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Mapping divers terrestrial orchids grown in the orchids garden of the Ranu Darungan Resort, the Bromo Tengger Semeru National Park

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Abstract. The aim of this research was to map and to determine terrestrial orchids grown in the Orchid Garden of Ranu Darungan Resort, the Bromo Tengger Semeru National Park. Garden was divided into four zones, namely A, B, C and D. Garden and orchids were mapped by recording their coordinates using GPS, then integrated into the Google Earth. Terrestrial orchids were identified, while their density of each subzone was determined. Results showed that there were 45 species belonging to 25 genera, some variants and a natural hybrid. Among them, *Calanthe triplicata* and *Nephelaphyllum pulchrum* showed the highest density. There were four endemic species of Java such as *Paphiopedilum javanicum*, *Macodes javanica*, *Liparis javanica*, and *Acanthephippium javanicum*. We found two variants of *Eria javanica*, two variants of flower colors in *Phaius amboinensis*, and two variant of labellum tip colors in *Arundina graminifolia*. We recorded a natural hybridization between *C. triplicata* and *C. sylvatica*, and then the hybrid flowers were light purple with a labellum shape of *C. triplicata*. The A zone was the richest and grown by 31 species followed by the D zone. However, the C and B zones showed the lowest diversity and codominated by *N. pulchrum* and *C. triplicata*.

1. Introduction

A high diversity of epiphytic and terrestrial wild orchids naturally grows in the Bromo Tengger Semeru National Park (BTSNP). BTSNP mandated the Ranu Darungan Resort to conserve the diversity of wild orchids in a garden of the BTSNP area. Therefore, the local resort established a Orchids Garden of Ranu Darungan Resort in 2017. The garden is managed by the Ministry of Environment and Forestry, the Bromo Tengger Semeru National Park Center, Regional II of National Park Management Section, Region IV of National Park Management Section, the Ranu Darungan Resort. Administratively, the garden is located in the Pronojiwo Village, Pronojiwo, Lumajang. The collected orchids were identified and labelled to species name of the orchids. Enrichment of orchid species continued until 2018, and there were 132 species of orchids of epiphytic and terrestrial orchids [1]. However, the terrestrial orchids show a higher sensitivity to the water stress than epiphytic orchids. Epiphytic orchid has a pseudobulb to water reserve system, and is different to terrestrial ones. It does not have a pseudobulb structure, so it could not store a large amount of water [2]. Terrestrial orchid has a root epidermal structure that is modified into root hair to expand the field of water absorption. Terrestrial orchid also has a cuticle layer in the leaf epidermis to reduce water evaporation [3].



This enrichment activity continues to this day, but there are no recent data on the species and number of collected orchids. The site of each orchid species is also unknown. Based on the above description therefore, it is urgently to map and list orchid species that had been collected, especially on terrestrial species. Aims of the research were to map their growth site in the garden, and to determine their diversity, as well as their number of clumps. This research will be useful to find out the species of terrestrial orchids that already had been conserved in the Orchids Graden of Ranu Darungan Resort BTSNP. Besides, the location of terrestrial orchid species in the garden will also be useful for management, to monitor the success of life, and to provide a better information of orchid species for visitor.

2. Method

Research was held in the end of rainy season in 2019 in the Orchids Garden of Ranu Darungan Resort of the Bromo Tengger Semeru National Park (BTSNP). In order to map the orchids, the garden area was firstly divided into four big zones, namely Zone A, B, C and D based on the local resort management system. The four zones were then subdivided into some sub zones based on maintenance routes. The similar method was applied in the orchid conservation system in the Purwodadi Botanical Gardens [4]. Around the garden, the intersection between the lanes in the large zone and subzone along with sharp bends, as well as each orchid's coordinates were recorded using the Global Positioning System (GPS). Then the coordinate were integrated into the Google Earth.

Furthermore, terrestrial orchids were recorded using census method. Orchids were listed based on the number of clumps and species. The identification process was based on flower morphology using the Orchids of Java book [5]. Meanwhile, orchid species that has not bloomed or have not yet flowered were identified into genus level. The taxa richness and diversity index in each large zone were determined based on the records. The genetic diversity and natural hybrid of orchids were observed by comparing morphological characters. The data of terrestrial orchid species and their number of clumps were then analyzed using descriptive statistics of Microsoft Excel.

