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Short communication: A new record of *Etlingera megalocheilos* (Griff.) A.D. Poulsen (Zingiberaceae) in Sulawesi, Indonesia

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Abstract. *Trimanto, Hapsari L. 2018. Short communication: A new record of* Etlingera megalocheilos *(Griff.) A.D. Poulsen (Zingiberaceae) in Sulawesi, Indonesia. Biodiversitas 19: 1227-1235.* A through morphological examination has been conducted to a living specimen of Zingiberaceae collection of Purwodadi Botanic Garden, East Java which was collected from Pangi Binangga Nature Reserve, Central Sulawesi. The result showed that the characters of the species match very well with the description of *Etlingera megalocheilos*. The distribution of *E. megalocheilos* was previously reported to occur only in Sundaland includes Peninsular Malaysia, Singapore, Sumatra, Java, and Borneo. Thus, *E. megalocheilos* is a newly recorded species in Sulawesi; and confirmed that its distribution record now has expanded to Wallacea. The key morphological characters of *E. megalocheilos* are labellum hourglass-shaped, dull red or red to orange-red with the yellow margin, the anther is not covered by the corolla lobe, and have slightly angled filament. Detailed descriptions, photographs, and notes of the species are presented in this paper. Due to its high potential medicinal properties, further bioprospecting studies are necessary to conduct.

Keywords: *Etlingera megalocheilos*, new record, Sulawesi, Zingiberaceae

INTRODUCTION

Etlingera Giseke is a large genus and morphologically diverse in the family Zingiberaceae. It represented by approximately of 150 to 200 species (Poulsen 2012). *Etlingera* species are evergreen and found mostly in equatorial evergreen forests, growing from lowlands to high altitudes of 2700 m. It is widely distributed from Northeast India and extends from Asia to Pacific Islands (Poulsen 2012; Yeats 2013). Due to present anthropogenic pressures on land and the consequential conversion of forested area to other uses, many of rainforest habitats are now greatly degraded, fragmented or lost entirely. However, some *Etlingera* species are found at forest margins and can exhibit vigorous growth in disturbed areas (Yeats 2013). Some species are cultivated for various purposes, such as *E. elatior, E. fulgens, E. hemisphaerica, E. walang,* etc. (Khaw 2001; Poulsen 2006; Poulsen 2007; Yeats 2013).

The genus *Etlingera* is a terrestrial perennial herb which can range in height from less than 50 cm to nearly 10 m. The larger species have strong, stout, leafy shoots called pseudostems arising from thick rhizomes which become robust with age. Several species have stilt roots to supports roots growing laterally and downward from their rhizome. The flowering shoot of *Etlingera* is a cone-like spike composed of bracts and flowers which are held on a peduncle of various lengths, with attractive and colorful tubular flower (Yeats 2013). Many species of *Etlingera* are used traditionally and commercially as food, herbs, medicines, and ornamentals; and also play an important role in the understorey layer as animal food source (Heyne 1927; Noweg et al. 2003; Poulsen 2007; Chan et al. 2007; Gobilik and Limbawan 2010; Poulsen 2012; Lamb et al. 2013; Lim 2014).

Etlingera megalocheilos (Griff.) A.D. Poulsen is one of wild ginger commonly called as Tepus (Heyne 1927; Poulsen 2006; Poulsen 2007). This species was described for the first time as *Achasma megalocheilos* by Griffith (1851) according to a specimen from Peninsular Malaysia. It was also mentioned by Ridley (1899), Holttum (1950), and Khaw (2001) was called *E. littoralis* following Burt and Smith (1986), and lastly was described by Poulsen (2007). Distribution of *E. megalocheilos* was previously reported to occurs in Peninsular Malaysia (Khaw 2001; Poulsen 2007), Sumatra (Poulsen 2007), Java (Poulsen 2007), and the last report is distributed in Borneo (Poulsen 2006; Poulsen 2007).

