

Assessing the conservation status of tree fern *Cibotium arachnoideum* (C. Chr.) Holttum

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Abstract. *Praptosuwiryo TN. 2020. Assessing the conservation status of tree fern Cibotium arachnoideum (C.Chr.) Holttum. Biodiversitas 21: 1379-1384. Cibotium arachnoideum (C.Chr.) Holttum (Cibotiaceae), is a large terrestrial fern with an upright or prostrate rhizome having densely shining reddish-brown of rigid hairs and one or two pairs of sori with two indusia forming a small cup on each lamina-segment. This tree fern is a rare species and strictly distributed in the Malesian region. The study aims to assess the conservation status of C. arachnoideum by using the 2012 IUCN Red List Categories and Criteria (version 3.1.). Population size was estimated and observed both based on specimens deposited at the Herbarium Bogoriense (BO) and field studies in Sumatra. The area of occupancy (AOO) of this species is 44 km². Cibotium arachnoideum is occurred in severely fragmented locations in the West Malesian region, in 2 locations, viz. Sumatra and Borneo. Sumatra has only two subpopulations, and Borneo has nine subpopulations. The number of mature individuals was only found 372 in one location of North Sumatra and 19 individuals in one location of Bengkulu. Therefore, C. arachnoideum is proposed as an endangered species, En: B2ab (i,ii,iii) + C2a (ii).*

Keywords: Area of occupancy (AOO), *Cibotium arachnoideum*, conservation status, extent of occurrence (EOO), tree fern

INTRODUCTION

As stated in global conservation priority in the GSPC Target 2 of the objective 1, assessing a conservation status of plant species is very important, because it is a fundamental step to guide conservation action. This target is critical to reaching the Target 7 and 8 of the GSPC programs (GSPC 2002). Conservation status assessments are intended to be policy-relevant and can be used to set a baseline conservation planning and priority setting processes (García-Criado et al. 2017). A comprehensive list of species of conservation concern would be useful in determining those species in need of further study and support development of management plans for their survival (Miller et al. 2012) and sustainable uses.

The IUCN Red List of Threatened Species (<http://www.iucnredlist.org>) is the most comprehensive and authoritative resource dealing with the conservation status of living organisms (Butchart et al. 2004, 2005; Rodrigues et al. 2006). The Red List is the product of a flexible system that can use five criteria to assign each species to a category indicating whether it is extinct, or included in one of three increasingly severe threatened categories, from vulnerable to endangered, or maybe of least concern (IUCN 2012). The conservation status of a species can be assessed based on the current status of species, take into account the history of species, or may speculate about future decline (IUCN 2012; Burgman et al. 2000).

Ferns and lycophte flora of Asia are remarkably abundant. It estimated that 4500 species of ferns and lycophte flora, or more than one-third of the world's diversity, occurs in Southeast Asia (Moran 2008), and 2197

species of them are existed in Indonesia (LIPI 2014). The publications Flora Malesiana series II (Pteridophytes) do not yet even cover half of the species that occur in the region, and it would need a considerable amount of time for their completion (Roos 1996). Meanwhile, the speed of deforestation in Asia, including in Southeast Asia, is remarkably high (Sodhi and Brook 2006). Ferns and lycophtes, which are the major components of the forest understorey, are undoubtedly under threat (Brummitt 2016). Ferns and lycophtes have faced a new kind of risk as humans have destroyed the natural habitats and unparalleled species extinction (Pimm and Raven 2000). A list of narrowly distributed Asian pteridophyte taxa towards an assessment of globally threatened species has been published yet. Of the total 886 taxa (835 species and 51 infraspecific taxa) enumerated, 577 occur in Southeast Asia, 215 in East Asia, and 101 in South Asia (Ebihara et al. 2012).