3. Result and Discussion

The Orchids Garden of Ranu Darungan Resort BTSNP was divided into four large zones named Zone A, B, C and Zone D as shown in Figure 1. The division of these zones were based on the management system of the Ranu Darungan Resort BTSNP. Furthermore, each large zone was subdivided into several sub zones to provide a better maintenance such as weeding, watering and fertilizing. Zone A and D were divided into 10 sub-zones, Zone B was divided into nine sub-zones, and Zone C had 15 sub-zones. The entrance was between Zones A and B, while the exit was between Zones A and D. The garden also had a Green House located in the Zone D which was planned to be used as a breeding ground for orchids that had been collected. The zone division proved to effectively improve collection management in the Botanical Gardens Purwodadi [4].



Figure 1. Orchids Garden of Ranu Darungan Resort BTSNP

Note: A, B, C and D were zones in the garden, no 1-15 indicated subzones

The zone was also divided based on the vegetation profile in the garden. The vegetation profile of each zone was almost same but slightly different in the Zone C, precisely in Subzone C12. Subzone C12 had two large trees, so the canopy of two trees covered most of the zones C12, C11 and C10. Therefore, these three zones were used to plant some sensitive to excessive sunlight orchid species such as in *Nervilia*. According to [6] members of the genus *Nervilia* such as *N. punctata*, *N. plicata* and *N. aragoana* (Figure 2) grew well under shading of tree vegetation. Besides the genus *Nervilia*, *Acanthephippium javanicum* also grew well under low light intensity condition [5]. Half of the Subzone A9, C14, C15, D9 and D10 were exposed to excessive sunlight so it was area to plant orchids that were resistant to excessive sunlight such as *Arundina graminifolia* [5 and 7], and *Spathoglottis plicata* [7] shown in Figure 3. According to [5] the bamboo orchids or *A. graminifolia* was generally found in the area with altitude of 300 to 2,000 m asl in the open grasslands, on rocks or anywhere with a fairly short dry season. Therefore according to [7] *A. graminifolia* could continue flowering even during the dry season.

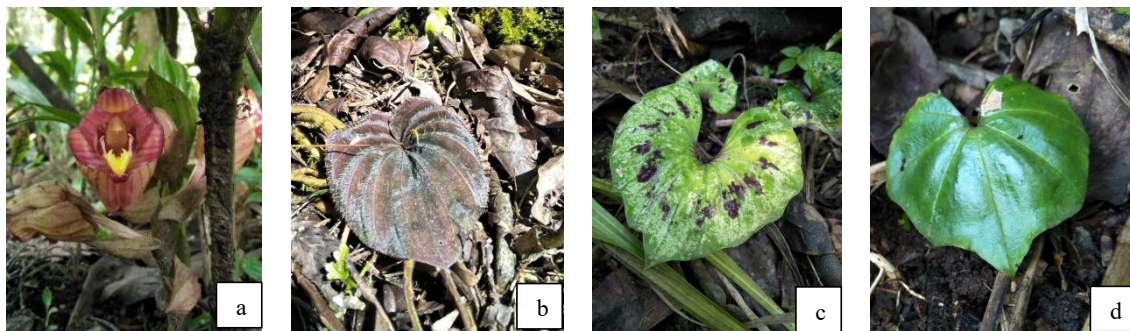


Figure 2. Orchids grown in the shading area

Note: (a) *A. javanicum*, (b) *N. plicata*, (c) *N. aragoana* and (d) *N. punctata*



Figure 3. Sunlight tolerant terrestrial orchids grown in under open area

Note: (a) *Spathoglottis plicata* and (b) *Arundina graminifolia*

Orchids Garden of Ranu Darungan Resort BTSNP collected 45 terrestrial orchid species belonging from 26 genera which were summarized in Table 1 and shown in Figure 4. *Nephelaphyllum pulchrum* and *Calanthe triplicata* were the species with the highest population density. Population density of *N. pulchrum* was 596 clumps, while *C. triplicata* was 504 clumps as shown in Figures 5a and 6. These two orchids were also widely distributed almost all sub-zones. Each zone showed different diversity of terrestrial orchid species shown in Figure 5b. Zone A showed the highest diversity index than other zones, where in Zone A we found 31 species, then followed by zone D where we recorded 30 terrestrial orchid species. Zone C and Zone D were low diversity index because both were dominated by *C. triplicata* and *N. pulchrum*. Orchid *C. triplicata* was a native orchid that had been grown long before the garden was established. Beside it, the orchid showed a fairly wide elevation habitat starting from the coastal area to an altitude of 1,850 m asl [5], and the garden was on the altitude of 850 m asl. Orchid *C. triplicata* showed a white inflorescence, so the seed production was also quite high [8]. Moreover *N. pulchrum* had brownish red leaf color, so the color was almost similar to deciduous leaves litter. This orchid could also propagate vegetatively by rhizomes creeping on the soil and the node could grow roots and new shoots [9]. For this reason *N. pulchrum* had a high population density in the garden.

