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# Mycoheterotrophic Plants of Gunung Halimun-Salak National Park, West Java, Indonesia

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## ABSTRACT

Gunung Halimun Salak National Park (GHSNP) is the largest protected tropical forest in West Java and has high plant diversity, including high diversity of mycoheterotrophic plants. Mycoheterotrophic plants (MHPs) are a unique group of the plants that have no chlorophyll and their sources of carbon are obtained through a symbiotic relationship with fungi. However, the information on the diversity of MHPs species in the GHSNP region is limited. In this paper, the description, distribution, and ecological preferences of MHPs species of GHSNP are presented. There are 33 MHPs species recorded in GHSNP region so far, consisting of 14 species of ferns and lycophytes, 16 species of monocotyledons, and 3 species of dicotyledons. From all of these species, one species (*Gastrodia crispa* J.J.Sm.) is endemic to Java. Therefore, the forest of GHSNP is important for the conservation of many MHPs species.

**Keywords:** Gunung Halimun Salak National Park, Mycoheterotrophic, Species Diversity

## INTRODUCTION

Mycoheterotrophic plants (MHPs) are a unique group of plants. Unlike the majority of plants which perform photosynthesis to obtain their source of carbon (C), MHPs get a carbon source from a symbiotic relationship with a fungus (Leake 1994, Cameron & Leake 2007, Merckx 2013). Similar to parasitic plants, MHPs also lack chlorophyll or have very low level of chlorophylls, extremely reduced leaves, and the production of many seeds (Cameron & Leake 2007). In the past, MHPs were commonly referred to as 'saprophytes', but this term is inappropriate because there is no evidence that the plants get a direct carbon source from organic material in the soil. In addition, the definition of 'saprophyte' for plants is often inconsistently applied (Leake 2005, Merckx 2013). In some recent literature, MHPs can be also called holomycotrophic plants (ex. Campbell 2014).

Currently MHPs occur in 17 families, 101 genera and 880 species (Merckx *et al.* 2013a). In particular, MHPs species are monocotyledons especially orchids (Leake 1994, Merckx *et al.* 2013a). The majority of MHPs species live in forest habitat that is shaded and damp. Therefore, MHPs species are very abundant in the tropics (Leake 1994).

Java is a tropical area in the Sundaland region rich in MHPs species, especially *Didymoplexis* and *Gastrodia* species (Merckx *et al.* 2013b). Some of these taxa are endemic to Java. In addition, new MHPs species have recently been found in the region (Tsukaya & Hidayat 2016, Metusala & Supriatna 2017). Nevertheless, MHPs species in Java are poorly known and little studied. On the other hand, the existence of MHPs species has become more threatened due to habitat destruction as the extent of Javan rainforest decreases. Therefore, an inventory, as well as a list of species are needed to know the latest condition of the Javan MHPs species.

One of the areas that are assumed as an important location for the MHPs species in Java is Gunung Halimun Salak National Park (GHSNP). GHSNP region which has an area of 113.357 ha is an important protected area for the remaining tropical rainforest in West Java. This National Park occurs at elevation of 500–2211 meter above sea level and very high rainfall ranging between 4000–6000 mm/year (Mirmanto *et al.* 2008). GHSNP also has considerable habitat preferred by tropical MHPs species, such as wet primary forests, from submontane to upper montane zones and bamboo forest. Until now, information on MHPs species in the region of GHSNP are scattered throughout the literature

and no one has completely documented these taxa. In this paper, for the first time, we provide information on all MHPs species recorded in GHSNP.

## MATERIAL AND METHODS

This study is based on an extensive survey of the literature, examination of herbarium specimen held at BO, and a few recent field explorations. The field explorations were carried out from 2010 until 2017 in Cikaniki-Citalahab trail and Cikudapaeh, especially in locations suspected to represent the habitat for tropical MHPs species, such as bamboo forest or dense forest with thick accumulated of litter (Leake 1994, Merckx *et al.* 2013b). The literature used to determine the species recorded in this paper was based from Jonker (1948), Backer & Bakh.f. (1963, 1965, 1968), Comber (1990), Uji (2002), Hidayat & Wiradinata (2003), Mahyar & Sadili (2003), Mirmanto *et al.* (2008), and Suetsugu *et al.* (2018).

The species included in this paper that are categorized as fully mycoheterotrophic. That is, only those species that depend solely on the carbon source from the fungus, in all phases of its life. These species can be characterized by the absence or lack of chlorophyll or by the absence of green leaves. Species of lycophytes and ferns that have mycoheterotrophic gametophyte are also included in the list, given the body of the gametophyte has a mode of life similar to full mycoheterotrophy species in general. That is, the source of carbon is dependent on the fungus (Leake 1994, Merckx *et al.* 2013a). Meanwhile, partial mycoheterotrophy species (living as autotrophy and mycoheterotrophy) and initial mycoheterotrophy species (mycoheterotrophy only at the stage of germination like most orchids) (Merckx 2013, Merckx *et al.* 2013a) are not included in the list.

List of MHPs species presented in this paper consists of scientific name, synonyms, species description, distribution, ecological information, and additional notes of related species. The species descriptions are adopted from various literature, such as Alderwerelt (1915), Backer & Bakh.f. (1965), Backer & Posthumus (1939), Boonkerd *et al.* (2005), Comber (1990), Jonker (1948), Lindsay & Middleton (2012), Verdcourt (2005), Zhang & Iwatsuki (2013), and Zhang *et al.* (2013). The classification for the group of lycophytes and ferns is based on PPG I (2016), whereas flowering plants are based on APG IV (2016). Classification of taxa in flowering plants is divided into monocotyledons and dicotyledons. Monocotyledons are the group that the seeds have one embryonic leaf or cotyledon, whereas dicotyledons have two cotyledons. In APG IV (2016), dicotyledons include basal angiosperms and eudicots group. For information on the family and genus included in the category of full mycoheterotrophy, referred to Leake (1994) and Merckx *et al.* (2013a).

## RESULT AND DISCUSSIONS

A total of 33 MHPs species belonging to 22 genera in 7 families has been recorded in GHSNP. Monocotyledons are a group of flowering plants that have the highest number of species in GHSNP (16 species). This result agrees with previous research, that the majority of MHPs species belong to monocotyledons, which is about 88% (Imhof 2010). Ferns and lycophytes consist of 14 species, with remainder of species belonging to dicotyledons (3 species). Considering the plant families, Orchidaceae has the highest number of species (13 species), followed by Lycopodiaceae (10 species). Seven out of 33 species were relocated during field exploration in 2010 to 2017. One species still needs to be further identified, that is *Didymoplexis* sp. (Orchidaceae) which was found on Cikaniki Trail (Fig. 1C.).

