed with the judging center Chair pending taxonomic verification supplied by the exhibitor.
- **CCM (Certificate of Cultural Merit):** Awarded to the exhibitor of a well-flowered specimen plant of robust health. The plant must score between 80 and 89 points inclusive on a 100-point scale.
- **CCE (Certificate of Cultural Excellence):** Awarded to the exhibitor of a well-flowered specimen plant of robust health. The plant must score more than 90 points on a 100-point scale. Plants receiving this award represent the highest level of orchid culture.

For example;

Paphiopedilum Jim Kie 'Springwater' HCC/AOS

- *Paphiopedilum*: Genus name
- Jim Kie: Hybrid (or Grex) name
- 'Springwater': Cultivar (clonal) name
- HCC/AOS: Received a Highly Commended Certificate (HCC) from the American Orchid Society for its flowers, which scored from 75 to 79 points on a 100-point scale.

Orchid abbreviations

Orchidaceae has a huge number of the member. Most of the genus name is long, so the short form of the botanical name is needed. The complete abbreviation of the orchid genera list is available at http://midamericanorchids.org/judging/. Some of the abbreviations are mentioned below:

Brassia	*Brs.*	*Bulbophyllum*	*Bulb.*
Coelogyne	*Coel.*	*Cymbidium*	*Cym.*
Dendrobium	*Den.*	*Grammatophyllum*	*Gram*
Laelia	*L.*	*Odontoglossum*	*Odm.*
Oncidium	*Onc.*	*Phaius*	none
Phalaenopsis	*Phal.*	*Paphiopedilum*	*Paph.*

Rhynchostylis *Rhy.* *Vanda* *V.*

Lesson 3

Orchid Propagation

Orchids are like most plants that able to propagate themselves by seed (sexual propagation) and vegetative parts (asexual propagation). In the nature, bats, small birds, bees, wasps, flies, ants are able to be the pollinator for the orchids. Figure 3.1 shows how the bees take the pollen from the orchid flower.

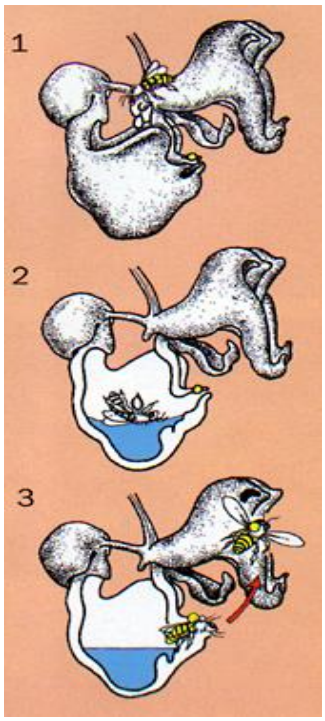


Figure 3.1. The process how the bees take the pollen from *Coryanthes* orchid. 1) Bees land on the orchid flower. 2) The bee falls into the

Sexual propagation

Sexual propagation is the reproducing involved the fusion of the male and female gamete, and the meiosis process during cell division. This method is archived by the pollinators the same as the other flowers. After fertilization, the ovary will swollen like a capsule, call 'pod', contain the seeds inside. When the pod gets mature, the tiny seeds will be dispersed from the dehiscent pod by wind and start to grow the plantlets as a mycoheterotropic relationship with the specific mycorrhiza (Figure 3.2). In the orchid farms, the breeders who would like to produce the new varieties are generally use hand pollination technique

(Figure 3.3). The pod from human breeding will be used to multiply the plantlet in the laboratory through *in vitro* plant tissue culture technique.

Figure 3.2. The steps from pod to the new plantlets. a) Orchid pods b) the dehiscent of orchid pod c) orchid seeds (40x). d) orchid plantlets on the bark tree.

Figure 3.3. The hand pollination in orchid. a) Opening the anther cap with the toothpick. b) Pollens attach at the tip of the toothpick. c) Pollens. d) Placing the pollen at the stigma of the orchid.

Asexual propagation

Asexual propagation is the reproducing without interaction of two sexes or genders. Generally, five techniques are used to propagate the orchids; division, keiki, back bulb, stem cutting, and plant tissue culture.

1. Division

The simple meaning of division means splitting. This technique divides the plant into two or more by cutting them. We divide the orchids because some have grown too large to handle, no more space in the basket for the new coming growth, and sometimes we would like to share with the others. The most important thing to cut any part of plants, we should sterile the knife with alcohol or clean it very well to reduce the infection. However, orchids have the different growth habits, monopodial and sympodial, so the methods which use to divide those plants are also different.

1.1 Monopodial

The orchids in this group grow in an upward direction. The new leaves and roots emerge from the vertical stem, so some people mention monopodial as a 'one-footed'. To divide them, we usually cut the stem below the roots (Figure 3.4). The orchids which usually use this technique, such as *Aerides, Arachnic, Epidendrum, Renanthera, Phalaenopsis, Vanda* and *Dendrobium.*

Figure 3.4. The division of monopodial orchids.

1.2 Sympodial

The orchids in this group have a horizontal growth, the new growths emerge from the apex of the rhizome. The sharp knife is used to separate the bunch of these orchids. 3-5 pseudobulbs should be remained in each part of orchid bunch. The orchids in this group, such as *Coelogyne, Catteleya, Dendrobium* and *Cymbidium*.

Figure 3.5 The division of the sympodial orchids.

2. Keikis/Offshoots

Keikis, Hawaiian name means ‘baby’, are the young plants which some orchids be able to produce on the flower spike. Many dendrobiums, vandas, and phalaenopsis produce keikis. When the keikis developed roots for a few inches, we can cut below the roots (Figure 3.6) and place them to the new basket.

Figure 3.6. The method to propagate orchid with keikis.

3. Back bulbs

Back bulbs or old pseudobulbs which are usually leafless after previously flowered. During re-potting time, the older back bulbs are generally removed from the new stem. Placing them under an ideal condition; for example, putting them in the plastic bag to control the humidity, may affect to introduce rooting and shooting (Figure 3.7).

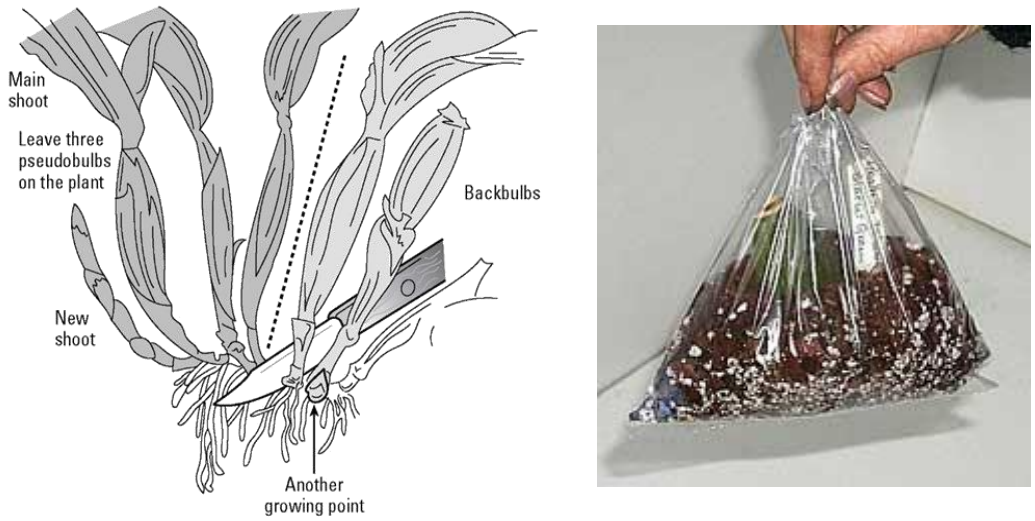


Figure 3.7. Back bulbs propagation. a) The diagram shows the position of the backbulbs and the location to cut the rhizome (From: http://lh4.ggpht.com/_LenCZlyza20/TRHpd06jtLI/AAAAAAAAFzc/s5-XQfn5mas/tmp2B39_thumb_thumb.jpg?imgmax=800). B) Controlling the humidity with the plastic bag.

4. Stem cutting

Some orchids have a long stem, or long canes and several nodes belong the stem. Cutting the stem into stem sections with the nodes can produce the new plantlets. The processes are shown in Figure 3.8. *Dendrobium* and *Phaius* can propagate by this method.