Tree ferns are keystone species of a wet tropical forest as they are often dominating the sub-canopy layer with tall trunks and crowns of large fronds (Walker and Aplet 1994, Durand and Goldstein 2001, Roberts et al. 2005). *Cibotium Kaulfuss* is giant tree ferns with usually prostrate or erect trunk-like rhizome with the apex of rhizome and stipes which are protected by a thick cover of long slender golden shining yellow-brown hairs. This genus is also characterized by two indusia joined together for a short distance at the base and forming a small cup around the receptacle of the sorus (Holttum 1963). This genus has a member of about 12 species, which is distributed in Central America, Mexico, Hawaii, Assam to southern China, Western Malesia, and Philippines (Holttum 1963; Hassler

and Swale 2002). Three species are occurring in the Malesian region, namely, *C. arachnoideum* (C. Chr.) Holttum, *C. barometz* (L.) J. Sm., and *C. cumingii* Kunze (Holttum 1963).

In Indonesia, we recognize only two species of *Cibotium*, namely *C. arachnoideum* and *C. barometz*. Recently field studies on *Cibotium* in Sumatra, Indonesia, revealed that populations of *C. arachnoideum* are restricted from two severely fragmented locations, while *C. barometz* is more widely distributed (Rugayah et al. 2009; Praptosuwiryo et al. 2011, 2017). The national conservation status of *C. barometz* has been assessed. This species is included in the vulnerable category (VU A4cd) (Praptosuwiryo and Rugayah 2017); meanwhile, the conservation status of *C. arachnoideum* has not been reported yet. This study aims to assess the conservation status of *C. arachnoideum*.

MATERIALS AND METHODS

Status assessment

The conservation status of *C. arachnoideum* was assessed using the 2012 IUCN Red List Categories and Criteria (version 3.1). The majority of threatened ferns and lycophyte species have been evaluated for the IUCN for Plants using IUCN Criterion B and therefore categorized based on the geographic range (Brummitt et al. 2016). Based on the population size and distribution data collected from the field, it is estimated that the conservation status of *C. arachnoideum* falls into the category of endangered under IUCN B and C criteria.

Specimen examination

In ferns and lycophytes, for most species, the most comprehensive, easily accessible, and reliable information representing the known distribution of that species and on which a conservation assessment could be based was accurately-identified herbarium specimens. Herbarium records were used to identify provincially uncommon, rare, and very rare plant taxa recorded in an area (MacDougall et al. 1998). Herbarium specimens are verifiable records, indicating the existence of a species at a given time and place (Brummitt et al. 2016). The dried materials of *C. arachnoideum* deposited at BO (Herbarium Bogoriense) which were used in assessing the conservation status of the species as follows.

Specimens examined: - East Kalimantan: Krayan, north of Long Bawan, En route from Para ya to Sinar baru. 115°45' E, 4° N. 1150 m. 17 July 1981. M. Kato, M. Okamoto, dan E. B. Walujo - B.9088; Krayan, North of Long Bawan, Sinar Baru. 115°45' E, 4°N. 1150 m. 4 August 1981. M. Kato, M. Okamoto, dan E. B. Walujo - B.106; Krayan, north of Long Bawan, Mount Buduk Rakik; Krayan, north of Long Bawan, Mt Batu Harun.

115°47' E, 4°8' N. 1150 - 1650 m. 25 July 1981. M. Kato, M. Okamoto, dan E. B. Walujo - B.9858; Krayan, north of Long Bawan, Mt Leputung. 3°55' N, 115°40' E. 900 - 1375 m. M. Kato, M. Okamoto, K. Ueda dan E. B. Walujo - B.8069; Krayan, south of Long Bawan, Mt Paris. 3°50' N, 115°40' E. 900 - 1050 m. M. Kato, M. Okamoto, K. Ueda dan E. B. Walujo - B.7384; Krayan, West to Long Bawan, Near Pa Nanado. 16 July 1981. 3°55' N, 115°35' E. 1000 - 1200 m. K. Ueda dan D. Darnaedi - B.8553 (D. 2495); Krayan, south of Long Bawan, Mt Buduk Rian. 115°42' E, 3°50' N. 900 - 1500 m. 31 August 1981. M. Kato, M. Okamoto, dan E. B. Walujo-B.11425; Krayan, north of Long Bawan, South foot of Mt Batu Linanit, 115°40' E, 4°8' N, 1100 m. M. Kato, M. Okamoto, dan E. B. Walujo s.n.; Sarawak, Mt Kinabalu, Eastern Shoulder. 60°05' N, 116°36'-40' E. 2500 ft. 26 August 1961. W. L. Chef, E. J. H. Corner, A. Stainton-998 (BO).