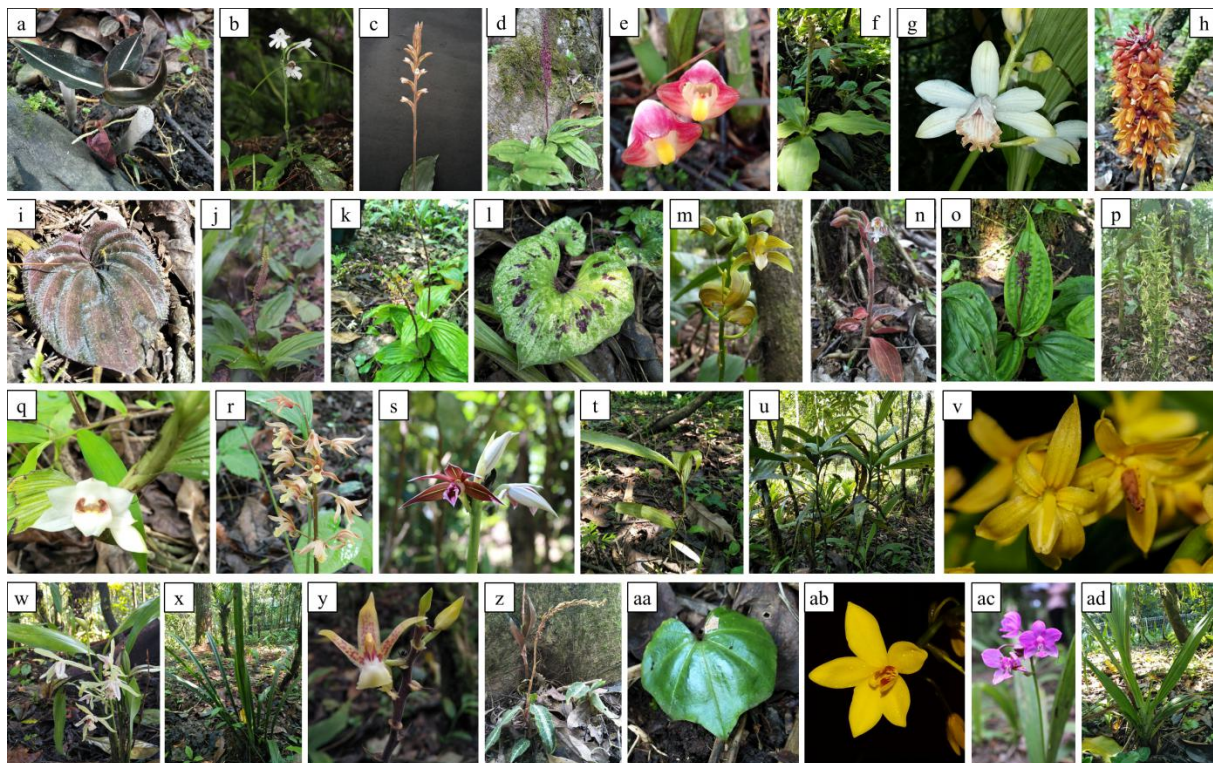


Figure 4. Diversity of terrestrial orchids in Orchids Garden of Ranu Darungan Resort BTSNP