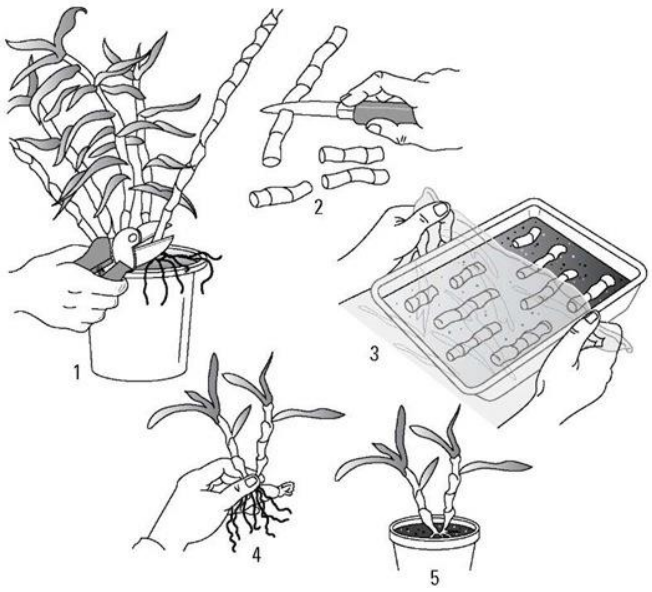


Figure 3.8. Orchid propagation from stem cutting technique. 1) Cut the stem with sharp and clean pruners. 2) Cut the stem into a section contains the nodes in each section. 3) Half-buried the section stems on sand or sphagnum moss, and cover the container with plastic. 4) The new plantlets grow from the section stem in a few months. 5) Move the plantlets into a new basket. (From: http://lh3.ggpht.com/_LenCZlyza20/TRHpoYukvaI/AAAAAAAAF0A/PNQm_Hdm3sA/tmp2B43_thumb_thumb.jpg?imgmax=800)

5. Plant tissue culture (PTC) technique

PTC is another form of asexual propagation. It refers to the growth of plant parts; bud, shoot, seed, leaf, in the sterile environment. The variety of culture media are used to grow these explants in the glass bottle (*in vitro* culture) (Figure 3.9). The basic principle for PTC is “Totipotency”, the ability of plant cells to generate into a whole plant with an appropriate culture medium.

PTC were applied to orchids in 1960. The reasons why PTC has become a famous technique are as follows:

- To save time and labor in comparison to conventional hybridization techniques
- To save the species from extinction
- To produce the virus-free plants
- To produce plants with enhanced stress or pest resistance
- To create new plant varieties

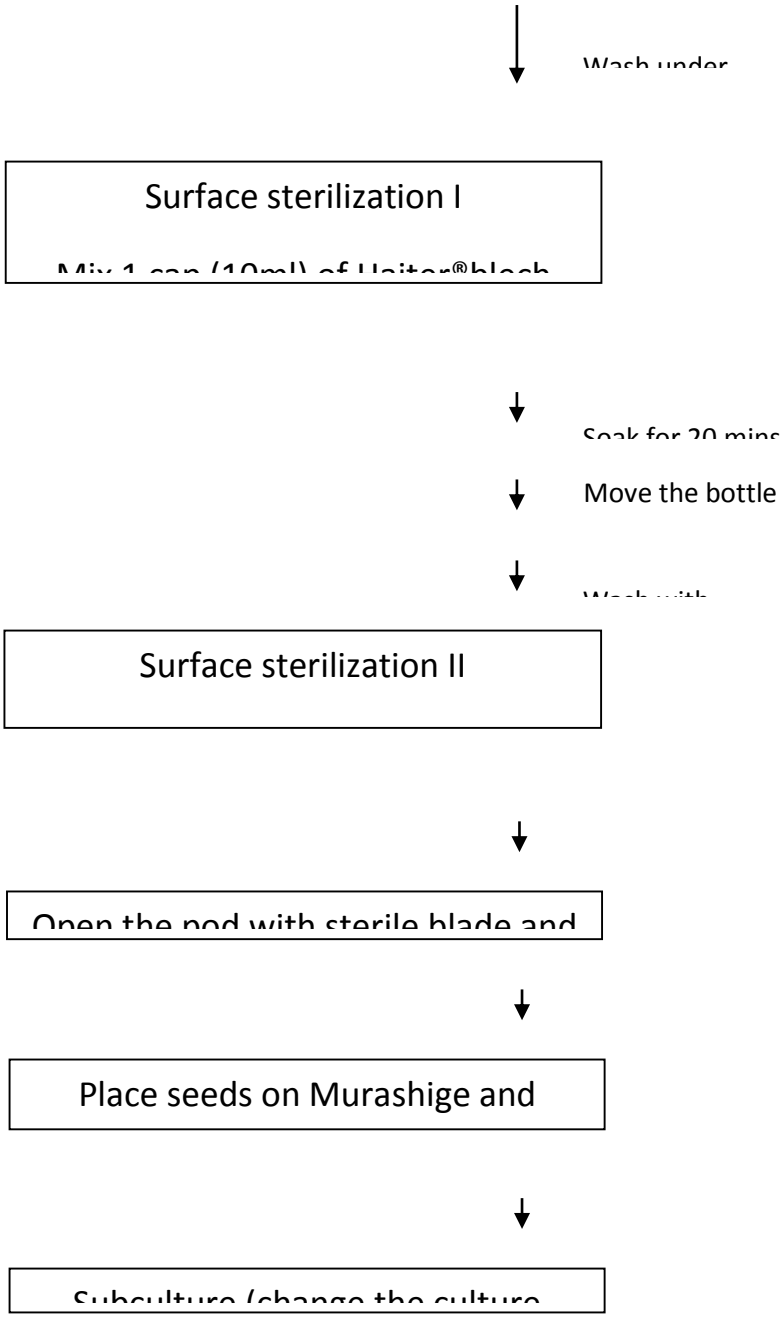
In the world orchid market, PTC is necessary to produce the numerous clone orchids maintain all the characters of the gorgeous mother plant. Some orchid farms sell the plantlets from PTC in the bottle which is good for export and import the orchid under CITES regulation.

Figure 3.9. *In vitro* culture orchids.

Rural Development Training Centre (RDTC), Zhemgang had tried to propagate cymbidiums through this technique, but it did not succeed because there is no appropriate culture media for this plant and also the proper room to storage them. The steps of surface sterilization and seed germination stage of RDTC was metioned in Figure 3.10.

Cymbidiums need the rich nutrition source culture media as Murashige and Skoog's (MS) or Knudson C (KC), but in Bhutan only the package of Vacine and Went's (VW) culture media is available. Moreover, most of the data from research publications for cymbidiums usually use hormones supplemented with the culture medium to activate the orchid cells to produce callus, shoot, or root. Auxins stimulate rhizome by enhancing branches, but they may suppress shoot formation. The proper proportion of auxin:cytokinin for each species is under study. Table 3.1 shows the culture medium and hormone used for cymbidiums.

7 month old pollinated green



*The pH of the culture medium is still needed the research to support for each species.

Figure 3.10 The steps for *Cymbidium* sp. tissue culture in RDTC (Developed by Pimsiri, a Thai Volunteer (2016))

Table 3.1. Some previous *in vitro* culture studies of *Cymbidium* sp.

Species	Culture medium	Hormone	Note
C. aloifolium (Nayak et al., 1997)	MS pH 5.8	N^6-benzyladenine (BA) Thidiazuron (TDZ) NAA	Shoot development
Cymbidium Twilight Moon 'Day Light' (Teixeira da Silva et al., 2006)	VW pH 5.3	NAA Kinetin Tryptone	Protocorm-like body (PLB) and callus formation
Cymbidium mastersii (Mohanty et al., 2012)	MS, half-MS, KC, VW pH 5.8	Cytokinins (6-Benzylaminopurine (BAP) and KN) Auxins (NAA and IBA)	Protocorm, root and shoot formation
Cymbidium giganteum (Hossain et al., 2010)	MS, Phytamax, Mitra et al., KC	Auxins (NAA and 2,4-dichlorophenoxyacetic acid (2,4-D)) Cytokinins [BAP and kinetin (KN)	Protocorm, root and shoot formation

Hossain et al. (2010) reported the clearly seed germination process of *Cymbidium giganteum* from plant tissue culture. For this research, they use liquid medium for the first stag to multiply primary protocorm, and then transfer to solid medium to generate the secondary protocorm. Their study covered from *in vitro* seed germination, protocorm formation, shoot and root formation, acclimatization and growing in the pot (Figure 3.11 and 3.12).

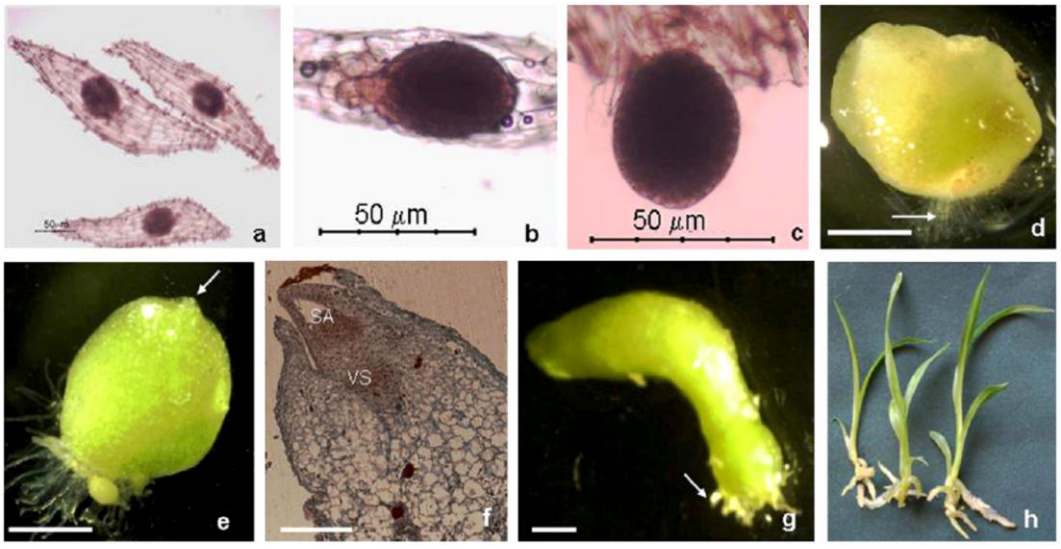
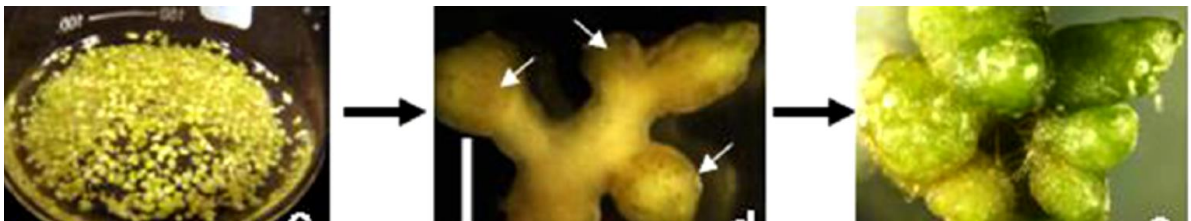


Figure 3.11 Different stages of germination of seeds of *Cymbidium giganteum* from Hossain et al. (2010). (a) Amature seed. (b) Seeds after 15 days of culture. (c) Embryo after 30 days of culture. (d) Spherule with hairs (arrow). (e) Young protocorm with a growth appendicle (arrow). (f) LS of protocorm showing shoot apex (SA) and development of vascular strand (VS). (g) A protocorm with root initial (arrow) and (h) Complete seedlings. (Bar = 1 mm).