The morphological characteristics of *E. megalocheilos* is most easily confused with *E. coccinea* since they both have inflorescence embedded in the soil and an elongate, with red and yellow labellum (Poulsen 2007). Moreover, *E. megalocheilos* is also closely related and similar to *E. littoralis.* It is known that *E. littoralis* has median red with a yellow lateral labellum (Chongkraijak et al. 2013). However, Smith (1986) was placed the species as synonymous as *E. littoralis,* even though their flowers bright red with no yellow color on the labellum. According to Poulsen (2007), the spesific characteristics of the species are petiole 1-4 cm, dorsal corolla lobe not covering the anther, the labellum is red with more or less pale red or

yellowish lateral lobe margins, the margins of the labellum are not enrolled, anther dehiscing in upper half only; and fruit top rounded, smooth or with a few warts.

During field inspections to the gingers living collection in Purwodadi Botanic Gardens - Indonesian Institute of Sciences (Pasuruan, East Java), we have noticed a species collected from Pangi Binangga Nature Reserve, Central Sulawesi which suspected as *E. megalocheilos*. After a through examination, the morphological characteristics of the species were matched very well with the description of *E. megalocheilos*. The latest revision of *Etlingera* species in Sulawesi by Poulsen (2012) included 48 species, but *E. megalocheilos* was not listed. Therefore, this paper is aimed to report the first occurrence and new distribution record of *E. megalocheilos* in Sulawesi, Indonesia. This paper presents the detail morphological description of *E. megalocheilos* as a new record in Sulawesi and also discussed the comparison to its close related species *i.e. E.littoralis* and *E. coccinea*, its conservation concerns, potential uses and also future prospects.

MATERIALS AND METHODS

Study area

The specimen examined was collected from Pangi Binangga Nature Reserve which located in Parigi Moutong Regency, Central Sulawesi, Indonesia (Figure 1). It has typical ecosystem of lowland tropical rainforest (< 1000 m alt.), with general topography of very steep (81.65 %) and steep (18,35%), annual rainfall in depth of 2,355 mm, daily temperature 19.8^0 to 26.2^0 C and relative humidity of 80% (BKSDA Sulteng, 2018). Furthermore, the living plants were ex situ conserved and well-cultivated at Purwodadi Botanic Gardens, Indonesian Institute of Sciences (Pasuruan, East Java, Indonesia) which has typical lowland and dry climate. The topography is flat to bumpy (±300 m alt.), with annual rainfall in depth of 1,812.5 mm, daily temperature 28.9^0 to 34.6^0 C, and relative humidity of 79% (Purwodadi Botanic Garden, 2018). The specimen examined was located at Vak V.E.I.62.

Morphological characterization method

The morphology of a newly recorded species was characterized from cultivated living plants from Sulawesi in Purwodadi Botanic Garden. Detailed morphological measurements in both vegetative and generative parts were made using a ruler, digital caliper, and a long arm microscope. Herbarium specimens were taken from the plants cultivated in the Garden, covering of leaves (dried), rhizomes and inflorescences (spirit); and deposited at the Herbarium of Pasuruan Hortus Botanicus Purwodadiensis (PHBP). For comparison, some digitized herbarium specimen sheets of *E. megalocheilos* from Herbarium of the Royal Botanic Garden of Edinburgh (E), materials from Malaysia and Indonesia; and living plant material of *E. megalocheilos* from Java were also observed. The morphological characteristics of the specimen examined were compared to descriptions of the protologue *E. megalocheilos* (*Etlingera* of Borneo 2006:167), digitized herbarium specimens, and *E. megalocheilos* from Java, also with some references.