From the 33 species of MHPs in GHSNP, 13 species have a limited distribution in the western part of Java (see Appendix). From these species, *Didymoplexis striata* and *Gastrodia crispa* were regarded as endemic to Java (Comber 1990), but now only *G. crispa* is still considered endemic because *D. striata* was eventually also found in Borneo and Solomon Islands (Hsu *et al.* 2016). One species, *Gastrodia spathulata*, was recently discovered in GHSNP based on the Sadili & Komara 623 specimen that previously identified as *G. javanica*. *Gastrodia spathulata* occurs in Borneo (Mt. Kinabalu, Sabah) and Java (Cepak Datar-Leuwi Jamang, Res. Cigudeg, GHSNP) (Suetsugu *et al.* 2018).

[LYCOPHYTES AND FERNS]

## Lycopodiaceae

1. ***Diphasiastrum complanatum*** (L.) Holub, *Preslia* 47 (1975) 108  
*Lycopodium complanatum* L., *Sp. Pl.* 2 (1753) 1104; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 274; Zhang & Iwatsuki, *Fl. China* vol. 2–3 (2013) 30–31  
Main stems (stolon) completely or mostly subterranean; leaves on stolon spatulate or ovate; aerial shoots creeping, up to 100 cm. Lateral branches suberect, up to 15 cm tall, dichotomously branched with well-differentiated lateral branchlets much branched, branchlets obviously flattened; sterile branchlets light green or grayish green abaxially. Leaves arranged in 4 rows, dense, triangular, 1–2 × c. 1 mm, herbaceous, midrib indistinct, base appressed on branches, sessile, margin slightly involute, entire, apex acute. Strobili (1–)3–5(or 6), 1.5–3 cm long, terminal on peduncles (10–20 cm long), pale yellow, terete; sporophylls broadly ovate, imbricate, c. 2.5 × 1.5 mm, with irregular teeth, apex acute, caudate.  
**Distribution:** Cosmopolitan in northern temperate regions and alpine regions in the tropics.  
**Ecology:** Terrestrial on mountain slope, dry ground to marshy places, usually in open areas above 2000 m elevation.  
**Specimen examined:** BO186075 (*De Voogd s.n.*); BO186076 (*De Voogd s.n.*).
  
2. ***Huperzia serrata*** (Thunb. ex Murray) Trevis., *Atti Soc. Ital. Sci. Nat.* 17 (1875) 248; Zhang & Iwatsuki, *Fl. China* vol. 2–3 (2013) 18  
*Lycopodium serratum* Thunb. ex Murray, *Syst. Veg.* ed. 14 (1784) 944; Thunb, *Fl. Jap.* (1784) 341, t. 38; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 276–277  
Stems ascending with several erect branches, 8–20 cm tall, slender, 1–3 times dichotomously forked. Leaves elliptic to oblanceolate, 1.5–2.5 × 0.3–0.5 cm, patent, thin but firm in texture, deep green, margin irregularly serrate, midrib normally distinct. Strobilus indistinct. Sporophylls lanceolate, usually below apex of vegetative branches. Sporangia reniform, in the axils of sporophylls.  
**Distribution:** Widely distributed in South to East Asia, Malesia except New Guinea, Australia (NE Queensland), Pacific Islands including Hawaii, Mexico and Carribean Islands (Cuba and Haiti).  
**Ecology:** Terrestrial on humus-rich ground in evergreen forest above 1000 m elevation.  
**Specimen examined:** BO1456166 (*W.S. Hoover 30546, A. Sadali, & J. Hunter*); BO1522659 (*Afriastini 23*); BO1533660 (*MMJ van Balgooy 2863 & H. Wiriadinata*); BO187091 (*van Steenis 132*); BO187118 (*Raciborski s.n.*); BO187138 (*Backer 9233*); BO187139 (*Backer 10741*); BO1831613 (*Arief Hidayat 508*).  
**Notes:** Hidayat & Wiriadinata (2003) record this species as occurring in GHSNP.
  
3. ***Lycopodium clavatum*** L., *Sp. Pl.* 2 (1753) 1101; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 275; Zhang & Iwatsuki, *Fl. China* vol. 2–3 (2013) 30 – 31  
Stem subterranean, slender and creeping, 1 or 2 times forked, green, with sparse entire leaves; lateral branches erect, 20–25 cm tall, 3–5 times forked, sparse, flattened (young branches terete). Leaves spirally arranged, dense, angled upward, lanceolate, 4–6 × c. 1 mm long, leathery, with transparent hairs, midrib visible on both surfaces, base cuneate, decurrent, sessile, margin entire, apex acuminate. Strobili 2 or 3 together on a peduncle, peduncle up to 12 cm long, bracts of peduncle spirally arranged, sparse, herbaceous, narrowly lanceolate; strobili erect, terete, 3.5–4.5 × c. 0.4 cm, subsessile or with short, equally long pedicels; sporophyll broadly ovate, c. 1.5 × 1.3 mm, papery, margin membranous, erose, apex acute, with short acute tip.  
**Distribution:** Cosmopolitan.  
**Ecology:** Terrestrial on wet ground on hill slopes, grasslands or roadsides, in fully exposed areas, above 1200 m elevation.  
**Specimen examined:** BO185868 (*JJ Smith 386*); BO1523996 (*Backer s.n.*); BO1524015 (*De Voogd s.n.*).
  
4. ***Phlegmariurus carinatus*** (Poir.) Ching, *Acta Bot. Yunnan.* 4 (1982) 120; Zhang & Iwatsuki, *Fl. China* vol. 2-3 (2013) 28  
*Huperzia carinata* (Desv. ex Poir.) Trevis., *Atti Soc. Ital. Sci. Nat.* 17 (1875) 247

*Lycopodium carinatum* Desv. ex Poir., *Encycl. suppl.* 3 (1813 [1814]) 555; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 278

Stems at least 50 cm long, slender, 1–3 times dichotomously forked. Leaves narrowly lanceolate, apex subulate, base attenuate, sessile, about 1.25 × 0.13 cm, chartaceous in texture, margin entire, appressed and revolute, midrib indistinct. Strobilus indistinct. Sporophylls about the same size as microphyll, oblong subdeltoïd, to 5 mm long, 1.5 mm wide.

