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Population Study of the Golden Chicken Fern (*Cibotium barometz* (L.) J. Sm.) in Riau Province, Sumatra

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ABSTRACT

Cibotium barometz (L.) J.Sm. (Cibotiaceae) is an important export commodity for both traditional and modern medicine. Populations of this species in several countries have decreased rapidly due to the uncontrolled collection of the rhizome parts for medicinal purposes. Since 1976, this species has been included in Appendix II of the Convention on International Trade in Endangered Species (CITES). This means that no export is allowed without a prior permit issued by the CITES committee. In order to utilize an endangered species sustainably, the global NDF (Non-Detriments Finding) system is applied for determining annual quotas. Therefore, monitoring and updating the inventory of *C. barometz* in its natural habitat should be carried out annually. A population study of *C. barometz* carried out in 2011 in Riau Province, Sumatra, is reported here. The aims of the study were: 1) to inventory *C. barometz* and determine its variation in Riau Province, Sumatra, 2) to study the distribution and ecology of *C. barometz*, and 3) to assess the population size of this species by using random search methodology incorporating belt line transects. Two variants of *C. barometz* are recognized; they are the golden yellow and golden brown variants. *C. barometz* is distributed in eight locations of Kampar District of Riau Province, in the secondary forest and rubber agroforest between 80 m and 600 m above sea level (asl). This species grows well in open to partially opened areas of secondary forest and rubber plantation in hills with a range of slope between 30° and 90°, with a relatively high humidity, 60 – 90%, in acid to nearly neutral soil, with a range of soil fertility from very poor to very humus rich soil. The average population density determined in our study was 20 plants per 100 square meter. The highest population size was in the secondary forest of Bukit Kuda Beban at 590 – 600 m asl., viz. 9405 plants with a population density of 47 plants per 100 square meter.

Keywords: *Cibotium barometz, medicinal fern, morphological variation, habitat characteristic, population size*

INTRODUCTION

The name *Cibotium* is from the Greek kibootion, meaning chest or box. It is a genus of 11 species of tropical tree ferns [1], which is a subject of much confusion and revision. Therefore it has been placed in different families at different times, such as in the subfamily Cibotioideae of the Cyatheaceae [2] or in the Cibotiaceae [3, 4]. The genus is distributed widely; in Central America and Mexico, Hawaii, Assam to southern China, southwards to Western Malesia and Philippines [2].

There are only two species of *Cibotium* occurring in Indonesia, namely *Cibotium barometz* (L.) J. Sm. and *Cibotium arachnoideum* (C. CHR.) Holtt. [2]. C. barometz, known as the golden chicken fern, is easily recognized because of the gold yellowish-brown smooth and shining hairs covering its rhizome and basal stipe. The plant habit is usually prostrate or erect and the rhizome rarely more than 1 m high. *C. barometz* can be distinguished from *C. arachnoideum* by a combination of diagnostic characters as follows: *C. barometz* has sori 2-6 or more pairs on each pinnule-lobe of larger fronds, largest pinnules 20 – 35 mm wide, pinnules on the two sides

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of a pinna not greatly different in length, hairs on lower surface of costae and costules flaccid and never spreading. In contrast *C. arachnoideum* always has two pairs of sori on each pinnule-lobe of larger fronds, largest pinnules 15 – 26 mm wide, pinnules on basiscopic side of lower pinnae much shorter than those on acroscopic side, hairs on lower surface of costae and costules rigid and spreading [2, 5].

The golden chicken fern is also known as golden lamb, Scythian lamb and Tartarian lamb [6]. In Chinese, *C. barometz* is named "jinmao gouji" (golden hair dog) or "Huanggoutou" (yellow dog head) [7]. In Indonesia the species has several local names, such as penawar jambi, paku simpai or bulu jambe [6].