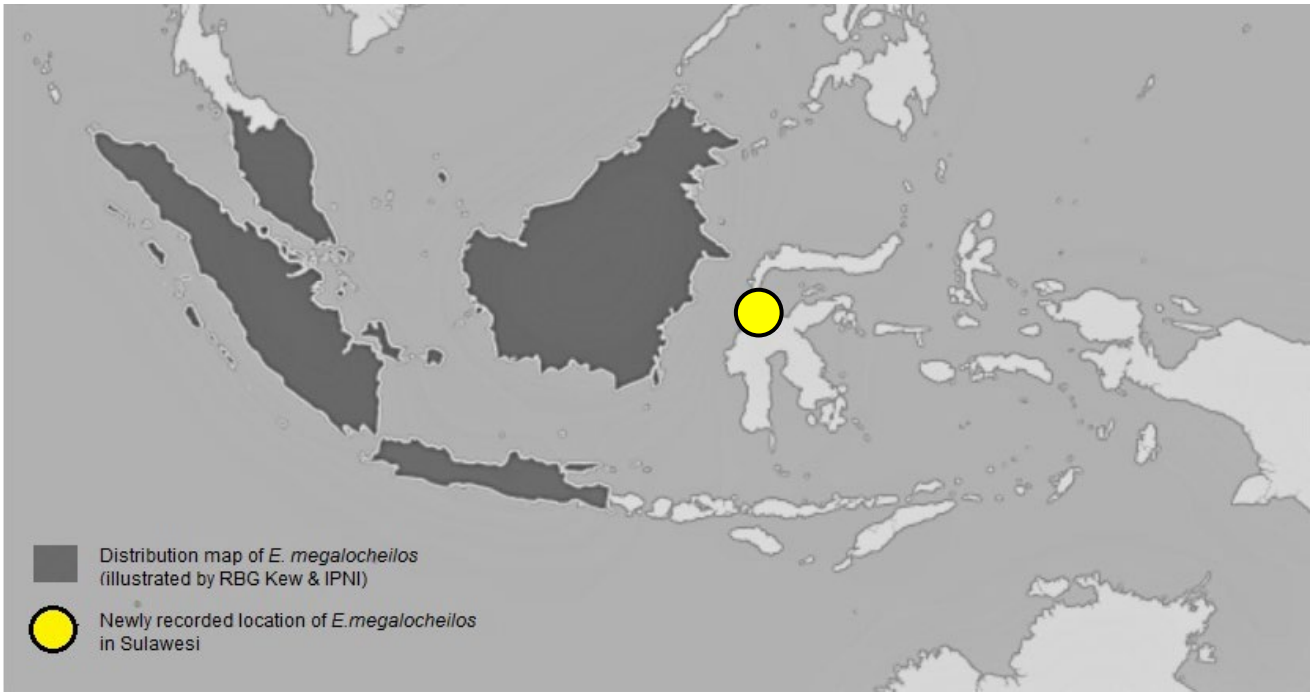

Figure 1. Distribution map of *E. megalocheilos* and its newly recorded location in Sulawesi, Indonesia

RESULTS AND DISCUSSION

A detailed account comprising taxonomic treatments, basionym, synonym, descriptions, distribution, habitat and ecology, phenology, specimens examined, photographs and notes of this newly recorded species is provided hereunder:

Taxonomic treatments

Etlingera megalocheilos (Griff.) A.D. Poulsen, *Etlingera* of Borneo (2006) 167, Gard. Bull. Singapore 59 (1&2) (2007) 161 — Type: W. Griffith s.n. (specimen not found): Malaysia, Johore, Mt. Ophir; Poulsen *et al*. 2341 (AAU, BO, E): Indonesia, Banten Province; Poulsen *et al*. 2461 (BO, E): Indonesia, West Java Province.

Basionym: *Achasma megalocheilos* Griff., Not. Pl. Asiat. 3: 426 (1851), Ic. Pl. Asiat. 3: 355 (1851).

Synonym: *Amomum megalocheilos* (Griff.) Baker, Fl. Brit. India 6: 236 (1892); *Amomum rubroluteum* Baker, Fl. Brit. India 6: 236 (1892); *Etlingera rubrolutea* (Baker) C.K. Lim, Folia Malaysiana 2: 157 (2001), *Hornstedtia megalocheilos* (Griff.) Ridl., J. Straits Branch Roy. Asiat. Soc. 32: 146 (1899).