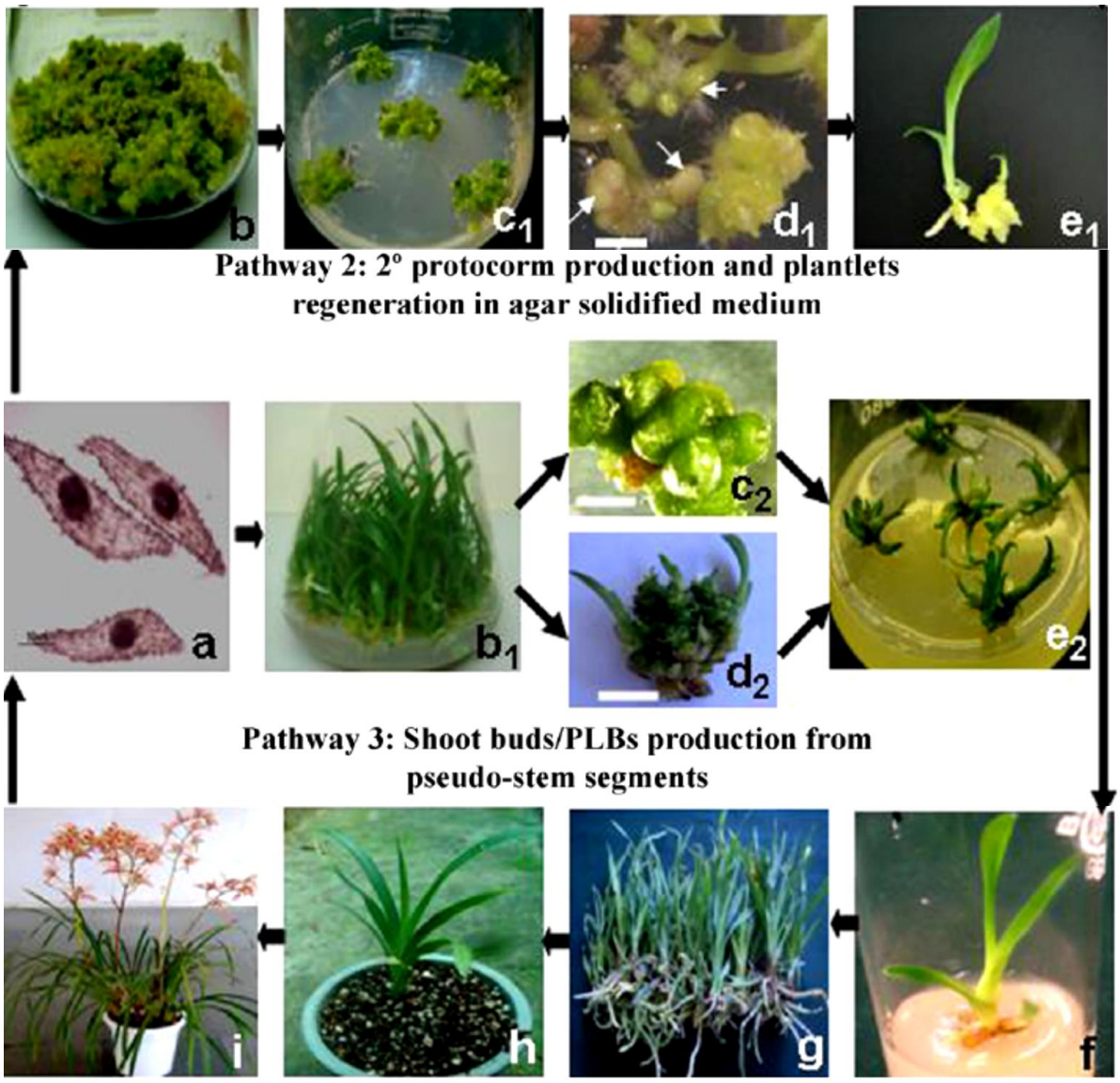


Figure 3.12. Multiple regeneration pathways in *C. giganteum* from Hossain et al. (2010). (a) Seeds. (b) 1° Protocorms. (c) 1° Protocorms multiplying in liquid medium. (d) Development of 2° protocorms from 1° protocorms (arrow). (e) 2° protocorms undergoing further proliferation. (c1) Protocorms multiplying in agar-solidified medium. (d1) Development of 2° protocorms from 1° protocorms (arrow). (e1) Plantlet development from 2° protocorms. (b1) In vitro germinated seedlings. (c2) PLBs development from pseudo-stem segment. (d2) Shoot buds development from pseudo-stem segment. (e2) Plantlet development from shoot buds/PLBs. (f) Development of stout root system in plantlet. (g) Well-rooted plants ready for transfer to pots. (h) Hardened plant growing in pot in greenhouse. (i) Plants at flowering stage. (Bar = 1 mm).

Lesson 4

Orchid Cultivation

It is impossible to take care of the different species with the same treat. Each orchid species has the different needs. However, if we observe their characteristics, we may get the clues how to take care of them. For example, the orchids which have a few leaves or leathery leaves (like most cattleyas), they need a high light intensity. While the one with soft and limp leaves (like some phalaenopsis and most paphiopedilum), they require a very low light intensity. The orchid lovers should study the environments that the orchids need before growing them.

Environment for growing orchids

1. Light

Light is one of the major factors for plants to grow. Light intensity, light duration, and light quality are related to growth and blooming of the orchids.

Light intensity - Generally light intensity is measured in foot-candles (fc), the amount of light falling on a surface that is 1 foot away from candle, using light meter. During the bright day in the summer, the light intensity outdoor may higher than 10,000 fc, and drop to 500 fc in the overcast day. The shade net is necessary to reduce the light intensity, if you would like to grow the orchid outdoor. Inside the house, the area close to the window may have 4,000-5,000 fc, while the area further than the window may have around 500 fc. Most of the orchids require 1,500-3,000 fc. Some can do well in 500 fc, some can tolerate 4,000 fc. The hybrids can tolerate a broader range of intensities.

The easiest way to measure the light, we can observe the shadow of our hands; highest light (more than 3,000 fc)-can see the shadow obviously, moderate light (1,500-2,500 fc)-can see the light shadow, and lowest light (500-1,500 fc)- no shadow (Roger, 2008) (Figure 4.1).

The highest light orchids: Vandas, Cymbidiums

The moderate light orchids: Oncidiums, Cattleyas

The lowest light orchids: Lady's slipper, Phalaenopsis, jewel orchids

Moreover each genus requires the different range of light intensities (Figure 4.2).

Light Duration – Light duration is the length of the day or how long light shines on the plants. Most of the plants require 8-16 hours of light every day. The cycle between light and dark and the length of each period is important to

Figure 4.1. Measuring light with hands from Roger (2008). a) The shadow from the highest light intensity. b) The shadow from the moderate light.