C. barometz is distributed from North-East India to South China and Taiwan, southwards to the Malesian region; in Malesia this species is found in Sumatra, Malay Peninsula, and Java [2]. *C. barometz* generally grows in environments of acidic rich soil, under high density canopies [5, 8, 9], in primary and secondary forests on the slopes of a hill or mountain at an altitude of 600 – 1200 m above sea level [2, 5], and in open forest areas at an altitude of 1600 m above sea level [2, 6, 10].

C. barometz is an important export commodity for both traditional and modern medicine. The golden hairs on its rhizome and stipes have been used as a styptic for treating bleeding wounds. An extract from the rhizome, "gouji", is also used as an anti-rheumatic, to stimulate the liver and kidney, to strengthen the spine, as a remedy for prostatic disease, and to treat various other illnesses, including flatulence [6]. Yao [11], Ou [12], and Jia and Zhang [7] reported that rhizomes of *C. barometz* in China is used as a herbal medicine called "gouji" used to replenish the liver and kidneys, strengthen the bones and muscles, and ease the joints. The hairs on the rhizome are also used as a styptic for bleeding wounds. In Vietnam, the rhizomes are used as anti-inflammatory substances, anodynes, and vermifuges. They are used in the treatment of rheumatism, lumbago, sciatica, leucorrhoea, dysuria, and polyuria in the aged etc. [13]. The yellow hairs on the rhizomes contain tannins and are astringent. They are used in poultices on wounds to stop bleeding [13]. In Malaysia an infusion of the leaves is used to cure fainting.

Populations of *C. barometz* in several countries have decreased rapidly because of over exploitation. Since 1976, this species has been included in appendix II of the Convention on International Trade in Endangered Species (CITES).This means that no export is allowed without prior permit issued by the CITES committee or by the management authority which is recommended by the appropriate scientific authority [6]. In order to utilize it sustainably, the global NDF (Non-Detriments Finding) system is applied for determining annual quotas. Therefore, monitoring and updating the inventory of *C. barometz* in its natural habitat should be carried out annually.

Recent botanical exploration and the inventory of *C. barometz* in Indonesia shows that this species is distributed widely in Sumatra. One the distribution records have been reported from North Sumatra [5]. This paper reports the inventory and a population study of *C. barometz* in Riau Province, Sumatra. For this study, populations were defined as spatially distinct assemblages of plants at certain sites, without considering the genetic structure of the populations [14]. The aims of the study were: 1) to inventory *C. barometz* and determine its variation in Riau Province, Sumatra, 2) to study the distribution and ecology of *C. barometz*, and 3) to assess the population size of this species by using random search methodology incorporating belt line transects.

MATERIALS AND METHODS

Study sites

Field studies were carried out in June 2011 in Riau Province, Sumatra, Indonesia. Inventory recordings and ecological observations of C. barometz have been conducted in eight sites of Kampar District, Riau Province-Sumatra (Figure 1.; Table 1-2); they are: (1) Rantau Berangin I, Bangkinang Barat subdistrict, about 72 Km from Pekan Baru, near Kampar Kanan River; (2) Rantau Berangin II, Bangkinang Barat subdistrict, near Kampar Kanan River; (3) Bukit Pemberhentian Papan, Kampung Batang Bio, Desa Salasuang, Kampar Kiri subdistrict; (4) Bukit Punggung Lading I, Kampung Batang Bio, Desa Salasuang, Kampar Kiri sub-district; (5) Bukit Punggung Lading II, Kampung Batang Bio, Desa Salasuang, Kampar Kiri subdistrict; (6) Bukit Punggung Lading III, Kampung Batang Bio, Desa Salasuang, Kampar Kiri subdistrict; (7) Hutan Kampung Batang Bio, Desa Salasuang, Kampar Kiri subdistrict; and (8) Bukit Kuda Beban, Kampar Kiri subdistrict. The sites were located between 80 m and 600 m above sea level (asl).