Description: *Rhizomes* long-creeping, subterranean (1.5-25 cm), stout, >2 cm in diameter, cream to pale brown, *scales* up to 6 cm, brown, pubescent at base. *Leafy shoot* to 5 m, with up to 26 leaves, base to 8 cm in diameter and 2 cm in the middle, dark green. *Ligule* up to 15 mm long, entire, green or tinged reddish brown, glabrous or with a few scattered hairs, margin ciliate. *Petiole* 15-35 mm, glabrous. *Lamina* to 78 x 16 cm, oblong, the broadest above the middle, mid to dark green, pale beneath; *young leaf* tinged reddish, glabrous (rarely pubescent), base unequal, apex acute. *Inflorescence* up to 13 cm long including peduncle, embedded in the soil, often some distance from base of leafy shoot, with 10-12 flowers, 2-5 open at a time. *Peduncle* 2 cm long, subterranean, *peduncular bracts* cream to red, acute, shiny, glabrous. *Spike* to 10 cm x 2,5 cm long, cylindrical; *flowers* extended 4 cm above the bracts, length only including bracts: 3-6 cm. *Sterile bracts* up to 8, loosely and spirally arranged, to 2-6 x 1-3.5 cm (upper longest and narrowest), ovate to broadly spathulate (widest above the middle), rigid, mucronate, cream-tinged pink or dark red, densely pubescent at least in lower half and shiny at upper half. *Fertile bracts* 5-7 x 0.6-1.5 cm, linear to spathulate, semitransparent, white in lower half and pink in upper half, pubescent in lower half, and pink; apex cucullate, ciliate. *Bracteole* 4.5-6 cm, pale pink, membranous, with two fissures of 1.5 cm; *pubescent* in lower half, apex 2-toothed, ciliate. *Calyx* 6-9 cm, almost reaching filament, ± as long as corolla lobes, white to pale red with pinkish apices, fissured 4-3.5 cm, pubescent in lower 1/4; apex irregularly 3-toothed, tufted. *Corolla tube* 5.5 cm, pale red, darker at apex, glabrous, tube hairy inside especially in a 10 mm band ending 10 mm from labellum. *Lobes* pale red or pink, glabrous, delicately membranous; *dorsal lobe* 21-30 x 7-9 mm, reaching near middle of anther (but pushed to the side by the lateral lobes of labellum leaving the anther ± exposed), elliptic, broadest below middle, apex slightly ciliate; *lateral lobes* 21-35 x 5-5 mm, linear-elliptic, the broadest below middle, apex slightly ciliate, insertion oblique, converging, 0-3 mm above dorsal lobe. *Staminal tube* 12-22 mm. *Labellum* hourglass-shaped, 45-50 x 20-25 mm, plain red or red to orange-red with yellow margin, with a longitudinal central ridge, glabrous, lateral lobes erect, adhering to sides of anther, central lobe 40-48 x 17 mm (measured from apex of anther and when flattened), spathulate, entire or emarginate (to 1.5 mm), margin recurved, apex extended 35 mm beyond anther. *Stamen* 17 mm; *filament* 4 x 5 mm, slightly hairy on outside, pale red; *anther* 9-10 x 4-5 mm, broadest at apex, emarginate 3 mm, slightly angled 135°-160°, red, darker at crest; *thecae* dehiscing in upper 1/2-2/3, glabrous with a few hairs at the base. *Style* up to 7 cm, glabrous to very sparsely hairy adaxially near apex. *Stigma* 3 mm wide, rounded-triangular with a rounded back, pale or dark red; *ostiole* transverse, 2.5-3 mm, facing downwards or forwards, perhaps flexi-stylous. *Ovary* 3-7 x 3-4,5 mm, densely hairy. *Fruit* and *seed* not observed (Figure 2).

Distribution: This species is distributed from Peninsular Malaysia (Khaw 2001; Poulsen 2007), Sumatra (Poulsen 2007), Java (Poulsen 2007), Borneo (Poulsen 2006; Poulsen 2007); to Sulawesi (this study) (Figure 1).

Habitat and ecology: There is no specific information about its natural habitat in Pangi Binangga Nature Reserve; since the plant materials were came from an early collection of Purwodadi Botanic Garden, in 1993. The natural habitat based on where the specimen examined was collected from the typical ecosystem of lowland tropical rainforest (alt. < 1000 m; Annual rainfall 2,355 mm). However, it was well grown and adapted in Purwodadi Botanic Gardens with typical lowland and dry climate (alt. ±300 m; annual rainfall 1,812.5 mm). According to Poulsen (2006; Poulsen 2007), this species is often dominant in the forest gaps or completely open areas at altitudes 30 m to 1300 m alt.; like old gardens, abandoned rubber plantations, grazing areas or bamboo thickets near rivers or streams. A scholar reported that it grows wild on the riverbanks, roadsides and the edges of the Traditional Forest at Lekuk 50 Tumbi Lempur, Jambi, Sumatra (Novinovrita 2016). It commonly found as ornamentals in nature trails of lowland garden at Tawau Hills Park, Sabah; it prefers moist areas such as riverbanks, stream banks, and edges of natural ponds (Gobilik and Limbawan 2010). It often found in open areas such as abandoned plantations, gardens or places near rivers or streams (Chimera 2016).