Note: (a) *Rhomboda velutina*, (b) *Habenaria loerzingii*, (c) *Malaxis slamatensis*, (d) *M. junghuhnii*, (e) *Acanthephippium parviflorum*, (f) *Peristylus djampangensis*, (g) *Phaius flavus*, (h) *Diglyphosa latifolia*, (i) *Nervilia plicata*, (j) *M. latifolia*, (k) *Liparis rheedii*, (l) *N. aragoana*, (m) *Chrysoglossum ornatum*, (n) *Anoectochilus setaceus*, (o) *M. kobi*, (p) *H. undulata*, (q) *P. pauciflorus*, (r) *Tainia paucifolia*, (s) *P. tankervilliae*, (t) *Tropidia curculigoides*, (u) *Corymborkis veratrifolia*, (v) *Apostasia wallichii*, (w) *Cymbidium lancifolium*, (x) *C. ensifolium*, (y) *Plocoglottis acuminata*, (z) *Goodyera reticulata*, (aa) *N. punctata*, (ab) *Spathoglottis aurea*, (ac) *S. plicata*, and (ad) *Calanthe speciosa*

Table 1. Terrestrial orchid species collected in the Orchids Garden of Ranu Darungan Resort

Genus	Species	Zone				Number of clump	Genus	Species	Zone				Number of clump
		A	B	C	D				A	B	C	D	

<i>Acanthephippium</i>	<i>Acanthephippium javanicum</i>	√	√	-	√	44		<i>Malaxis latifolia</i>	√	√	-	√	24
	<i>Acanthephippium parviflorum</i>	√	-	-	√	2		<i>Malaxis slamatensis</i>	√	-	-	-	1
<i>Anoetochilus</i>	<i>Anoetochilus setaceus</i>	-	-	-	√	17		<i>Malaxis sp.1</i>	-	-	-	√	1
<i>Apostasia</i>	<i>Apostasia wallichii</i>	√	-	-		5		<i>Malaxis sp.2</i>	√	-	-	-	1
<i>Arundina</i>	<i>Arundina graminifolia</i>	√	-	-	√	79		<i>Malaxis sp.3</i>	√	-	-	-	1
	<i>Calanthe speciosa</i>	√	-	-	-	6	<i>Nephelaphyllum</i>	<i>Nephelaphyllum pulchrum</i>	√	√	√	√	596
<i>Calanthe</i>	<i>Calanthe sylvatica</i>	√	√	-	√	88		<i>Nervilia aragoana</i>	-	√	-	√	10
	<i>Calanthe triplicata</i>	√	√	√	√	504	<i>Nervilia</i>	<i>Nervilia plicata</i>	√	-	-	√	6
<i>Chrysoglossum</i>	<i>Chrysoglossum ornatum</i>	√	-	-	-	5		<i>Nervilia punctata</i>	-	√	-	√	2
<i>Corymborkis</i>	<i>Corymborkis veratrifolia</i>	-	√	-	-	28	<i>Paphiopedilum</i>	<i>Paphiopedilum javanicum</i>	√	√	-	√	54
	<i>Cymbidium ensifolium</i>	√	-	-	-	24	<i>Peristylus</i>	<i>Peristylus djampangensis</i>	√	-	√	-	16
<i>Cymbidium</i>	<i>Cymbidium lancifolium</i>	√	√	√	√	196		<i>Peristylus sp.</i>	√	√	-	-	7
<i>Diglyphosa</i>	<i>Diglyphosa latifolia</i>	√	√	√	√	143		<i>Phaius amboinensis</i>	√	√	√	√	95
<i>Eria</i>	<i>Eria javanica</i>	√	√	-	√	19	<i>Phaius</i>	<i>Phaius flavus</i>	√	-	-	-	8
<i>Goodyera</i>	<i>Goodyera reticulata</i>	-	-	-	√	2		<i>Phaius pauciflorus</i>	√	-	-	√	34
	<i>Habenaria loeringii</i>	√	-	-	-	8		<i>Phaius tankervilleae</i>	√	√	√	√	146
<i>Habenaria</i>	<i>Habenaria undulata</i>	-	-	-	√	2	<i>Plocoglottis</i>	<i>Plocoglottis acuminata</i>	√	-	-	√	189
<i>Hetaeria</i>	<i>Hetaeria sp.</i>	-	-	-	√	7	<i>Rhomboda</i>	<i>Rhomboda velutina</i>	-	-	-	√	6
	<i>Liparis javanica</i>	-	-	-	√	3	<i>Spathoglottis</i>	<i>Spathoglottis aurea</i>	-	-	-	√	3
<i>Liparis</i>	<i>Liparis rheedii</i>	√	-	-	√	75		<i>Spathoglottis plicata</i>	√	-	√	√	60
<i>Macodes</i>	<i>Macodes javanica</i>	-	-	-	√	2	<i>Tainia</i>	<i>Tainia paucifolia</i>	√	√	-	√	116
	<i>Malaxis junghuhnii</i>	-	-	√	-	10	<i>Tropidia</i>	<i>Tropidia curculigoides</i>	√	-	-	-	6
<i>Malaxis</i>	<i>Malaxis kobi</i>	-	-	√	-	6							