Of eight localities, there are only two localities which are really in the pure secondary forest; namely, Bukit Kuda Beban and Bukit Punggung Lading II. Two locations (Bukit Pemberhentian Papan and Bukit Punggung Lading III) are a mixed type of vegetation; secondary forest adjacent to rubber (*Hevea brasiliensis*) agroforests (rubber plantation). Three locations, namely

Figure 1. Distribution map of *C. barometz* in Riau Province, Sumatra. 1. Bangkinang Barat sub-district (two localities); 2. Kampar Kiri sub-district (six localities)

Table 1. Distribution Map of *C. barometz* in Kampar Dsitrict, Riau Province-Sumatra

No.	*Locality*	*Coordinate*	*Variant Type*	*Voucher Specimens*
1.	Rantau Berangin I, Km 72 Pekan Baru, Bangkinang Barat sub-district	E 100°54'22." N 00°17'54.4"	Variant 1	TNgP 3273
2.	Rantau Berangin II, Bangkinang Barat sub-district	E 100°53'26.3." N 00°16'39.9"	Variant 1	TNgP 3274
3.	Bukit Pemberhentian Papan, Kampung Batang Bio, Desa Salasuang, Kampar Kiri, sub-district	E 100°47'10.7" S 00°06'39.3"	Variant 1	TNgP 3275, 3276, 3279, 3284.
			Variant 3	TNgP 3278, 3283, 3281
4.	Bukit Punggung Lading I, Kampung Batang Bio, Desa Salasuang, Kampar Kiri sub-district	E 100°46' 25.7" S 00°06'27.6"	Variant 1	TNgP 3285, 3287, 3289, 3291
				TNgP 3286, 3288
			Variant 3	TNgP 3290
5.	Bukit Punggung Lading II, Kampung Batang Bio, Desa Salasuang, Kampar Kiri sub-district	E 100°46' 18.9" S 00° 06' 23.9"	Variant 1	TNgP 3292, 3293, 3298, 3299, 3300
6.	Bukit Punggung Lading III, Kampung Batang Bio, Desa Salasuang, Kampar Kiri sub-district	E 100°46' 51.3" S 00° 06' 50.4"	Variant 3	TNgP 3304, 3305, 3306, 3307, 3308
7.	Hutan Kampung Batang Bio, Desa Salasuang, Kampar Kiri sub-district	E 100°46'13.8" S 00°06'09.2"	Variant 1	TNgP 3303
8.	Bukit Kuda Beban, Kampar Kiri sub-district	E 100°45'38.2" S 00°06' 06.6"	Variant 1	TNgP 3309
			Variant 3	TNgP 3310, 3311, 3312, 3314

Note: Variant code following Rugayah et al. (2009), Golden Yellow Hairs: Variant 1, Golden Brown Hairs: Variant 3; TNgP = Titien Ng. Praptosuwiryo.

Rantau Berangin I, Rantau Berangin II and Bukit Punggung Lading I are rubber agroforest. Hutan Kampung Batang Bio is a mixed plantation; a rubber plantation - *Uncaria gambir* intercrop.

As described by Beukema and Noordwidk [15], rubber agroforest (also called rubber plantation) is a plantation rubber production system in which there are a number of secondary products in addition to the rubber

Table 2. Population size and habitat characteristics of *C. barometz* in Kampar District, Riau Province-Sumatra