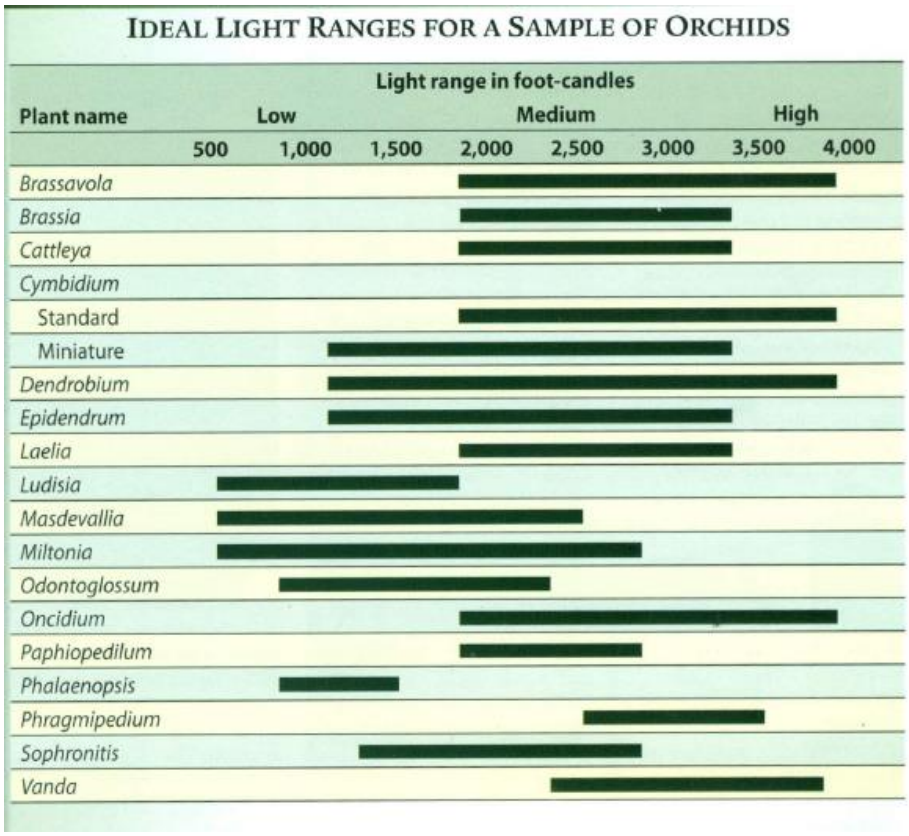


Figure 4.2. The range of light intensities for some genus of orchids from Roger (2008).

blooming plants because it triggers flowering. Some orchids flower in response to short days, including the hybrids of *Cymbidium, Dendrobium,* and *Phalaenopsis.* Day length is different depends on the season as follows: Nov-Jan (12hrs), Feb-June (14hrs), July-Aug (16hrs), Sep-Oct (14hrs).

Light quality – Quality refers to the light's color. Most plants, including orchids, require light in the red and blue ranges. Blues ensure healthy, well formed foliage growth. Reds are critical for flowering. The more natural light available to your plants, the higher the quality or the broader the spectrum of the light. Nowadays, there are varieties of light sources for plants to compensate an insufficient of the full spectrum of light energy.

If the orchids receive too much light, plants will show the character like these; the foliage becomes scorched (burnt) or develops a reddish or yellowish tinge, plants are dried out, the plants may bloom but its flower buds and inflorescences become deformed and the edges of the petals turn brown from lack of water. In the contrary, if plants receive less light, they will show the signal as follows; all plant parts decline in size and vigor, pseudobulbs and roots may become shriveled, leaves are limp, soft and dark green, plant is floppy, unable to support itself, and no flower.

2. Temperature

Orchids are normally be grouped into three temperature categories: cool, warm, and intermediate. The temperature range of each group is also different. Figure 4.3 demonstrates the ideal night temperature ranges for a sample of orchids. In the greenhouse, thermometer is needed to measure the temperature to grow the orchids

3. Humidity

Hygrometer is the machine used for measuring the humidity. The moderate humidity range is 50-60%. For growing orchid indoor, we have to limit the humidity to prevent home damage by growing the orchids in group provide extra humidity. Outdoor has lower humidity because of the wind. When the temperature rise up, spray plants and the ground beneath the pot with water to raise humidity quickly.

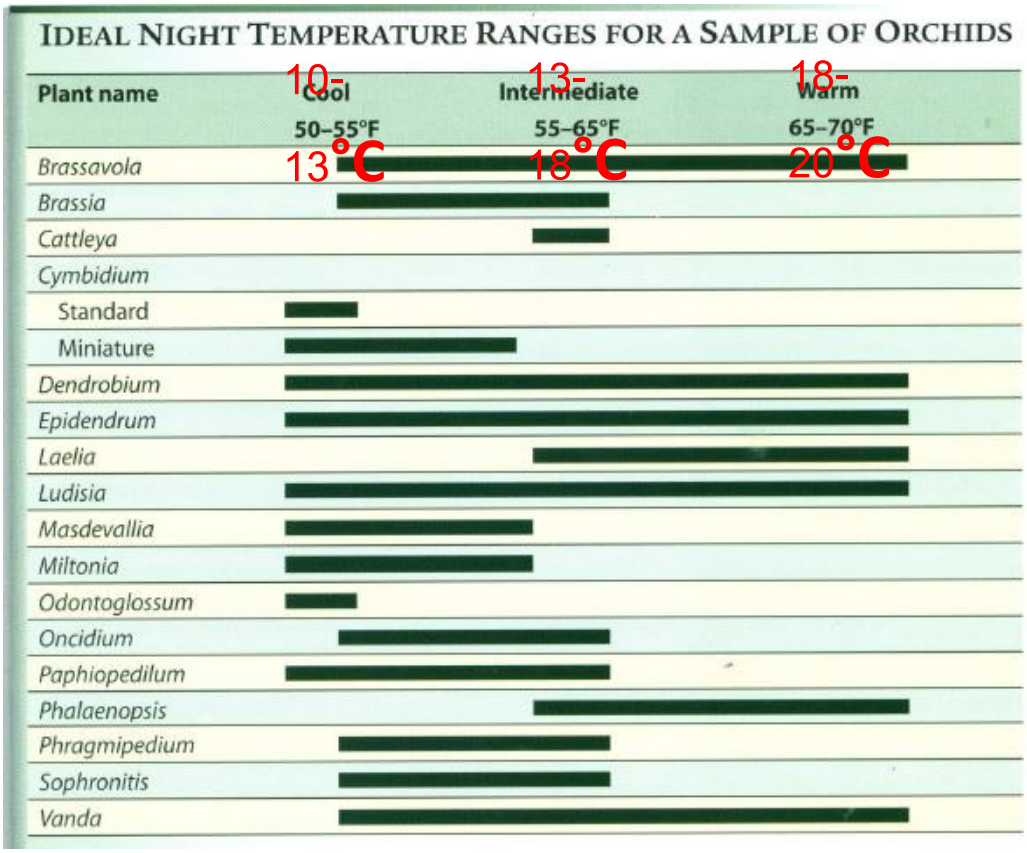


Figure 4.3. The ideal night temperature range for some orchid genus from Roger (2008).

4. Water

The orchid with pseudobulb should be watered less than the one with no pseudobulb. Moreover the different container and material of growing relate to watering period. During the watering, all the material should absorb water as much as possible. Some people soak the entire pot in the water for 10-15 minutes and lift it out to drain the excess water before putting the pot back in place. This technique is good for orchids potted in clay (clay pot has porous between its particles) and uses the bark chips as a material to grow.

If the orchid is potted in plastic, we should place it in an empty bowl, pour water up to below the edge of the pot, soak it for 10-15 minutes, and drain the water before return the pot to its place.

If you use sphagnum moss as the material to grow the orchids, you may not need to water them every day. Sphagnum moss has ability to absorb the water. Stick the figure into the mosses that is the way to check the water in your orchid pot.

We should water the orchid when we see these signs: the foliage (leaf) texture and pseudobulb are dried and turn brown; the weight of the plant in its container is lighter than usual; the drainage holes are dried; the material of growing are dried. The orchid will show darkening and deterioration of root surface when it has faced with over watering. Over watering causes the medium to decompose prematurely. In general, we should water the orchid every 4 to 5 days or once a week.

Materials for growing orchids

Most of the epiphytic and terrestrial orchid can grow on the similar growing material. Sphagnum moss and bark chips are generally use to grow the orchids. In Thailand, coconut husk is used in the orchid farming business. Moreover, there are several materials that used to grow orchid such as rockwool, loose tree fern, osmunda, fir bark, lava rock, aliflor. In Bhutan, the materials which are available are bark chips, charcoal, local mosses. We can mix them together and put them into the orchid pot.

Moreover, the clay ball made from clay, bark chips, saw dust and mosses, is use in RDTC. For my mini-research to grow cymbidiums clay ball mixed with bark chips and bark chips mix with mosses were used to study. After three months, cymbidiums from clay ball pot showed the healthy and white numerous roots more than the orchid from bark chip pot (Figure 4.4). This is just the beginning of the experiment. However, clay ball is proved that it can be an alternative material to grow cymbidiums.

Figure 4.4. A comparison of cymbidiums roots system after three months of growing with clay ball mixed with bark chips (right) and bark chips mix with mosses (left).

Containers for orchids

There are several types of orchid container (Figure 4.5). However, the thing we have to concern is the ventilation and the root character of the orchid.

Mounting – suitable for the creeping with rhizome, adapt to dry habitats, noticeable pseudobulb, thick and heavy leaves, large and heavy roots, no branch, deciduous orchids that require a dormant period.

Clay pot – suitable for noticeable pseudobulb, thick and heavy leave, roots that tolerate periodic drying, tall or top heavy orchids with small root system, large orchid.

Plastic pot - suitable for small or no pseudobulb, soft leave, fine and heavily root system, small orchid that need moisture.

Slatted basket – suitable for heavy-rooted monopodials that require fast drainage and excellent air circulation.

Figure 4.5. The containers for growing the orchid from left to right; mounting, clay pot, plastic pot, and slatted basket.

Orchid Care

Re-potting

When the orchids grow until no space in the pot, or grow out of the pot that is the time to change the pot. We can use division technique, if the orchids are in the big bunch. Re-potting includes changing the pot size, resize the orchid bunch, and also changing the material for growing.

Diseases and Pests

Pests that usually attack the orchids are grouped into three catagories; plant sap feeding insects (scale, mealybugs, aphids, thrips, whiteflies); spider mites; and chewing pests (snails and slugs, caterpillars, cockroaches, and grasshoppers).