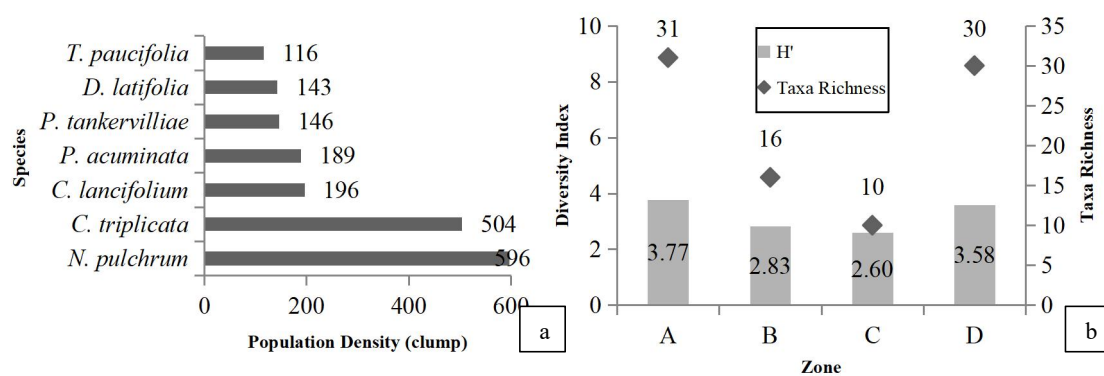


Figure 5. Profile of terrestrial orchids in the Orchids Garden of Ranu Darungan Resort BTSNP

Note: (a) Highest population density in seven species and (b) Diversity Index and Taxa Richness

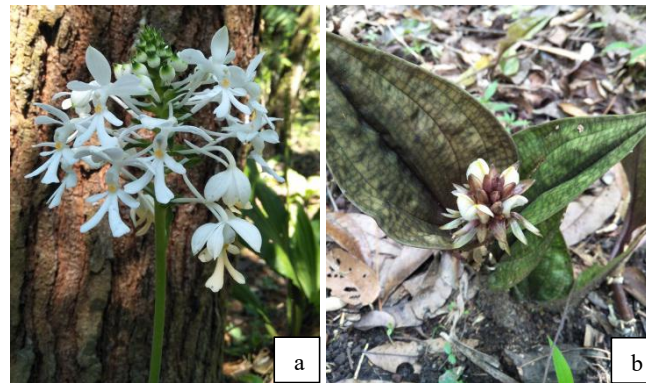


Figure 6. Terrestrial orchid species with the highest population density

Note: (a) *C. triplicata* and (b) *N. pulchrum*

We found five orchids that not yet be identified into species level. One of them was from the *Hetaeria*, three species of *Malaxis* and one of *Peristylus* based on identification book [5] as shown in Figure 7. The garden also collected several species of terrestrial orchids that was endemic in Java Island, including *Paphiopedilum javanicum*, *Acanthephippium javanicum*, *Liparis javanica*, and *Macodes javanica* [5] shown in Figure 8a-d. We also found an orchid species with two habitus (terrestrial and epiphytic) namely *Eria javanica* as shown in Figure 8e. This orchid grows as terrestrial orchid and attached to trees as epiphyte. Orchid *E. javanica* that found on the tree grows on the base trunk with a height not more than 2 m. According to [5, 16, 17, 18, and 19] *E. javanica* was an orchid with epiphytic habitus but we found *E. javanica* that lived on soil substrate, even though it was not far from the tree or under the tree shading.