Calculating of Extent of Occurrence (EOO) and Estimating Area of occupancy (AOO) using GeoCAT (Geospatial Conservation Assessment Tool)

The geographical and ecological data contained in the specimen labels of herbarium collections are an invaluable source of information for EOO, AOO, and fragmentation (Hernández and Navarro 2007). AOO is the area occupied by a taxon within its more general EOO (IUCN 2012), and it is usually taken as a measure of species distribution size. The AOO of species is one of the more commonly used parameters in Red List assessments (Hernández and Navarro 2007). Specific measures of species' geographic range (EOO) and AOO were used in carrying out IUCN Red List assessments under Criterion B.

GeoCAT is utilized to figure out the AOO and EOO. It is a web tool that utilizes primary biological data for semi-automated IUCN Red List assessment and analysis. The web address available at <https://www.kew.org/science/our-science/projects/geocat-geospatial-conservation-assessment-tool>. This web tool is an open-source to performs rapid geospatial analysis to ease the proses of Red Listing species (Bachman et al. 2011). The guide for using the GeoCAT tool is available on the website <https://www.kew.org/science/collections-and-resources/data-and-digital/tools/geocat-help>.

RESULTS AND DISCUSSION

Taxonomic Notes. *Cibotium arachnoideum* (Figure 1.) was established by Holttum (1963). It is tree fern species belong to the family Cyatheaceae *sensu* Holttum (1963). Smith et al. (2006) placed *Cibotium* in its own family, Cibotiaceae, based on the distinction of its spore morphological characteristics in addition to molecular data.



Figure 1. *Cibotium arachnoideum* (C.Chr.) Holttum. A. Rhizome with stipes covered by densely shining reddish-brown of rigid hairs; B. Basal stipe; C. Transversal cross-section of basal stipe; D. Middle rachise, showing the remains hairs attaching at the adjacent between rachise and costa. E. Parts of pinnulae with its fertile lobes bearing 1-2 rows of sori covering by reddish-purple of indusia

Cibotium arachnoideum is similar to *C. barometz*. However, the two species can be distinguished by three character combinations: (i) the existence of the hairs on costa and costule of the adult fronds; (ii) the incision of pinnulae segments; and (iii) the pair number of sori. *C. arachnoideum* has the remains hairs attaching on the costa and costule; rigid reddish appressed hairs always present, and sometimes abundant, small flaccid hairs present on lower surface of lamina between veins; largest pinnules 15-26 mm wide, pinnules on the basisopic side of lower pinnae much shorter than those on the acroscopic side; always have two pairs of sori on large fronds. Meanwhile, *C. barometz* has no persistent hairs on the costa and costule; small flaccid hairs absent on lower surface of lamina between veins; largest pinnules 20-35 mm wide, pinnules on the two sides of a pinna not significantly different in length, hairs on lower surface of costae and costules almost always thin and flaccid and never spreading; sori 2 - 12 pairs on each pinnule-lobe of larger fronds (Praptosuwiryo et al. 2011). Those character combinations met with the specimens described by Holttum (1963).