No.	Localities, Forest/Vegetation Type, Total Plot Area Observed (m^2)	Σ Individual per Total Plot Area Observed	Total Study Area (m^2)	Estimated Total Population Size	Average Population Density per 100 m^2	Habitat characteristics of Cibotium barometz							
						Slope (°)	Altitude (m)	Temperature (°C)	Air humidity	Canopy Coverage (%)	Major Soil type	Leaves Litter Depth (cm)	Soil acidity (pH)
1.	Rantau Berangin I; Rubber plantation (2000)	10	5000	25	0.5	47.5	120	30	64-66	30-50	Clay, rocky soil	15	-
2.	Rantau Berangin II; Rubber plantation (2000)	2	5000	5	0.1	35	87	30	64-66	20	Clay, rocky soil	15	-
3.	Bukit Pemberhentian Papan; Secondary forest Rubber plantation (3000)	344	40,000	4586	11.5	35-45	260 – 310	25.4-31.5	64-66	40-50	Yellow Entisol	2 – 13	6.5 – 6.7
4.	Bukit Punggung Lading I; Rubber Plantation (3500)	1352	20,000	7725	38.6	37	314 – 330	26-28	82-92	50-60	Yellow Entisol	2 – 12.5	6.5 – 6.7
5.	Bukit Punggung Lading II; Secondary forest (1500)	147	10,000	980	9.8	37	326 – 335	28	82	50-60	Yellow Entisol	2 – 12.5	6.5 – 6.7
6.	Bukit Punggung Lading III, secondary forest and rubber plantation (2500)	153	10,000	612	6.1	37	292 – 337	26-28	82-92	50-60	Dusty - sandy soil	20	6.5 – 6.7
7.	Kampung Batang Bio; rubber plantation-Uncaria gambir intercropping (2000)	372	30,000	5580	18.6	40-50, 80-90	316 – 369	26	88	20-30	Dusty - sandy soil, rocky soil	2 – 12.5	6.5 – 6.7
8	Bukit Kuda Beban; secondary forest (4000)	1881	20,000	9405	47	40-50	590 - 600	25.5-27.8	65-75	50-60	Enseptisol, Clay-dusty	14 – 15	6.5 – 6.7

(latex) that is the main product. Rubber is planted together with vegetables, herbs, and a limited number of useful trees such as fruit trees. Weeds are controlled manually and only during the first 2 – 3 years when vegetables are produced. After that, the secondary vegetation that comes in naturally and includes useful species is allowed to grow with the rubber. A dense secondary forest vegetation builds up. A secondary forest dominated by rubber is the result. The age of the rubber plantations in our study sites ranged between 10 years and 15 or more years.

The vegetation of the secondary forest of Bukit Kuda Beban is dominated by species belonging to the families Annonaceae, Apocynaceae, Poaceae, Elaeocarpaceae, Euphorbiaceae, Lauraceae, Melastomataceae, Moraceae, Myrtaceae, Rubiaceae, and Zingiberaceae. In the rubber plantations, the flowering plant species that dominate the locations are Euphorbiaceae, Myrtaceae, Myrsinaceae, Poaceae, Annonaceae, Araceae, and Zingiberaceae. The fern species and fern allies that usually grow in all the locations where *C. barometz* is also dominant are terrestrial ferns included in the families Adiantaceae, Blechnaceae, Cyatheaceae, Gleicheniaceae, Lomariopsidaceae, Pteridaceae, Lygodiaceae, Selaginellaceae, Thelypteridaceae, and Woodsiaceae.

Procedures

Data recorded on ecology and distribution was based on direct observation during field studies. Voucher specimens (fronds and pinnae) have been preserved at BOHB, Herbarium of Center for Plant Conservation-Bogor Botanical Gardens, Indonesian Institute of Sciences, Indonesia.

Dried herbarium collections of *C. barometz* were carried out using standard methodology for collecting tree ferns specimens [16]. Basal cuttings of stipe, 1-2 pairs of the largest pinnae, and the apex of lamina were taken for herbarium specimens. The other morphological data, such as rhizome size (length and diameter), the size (length and diameter) and color of stipe, size and colour of hairs, size (length and broad) and colour of lamina, the number or pinnae and the colour of indusia, were examined directly in the field. Five to ten collections have been taken at various elevations with intervals of 50 m asl for each locality and then recorded and measured for the main characters.