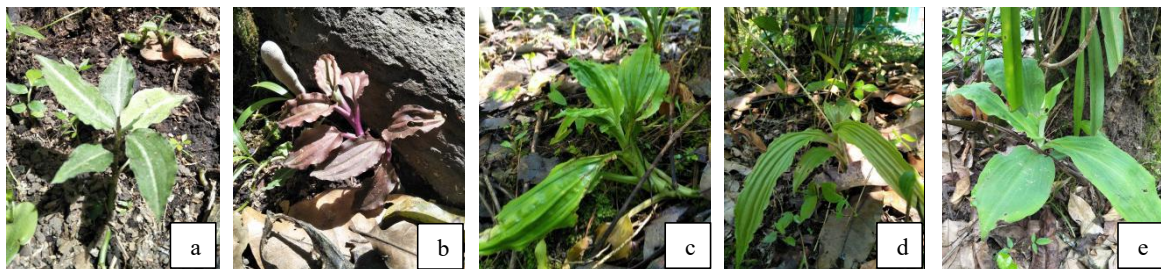


Figure 7. Unidentified orchid grown in the garden

Note: (a) *Hetaeria* sp., (B) *Malaxis* sp. 1, (c) *Malaxis* sp.2, (d) *Malaxis* sp.3 and (e) *Peristylus* sp.

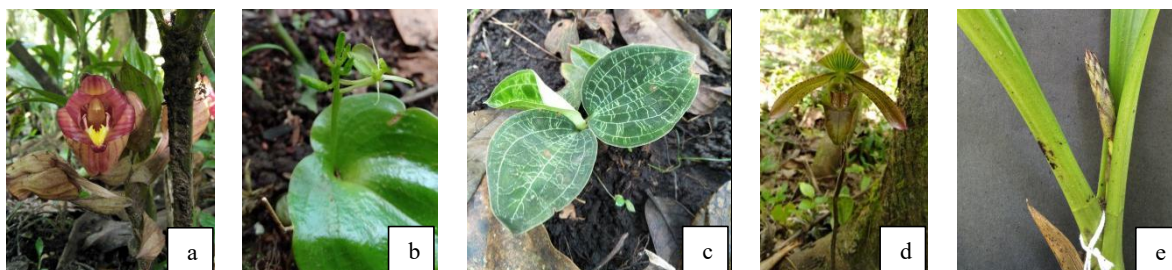


Figure 8. Five endemic orchid species of Java Island grown in the garden

Note: (a) *A. javanicum*, (b) *L. javanica*, (c) *M. javanica*, (d) *P. javanicum*, and (e) species with two habitats namely *E. javanica*.

The Orchids Garden of Ranu Darungan Resort BTSNP also collected some genetic diversity of orchids, such as in *A. graminifolia* and *Phaius amboinensis* as shown in Figure 9. Orchid *A. graminifolia* had two flower colors, the different color was in the lip of the labellum, purple and white color. This genetic variation could not be recorded by its stature, so it could only be distinguished when the flowers bloom. According to [5 and 10] these orchids were generally found with the purple to pink colored labellum lip, therefore it was different from a variant found in the Orchid Garden of Ranu Darungan Resort. This variant lip color of the labellum was also reported by [11] in Sumatra and reviewed by [12], which had white color in the lip of labellum. According to [12] the three flower color variants of *A. graminifolia* showed different flowering and pollination periods. The orchid *A. graminifolia* with pink and purple colored labellum lip had flowering and pollination faster than the white variant. This was also supported by research from [13], which explains that there were differences in the morphological structure of pollen from flowers with white lips and flowers with purple and pink lips. The form of spheroidal oblates found in white variants and spheroidal prolates in pink and purple variants.

The genetic diversty in *P. amboinensis* were evident both in the color, shape of the flower, and in the appearance of the orchid. The orchid *P. amboinensis* with white flowers had a thicker and wider leaf shape than *P. amboinensis* with yellow flowers. The distance between the nodes on the stem was longer *P. amboinensis* white variant than *P. amboinensis* yellow variant, so *P. amboinensis* white variant was higher than *P. amboinensis* yellow variant. According to [5] *P. amboinensis* was found with yellow flower and white labellum, but also found *P. amboinensis* with white flower and yellow labellum [15].