Diseases are divided into bacterial and fungal disease as follows:

- **Bacterial disease**
  - Soft and Brown Rots – *Erwinia*
  - Bacterial Brown Spot – *Acidovorax (syn.Pseudomonas)*
- **Fungal disease**

- Black rot – *Pythium and Phytophthora*
- Root rot – *Rhizoctonia*
- Fusarium wilt – *Fusarium*
- Anthracnose – *Colletotrichum (syn. Gloeosporioides)*
- Cercospora Leaf Spot - *Cercospora*
- Guignardia/Phyllosticta Leaf Spot – *Guignardia & Phyllosticta*
- Septoria Leaf Spot – *Septoria*
- Petal blight - Botrytis

Generally, fungicided and bactericided for treatment of various orchid diseases are the chemicals which not available in Bhutan. The staffs from National Biodiversity Centre (NBC), Serbithang, Thimphu recommended 'Neem Oil' to spray in the orchid garden. Neem oil is an organic insecticide. It helps to control fungi, insects and mites. It can be used on ornamental flowering plants, trees, shrubs, foliage, vegetables, herbs, fruits and nuts, and can top powdery mildew within 24 hrs. Neem oil is an organic insecticide, so it safe for mammals, humans, birds and many beneficial insects such as honeybees and ladybugs. The phytochemicals of neem oil affect to the brain of the insect, so it would be more effective to kill the chewing insects.

Fertilizing

During vegetative growth, large quantities of nitrogen are required while during flowering, nitrogen should be reduced and amount of phosphate increased. The best fertilizer for orchid contains nitrogen (N): phosphorus (P): Potassium (K) in 1:1:1 or 3:1:1.

- Use 1:1:1 ratio for orchids that are growing in any medium except bark. It is good during vegetative growth. E.g. Fertilizer 20:20:20 or 10:10:10 or 5:5:5

- Use 3:1:1 ratio for orchids growing in bark (requires higher nitrogen because the microorganism breaks down the bark for nitrogen). E.g. Fertilizer 30:10:10 or 15:5:5
- Use 10:20:30 or 7:12:40 is good during flowering stage.

The pH of the nutrient solution should be slightly acidic or neutral but not alkaline. Fertiliser should be made on sunny days during 8.00 am – 10.30 am for better absorption. Many orchids need little or no fertilizer during winter (light is reduced and temperatures low). If orchid is showing a reduced need for water, it probably needs less fertilizer as well.

In the world market, there is the fertilizer depends on the genus of our orchids. The recommended does must be written at their package. But in Bhutan, only some fertilizers are allowed to use following an announcement of Ministry of Agriculture and Forest (MoAF). Suphala 15:15:15, all-purpose fertilizer, is the general NPK fertilizer in Bhutan. There is no recommended dose for the orchids yet, but we should try with a half-strength or dissolve a tablespoon of Suphala with one gallon of water (4 liters). Then observe the character of leaves and orchids rhizome.

The signs of over fertilization are as follows: leaves become dark green and soft, plants more susceptible to disease, and less of blooming. For cymbidiums, they will not bloom if given too much nitrogen in the wrong time of the year, flower initiation (around August and September).

Cymbidiums care

Cymbidiums are called “Olachoeto” in Dzongkha. Their flower buds are famous and have a high price compare with the other vegetables. Most of the Bhutanese people use cymbidium flower buds addition in the curry. Learning how to take care of these orchids leads to the side income for the farmers as well.

Light - Cymbidiums prefer high light, but cool temperature. The high summer temperatures, especially at night, may prevent the plants from blooming. Light shade during the middle of the day, or about 20 percent shade is good for them.

The plants grow best with 3000 to 4500 foot candles of light intensity. Leaves should be a medium to golden green in color, not dark green.

Temperature - During the summer, standard cymbidiums are usually grown outside in semi-shade, where day temperatures should be 24 to 29 °C (or more), but night temperatures in the late summer to must be 10 to 15°C to initiate flower spikes.

Water - Watering should be done frequently, twice per week during the summer months. Fertilize during 3 out of 4 of those irrigations. Always keep potting soil moist, but not wet or soggy. Decrease watering cymbidiums and increase air circulation during the dark periods.

Growth - Cymbidiums may not get very much taller, but more leaves and pseudobulbs will grow in horizontal direction.

Blooming - From late September through November and last for one month.

Re-potting - Re-potting should do every two to three years after blooming phase with a well-draining medium.

Some cymbidiums are epiphytes and some are terrestrial orchid. To cultivation them, the farmers should make the wooden basket or use the clay pot to grow them instead of grow them on the floor. The material to grow them can be bark chips, mosses, clay balls, charcoal, or leave litter.

Lesson 5

Orchid Market and Utilities

Most of the orchids which available In the world market are the hybrids. Since 1856 when the first Orchid hybrid was produced, a very large number of artificial hybrid had been produced both at intergeneric and interspecific level. To date more than 125,000 hybrids have been registered with an average of 10,000 or more every year. The important genera which have given maximum number of manmade hybrids are *Cattleya, Cymbidium, Paphiopedilum, Vanda, Dendrobium*.

For example: *Aranda* and *Sophrocattleya* (Figure 5.1)

Arachnis X *Vanda* → *Aranda*

Cattleya X *Sophronitis* → *Sophrocattleya*

Figure 5.1. The breeding pedigree of *Aranda* (upper row) and *Sophrocattleya* (lower row).

Orchid in the global market

Among the cut flowers, orchids have taken a significant position. Their astonishing flower, long shelf life, and high productivity make them become popular. Cut flowers and potted plants are available in the market and account the large share of global floriculture trade. During 2007-2012, the average trade value was US$483 million. In 2012, there were more than 40 exporting and 60 exporting orchid countries, and the global trade size was US$504 million. The top orchid exporting country in the world is the Netherlands (39.67%) followed by Thailand (28.41%), Taiwan (10%), Singapore (10%), and New Zealand (6%). Japan is the biggest importing country (30%) followed by UK (12%), Italy (10%), France (7%), and the USA (6%) (De et al., 2015).

The cut flower trade of the world, mostly consists of 85% Dendrobiums, 15% Phalaenopsis, and Cymbidiums. Asia is the main source of orchid.

Cymbidiums – Cymbidiums are the most popular among the winter and spring semi-terrestrial orchids originating from tropical and subtropical Asia which usually grown in the cool climate at high elevation. They are highly valued for genetic resources, cut flowers, hanging baskets, potted plant and herbal medicines (Figure 5.2). In India, the Arunachal hills, Sikkim and Darjeeling hills with cool summer nights and monsoonal summer rain are ideal for cymbidium cultivation. In Bhutan, Gasa, Punakha, Wangduephrodang Dzongkhag are the places that grow cymbidiums for home consumption and selling the flower buds. Cymbidiums have the highest value in EU market averaging Euro cent 331 per stem during 2003-2007 (Table 5.1).

Figure 5.2. Some hybrid cymbidiums which are available in the world market.

Table 5.1. Average annual prices at Netherlands auction (2003-2007) (Euro cents /stem)

Orchids	2003	2005	2007	Average price
Phalaenopsis	38	46	37	40
Cymbidium (Big bud)	330	334	329	331
Cymbidium (Small bud)	138	148	140	142
Paphiopedilum	58	52	63	58

Source: CBI Market Survey, The Cut Flowers and Foliage Market in the EU

Dendrobium – Dendrobiums become the popular flower pot plants and cut flower because of their wide range in flower color, size and shape, year round availability, and lengthy vase life (Figure 5.3). Thailand hold the world largest exporter of tropical cut flower with the strong position in Dendrobium orchids.

Figure 5.3. Some hybrid dendrobiums in the world market.

Phalaenopsis – *Phalaenopsis* is the second most valuable flower pot plant and cut flower due to their easy cultural practices, diversity in flower color, size and shape, year round availability, delicacy and longer vase life (Figure 5.4). They are commercially grown in Germany, Japan, The Netherlands, Taiwan and United States. In USA, 75% of all orchids purchased are phalaenopsis.

Figure 5.4. Some hybrid *Phalaenopsis* in the world market.

Orchid Market in Thailand

Follow the Forest Act B.E. 2484 (A.D. 1941), the harvesting of wild orchids are banned except for research purposes and very restricted household use. There are additional bans, fines and prison terms associated with their harvest from protected areas (e.g., National Park Act B.E. 2504 (A.D. 1961)). Further domestic regulations ensure Thailand's compliance with CITES (Convention on International Trade in Endangered Species) commitments, including processes for allocating trades permits and penalties for unlawful trade (Plants Act No.2 B.E. 2535; Plant Quarantine Act No. 2 B.E. 2542). All orchid species are protected for the purposes of international commerce under **CITES** – Appendix I, II. The orchids in appendix I are strongly prohibited. Only propagated plants can be exported regardless of CITES appendix II. However, the illegally orchid trade is still found in the border area of Thailand, Laos, and Myanmar (Phelp, 2015).

Thailand is the largest world exporter of propagated tropical orchids. The major genus that is exported as cut flowers and orchid plant is Dendrobium (94.73%) (Table 5.2). From 2019 to 2016, Thailand has the averaging percentage of growth rate 19.24% (Table 5.3) that shows Thai orchid market still has the opportunity to grow year by your. The orchid trade partnership with Thailand are Japan, Korea, China, Italy, the Netherlands, USA, and Australia. In Asean country, the bright color, circle shape, and long inflorescence are needed. In European and Australia, the white of dark flower are required.