**Distribution:** South China, Ryukyu Isl., Taiwan, Indochina, Malesia and Polynesia.

**Ecology:** Epiphyte on mossy-tree trunk in shady places and humid areas.

**Specimen examined:** BO185203, BO185204 (*Backer* 1230).

5. *Phlegmariurus phlegmaria* (L.) Holub, *Preslia* 36(1) (1964) 21; Zhang & Iwatsuki, *Fl. China* vol. 2-3 (2013) 22

*Huperzia phlegmaria* (L.) Rothm., *Fedde, Repert.* 54 (1944) 62

*Lycopodium phlegmaria* L., *Sp. Pl.* 2 (1753) 1101; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 273 – 274

Stems at least 80 cm long, 1–3 times dichotomously forked. Leaves narrowly lanceolate to oblong-lanceolate, apex acuminate, base rounded to truncate, patent, about 0.5–1.6 cm × 0.15–0.6 cm, texture coriaceous, light green to yellowish green glossy, margin entire, midrib distinct on both surface. Fertile branches repeated 2–4 times dichotomously forked, bearing 4–8 strobili at apex of a sterile branch. Strobilus distinct at apex of vegetative branches, 5.5–12.5 cm long.

**Distribution:** Widely distributed in the Old World tropics.

**Ecology:** Epiphyte on mossy-tree trunk in shady places and humid areas at medium and high altitudes.

**Specimen examined:** BO1515203 (*Dransfield* 4211); BO1517967 (*Dransfield* 4257); BO1528946 (*S. Yoshida* 1533); BO-186747 (*Raciborski s.n.*); BO1831616 (*Arief Hidayat* 522); BO186721 (*Backer* 1336); BO186724 (*Backer* 9365); BO186688 (*Backer* 10674); BO1515170 (*M.A. Donk s.n.*); BO1527685 (*M.A. Donk s.n.*); BO186637 (*Backer* 25866); BO1517692 (*Raciborski s.n.*); BO1456218 (*W.S. Hoover* 32803, *M.Hendra*, & *J. Hunter*); BO145622 (*W.S. Hoover* 32694, *M.Hendra*, & *J. Hunter*); BO31493 (*H.Wiriadinata* 31493, *W.S. Hoover*, & *J. Hunter*); BO1528955 (*Bakhuizen van den Brink* 3215); BO1528945 (*Afriastini* 19); BO186649 (*Backer* 23256); BO1515162 (*Schiffner s.n.*); BO186488 (*leg.ign s.n.*); BO1508739, BO1508738 (*MMJ van Balgooy* 2932 & *H. Wiriadinata*).

**Notes:** Uji (2002) and Hidayat & Wiriadinata (2003) found this species at GHSNP. In addition, we found this species at Cikaniki trail, GHSNP, in 2014 & 2017.

6. *Phlegmariurus pinifolius* (Trevis) Kiew, *Phytokeys* 96 (2018) 108

*Huperzia pinifolia* (Bl.) Trev., *Atti Soc. Ital. Sci. Nat.* 17 (1875) 247

*Lycopodium pinifolium* Bl., *Enum. Pl. Jav.* 2 (1824) 264

Stems at least 15–35 cm long, pendulous, 1–3 times dichotomously forked. Leaves narrowly ovate, apex acute, narrowing towards sessile base, patent, about 0.6–1.5 × 0.4–0.6 cm, chartaceous in texture, margin entire, midrib more or less distinct on lower surface. Strobilus indistinct to slightly distinct. Sporophylls usually patent, the same shape as microphylls, but much reduced in size.

**Distribution:** Sri Lanka, Thailand, Peninsular Malaysia, Borneo, Philippines, Sulawesi, Java, Moluccas (Seram), Sumatra, Solomon Isl., Santa Cruz Isl. (Vanikoro), and Vanuatu.

**Ecology:** Epiphyte on mossy-tree trunk in evergreen forest.

**Specimen examined:** BO1456221 (*W.S. Hoover* 32694, *M.Hendra*, *J. Hunter*); BO186859 (*Backer* 9288); BO186904 (*Bakhuizen van den Brink* 3649).

**Notes:** Uji (2002) recorded this species from GHSNP. This species was recently transferred to *Phlegmariurus* from *Huperzia* (Kiew & Kamin 2018).

7. *Phlegmariurus proliferus* (Bl.) A.R.Field & Bostock, *Phytokeys* 20 (2013) 46

*Huperzia prolifera* (Bl.) Trev., *Atti Soc. Ital. Sci. Nat.* 17 (1875) 248

*Lycopodium proliferum* Bl., *Enum. Pl. Jav.* 2 (1828) 265; Alderw., *Malayan Fern Allies* (1915) 36 – 37

Stems pendulous, once or twice dichotomously branched, 15–45 cm long. Leaves ascending, crowded, linear-lanceolate, 10–15 mm long, acute, entire, subrevolute at the edge, the costa

obscurely prominent above or beneath, grooved on the other side, the base decurrent, the higher leaves growing gradually shorter. Sporophyll about ½ as long as the microphylls, similar shape with microphylls or ovate-lanceolate.

**Distribution:** Peninsular Malaysia (Perak, Pahang), Java, Borneo (Sabah), Sulawesi, Lesser Sunda Islands (Lombok), Moluccas (Seram) and Solomon Isl.

**Ecology:** Epiphyte on mossy-tree trunk in primary or secondary forest.

**Specimen examined:** BO186883 (*Raciborski s.n.*); BO1831637 (*Arief Hidayat* 547); BO1522646 (*van Steenis* 12454); BO186837 (*Bakhuizen van den Brink* 3214); BO186886 (*Raciborski s.n.*).

**Notes:** This species recorded from GHSNP by Hidayat & Wiriadinata (2003).

8. *Phlegmariurus squarrosus* (G. Forst.) Löve & Löve, *Taxon* 26 (1977) 324; Zhang & Iwatsuki, *Fl. China* vol. 2–3 (2013) 26

*Huperzia squarrosa* (G. Forst.) Trev., *Atti Soc. Ital. Sci. Nat.* 17 (1875) 247

*Lycopodium squarrosum* G. Forst., *Fl. ins. austr. Prodr.* (1786) 479; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 278

Stems at least 15–60 cm long, 1–3 times dichotomously forked. Leaves ± linear, apex acuminate, patent, 1.0–1.5 × 0.1–0.2 cm, coriaceous texture, margin entire, midrib more or less distinct on both surfaces. Strobilus indistinct. Sporophylls usually smaller than the microphylls, at the apex of vegetative branches, narrowly oblong to linear; sporangia reniform.

**Distribution:** Madagascar and Indian Ocean Islands, South to East Asia, throughout Malesia, Australia (NE Queensland) and Pacific Islands.

**Ecology:** Epiphyte on mossy-tree trunk or in rock crevices in shady or slightly exposed places above elevation of 1200 m

**Specimen examined:** BO187227 (*Raciborski s.n.*); BO187334, BO187335, BO1518334 (*Backer* 25885); BO1522428, BO187223, BO187224 (*Backer* 9176); BO1522430, BO187225 (*Backer* 10879); BO187247 (*leg.ign. s.n.*); BO1831639 (*Arief Hidayat* 515).