Cibotium arachnoideum also has a morphological similarity to *C. cumingii*, but *C. cumingii* fronds are smaller than those of *C. arachnoideum* and its pinnule ca.180 mm in length and 22 mm in width. The pinnae of the two species are asymmetrical, and the basisopic side is shorter than the acroscopic side. The number of sori in *C. cumingii* is either 1 to 2 pairs and it is located at the base of each fertile segment of a pinnule. The indumentum of the lower surface of costae and costules is variable with some stiff spreading hairs, which is pale or reddish (Maideen et al. 2018).

Geographic range. *Cibotium arachnoideum* is native to Indonesia and Malaysia and strictly distributed in the Malesian region, namely in Central and South Sumatra, Sarawak, and North Borneo (Holttum 1963). Based on the herbarium specimen records in 1981, it suspected that this species is still occurring in East Kalimantan (Indonesia). Population studies for *C. barometz* conducted in 2008 at Bengkulu (central Sumatra) and North Sumatra found the small population of *C. arachnoideum* in two localities (Praptosuwiryo and Wardani 2008; Praptosuwiryo et al. 2011).

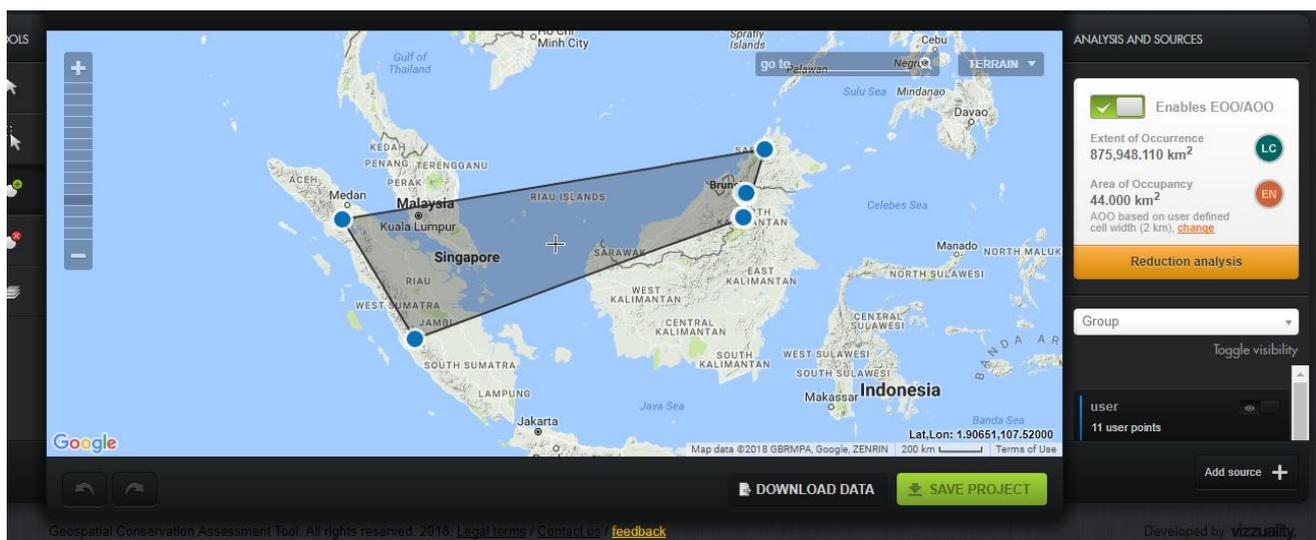


Figure 2. EOO and AOO of *Cibotium arachnoideum* in the Malaysian region established by using GeoCAT (geocat.kew.org)

EOO and AOO. Based the latitude and longitudes data compiled from specimen labels of the herbarium housed at BO and the direct observation of *C. arachnoideum* in Sumatra (Praptosuwiryo and Wardani 2008; Praptosuwiryo et al. 2011) the distribution map of *C. arachnoideum* is established, and the EOO and AOO are calculated (Figure 2).