Random search with belt line transects were set up to estimate the population size or abundance of adult plants of *C. barometz* in a particular area. Belt line transects are very commonly used in studies on the population biology of plants [17, 18] and they result in more precise estimates of population size, even for rare organisms, compared with square meter quadrats [19]. Following the procedures described by Praptosuwiryo et al. [5, 20], the belt line transects were 20 × 250 m^2 in size with 20 × 25 m^2 subplots. The position and number of transects were determined on the basis of the spatial distribution pattern of *C. barometz* in each distribution areas. In general *C. barometz* is distributed in the same direction as the contours of the hills. Therefore, in this study, the belt transects were established along the contours of the hills as this transect method is usually very suitable for field areas in hilly or mountainous areas. Only one transect was set up if the population of *C. barometz* in a particular area was only located on a specific slope. Minimally, three transects were set up in situations where *C. barometz* was distributed from lower slopes to upper slopes, viz. lower, middle, and upper slopes.

Population size data generated from transects were used to estimate the population size of *C. barometz* for specific area in which the populations were observed to be similar to the populations within the transects. The transects commonly covered 25 – 30% of the total distribution area of *C. barometz*. Population size in a certain area was determined as the local population, following the method described by Landi and Angiolini [21]; the local population of *C. barometz* is a cluster of plants of the species separated from other clusters by at least 500 m.

Population sizes of *C. barometz* were estimated using the formula:

$$N = \left(\frac{A}{a}\right) \times n$$

Note:

N : the estimated total population size
A : the total study area
a : the area of the belt line transect (total area observed)
n : the number of individual plant of *C. barometz* per total area observed

In collecting population data, only the mature plants were recorded; as described by Praptosuwiryo et al. [5] the mature plant was defined as follow: (i) rhizome at least 10 cm in height or more and 8 cm diameter or more (ii) lamina more than 60 cm long, (iii) presence of fertile fronds. *C. barometz* is usually growing solitary or in a clump (consists of 2 – 20 individuals). In this

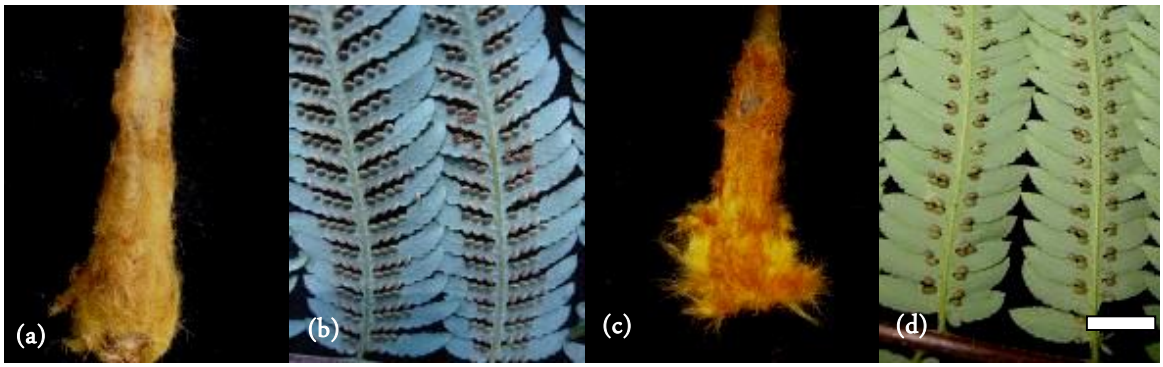

Figure 2. Morphological variants of C. barometz recorded in Riau Province, Sumatra. a-b. Variant-1 (golden yellow), lower part of stipe (a), part of pinnulae (b), Variant-3 (golden brown variant) (c and d), lower part of stipe (c), and part of pinnulae (d). Bar = 1.5 cm for a and c; 1.2 cm for b and d.