Table 5.2. Orchid export from Thailand in 2009 (% share of total export value)

Cut orchid		Orchid plant	
Orchid genera (20)	Value shared (%)	Orchid genera (211)	Value shared (%)
Dendrobium	94.73	*Dendrobium*	51.4
Mokara	3.69	*Phalaenopsis*	25.5
Aranthera	0.52	*Vanda*	8.9
Aranda	0.48	*Mokara*	3.7
Oncidium	0.44	*Oncidium*	3.1
Vanda	0.13	*Cattleya*	2.7
Arachnis	0.01	*Ascocenda*	1.2
Ascocenda	0.01	*Epidendrum*	0.6
		Cymbidium	0.3
		Rhyncostylis	0.3
		Spathoglottis	0.3
		Paphiopedilum	0.2
		Others	1.8

Table 5.3 The growth rate value of orchid export from Thailand 2009-2016

Year	Cut orchids (Flower)	Orchid plants	Total (Million THB)
2008	2,411	423	2,835
2009	2,550	450	3,000
2010	3,000	500	3,500
2011	3,400	600	4,000
2012	4,000	700	4,700
2013	4,980	870	5,850
2014	5,900	1,150	7,050
2015	7,200	1,300	8,500
2016	8,500	2,500	10,000
Growth rate (%)	19.09	25.31	19.24

Data from Thai National Orchid Committee

The route of orchid trade in Thailand demonstrated in Figure 5.5. More than 50% of the orchid exports to the international market. Moreover, the orchid industry in Thailand receives the support from government sector and also the related industries as mention in Figure 5.6.

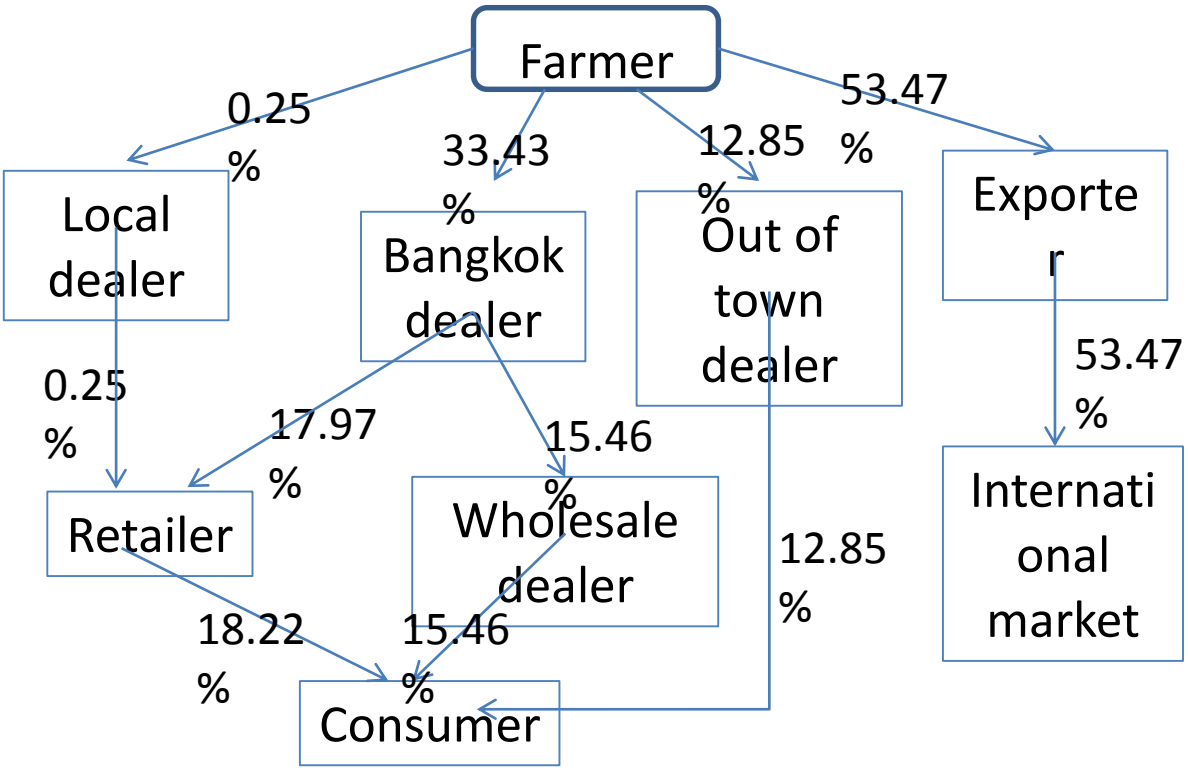
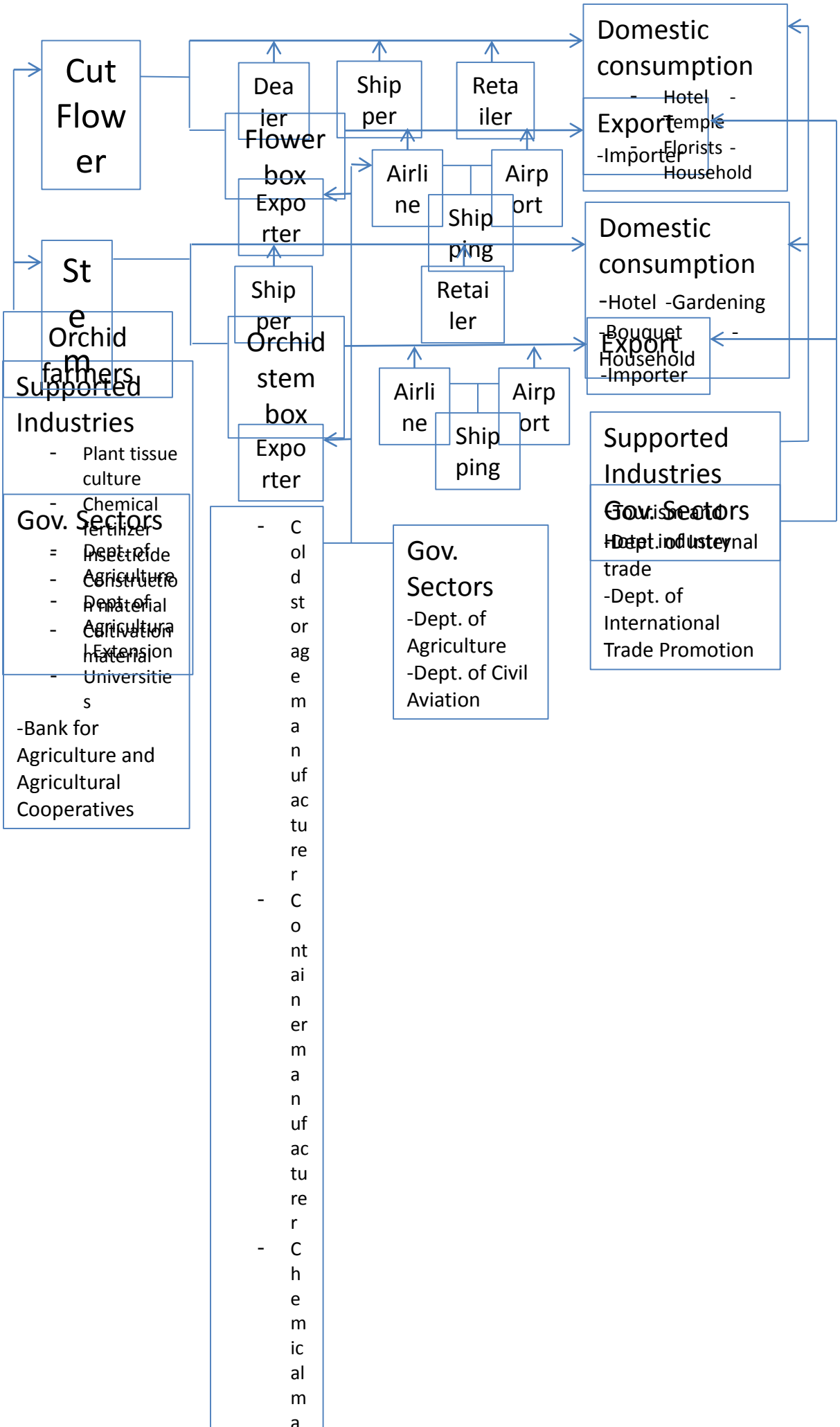


Figure 5.5. The route of orchid trade in Thailand. Data from Office of Agricultural Economics, Ministry of Agriculture and Cooperative, Thailand

Figure 5.6. The orchid industry in Thailand. Data from Office of Agricultural


Cut Flower
Stem
Orchid farmers
Supported Industries
- Plant tissue culture
- Chemical fertilizer
- Insecticide
- Construction material
- Cultivation material
- Universities
-Bank for Agriculture and Agricultural Cooperatives
Gov. Sectors
- Dept. of Agriculture
- Dept. of Agricultural Extension
Dealer
Shipper
Retailer
Flower box Exporter
Airline
Airport
Shipping
Domestic consumption
- Hotel - Temple - Florists - Household
Export
-Importer
Shipper
Retailer
Orchid stem box Exporter
Airline
Airport
Shipping
Domestic consumption
-Hotel -Gardening -Bouquet -Household
Export
-Importer
Supported Industries
- Tourism and Hotel industry
Gov. Sectors
-Dept. of Internal trade
-Dept. of International Trade Promotion
- Cold storage manufacturer
- Container manufacturer
- Chemical ma
Gov. Sectors
-Dept. of Agriculture
-Dept. of Civil Aviation

Economics , Ministry of Agriculture and Cooperative, Thailand.