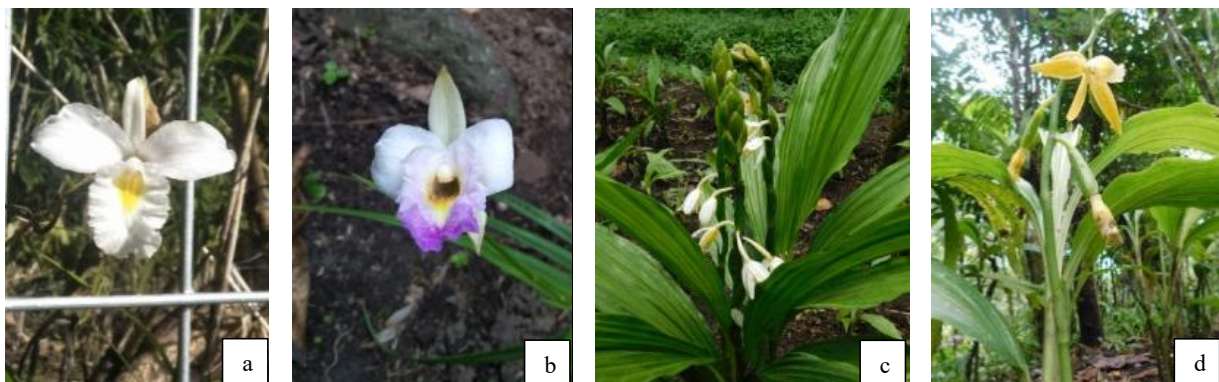


Figure 9. Some genetic diversity of terrestrial orchids recorded in the garden

Note: *A. graminifolia* (a and b) and *P. amboinensis* (c and d)

The Orchids Garden of Ranu Darungan Resort BTSNP also collected a natural hybrid from *C. triplicata* and *C. sylvatica* as in Figure 10, but this was only based on morphological characters, it was not yet verified by DNA testing. The natural hybridized orchid showed the flower shape like *C. triplicata*. However, the lip of labellum was more rounded almost similar to *C. sylvatica*. The color of this natural hybridized flower was purplish white and dominant purple in the column and labellum. According to [8] members of the genus *Calanthe* showed many natural hybrids, as found by [5] who reported a natural hybridization between *C. sylvatica* and *C. zolingeri*. There was also an artificial hybridization between *C. triplicata* and *C. sylvatica* in 1856. The hybrid flower had *C. triplicata* shaped flower but with a purplish pink colored flower similar to *C. sylvatica*. This hybridization process took place during 150 years to produce flower. This hybrid flower was called *Calanthe Dominyii* because it was taken from researcher John Dominy [14]. This orchid garden had a high diversity of species as well as genetic diversity.

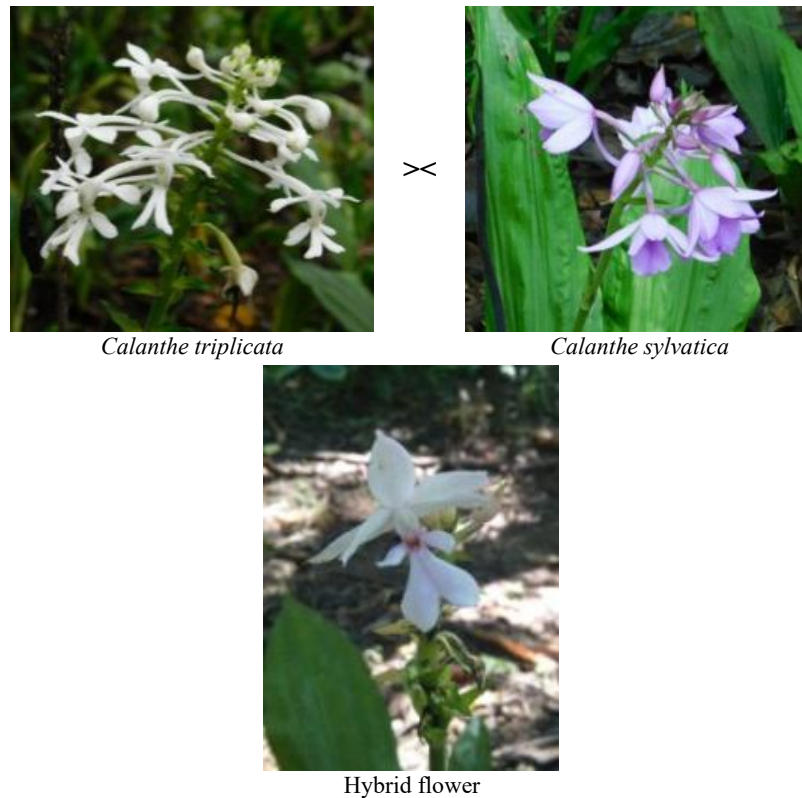


Figure 10. A natural hybrid of *C. triplicata* and *C. sylvatica* recorded in the garden