Population size. The population size of *C. arachnoideum* of Sumatra is described. Praptosuwiryo et al. (2011) recorded one specimen of *Cibotium* collected from North Sumatra, which housed at Herbarium Bogoriense (BO). It was compiled by H. Surbeck on 30 May 1941 (No. Coll.: H. Surbeck 114), from South Sibuctan, Lae Pandom, 1100 m, the edge of primary forest. This collection was identified as *C. barometz*. The correct name of this record is *C. arachnoideum*. There was no population size information written on the label. Praptosuwiryo (2011) reported the population size of *C. arachnoideum* of Lao Pandom protected area, in the year of 2009. There were only 372 mature individuals recorded in 2,500 square meters. Lao Pandom is the same name for Lae Pandom. It is located in Merek Subdistrict, Karo district, North Sumatra.

Praptosuwiryo and Wardani (2008, unpublished data) reported the existence of the population of *C. arachnoideum* at Blok 40 of Bukit Daun Mas, Kayu Manis Country, Selupu Rejang Subdistrict, Rejang Lebong District, Bengkulu Province, Sumatra. Formerly, Praptosuwiryo and Wardani (2008, unpublished data) reported this species as a variant *C. barometz*. There were only 19 mature individuals of *C. arachnoideum* recorded in 100,000 m square areas of Bukit Daun Mas.

Currently, information on the population of *C. arachnoideum* from Borneo is lack. The historical records of this species on the island have been reported, but their quantitative population data were not mentioned. Holttum (1963), in the Flora Malesiana, noticed that *C. arachnoideum* was abundant in the secondary forest of Mt. Kinabalu. Labels of the specimen records of *C.*

arachnoideum collected by Kato et al. in July 1982, from nine localities of Krayan, East Kalimantan, at the altitude between 900 - 1650 m asl, did not mention the population sizes. Parris et al. (1992) reported that *C. arachnoideum* occurred in Mt. Kinabalu at 900-1200 m asl.

Current population trend. The current population trend is suspected of being decreasing. In Sumatra, the habitat of *C. arachnoideum* is located in the disturbed protected forest, Lae Pandom Protected Forest, North Sumatra. Forest encroachment and illegal logging in Lae Pandom Protected area were quite widespread in 2018, tens of hectares of the protected areas have been deforested.

Habitats and ecology. In Lao Pandom Protected Forest, *C. arachnoideum* occurs at elevation range from 1740-1770 m sea level. This species grows on a range temperature of 23-23.5°C, moist condition (RH \pm 80%), soil type of sandy quartz-rockery with dust or clay soil, soil acidity of 5.8, humus soil depth 3-4 cm, leaves litter depth 2.5-12.5 cm. It grows on the hill with 0-80 % of slopes (Praptosuwiryo et al. 2011).

In North Sumatra, *C. arachnoideum* is growing among the terrestrial fern species of *Dipteris conjugata* Reinw., *Dicranopteris linearis* (Burm. f.) Underw., *Blechnum* sp., *Pyrrhosia* sp., *Hymmenophyllum* sp., *Hystiopteris stipulacea* (Hook.) Copel. *Phymatodes* sp. and *Elaphoglossum* sp. (Praptosuwiryo et al. 2011). In Mt. Kinabalu, Borneo, *C. arachnoideum* usually grows in cultivated areas among *Pteridium esculentum* and members of Gleicheniaceae (Parris et al. 1990).

Ecological studies in North Sumatra, in 2009 and 2015, revealed that *C. arachnoideum* would survive after land clearing. The surviving remaining rhizomes will grow new shoots. In Mount Kinabalu, at ca. 1000 m s.l., this species occurred on steep slopes, which were periodically cleared by burning for cultivation, apparently surviving the burning (Holttum 1963). The survival of *C. arachnoideum* towards the land clearing or burning has also been reported by Parris et al. (1992) on steep ladangs (fields) of Mt. Kinabalu, at 900-1200 m asl.