Orchid market in Bhutan

The situation of the orchids in Bhutan - Bhutanese generally take the bunch of the orchid or the orchid inflorescence from the forest and grow them at home. No restrict law and regulation for orchid harvesting and conservation, only follow the “Interim Framwork for Collection and Management of Non-Wood Forest Production” (NWFP).

The flower buds of cymbidiums are available in the market in Punakha, Wangdueprodang and Thimphu (Figure 5.6). Bhutanese consumes orchid as a vegetable. They cook orchids in the same method of cooking Emma dashi, or fried with butter and onion, or soup. Orchid with emma dashi is shown in Figure 5.7. From the survey, the farmers in Gasa, Punakha, Wangdueprodang, and Trongsa Dzongkhag have grown cymbidiums and sell the flower bud as their side income. As the orchids bloom once in a year, the price of the flower bud is a bit high compared to the other vegetable. The price can be up to 150-300 Nu/three inflorescences. In some area the villagers set up the orchid communities for marketing purpose. The members of that community have to take care of the orchids and earn the money from that activity.

Edible orchids in Bhutan are generally found as in this list (Figure 5.7):

- *Calanthe plantaginea*
- *Calanthe triplicata*
- *Coelogyne cristata*
- *Cymbidium erythraenum*
- *Cymbidium hookerianum*
- *Cymbidium iridioides*
- *Cymbidium longifolium*
- *Dendrobium hookerianum*
- *Esmeralda cathcartii*

Figure 5.7. Edible orchids of Bhutan. a) *Calanthe plantaginea* b) *Calanthe triplicata* c) *Coelogyne cristata* d) *Cymbidium erythraenum* e) *Cymbidium hookerianum* f) *Cymbidium iridioides* g) *Cymbidium longifolium* h) *Dendrobium hookerianum* i) *Esmeralda cathcartii* j) Orchid flower bud in the market. k) Orchid emma dashi (Bhutanese dish).

Follow the *Bhutan* Agriculture and Food Regulatory Authority (BAFRA) (2016), some orchid species are allowed to import such as Vanda Miss Joaquim hybrid, *Cymbidium, Phalaenopsis, Cattleya, Oncidium, Leptorchris, Ascocentrum,* and Jewel orchids.

Utilities

In some countries such as China and India, they have used the orchids as the traditional herbal medicines (Table 5.4). Moreover, there are several studies reported the phytochemicals found in orchids and also the antimicrobial, antioxidants, anti-inflammation, antitumor and so on (Table 5.5).

Table 5.4 Plant species used in three traditional Chinese Medicines, their possibly active ingredients and a summary of claimed uses (From Bulpitt et al., 2007)

Chinese drug	*Plant*	*Active ingredients*[12]	*Claimed uses*
Shi-Hu	*Dendrobium nobile**	Dendrobine Nobilonine Dendrine Dendroxime	Treatment for • Thirst • Dry mouth • Low grade fever • Swelling • Impotence • Insects in the ear • Menstrual pain • Hyperglycaemia Perfumes clothes
Tian-Ma	*Gastrodia elata*	Gastrodin Vanillin [extract of fungus—*Armillaria mellea*]	Treatment for • Headache • Dizziness • Epilepsy • Cramps • Pains • Migraine • Hemiplegia • Deafness • Tinnitus
Bai-Ji	*Bletilla striata*	Batatasin III Blespirol Blestriarine A-C Blestrin A-D etc	Treatment for • Bleeding o vomiting blood o coughing blood o nose bleeds o bleeding from trauma • Tuberculosis • Ulcers

*Many *Dendrobium* species are used to make various forms of Shi-Hu

Table 5.5 Secondary Metabolites isolated from Orchid (From Singh et al., 2012)

Secondary Metabolite	**Compound(s)**	**Source**	**Activities**	References
Alkaloid	Dendrobine	*Dendrobium nobile*	Reduces the β-alanine and taurine induced depolarizations of primary afferent terminals and have little effect upon GABA- and glycine induced depolarizations.	Kudo et al., 1983
Terpenoid	Dendroside A; Dendroside D; Dendroside E; Dendroside F; Dendroside G & Dendronobiloside A	*Dendrobium nobile*	Proliferation of murine T and B lymphocytes; Immunomodulatory activity	Zhao et al., 2001; Ye et at., 2002
Flavonoid	(2S)-5,2',6'-trihydroxy-6-lavandulyl-4"-(γ, γ -dimethylallyl)-2",2"-dimethylpyrano-[5",6": 7,8]-flavanone	*Spiranthes australis*	Antitumor activity	Peng et al., 2007
Alkaloid	N^6-(4-hydroxybenzyl) adenine riboside	*Gastrodia elata*	Prevents PC12 cell apoptosis induced by serum deprivation through suppression of JNK pathway	Huang et al., 2007

Nowadays, orchids can use for several purposes for example, adding the value in the products (Chinese green tea mix with orchid flower), orchid tea from dried orchid flower, food decoration, perfume, etc.

As Bhutan has plenty of orchids in the forest, in the future orchid may become one of the products from here.

Figure 5.7. Some utilities of orchid. a) Adding value of green tea. b) Orchid flower tea. c) Food decoration. d) Perfume.

Lesson Plan

Lesson Plan
for
Orchid Cultivation and Propagation Class

Introduction

Orchids are the monocot plant in Orchidaceae family, which has highly distribution in all over the world. They are grown generally as an ornamental plant due to their astonishing beautiful flowers. This module will provide the basic knowledge of the orchids including their characteristics, identification, nomenclature, cultivation, propagation, orchid market, and orchid utilization. In Bhutan, the orchids are widely found in the forest. Follow the rules in Bhutan, the orchids are restricted to take from the forest. However, some Bhutanese people take them from the forest and grow in their own home garden for home

consumption and decoration, that may affect to their number in the nature. Learning to cultivate and propagate the orchid may be the future plan for Bhutan to contribute the orchids available in the market instead of taking them from the forest only.

Objectives:

- To be able to differentiate the orchids from the other flowers.
- To be able to cultivate, propagate, and take care of the orchid.
- To be able to learn the orchid market.

Target Group: Youth, Grduate trainee

Duration: 4 days

Methodology:

The course will be conducted through lectures, group exercise, games, field works, and the test. The participants should have an interaction with the lecturer in the class, share their own experiences related to the sources of orchid, orchid cares, and consumptions. The activities will be set up and lead to the class discussion.

Materials Required:

- Audio visual equipment
- Computer
- Field work equipments (plastic rope, knife, label, basket, plastic bottles)
- Table and chairs
- Paper

Lesson 1 Orchid Overview

Time: 5 hours
Learning objectives:

1. To gain the basic knowledge related orchid plants.

Differentiated Learning Outcomes:

1. All the students will be able to differentiate the orchid from the other flowers.
2. All the students will know the importance of the orchid in the ecosystem and the world market.
3. The students get some idea about the future of orchid in Bhutan.

Material required:

1. Audio visual with extension cable
2. Blackboard with chalks

3. A4 Paper
4. Tables and chairs
5. Chart papers (for group discussion)
6. Pin board with pins

Prior Learning: -

Keywords: Pseudobulb, Terrestrial, Epiphyte, Lithophyte, Saprophyte, Labellum, Column, Velamen,Resupination

Lesson plan for 'Orchid Overview'		
Main Content	**Differentiation Strategies that support outcomes**	**Key question that support outcomes**
Starter		
(10-15 mins) Ice breaking	- Questioning - Peer support	- What is your name? - Where are you from? - What is your job?
Learning activities		
(5 mins) Discuss and define own knowledge about orchid using circle map (60 mins) Orchid overview ppt - Orchid general information - Flower structure – drawing flower structure and labelling - Pseudobulb	- Questioning - Peer support - Questioning - Peer support	- Could you define what the orchid is? - What is the benefit of orchid? - Which picture is the orchid? - Quiz – Label the flower structure

- Leave - Fruits - Seeds (10 mins) Break (45 mins) Orchid overview ppt - Types of orchid (60 min) Orchid management (60 min) Site visit the orchid garden in RDTC (40 min) Group discussion about the orchid of Bhutan nowsaday	 - Questioning - Peer support - Questioning - Peer support - Peer support - Peer support	 - Do you think epiphytic orchids are the parasitic plant? Why? - Do you think what kind of environment that orchid can grow well?
Plenary		
(20 mins) Recap topics and emphasize the main points of the lesson Asking about the lesson		

Lesson 2 Classification and Nomenclature

Time: 3 hours
Learning objectives:

Differentiated Learning Outcomes:

Material required:

1. Audio visual with extension cable
2. Blackboard with chalks
3. A4 Paper
4. Tables and chairs
5. Chart papers (for group discussion)
6. Pin board with pins
7. Exercise paper for dichotomous key

Prior Learning: -

Keywords: Classification, Nomenclature, Dichotomous Key, Hybrid, Grex name

Lesson plan for 'Classification and Nomenclature'		
Main Content	**Differentiation Strategies that support outcomes**	**Key question that support outcomes**
Starter		
(10-15 mins) Revise the previous lesson	- Questioning - Peer support	- What did you learn from yesterday?
Learning activities		
(40 mins) Orchid ppt - Plant Classification - Plant Identification	- Questioning - Peer support	- Have you ever seen these orchids before? - Do you think what is the subfamily of the orchid in this picture? - What kind of plant characteristics are needed for identification?