We also recorded in the garden a natural hybrid of *C. triplicata* and *C. sylvatica* as shown in Figure 11. The forms of sepal, tepal and labellum were similar as flower that we found in the orchid garden. However, the hybrid flowers that we found in the forest had more purple color and almost same to *C. sylvatica*. This hybrid had a length of flower ± 7.5 cm and a width of flower ± 5 cm. The following (Table 2) was a comparison of the size of parents (*C. triplicata* and *C. sylvatica*) [8 & 20] with the hybrid flowers.

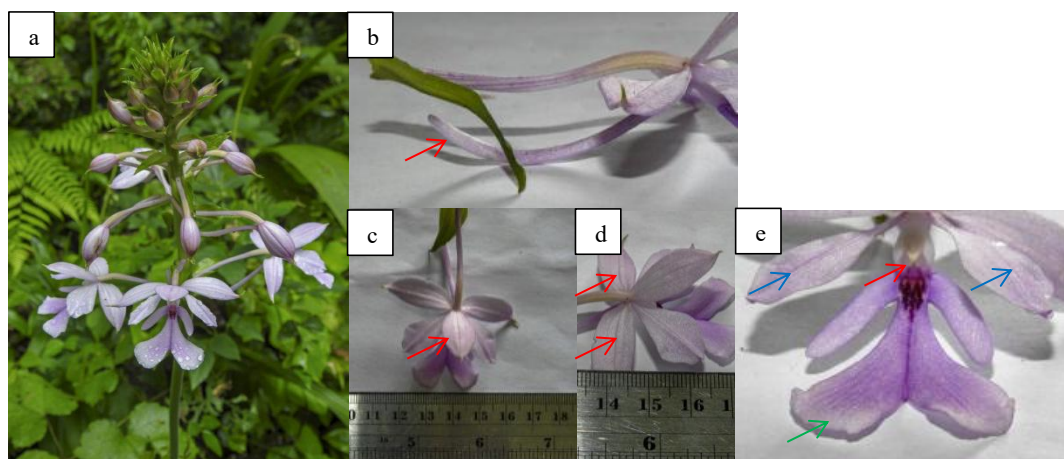


Figure 11. Hybrid flower between *C. triplicata* and *C. sylvatica* found in the garden

Note: (a) inflorescence, (b) spurs, (c) dorsal sepals, (d) lateral sepals, and (e) labellum (green), column (red), and petals (blue)

Table 2. Comparison flower size of parents with hybrid flowers

Parameter	<i>C. triplicata</i>	<i>C. sylvatica</i>	Natural hybrid
Sepals:			
-dorsal (cm)	1–1.2 × 0.45–0.55	2-2.6(-3) × 0.82-1.1(-1.3)	2.5-2.7 x 1-1.4
-lateral (cm)	1–1.3 × 0.5–0.6	2.1-2.5(-2.8) × 0.6-1(-1.2)	2-2.5 x 1-1.2
Petals (cm)	0.82-1.55 × 0.2-0.6(-0.8)	1.9-2.5 × 0.7-1.5	2-2.5 x 1-1.3
Labellum (cm)	1.4-2.2	1.7-2.6	2.8-3.3
Spurs (cm)	1.8-2.7(-4.8)	3-4.8	3.5-3.8

4. Conclusion

The Orchids Garden of Ranu Darungan Resort BTSNP was divided into four large zones named Zone A, B, C and D. Zone A and D were divided into 10 sub-zones, Zone B into 9 sub-zones and Zone C into 15 sub-zones. The garden had 45 species of terrestrial orchids from 26 genera. Orchids *N. pulchrum* and *C. triplicata* had the highest number of clumps. There were five orchids that could not be identified into the species level and there were four species endemic to Java Island. This garden also was grown an orchid species with two habitats named *E. javanica*. We recorded also genetic diversity in *A. graminifolia* with purple and white colored labellum lip, as well as *P. amboinensis* with white and yellow colored flower. It was also found the natural hybridization of *C. triplicata* with *C. sylvatica*, which the hybrid flower shape was similar to *C. triplicata* shaped flower but purplish white colored flower as *C. sylvatica*.

5. Acknowledgments

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