Phenology: It was reported by Griffith (1851) according to specimens from Peninsular Malaysia flowering in February. Whereas, Poulsen (2007) reported it was flowering on April in Banten Province and on August in West Java Province. However, according to our observation in Purwodadi Botanic Gardens (East Java), it was flowering from November to December. It may due to the differences of the climatic condition of each location. In addition, the flowers did not produce fruit and seed set, since it requires specialized pollinators. The inflorescence is adapted for pollination by birds hopping on the ground such as the sunbird *Anthreptes malaccensis* (Ibrahim and Setyawati 1999) and spiderhunters *Arachnonthera longirostra* (Poulsen 2006).

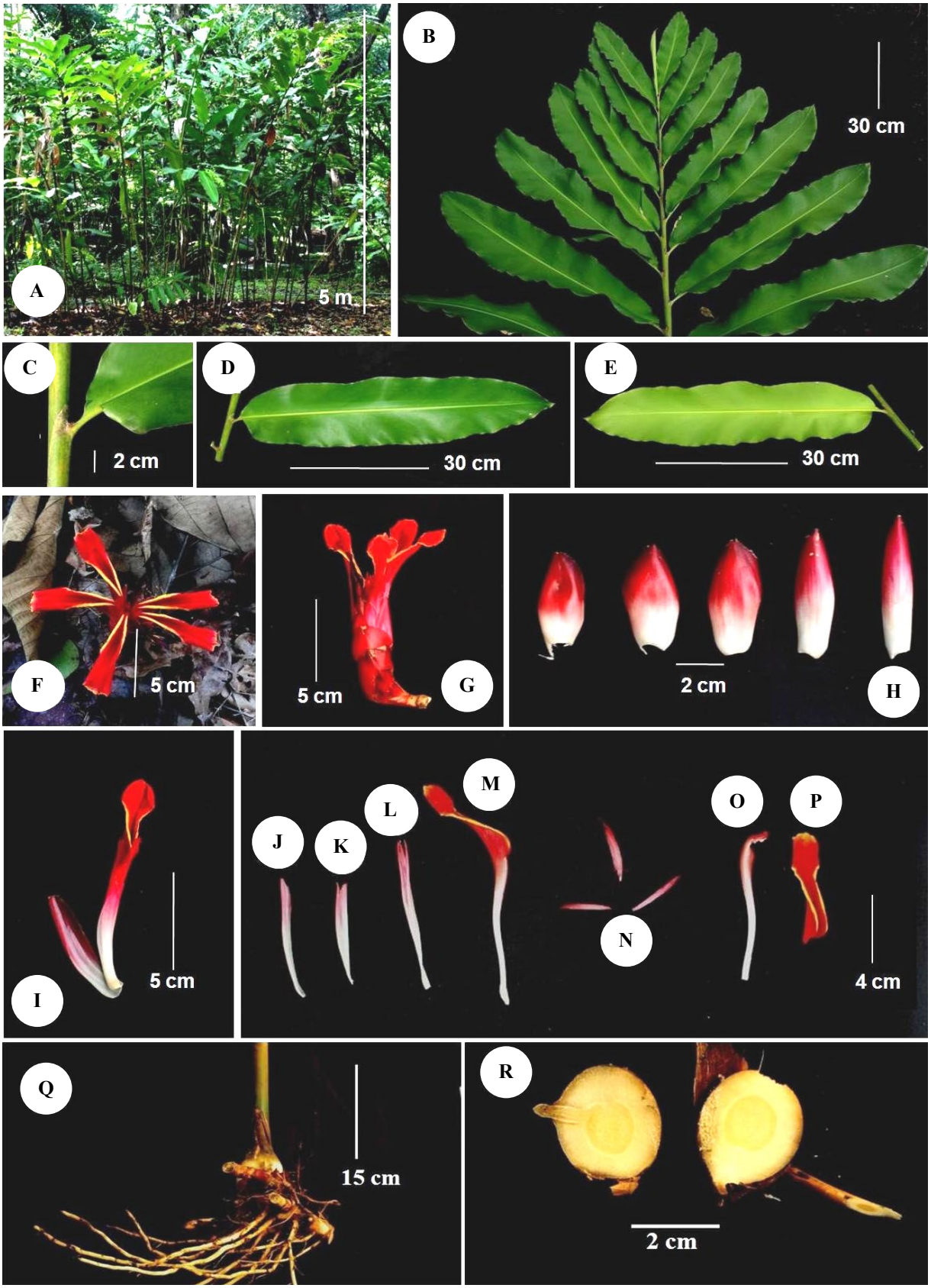

Figure 2. *Etlingera megalocheilos* (Griff.) A.D. Poulsen from Pangi Binangga Nature Reserve, Central Sulawesi cultivated in Purwodadi Botanic Garden. A. Habitus, B. Leaves, C. Ligule, D. Upper surface of leaves, E. Lower surface of leaves, F. Inflorescence (aerial view), G. Inflorescence with peduncle (side view), H. Sterile bracts, I. Flower with fertile bract, J. Fertile bract, K. Bracteole, L. Calyx, M. labellum with reproductive organ, N. Corolla lateral and dorsal lobes, O. Corolla tube, staminal tube, stamen and stigma, P. Labellum, Q. Rhizome, R. Transversal section of rhizome.

Specimens examined: P19930724/Sim.007, collected from Pangi Binangga Nature Reserve, Parigi Moutong Regency, Central Sulawesi (no GPS location recorded), planted in Purwodadi Botanic Gardens, East Java, at Vak V.E.I.6 on 26 December 1994, living plants flowering; PHBP 0002018 (dried herbarium) and PHBP 467 (spirit