(10 mins) Break (40 mins) Orchid ppt - Orchid Nomenclature (30 mins) Exercise - Orchid identification	- Questioning - Peer support - Practice to identify the orchid species by using dichotomous key	- What is the abbreviation after the species name? - What is the meaning of "*Paphiopedilum* Jim Kie 'Springwater' HCC/AOS"? - What is the species name of this orchid?
Plenary		
(20 mins) Recap topics and emphasis the main points of the lesson Asking about the lesson		

Lesson 3 Orchid Propagation

Time: 2.30 hours
Learning objectives:

Differentiated Learning Outcomes:

Material required:

1. Audio visual with extension cable
2. Blackboard with chalks
3. A4 Paper
4. Tables and chairs
5. Chart papers (for group discussion)
6. Pin board with pins

7. Equipment for gardening: small knife, rope, pot, bark chips, leaves litter, mosses, bucket

Prior Learning: Orchid Overview

Keywords: Division, Keiki, Back Bulb, Stem cutting, Plant Tissue Culture (PTC), Pod, Mimicry, Mounting

Lesson plan for 'Orchid Propagation'		
Main Content	**Differentiation Strategies that support outcomes**	**Key question that support outcomes**
Starter		
(10-15 mins) Discuss how to increase the number of the beautiful orchids.	- Questioning - Peer support	- How to increase the number of the beautiful orchids?
Learning activities		
(40 mins) Orchid ppt - Sexual propagation - Asexual propagation	- Peer support - VDO clip	

(10 mins) Break (50 mins) Field practice - Hand-pollinated technique - Division - Back bulb - Keiki - Stem cutting - Mounting technique	- Hands on practice - Peer support	
Plenary		
(20 mins) Recap topics and emphasize the main points of the lesson Asking about the lesson		

Lesson 4 Orchid Cultivation

Time: 2.30 hours
Learning objectives:

Differentiated Learning Outcomes:

Material required:

1. Audio visual with extension cable
2. Blackboard with chalks
3. A4 Paper
4. Tables and chairs
5. Chart papers (for group discussion)
6. Pin board with pins

Prior Learning: Orchid overview

Keywords: Cultivation, Neem oil

Lesson plan for 'Orchid Cultivation'		
Main Content	**Differentiation Strategies that support outcomes**	**Key question that support outcomes**
Starter		
(10-15 mins) Discuss the environment to grow the orchid plants.	- Questioning - Peer support	- What are the relevant factors for orchids to grow?
Learning activities		
(40 mins) Orchid ppt - Environment for growth - Materials for potting - Containers for potting (10 mins) Break	- Questioning - Peer support	

(40 mins) Orchid ppt - Orchid care - Cymbidium care	- Questioning - Peer support	
Plenary		
(30 mins) Recap topics and emphasize the main points of the lesson Asking about the lesson		

Lesson 5 Orchid Market

Time: 3 hours
Learning objectives:

Differentiated Learning Outcomes:

Material required:

1. Audio visual with extension cable
2. Blackboard with chalks
3. A4 Paper
4. Tables and chairs
5. Chart papers (for group discussion)

6. Pin board with pins

Prior Learning: Orchid Overview

Keywords: Breeding, CITES, Edible Orchid, Orchid Community

Lesson plan for 'Orchid Market'		
Main Content	**Differentiation Strategies that support outcomes**	**Key question that support outcomes**
Starter		
(10-15 mins) Discuss the orchid photo.	- Questioning - Peer support	- How do you think about the orchid in the photo?
Learning activities		
(40 mins) Orchid ppt - Orchid in the world market - Orchid in Thailand (10 mins) Break	- Questioning - Peer support	

(40 mins) Orchid ppt - Orchid in Thailand - Orchid utilities	- Questioning - Peer support	
Plenary		
(20 mins) Recap topics and emphasize the main points of the lesson Asking about the lesson		

References

Brickell, C., McDonald, E., & Cole, T. (1993). *The American Horticultural Society-Encyclopedia of Gardening*. London, England: DK publishing.

Bulpitt, C. J., Li, Y., Bulpitt, P. F., & Wang, J. (2007). The use of orchids in Chinese medicine. *J. R. Soc. Med., 100,* 558-563.

Cameron, D. D., Leake, J. R., & Read, D. J. (2006). Mutualistic mycorrhiza in orchids: Evidence from plant– fungus carbon and nitrogen transfers in the green-leaved terrestrial orchid Goodyera repens. *New Phytologist, 171*, 405-416.

Chen, X., Liu, Z., Zhu, G., Lang, K., Ji, Z., & Luo, Y. (n.d.). Flora of China - Orchidaceae. Retrieved August 21, 2016, from http://www.efloras.org /florataxon.aspx?flora_id=2&taxon _id=10638.

De, L. C., Pathak, P., Rao, A. N., & Rajeevan, P. K. (2014). Commercial Orchids-Global Orchid Industry. Retrieved April 25, 2016, from http://www. degruyter.com/downloadpdf/books/9783110426403/ 9783110426403.2/9783110426403.2.xml

Dorji, S. (2008). *The Field Guide to the Orchids of Bhutan*. Thimphu, Bhutan: Bhutan Orchid Science Society.

Dressler, R. L. (1981). *The orchids: Natural history and classification*. Cambridge, MA: Harvard University Press.

Dressler, R. L. (1993). *Phylogeny and classification of the Orchid family*. Cambridge: Cambridge University Press.

Gurung, D. B. (2006). *An Illustrated Guide to the Orchids of Bhutan*. Thimphu, Bhutan: DBS Publication.

Huang, N.K., Chern, Y., Fang, J.M., Lin, C.I., Chen, W.P., Lin, Y.L. (2007). Neuroprotective principles from *Gastrodia elata*. J. Nat. Prod. 70, 571-574

Kocyan, A., Qiu, Y. L., Endress, P. K., & Conti, E. (2004). A phylogenetic analysis of Apostasioideae (Orchidaceae) based on ITS, trnL-F and matK sequences. *Plant System Evolution, 247*, 203-213. doi:10.1007/s00606-004-0133-3

Kudo,Y., Tanaka, A., Yamada, K., (1983). Dendrobine, an antagonist of beta-alanine, taurine and of presynaptic inhibition in the frog spinal cord. *Brit. J. Pharmacol*. 78, 709-715.

Leake, JR. (1994). The biology of myco-heterotrophic (saprophytic) plants. *New Phytologist* 127: 171–216.

Mellard, D. (2013). Orchid Names: The Basics. Retrieved July 20, 2016, from http://www.atlantaorchidsociety.org/wp-content/uploads/2012/02/Orchid-Names-The-Basics.pdf

Orchid Management Plan, Simpho Village, Nubi Geog, Trongsa Dzongkha (Working paper). (2011). Trongsa, Bhutan.

Pearce, N. R., & Cribb, P. J. (2002). *Flora of Bhutan* (Vol. 3, Part3, The Orchids of Bhutan). Edinburgh, England: The Royal Botanic Garden Edinburgh.

Peng, J., Xu, Q., Xu, Y., Qi, Y., Han, X., Xu, L. (2007). A new anticancer dihydroflavanoid from the root of *Spiranthes australis* (R. Brown) Lindl. *Nat. Prod. Res.* 21: 641-645.

Phelps, J. (2015). *A Blooming Trade: Illegal trade of ornamental orchids in mainland Southeast Asia (Thailand, Lao PDR, Myanmar)*. Selangor, Malaysia: TRAFFIC. Retrieved June 21, 2016, from http://www.cifor.org/library/5946/a-blooming-trade-illegal-trade-of-ornamental-orchids-in-mainland-southeast-asia-thailand-lao-pdr-myanmar/

Pridgeon, A. M. (1999-2005). *Genera Orchidacearum* (1-4 ed.). Oxford: Oxford University Press.

Rittershausen, W., & Rittershausen, B. (2001). *A Gardener's Directory of Orchids - Collecting and cultivating beautiful orchids*. London, England: Anness Publishing Limited.

Rogers, M. (2008). *Miracle-Gro Complete Guide to Orchids* (1st ed.). USA: Meredith Publishing Group.

Royal Government of Bhutan, Ministry of Agriculture. (2003). *Plant Quarantine Rules of Bhutan*. Thimphu: MoAF

Singh, S., Singh, A. K., S. K., & M. K. (2012). Medicinal properties and uses of orchids: A concise review. *Elixir Appl. Botany, 52*, 11627-11634.

Social Forestry Division, Department of Forest Ministry of Agriculture. (2009). *Interim Framework for Collection and Management of Non-wood Forest Products*. Thimphu: MoAF

Stern, W. L. (2014). *Anatomy of the monocotyledons. X, Orchidaceae*. Oxford: Oxford University Press.

Tibbs, M. (2008). *Orchids : A practical guide to care and cultivation*. New Holland, London.

Ye, Q., Qin, G., Zhao, W. (2002). Immunomodulatory sesquiterpene glycosides from *Dendrobium nobile*. *Phytochemistry*. 61, 885-890.

Zhao, W., Ye, Q., Tan, X., Jiang, H., Li, X., Chen, K., Kinghorn, A.D. (2001). Three new sesquiterpene glycosides from *Dendrobium nobile* with immunomodulatory activity. Journal Natural Products 64: 1196-2000

Appendix I

Power point presentation