**Notes:** This species cited in GHSNP by Hidayat & Wiriadinata (2003). In addition, we found this species at Cikaniki trail, GHSNP, in 2017.

9. *Phlegmariurus verticillatus* (L.f.) A.R.Field & Testo, *Molec. Phylogen. Evol.* 94(B) (2015) 645

*Huperzia verticillata* (L.f.) Trev., *Atti Soc. Critt. Ital.* 17 (1875) 248; Verdcourt, *Fl. of Tropical East Africa: Lycopodiaceae* (2005)

*Lycopodium verticillatum* L.f., *Suppl. Pl.* (1782) 448; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 278

Stems pendulous or occasionally on rocks; rooting stem 4–6 cm long, branching dichotomously several times, first branching at c. 4–8 cm from root; total length 25–50 cm long, 3–6(–10) mm wide near base, 2–3 mm wide at apex. Leaves ± adpressed to spreading, linear, 5–6(–10) mm long, 0.2–0.5 mm wide, with distinct midrib. Sporophylls similar with microphylls. Sporangia can occur all along the stems but mainly in the upper parts, not hidden, 2–2.5 mm wide.

**Distribution:** Throughout the tropical regions of the world. In Malesia, it has been recorded from Peninsular Malaysia (Pahang and Selangor), Java and Borneo (Sabah and Sarawak).

**Ecology:** Around 950–2100 m elevation.

**Specimen examined:** BO1529047 (*M.A. Donk s.n.*); BO1831636 (*Arief Hidayat* 548); BO187463 (*Raciborski s.n.*); BO187464 (*Bakhuizen van den Brink* 6646); BO187462, BO187462 (*Bakhuizen van den Brink* 4008); BO187458, BO187459, BO187460 (*Backer* 10727).

**Notes:** Hidayat & Wiriadinata (2003) found this species at GHSNP.

10. *Pseudodiphasium volubile* (G.Forst.) Holub, *Folia Geobot. Phytotax.* 18 (1983) 442

*Lycopodium volubile* G.Forst., *Prodr.* (1786); Backer & Posthumus, *Varenfl. voor Jav.* (1939) 274

Main stems scandent, branched, up to 5 m long, wiry, flexuose, with scattered minute appressed lvs. Leaves dimorphic. Lateral leaves flattened, subdistichous, spreading, 3–5 mm. long, lanceolate with broad decurrent base, ascending, falcate, acuminate, midrib evident; other leaves minute, linear, appressed. Strobili 2–10 cm long, terminal on paniculate branchlets. Sporophylls small, broad-ovate, abruptly narrowed to subulate tip.

**Distribution:** Peninsular Malaysia (Pahang), Borneo, Philippines, Java, Sulawesi, Lesser Sunda Isl. (Lombok), Moluccas (Seram), New Guinea, Solomon Isl., Vanuatu, Australia (NE-Queensland), New Caledonia, Society Isl. (Tahiti) and New Zealand (including the Kermadec and Chatham Isl.).

**Ecology:** Climbing on other plants, in light shade, at above 1500 m elevation.

**Specimen examined:** BO1540889 (*De Voogd s.n.*); BO1462041 (*Hovenkamp 552*); BO1538948 (*van Steenis 8261*); BO1534877, BO187546 (*Raciborski s.n.*); BO187517, BO187518 (*Bakhuizen van den Brink 4157*).

## Ophioglossaceae

### 11. *Ophioderma pendula* (L.) Presl, *Suppl.* 56 (1845)

*Ophioglossum pendulum* L., *Sp. ed. II*, 2 (1763) 1518; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 269; Zhang *et al.*, *Fl. China* vol. 2-3 (2013) 78

Leaves 1-3 or more. Sterile lamina sessile, pendulous and ribbonlike, usually lanceolate, sometimes dichotomously divided, up to 30-50(-100) × 1-3 cm; veins reticulate, without distinct midrib, forming diagonal and hexagonal areoles; veinlets ± visible. Sporophore arising from near base or middle part of sterile lamina and never longer than sterile lamina, pendent; stalk to 7 cm, spike 5-30 cm; sporangia 40-200 on each side.

**Distribution:** W. Africa, Sri Lanka, India, China, Taiwan, Korea, Japan, Malaysia, Philippines, Indonesia, Australia, Hawaii Isl.

**Ecology:** Epiphyte on tree trunks in tropical rain forests.

**Specimen examined:** BO1516153, BO1519771 (*Backer 10633*); BO1516108 (*MMJ van Balgooy 2941 & H. Wiradinata*); BO1830141 (*Arief Hidayat 542*); BO1519797 (*van Steenis 160*); BO1519809 (*Backer 25887*).

**Notes:** Hidayat & Wiradinata (2003) found this species at GHSNP.

### 12. *Ophioglossum reticulatum* L., *Sp. Pl.* 2 (1753) 1063; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 268 - 269; Zhang *et al.*, *Fl. China* vol. 2-3 (2013) 79

Plants 10-30 cm tall. Rhizomes erect, slender, bearing a few thick fleshy roots. Common stalk 4-8 cm, light green, gradually pale toward base. Sterile lamina with a short stalk or almost sessile, ovate or orbicular-ovate, 3-4 × 2.6-3.5 cm, herbaceous, base deeply cordate, margin ± wavy, apex rounded or subobtuse; veins distinct, reticulate. Sporophore arising from base of sterile lamina, slender, 10-15 cm long; spike 3-3.5 cm long, slender.

**Distribution:** Widely distributed in the tropics and subtropics regions of the world.

**Ecology:** Terrestrial in shaded forest or open places.

**Specimen examined:** BO1522234 (*Bakhuizen van den Brink 2833*); BO1522245 (*Bakhuizen van den Brink 6306*); BO1522162 (*Bakhuizen van den Brink 5306*); BO1462034 (*Hovenkamp 562*).

### 13. *Sceptridium daucifolium* (Wall. ex Hook. & Greville) Lyon, *Bot. Gaz.* 40

*Botrychium daucifolium* (Wall.) Hook. & Grev.,  *Ic. Fil.* 2(9) (1830) t. 161; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 271; Zhang *et al.*, *Fl. China* vol. 2-3 (2013) 76

Stems or rhizomes erect, bearing many fleshy roots. Leaves 30-40 cm tall with stalk 10-12 cm. Lamina bipinnate to tripinnatifid, subpentagonal, 15-20 × 16-24 cm, herbaceous; pinnae 6 or 7 pairs, alternate; basal pinnae largest, triangular, 12-14 × 6-10 cm, bipinnatifid; pinnules 4 or 5 pairs, narrowly ovate to broadly lanceolate, lower basal pinnule largest, up to 8 × 3 cm, pinnatifid, ultimate segments sharply serrate, apex acute or acuminate; veins obvious, rachis and costae with sparse, white, long hairs. Sporophore arising from above middle of common stipe, 10-12 cm long, more or less as long as sterile lamina, with stalk 14-16 cm long, bi-tripinnate.