herbarium); P199109107/Is.11, collected from Alas Purwo National Park, Banyuwangi, East Java, planted in Purwodadi Botanic Garden, East Java, at Vak V.E.I.52-ab on 30 November 1992, living plants flowering. Digitized herbarium specimen sheets includes E00211420, material from Kinabalu National Park, Malaysia, Smith 31/86; E00211423, material from Tenom District, Sabah, Malaysia, Lamb 229/86 (Figure 3A); E00226789, material from Ujung Kulon National Park, Banten, Indonesia, Poulsen et al. 2341 (Figure 3B); and E00226817, material from Cibabi, West Java, Indonesia, Poulsen et al. 2461.

Discussion

After a through morphological observations, herbarium specimens, protologue and references studies, we concluded that the specimen examined is identified as *E. megalocheilos*. The characters were matched very well with the protologue description of *E. megalocheilos* from Borneo by Poulsen (2006) and also *E. megalocheilos* from Java (Poulsen, 2007). At first, this species was misidentified in the Garden as *Amomum* sp. When the living plants in the Garden was flowering, then we could fully characterize and identify it. We were also conducted a morphological comparison to the living collection of *E. megalocheilos* from Java, and the description result was similar. The key morphological characters of *E. megalocheilos* are labellum hourglass-shaped, plain red or red to orange-red with the yellow margin, the anther is not covered by the corolla lobe, and have slightly angled filament (Figure 2). Nonetheless, genetic testing using the molecular approach such as DNA barcodes is required to confirms the morphological identity result and compares to its closely related species.