Figure 3. Morphological variant type of C. barometz in Sumatra. Variant-1 (a, b, and c); rhizome with stipe and crozier (a); part of pinna (b), Variant-3 (c and d); Rhizome with stipe and crozier (c); Part of pinna (d). Bar = 5 cm for a and c; 2.1 cm for b and d (Rugayah et al., 2009)

research, population size was determined by counting individual plants not clumps.

To describe the relevant plant communities, lists of associated species were recorded. To describe the habitat at each locality, ecological variables recorded included elevation (altitudinal range, slope, air temperature, air humidity, canopy coverage, soil pH, major soil type, leaf litter depth, and soil pH (Table 2.). Ferns and fern ally species associated with *C. barometz* were also recorded. Fern families have been arranged according to the classification of Smith et al. [4].

RESULTS AND DISCUSSION

Botanical inventory: Morphological variation of Cibotium barometz in Riau Province, Sumatra

Results of observations on herbarium specimens are reported as follows. Measurement and recording of the characters was based on worksheets from 34 collection numbers of *C. barometz* herbaria specimens collected during field research in two sub-district of Kampar districts, namely Bangkinang Barat sub-district and Kampar Kiri sub-district. Two variants of *C. barometz* in Riau were recorded, viz. golden yellow hairs variant (Figure 2.a-b) and golden brown hairs variant (Figure 2.c-d). The two variants are similar to variants recorded in West Sumatra by Rugayah et al. [22] (Figure 3).

Rugayah et al. [22] recognized three variants of *C. barometz* in West Sumatra, namely variant-1 (golden yellow hairs variant), variant-2 ("bule" variant) and variant-3 (golden brown hairs variant). Following those described by Rugayah et al. [22], the golden yellow hairs variant and golden brown hairs variant of Riau Province are encoded as Variant-1 and Variant-3, respectively. The two variants are differentiated by character combinations as follows: (1) Hair color on the rhizome; (2) Hair existence on rachises and veins; (3) The existence of tertiary leaflets; (4) Segment distance; (5) Veinlets branching; (6) The colour of indusium and number of

sori. Morphological comparison between the two variants are presented in Table 3. The variant-2 which is easily recognized by the whitish-pale brown hairs on its rhizome or croziers (uncoiled young fronds) [22] is not found in Riau Province. The existence of intraspecific variation of *C. barometz* Sumatra should be more extensively studied. The formal status of these variations should be clarified. Cytological, reproductive and molecular study approaches will be useful tools to clarify the taxonomic status of the variants of *C. barometz* in Sumatra. Molecular analysis of *C. barometz* in China showed intraspecific variation in this species. The analysis of genetic diversity of *C. barometz* in China by You and Deng [23] showed 41.06% of genetic diversity among populations and 58.94% of genetic diversity within populations.

Distribution and ecology of C. barometz in Riau Province

The distribution of populations of *C. barometz* in eight locations in two sub-districts in the district of Kampar, Riau Province are presented in Table 1. The range of distribution of this species is between the coordinates E-100°54'22" N-00°17'54.4" and E-100°47'10.7" S-00°06'39.3". These localities included two main vegetation types, namely secondary forest and rubber plantation, on a hilly contour with altitude range between 80 m and 600 m above sea level.

Table 2 and Figure 4 show the habitat characteristics of *C. barometz* in Riau Province. Data on the presence of *C. barometz* in Rantau Berangin district, of Bangkinang West, gives new perspective about the habitat range of *C. barometz* in Sumatra, because the location is at an altitude below 200 m asl; to be precise, at a height of 85-120 m above sea level. This is new information about the existence of *C. barometz* in the lowlands of Sumatra below 300 m asl. Generally the habitats of *C. barometz* in Sumatra are found in an altitudinal range between 500 and 1200 m above sea level [5]. In the hilly forest of Kampar Kiri Subdistrict, *C. barometz* usually forms a dense population and is restricted to a spatially fragmented habitat type on the northern slopes at an altitude of 250-600 m above sea level. Slope angle varied among locations from gentle to steep, nearly vertical; from 35° to 90°. Plants were found on soil that was clay-rocky, dusty-sandy, granular and usually dry, of the major soil types yellow entisol and inceptisol. This species can grow on very poor soil, for example on sedimentary rock formations or rocky ground at a slope 80 – 90° in which the humus or litter layer is less than 2 cm in depth (Figure 4.b-c.). However, this species will also grow well and make a dense thicket on fertile soil or humus rich soil with a litter depth between 2 cm and 15 cm. The soil pH is acid to nearly neutral, between 6.5 and 6.7. In North Sumatra, Praptosuwiryo et al. (2011a) [5] reported that this species grows in a soil acidity range between 5.0 and 6.5.