**Distribution:** India (NE and S), Sri Lanka, Himalayan region (Bhutan and Nepal), Myanmar, Vietnam, Sumatra, Peninsular Malaysia, Java, Borneo, Philippines, Sulawesi, Lesser Sunda Isl. (Bali, Flores), Moluccas (Seram).

**Ecology:** Terrestrial in shaded wet places, forest.

**Specimen examined:** BO-1409558 (*Raciborski s.n.*); BO-1830216 (*Arief Hidayat 577*).

**Notes:** Hidayat & Wiradinata (2003) found this species at GHSNP.



**Psilotaceae**

14. *Psilotum complanatum* Sw., *Schrad., J. Bot.* 1800(2) (1801) 110; Backer & Posthumus, *Varenfl. voor Jav.* (1939) 286; Lindsay & Middleton, *Ferns of Thailand, Laos and Cambodia* (2012)

Rhizomes creeping. Aerial stems and branches flattened with a distinct midrib, usually 20–100 cm long, exceptionally to 2 m long, lower unbranched part 9–36 cm long and 2–4 mm wide, upper branches (13–)35(60) cm long, 2–4 cm wide, synangia inset laterally giving the stem a jagged appearance, appendages lateral and alternate, 1–2 mm long. Synangia 1(–3) mm diameter, yellowish green becoming yellow when mature.

**Distribution:** Widely distributed throughout the tropical regions of the world.

**Ecology:** Epiphyte on tree trunks in light shade.

**Specimen examined:** BO1876922 (*M.A. Donk* P321); BO1876923 (*Bakhuizen van den Brink* 405); BO1876935 (*J.G.B. Beumee* 53a); BO1548775 (*W.C. van Hennig s.n.*); BO1542774 (*Bakhuizen van den Brink* 6648); BO1548819 (*Bakhuizen van den Brink s.n.*); BO1540168 (*leg.ign. s.n.*); BO1540167 (*van Slooten* 696).



**Figure 1.** Some Mycoheterotrophic plants in Gunung Halimun Salak National Park. A. *Gymnosiphon aphyllus*. B. *Cyrtosia javanica* (photo from Central Java specimen). C. *Didymoplexis* sp. D. & E. *Epipogium roseum*. F. *Gastrodia crista*. Photo by: W.A. Mustaqim.



## [ANGIOSPERMS – MONOCOTYLEDONS]

**Burmanniaceae**

15. *Burmannia lutescens* Becc., *Malesia I* (1877) 246; Jonker, *Fl. Malesiana* 4, 1 (1948) 19

*Gonianthes candida* Bl., *Cat. Gew. Buitenzorg* (1823) 20

*Gonyanthes candida* Bl., *Flora* 8 (1825) 123.

Achlorophyllous herbs, up to 23 cm. Stem thickly filiform to robust, simple or branched, usually bearing 1 flower or forked into inflorescences. Leaves reduced into small scale, 1–3.5 mm long. Flowers 3-winged, white, limb sometimes yellow or bluish, perianth tube trigonous, 2.5–5 mm long, inner perianth present although sometimes very small, perianth persistent in fruit. Stamens 3, connective without basal spur. Ovary 3-celled. Style thick, bearing 3-subsessile, funnel-shaped to bowl-shaped stigmas.

**Distribution:** Sumatra, Peninsular Malaysia, Java, Borneo and New Guinea (including New Ireland).

**Ecology:** Usually in the humus of shady moist forest, up to 1500 m.

**Specimen examined:** 400.15, BO1846407 (*K.B. Boedijn s.n.*); 400.19, BO1568339 (*Leeuwen-Reijnvaan* 8278); BO1568347 (*Bakhuizen van den Brink* 697); BO1845598 (*Raciborski s.n.*); BO1845599 (*R.H.C.C Schffer s.n.*).

**Notes:** This species known previously in GHSNP by Jonker (1948) and Mirmanto *et al.* (2008).

16. *Gymnosiphon aphyllus* Bl., *Enum. Pl. Jav.* 1 (1827) 29; Jonker, *Fl. Malesiana* 4, 1 (1948) 20.

*Gymnosiphon borneense* Becc., *Malesia I* (1877) 241

*Gymnosiphon pedicellatum* Schltr., *Bot. Jahrb.* 49 (1913) 105.

Achlorophyllous herbs, with stem to 17 cm, forked into a bifid cincinnus or bearing a simple cincinnus. Leaves reduced to scales, appressed, 1–1.5 mm long, acute. Inflorescences a loose, many flowered cincinni or bifid cincinni, many flowered. Flowers pedicellate, 1–5 mm long. Perianth white or lilac, tube cylindrical or trigonous, 4 mm long, limb c. 2.5 mm long, outer ones ovate, inner ones linear-lanceolate, minute, perianth deciduous in fruit. Stamens 3, anthers inserted above the middle of the perianth, sessile. Ovary 1-celled. Capsule about 3 mm long. – **Fig. 1A.**

**Distribution:** Southern Thailand and throughout Malesia.

**Ecology:** On humus, decaying wood or leaves in the shade moist forests, below 1500 m

**Specimen examined:** 401.24 (*Bakhuizen van den Brink* 4240).

**Notes:** This species still found in GHSNP at 2017.

17. *Thismia javanica* J.J.Sm., *Ann. Jar. Bot. Btzg.* 23 (1910) 32; Jonker, *Fl. Malesiana* 4, 1 (1948) 23.

Achlorophyllous herbs, stem simple or branched, up to 12 cm, 1–5-flowered. Leaves reduced to scales, 3 mm long, acute. Flower subtended by 3 involucre bracts. Flowers with perianth tube urceolate, longitudinal stripes 12, orange, inside with longitudinal bars connected by transverse bars, outer perianth lobes obtuse, ovate, inner perianth lobes free, triangular, terminated in up to 3 cm long, filiform tentacles. Stamens 6, anthers 3-toothed at the free apical margin, each terminating in a hair. On the outer side of the anther, inserted in the middle, a quadrangular appendages present, wider than stamen. Style orange, stigma sessile. Ovary obovoid. Capsule orange, c. 6 mm long. Seeds ellipsoid.

**Distribution:** Sumatra and Java (West).

**Ecology:** Humus, shaded forest, below 1000 m

**Vernacular name:** Angkrek rambut (Java).

**Notes:** This species still occurs on the Tanjakan Cikudapaeh trail, at 2017.

**Orchidaceae**

18. *Aphyllorchis pallida* Blume, *Tab. Pl. Jav. Orchid.* (1825) Set. 77.