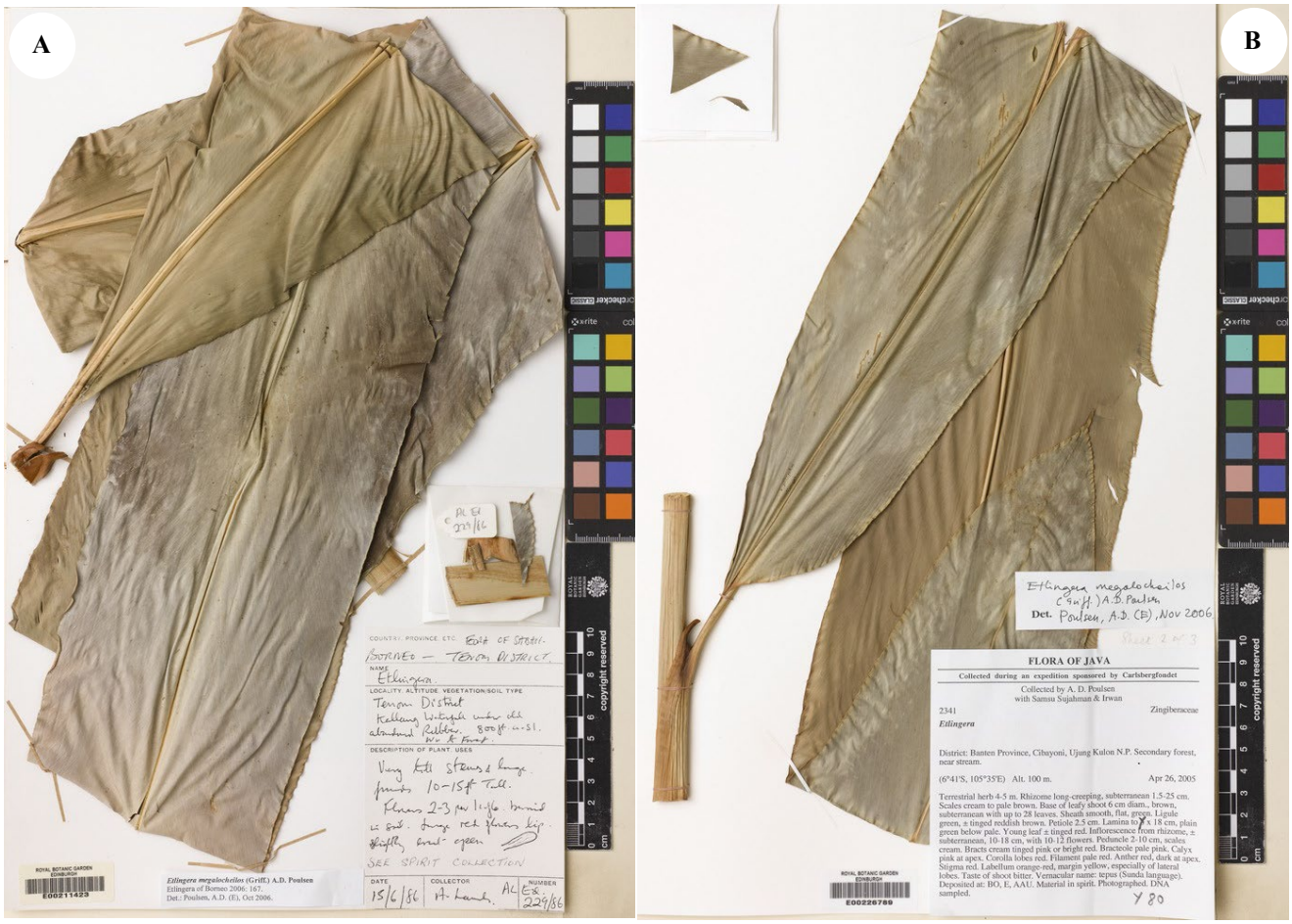

Figure 3. Digitized herbarium specimen sheets of *Etlingera megalocheilos* (Griff.) A.D. Poulsen from Herbarium of the Royal Botanic Garden Edinburgh (E): A. E00211423, material from Sabah, Malaysia and B. E00226789, material from Ujung Kulon NP, Indonesia

Notes of E. megalocheilos *compare to its closely related species*

Before the latest revision by Poulsen (2006), the first report and whom describe this species was by Griffits (1851) called *Achasma megalocheilos* Griff. and then Khaw (2001) mentioned this taxon as *E. littoralis*. Indeed, the morphological characteristics of *E. megalocheilos* is confusing with *E. littoralis.* According to Khaw (2001), *E. littoralis* has horizontal labellum, blade elongate 7 cm long, 2 cm wide, blade and basal lobes entirely red or with a yellow margin sometimes not reaching the broad apex, the margin of blade plain or crisped and crinkled, apex rounded, entire or slightly retuse. They have variations in lip color, most commonly encountered are plants with scarlet lips and a yellow margin. However, plants growing nearby may have scarlet lips edged orange-red or a third type. Whilst, description of *E. megalocheilos* by Poulsen (2007) is labellum hourglass-shaped, 52-70 x 20-22 mm, plain red or red to orange-red with yellow margin (Figure 4A), with a longitudinal central ridge, glabrous, lateral lobes erect, adhering to sides of anther, base slightly auriculate.