In the secondary forest, common Angiosperm associates included species belonging to the families Annonaceae, Apocinaceae, Poaceae, Euphorbiaceae, Myrtaceae, Clusiaceae, Melastomataceae, Elaeocarpaceae, Rubiaceae, Moraceae, Araceae, and Zingiberaceae. On the other hand, in rubber plantation, the flowering plant species that dominated the locations belonged to the Euphorbiaceae, Araceae, Myrtaceae, Myrsinaceae, Poaceae, and Zingiberaceae.

The associated plant species of pteridophytes in the secondary forest and rubber plantation were recorded. There were 54 species belongs to 29 genus and 19 family of ferns and fern allies grow surrounding *C. barometz*. *Blechnum orientale* L., *Dicranopteris linearis* (Burm. F.) Underw., *Dipteris conjugata* Reinwardt, *Nephrolepis biserrata* (Sw.) Schott., *Pteridium caudatum* (L.) Maxon subsp. yarrabense, and *Stenochlaena palustris* (Burm.) Bedd. were relatively abundant species. *B. orientale* L., *Dicranopteris linearis* (Burm. F.) Underw., *Dipteris conjugata* Reinwardt, *Nephrolepis biserrata* (Sw.) Schott., *Pteridium caudatum* (L.) Maxon subsp. yarrabense and *Stenochlaena palustris* (Burm.) Bedd. commonly make a thicket in the open areas of marginal secondary forest or in patches of secondary forest and rubber plantation. *Taenitis blechnoides* (Willd.) Sw. grows scattered in the two vegetation types. The tree fern *Cytathea* contaminants grows scattered among *C. barometz* in the two vegetations. Cyathea contaminants usually makes a dense thicket in patches of the two vegetations along the margins of streams or rivers where *C. barometz* is also growing. In China, the species of Gleicheniaceae (*Dicranopteris pedata*) also make a thicket surrounding *C. barometz* [8].

Population size and population density of Cibotium barometz in Riau Province, Sumatra

Population size and population density data of *C. barometz* Riau are also presented in Table 2. Average population density of *C. barometz* in Kampar District was 20 plants per 100 square meter. The ranges of population size were 5 - 25 plants in Bangkinang Subdistrict and 612 – 9,405 plants in Kampar Kiri Sub-district.

Why is the population size of *C. barometz* in

Figure 4. Habitat of *C. barometz* in Riau Province-Sumatra. Bukit Punggung Lading, hilly secondary forest and rubber plantation in Salasuang Country, Kampar Kiri Sub-district, Kampar District (a); *C. barometz* growing on sedimentary rock formation or rocky ground at the slope 80-90° on the humus soil or litter less than 2 cm depth (b and c), sporelings (b), mature sporophyte (c), mature sporophyte of *C. barometz* (d) growing among the dense of understorey in the rubber plantation in Bukit Punggung Lading I.; clump of *C. barometz* (e) growing among the dense of understorey in the dense secondary forest in Bukit Kuda Beban.