All part glabrous, about 30 cm tall. Inflorescence erect, with 7–10 flowers. Flowers c. 4 mm across, not opening widely; dorsal sepal concave, oblong, c. 4.7 × 1.0 mm, acute; lateral sepals oblong ovate c. 4 × 1.3 mm, acute; petals elliptic oblong, slightly oblique, c. 4.5 × 2 mm, obtuse; lip c. 4 × 2 mm;

hypochile concave, 1.3 mm long; epichile 3-lobed, 2.6 mm long; column obovoid-cylindrical, slightly arcuate.

**Distribution:** Thailand, Vietnam and Malesia. In Malesia, it was recorded from Sumatra, Peninsular Malaysia, Java, Borneo and the Philippines.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO0045487 (*Bakhuizen van den Brink* 5970).

19. *Cyrtosia javanica* Blume, *Bijdr. Fl. Ned. Ind.* (1825) 396, pl. 6

Plant small, c. 10 cm tall. Stem 1 or 2 arising from a rhizome, erect, 6–8 cm tall, with implicate scales at nodes. Inflorescence racemose, 5–7 flowers. Flowers not fully opening, yellowish brown, fleshy; dorsal sepal oblong c. 16 × 8 mm, slightly concave; lateral sepals broadly ovate c. 16 × 9 mm; petals oblong, c. 15 × 7 mm; lip adnate to base of column, suborbicular with thickened disk; column clavate c. 8 mm, winged at apex. – **Fig. 1B.**

**Distribution:** Widely distributed in Southeast Asia (including Taiwan) and throughout the regions of Malesia.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** 716.1 (*A.J.P. Oort s.n.*); 716.2 (*van Leeuwen* 8270); BO0068841 (*Nangnong s.n.*).

**Notes:** Mahyar & Sadili (2003) recorded also this species in GHSNP area. We also found this species at Cikaniki area in 2012.

20. *Cystorchis aphylla* Ridl., *J. Linn. Soc. Bot.* 32 (1896) 400.

Plant erect, c. 15 cm tall. Inflorescence 2–17-flowered. Flowers brownish; sepals 6 mm long, lateral with swollen bases enclosing the spur of the lip forming a short 2 mm long mentum; lip as long as sepals, narrow, basal part concave, middle part narrower and densely papillose, tip small obtuse separated by a small constriction; column short.

**Distribution:** Thailand and Malesia as far as Moluccas.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** 581.4, BO0112042 (*Bakhuizen van den Brink* 5982).

**Notes:** Mahyar & Sadili (2003) recorded also this species in GHSNP area.

21. *Didymoplexis striata* J.J.Sm., *Icon. Bogor.* (1903) t. 104 B

Plant small, erect. Inflorescence with 2–3 flowered. Flower 6–7 mm wide, brownish; lateral sepals triangular, falcate, concave, joined together at basal half, obtuse; petals and dorsal sepal joined together for most of its length, free parts triangular, obtuse; lip ovate to elliptic, rounded to obtuse; column straight.

**Distribution:** Thailand, Java, Borneo and Solomon Isl.

**Ecology:** Humid, shaded habitat.

**Notes:** This species mentioned in GHSNP area by Backer & Bakh.f. (1968) and Comber (1990). In Java, only found in Mt. Salak without elevation record.

22. *Eulophia zollingeri* (Rchb.f.) J.J.Sm., *Orch. Java* (1905) 228

Plant 15–80 cm tall, tuberous. Inflorescence brownish red, erect, racemose, with several clasping sheaths, c. 8–20 flowered. Flowers dull purple-red to brownish yellow, 2.5–3 cm in diam; dorsal sepal elliptic oblong, 15–23 × 4–7 mm, acuminate; lateral sepals suboblong, slightly oblique, 16–25 × 6–9 mm, acuminate; petals oblanceolate, 11–18 × 5–7 mm, mucronate; lip adnate to column foot, subobovate to oblong-obovate, 14–15 × 15–18 mm, trilobed, very shortly saccate-spurred at base; column c. 5 mm.

**Distribution:** Distributed widely from tropical to subtropical Asia and also in Australia.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO0066303 (*Backer* 22169).

23. *Epipogium roseum* (D.Don) Lindl., *J. Proc. Linn. Soc., Bot.* 1 (1857) 177

Plant 10–45 cm tall, tuberous. Inflorescence 2–16 flowered, floral bract ovate-lanceolate. Flowers resupinate, pendulous, opening widely or not, white with faint purple spots on lip; sepals linear-

lanceolate 8–11 × 2–3 mm, subacute; petals similar to sepals, slightly oblique, 7–10 × 2–3 mm, acute to acuminate; lip elliptic-ovate, concave, 8–12 × 6–7 mm, spurred at base; column 2.5–4.5 mm long. – **Fig. 1D–E.**

**Distribution:** Widespread from Tropical Africa to Tropical Asia as far as New Guinea, also in Australia and Pacific Islands (Vanuatu).

**Ecology:** Open or shaded habitat.

**Specimen examined:** BO0064586 (*A. Rant s.n.*); BO0064578 (*Middeloer s.n.*); BO0064584 (*Backer 10793*).

**Notes:** We also found this species two times, in 2014 and 2017.

24. *Gastrodia crispa* J.J.Sm., *Bull. Jard. Bot. Buitenzorg* III, 3 (1921) 248

Plant erect, c. to 30 cm tall, 2–6 flowered. Flower 1.75 cm long, pale greenish-brown, with some warty outside; sepals and petals united into an oblong campanulate tube; sepals petals all joined together with free part of sepals oblong obtuse and petals ovate obtuse; lip c. 7–8 mm long with two callus; column 6–7 mm long, truncate. – **Fig. 1F.**

**Distribution:** Endemic to West Java.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO1371668 (*Asep Sadili 239 & Nurdin*); BO1371669 (*Asep Sadili 270 & Nurdin*); BO1416068 (*Asep Sadili 242 & Nurdin*).

**Notes:** This species found in GHSNP area by Comber (1990), Mahyar & Sadili (2003), and our personal observation (2014, 2017).

25. *Gastrodia javanica* (Blume) Lindl., *Gen. Sp. Orchid. Pl.* (1840) 384

Plant erect, c. to 70 cm tall, 10–12 flowered. Flower 1.5 cm long, pale dull purplish brown-inside with yellow lines on the lateral sepals; sepals petals all joined together except for free tips about 3 mm long, the lateral sepals separated at base; lip narrowly diamond-shaped, the sides raised; column straight, as long as the lip.