Uses. The local people surrounding Mount Kinabalu use the soft hairs of *C. arachnoideum* for staunching bleeding wounds (Parris et al. 1992). For the local people in Sumatra, especially in North Sumatra, the uses of *C. arachnoideum* may be similar to *C. barometz*. As stated in some literature (see Ong and Nordiana 1999, Praptosuwiryo 2003), *C. barometz* is used as a medicinal and ornamental plant. It is suspected that in the field, the local people of North Sumatra do not differentiate the two species as two different plant species; therefore when harvesting the *pilli cibotii* (hairs of *Cibotium*), they mixed the hairs of the two species. The plants which are recognized as pakis kijang with golden yellow hairs are *C. barometz*, meanwhile, those with reddish-brown hairs are *C. arachnoideum* (Holtum 1963). The native people of North Sumatra stated that pakis simpey or pakis emas or pakis kijang (the vernacular name of *Cibotium* in Sumatra) consisted of two varian, gold yellow, and brown yellow.

Threats. Local action that potentially threatens the species is overexploitation and change of the land use. The population of *C. arachnoideum* in Sumatra is at risk. One of its habitat localities, in Lae Pandom Protected Forest, is deforested, as the protected forest is very close to the main road of North Sumatra. Meanwhile, the habitat of this fern in Bengkulu Province (Central Sumatra) is an industrial privacy forest. There was only one sub-population existed in that privacy industrial forest in Central Sumatra.

Conservation. *Cibotium arachnoideum* has been planted in the greenhouse of Bogor Botanic Gardens since 2008. The conservation actions that would be beneficial to the species should be performed. Studies dealing with the *in vitro* spore culture and somatic embryogenesis would be useful to facilitate the rapid propagation and conservation of the tree fern.

Red list assessment and rationale. *Cibotium arachnoideum* is tree fern with a wide range from Indonesia (Bengkulu and South Sumatra) to Malaysia (Sarawak and North Borneo). The estimated extent of occurrence (EOO) is 875,948.110 km², exceeding the values needed for a threatened category. Based on the EOO, *C. arachnoideum* is included in LC category; However, the distribution is not continuous in an imaginary boundary, which can be drawn to encompass all the occurrence of this species. In addition, the EOO shown in Fig. 2 covers a large area of ocean. The area of occupancy (AOO) of this species is 44 km². It meets the criterion of B, the area of occupancy estimated to be less than 500 km², and estimates indicating at the subcriterion of a and b, under sub subcriterion of i, ii, and iii (IUCN 2012). It is therefore considered to be facing a very high risk of extinction in the wild.

Besides, the population size estimated to number fewer than 2,500 mature individuals (Criterion C). The number of mature individuals reported was only 372 in one location of North Sumatra, and 19 individuals in one location of Bengkulu. Based on the observation in the two localities and inferring the degradation of the habitat, the population of *C. arachnoideum* will be continuing decline in numbers of mature individuals (Criterion C2), and it is included in the sub-criterion of a (Population structure in the form of)

under sub-criterion of ii, at least 95% of mature individuals in one subpopulation. Therefore the conservation status proposed for *C. arachnoideum* is En: B2ab (i,ii,iii) + C2a (ii).

To conclude, the conservation status of *C. arachnoideum* has been assessed by using the 2012 IUCN Red List Categories and Criteria (version 3.1). The area of occupancy (AOO) of this species is 44 km². *Cibotium arachnoideum* is occurred in severely fragmented locations in the West Malesian region, viz. Sumatra and Borneo. Sumatra has two subpopulations, and Borneo has only nine subpopulations. The recorded number of the mature individuals was only 372 in one location in North Sumatra and 19 in one location in Bengkulu. The conservation status proposed for *C. arachnoideum* is En: B2ab (i,ii,iii) + C2a (ii). Currently, information on *C. arachnoideum* populations in Kalimantan and Sarawak is still lacking. In the future, the population study of *C. arachnoideum* in Borneo to gain a more comprehensive status needs to be carried out to provide further conservation policies.

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