Bangkinang Subdistrict so low? The habitats of *C. barometz* in Bangkinang Subdistrict were areas of a rubber plantation about 5 – 8years old, with a canopy coverage between 20 – 50%. The two localities are on the edge of the province's main road. Land use change seems to be the main factor responsible for the low population size in these locations. Formerly the localities were secondary community forests which were transformed into rubber agroforest or rubber plantation. Not so far away, surrounding the habitats of *C. barometz*, we found palm

Table 3. Morphological comparison between two variants of *C. barometz* of Riau Province, Sumatra

Character	*Variant 1 (Golden yellow hairs)*	*Variant 3(Golden brown hairs)*
Hair color	Golden yellow - reddish brown Brown - yellow	Golden brown - reddish, Red - brownish
Hair existence	Hair on the rachis thin or absent; hair on the lower veins absent; dirty white	Hair on the rachis thin or absent; hair on the lower veins absent; dirty white
Tertiary leaflets	Absent, if present has not divided perfectly or only one well divided segment on the basal	Present on secondary leaflet mainly on the upper basal
Segment distance	Wide (2-3 mm)	Narrow (0.5 mm)
Veinlets branching	1-2	1
Indusium and sorus	(2-), 3-6; light green - brownish	1-2; olive - green - purple - reddish

tree plantations.

Two locations revealed a relatively high population size, namely Bukit Punggung Lading I and Bukit Kuda Beban, with estimated total populations of 7,725 plants and 9,405 plants, respectively, in the same total study area, viz. 20,000 m^2. The population density were 38.6 plants per 100 square meter and 47.0 plants per 100 square meter for Bukit Punggung Lading I and Bukit Kuda Beban, respectively. The habitats of the two localities seems to be very suitable for *C. barometz*. Bukit Punggung Lading I was a rubber plantation with 10-15 years old rubber plants with a relatively dense canopy (50-60%) and a relative atmospheric humidity of 82-92%. As reported by Praptosuwiryo et al., *C. barometz* usually grows well and forms a dense population in habitats with canopy coverage and relative air humidity 50 – 70% [5].

As stated by Praptosuwiryo et al. [5], the relative density of *C. barometz* per hectare is usually determined by distance among the individual plants or clumps, by clump size, and by the dominance of the habit, whether solitary or forming a clump. Individual plants or clumps of *C. barometz* in the secondary forest of Bukit Kuda Beban grew with a spacing of between 1 m and 4 m apart, consisting of two to four plants per clump, whereas in the rubber plantation of Bukit Punggung Lading I, this species grew as solitary plants or in clumps consisting of only 2 plants. The land use status also affects the population size and population density of *C. barometz* in a locality. The habitat of *C. barometz* in the secondary forest of Bukit Kuda Beban was relatively safer from human disturbance, such as burning and clearing for cultivation.

CONCLUSION

The report of distribution sites for *C. barometz* in Riau Province is a new record for Sumatra. Two morphological variations of *C. barometz* in Riau are recognized, namely Varian-1 (Golden Yellow Hairs) and Variant-3 (Brown Yellow Hairs). The two variants are differentiated by character combinations as follows: (1) Hair color on the rhizome; (2) Hair existence on rachis and veins; (3) The existence of tertiary leaflets; (4) Segment distance; (5) Veinlets branching; (6) The colour of indusium and number of sori.

C. barometz is distributed in eight locations of the hilly secondary forest and rubber plantations in two subdistricts (Bangkinang Barat and Kampar Kiri) of Kampar District, between 80 m and 600 m above sea level. The finding of an altitude range of *C. barometz* in the lowland area of Sumatra between 80 m and 250 m above sea level is also new data for Sumatra, because this species is usually found above 600 m asl.

The average population density of *C. barometz* in Kampar District, Riau Province is relatively high, namely 20 plants per 100 square meter. The range of populations were 5 – 25 plants in Bangkinang Subdistrict and 612 - 9,405 plants in Kampar Kiri Sub-district. The highest population size was in secondary forest of Bukit Kuda Beban at 590 – 600 m asl, viz. 9,405 plants with population density 47 plants per 100 square meter.

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