**Distribution:** Thailand, Sumatra, Peninsular Malaysia, Java, Borneo, Philippines and Lesser Sunda Islands.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO0066494 (*Bakhuizen van den Brink 5272*).

26. *Gastrodia spathulata* (Carr) J.J.Wood, *Orchids Mount Kinabalu* 2 (2011) 355

*Neoclemensia spathulata* Carr, *Gardens' Bull.* 8 (1935) 180, fig. 45; Wood *et al.*, *The plants of Mount Kinabalu: 2. Orchids* (1993) 265

Plant erect, tuberous. Rhizome cylindrical, villose. Inflorescence erect, terminal, laxly 2–3 flowered; floral bracts appressed to pedicel. Flower medium-sized, white with orange petals and greenish-brown lip; sepals adnate, forming a tube, recurved and papillose at apex; petals adnate at base to lateral sepals, much shorter than sepals, linear-spathulate, fimbriate; lip adnate to base of column, entire, clawed, claw oblong or subquadrate and bearing 2 subglobose; column stout, with acute stelidia (description based Wood *et al.* 1993).

**Distribution:** Java (West, only from Leuwi Jamang, GHSNP) and Borneo (Sabah, only from Mount Kinabalu).

**Ecology:** Humid, hill forest, elevation 1100 m

**Specimen examined:** BO1405196 (*Asep Sadili 623 & Dian Komara*).

**Notes:** This species has been reported recently in Java (Suetsugu *et al.* 2018).

27. *Gastrodia verrucosa* Blume., *Mus. Bot.* 2 (1856) 175

Plant erect, tuberous, c. 10 cm long. Inflorescence 2–4 flowered, fleshy, with 2–3 tubular sheaths. Flower pale pinkish-brown, warty outside; sepals and petals united into a short campanulate tube; sepals with the free parts orbicular-ovate; petals orbicular ovate, lip attached below sinus between lateral sepals, ovate-lanceolate, 6–7 × 4–5 mm, obtuse to acute, margin irregular dentate; column 7–8 mm long with triangular-acute wing on each side.

**Distribution:** Thailand, Sumatra, Peninsular Malaysia and Java.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO0066385 (*leg.ign. s.n.*).

28. *Lecanorchis javanica* Blume, *Mus. Bot.* 2 (1856) 188

Plant erect, thin, angular, 8.5–40 cm long. Flowers opening widely, 1.6 cm wide; dorsal sepal reflexed, lanceolate, concave, 8 × 2 mm, obtuse; lateral sepals obliquely lanceolate, concave, 8–9 × 2–3 mm, obtuse; petals recurved, lanceolate to spatulate, concave, 8 × 2–3 mm, obtuse; lip 9 mm long, midlobe obovate-triangular, crenulate-finely erose; column slender, clavate, 5–6 mm long.

**Distribution:** Thailand, Vietnam, Peninsular Malaysia and Java (West).

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO1416072 (*Uway W. Mahyar & A. Sadili* 277); BO0069689 (*Dransfield* 4239).

**Notes:** This species mentioned found in GHSNP area by Mahyar & Sadili (2003) and Mirmanto *et al.* (2008).

29. *Lecanorchis multiflora* J.J.Sm., *Bull. Jard. Bot. Buitenzorg* II, 26 (1918) 8

Plant c. 60 cm long, sometimes branched. Inflorescence many flowered. Sepals and petals opened widely, pale green or white, 9–10 × 3 mm. Lip trilobed, 8–10 mm long, sidelobes rounded, midlobe rounded covered with white hairs and two low keels, column 6 mm long.

**Distribution:** China, Thailand, Sumatra, Peninsular Malaysia, Java and Borneo.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO1407626 (*A. Sadili* 407 & *Nurdin*); BO1416073 (*Uway W. Mahyar & A. Sadili* 368); BO1407890 (*A. Sadili* 461 & *Dian Komara*); BO1407353 (*A. Sadili* 510 & *Dian Komara*).

**Notes:** This species mentioned found in GHSNP area by Mahyar & Sadili (2003) and Mirmanto *et al.* (2008).

30. *Stereosandra javanica* Blume, *Mus. Bot.* 2 (1856) 176

Plants c. 30 cm tall. Rhizome 1.5–4 × 1–2.5 cm. Inflorescence 5- to 10-flowered, floral bracts erect, 6–7 mm. Flowers pendulous; sepals and petals similar, lanceolate, c. 7–9 × 2.5 mm, acute; lip ovate-lanceolate, c. 8 × 3.5 mm, concave, containing 2 low, wartlike calli at base. Column short, c. 2 mm excluding anther.

**Distribution:** Southeast Asia, throughout Malesia and also in the Solomon Islands.

**Ecology:** Humid, shaded habitat.

**Specimen examined:** BO1407870 (*A. Sadili* 599 & *Dian Komara*).

**Notes:** This species mentioned found in GHSNP area by Mahyar & Sadili (2003).

[ANGIOSPERMS – DICOTYLEDONS]

**Gentianaceae**

31. *Exacum tenue* (Bl.) Klack., *Bot. Jahrb. Syst.* 126 (2006) 478

*Cotylanthera tenuis* Bl., *Bijdr. Fl. Ned. Ind.* 13 (1826) 708; Backer & Bakh.f. *Fl. Java* 2 (1965) 438

Erect, small achlorophyllous herbs, branched or simple. Leaves reduced into opposite scales, appressed, ovate, 1–5 mm long. Flowers borne solitary at the apex of stem, perianth 4-merous. Calyx fleshy, white or yellowish white, divided halfway down or slightly deeper, lobes erecto-patent, triangular. Corolla contorted in bud, deeply divided, contorted at bud, tube 1–3 mm long, lobes finally widely patent, oblong or subobovate, white or pale lilac, 4–9 × 1.25–3.5 mm. Stamens with filaments shorter than corolla lobes, anthers erect, exceeding the filament, bright yellow, 2-celled, style filiform, stigma capitate.

**Distribution:** East India (Odisha), Sumatra, Java, Borneo, Sulawesi and New Guinea (Averyanov *et al.* 2014).

**Ecology:** Lowland closed rain forest, among leaf litter.

**Specimen examined:** BO1355566 (*Th Valetton s.n.*).

**Polygalaceae**

32. *Epirixanthes cylindrica* Bl., *Cat. Gew. Buitenzorg (Blume)* 82 (1823); Backer & Bakh.f. *Fl.*

Java 1 (1963) 200

Erect, delicate mycoheterotrophic herbs, stem yellowish white or violet, mostly with rigid, fastigiate branchlets, 7–25 cm high. Leaves simple, spirally arranged, minute, scale like, ovate or ovate-oblong, appressed. Inflorescence a very dense spike, with a rounded top, fertile portion 8–20 mm long, 4–6 mm thick, bracts obovate or subspathulate, c. 2 mm long. Flowers with sepals free, 1.5–1.75 mm long. Petals 3, yellowish white. Anthers 5. Style shorter than 1/3 mm. Fruit somewhat exceeding the calyx, obovoid-urceolate, 1.25–1.75 mm long, contracted at the top.

**Distribution:** Sumatra, Java (West), Borneo and New Guinea.

**Ecology:** Humus soil, in shaded rain forest, among leaf litter.

**Specimen examined:** BO1791075 (*Schiffner* 3123); BO1791076 (*van Steenis* 139); BO1791095 (*van Steenis* 12429); BO1478684 (*Bakhuizen van den Brink s.n.*); BO1478685 (*Bakhuizen van den Brink s.n.*).

33. *Epirixanthes elongata* Bl., *Cat. Gew. Buitenzorg (Blume)* 82 (1823); Backer & Bakh.f. *Fl.*

Java 1 (1963) 200

Erect, delicate mycoheterotrophic herb, stem violet or yellow brown, mostly with rigidly erect branches, 6–25 cm high. Leaves simple, spirally arranged, minute, scale like, ovate or ovate-oblong, appressed. Inflorescence a dense spike, bracts ovate-lanceolate, very acute, 1.25–1.75 mm long, violet or yellow, spikes with fertile portion 1–3.5 cm with fruiting part 1.5–3 mm thick. Flowers with sepals free, acute, yellowish white, whether or not with a violet median streak or blotch. Petals 3, 1.5–2 mm long, yellowish white. Stamens 5, with tube adnate to corolla-tube. Ovary 2-celled, style 0.5–1.25 mm long, equaling ovary or somewhat longer. Fruit indehiscent, enclosed by the calyx, transversely oval, 1–1.25 mm wide.

**Distribution:** East India, southern Myanmar, southern China, northern Vietnam, Sumatra, Peninsular Malaysia, Java (West), Borneo and Moluccas (Ambon and Seram).

**Ecology:** Humus soil, in shaded rain forest, among leaf litter.

**Specimen examined:** BO1791065 (*Schiffner* 2124); BO1791082 (*van Steenis* 3000); BO1478696 (*Backer* 10849); BO1478692 (*Bakhuizen van den Brink* 4132); BO1478694 (*Bakhuizen van den Brink* 4142); BO1794912 (*Bakhuizen van den Brink s.n.*).

**CONCLUSION**

Based on this study, there are 33 species (7 families, 22 genera) of mycoheterotrophic plants in the Gunung Halimun Salak National Park. This represents about half of the total species in Java, with 33 out of 67. *Gastrodia crispa*, a species endemic to Java, can be found in this area. We concluded that this National Park provides important habitats for mycoheterotrophic plants species on Java. Continuous protection of the Gunung Halimun Salak National Park is essential to ensure the future existence of mycoheterotrophic plants.

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### Appendix. List of MHPs species from Java

This list collected from various sources, such as Jonker (1948), Backer & Bakh.f. (1963, 1965, 1968), Comber (1990), Uji (2002), Hidayat & Wiriadinata (2003), Mahyar & Sadili (2003), Mirmanto *et al.* (2008), Tsukaya & Hidayat (2016), Metusala & Supriatna (2018), Suetsugu *et al.* (2018). Notes: W = Western Java (Banten, West Java), C = Central Java (Jogjakarta, Central Java), E = Eastern Java (East Java).

#### [FERNS & LYCOPHYTES]

**Lycopodiaceae:** *Diphasiastrum complanatum* (W,C), *Diphasiastrum wightianum* (W,C,E), *Huperzia miniata* (W,C), *Huperzia serrata* (W,C,E), *Huperzia zollingeri* (W,C), *Lycopodium clavatum* (W,C,E), *Phlegmariurus carinatus* (W,C,E), *Phlegmariurus nummulariifolius* (W,C,E), *Phlegmariurus phlegmaria* (W,C,E), *Phlegmariurus pinifolius* (W,C,E), *Phlegmariurus proliferus* (W), *Phlegmariurus squarrosus* (W,C,E), *Phlegmariurus tetrastichus* (E), *Phlegmariurus verticillatus* (W), *Pseudodiphasium volubile* (W,C,E). **Psilotaceae:** *Psilotum complanatum* (W,C), *Psilotum nudum* (W,C,E). **Ophioglossaceae:** *Helminthostachys zeylanica* (W,C,E), *Japanobotrychium arisanense* (W,C), *Ophioderma pendulum* (W,C,E), *Ophioderma intermedium* (W), *Ophioglossum reticulatum* (W,C,E), *Ophioglossum parvifolium* (W,C,E), *Sceptribidium daucifolium* (W,C), *Sceptribidium ternatum* (W,C,E).

#### [ANGIOSPERMS – MONOCOTYLEDONS]

**Burmanniaceae:** *Burmannia bifaria* (W), *Burmannia championii* (W), *Burmannia coelestis* (W,E), *Burmannia lutescens* (W,C), *Burmannia steenisii* (E), *Gymnosiphon aphyllus* (W), *Gymnosiphon neglectus* (W,C), *Thismia clandestina* (W), *Thismia javanica* (W). **Orchidaceae:** *Aphyllorchis pallida* (W), *Cyrtosia javanica* (W,C,E), *Cyrtorchis aphylla* (W,C,E), *Didymoplexis cornuta* (W), *Didymoplexis flexipes* (W), *Didymoplexis micradenia* (W), *Didymoplexis obreniformis* (W), *Didymoplexis pallens* (W,C,E), *Didymoplexis striata* (W), *Epipogium roseum* (W,C,E), *Erythrorchis altissima* (W), *Eulophia zollingeri* (W,C,E), *Galeola nudiflora* (W,C,E), *Gastrodia abscondita* (W), *Gastrodia bambu* (W,C), *Gastrodia callosa* (W), *Gastrodia crispa* (W), *Gastrodia javanica* (W), *Gastrodia selabintanensis* (W), *Gastrodia spathulata* (W), *Gastrodia verrucosa* (W), *Lecanorchis javanica* (W), *Lecanorchis multiflora* (W,C,E), *Silvorchis colorata* (W), *Stereosandra javanica* (W,C,E).

#### [ANGIOSPERMS – DICOTYLEDONS]

**Triuridaceae:** *Sciaphila arfakiana* (W), *Sciaphila maculata* (W), *Sciaphila nana* (W), *Sciaphila tenella* (W). **Gentianaceae:** *Exacum tenue* (W). **Polygalaceae:** *Epirixanthes cylindrica* (W), *Epirixanthes elongata* (W), *Epirixanthes papuana* (W).