A comparison between those two species by Chongkraijak et al. (2013) confirms that *E. megalocheilos* was not synonymous with *E. littoralis*, they both are different species. The inflorescences of *E. littoralis* and *E. megalocheilos* are quite analogous, except the fruits are rather different. Morphologically, the inflorescence of *E. megalocheilos* has longer lip, a longer corolla tube, a longer labellum with median red and yellow edged (Figure 4A), a narrower central lobe of the labellum, and a shorter and narrower stamen (Poulsen 2006; Poulsen 2007), while inflorescence of *E. littoralis* is short and compact; each flower shows bright red and yellow labellum (Chongkraijak et al. 2013; Figure 4B). The stamen of *E. megalocheilos* has angled filament *ca.* 135°-160° (Poulsen 2006; Poulsen 2007; Figure 5A; Figure 5B) whilst *E. littoralis* is quite erect with very slight angled filament *ca.* 10°-15° (Chongkraijak et al. 2013, Figure 5B). The fruits of *E. megalocheilos* are rounded and smooth (not ridged) (Poulsen 2006; Poulsen 2007; Figure 6A) whereas the fruits *E. littoralis* are also rounded but deeply ridged (Chongkraijak et al. 2013; Figure 6B).

The other species which closely related to *E. megalocheilos* is *E. coccinea. E. megalocheilos* is most easily confused with *E. coccinea* that also has the inflorescence embedded in the soil and an elongate, with red and yellow labellum. However they both are different, *E. coccinea* distinguished in its (most often) sessile leaves, absence of tufts on the apex of the calyx, the broad and pink dorsal corolla lobe hooded (covering) over the stamen and stigma, the long-elongate labellum with a broad yellow center and red margin and thecae dehiscing almost to base. The margins are inrolled and like a tube so that the red at first glance appears to be in the center of the labellum (Poulsen 2006; Poulsen 2007; Naive et al. 2018; Figure 4B). Whereas in *E. megalocheilos* the anther is not covered by the corolla lobe, the margins of the labellum are not enrolled, and the labellum is red with more or less pale red or yellowish lateral lobe margins (not yellow with red margins) (Poulsen 2006; Poulsen 2007; Figure 4A). Infructescence of *E. megalocheilos* is embedded in the soil, bracts not persistent, with rounded, smooth and densely pubescent fruits (Poulsen 2006; Poulsen 2007; Figure 6A), whilst infructescence of *E. coccinea* is partly embedded in the soil, bracts persistent, with young fruit subglobular and densely pubescent (Naive et al. 2018; Figure 6C).

New distribution record of *E. megalocheilos* in Sulawesi

The discovery of *E. megalocheilos* at Pangi Binangga Nature Reserve from this study is considered as a new record in Sulawesi, since some previous studies reported that the distribution of *E. megalocheilos* occurs only in Peninsular Malaysia, Singapore, Sumatra, Java, and Borneo (Khaw 2001; Poulsen 2006; Poulsen 2007; Figure 1). Moreover, the latest revision of *Etlingera* in Sulawesi by Poulsen (2012) consists of 48 species, but *E. megalocheilos* was not listed. The checklist including *E. acanthoides, E. aculeatissima, E. alba, E. aulocheilos, E. bicolor, E. biloba, E. borealis, E. bullata, E. calobates, E. calophrys, E. canarina, E. caudata, E. chlorodonta, E. chrysantha, E. cylindrica, E. doliiformis, E. eburnea, E. echinulata, E. elatior, E. elegans, E. elliptica, E. flavovirens, E. flexuosa, E. grallata. E. heloconiifolia, E. heliconiifolia* subsp. *leucocheilos, E. hyalina, E. mundumiae, E. mucida, E. mucronata, E. orbiculata, E. orophila, E. pausodipsus, E. penicillata, E. polycarpa, E. polycarpa* subsp. *ligulata, E. rubroloba, E. sarasinorum, E. serrata, E. spinulosa, E. stenophylla, E. steringophora, E. sublimata, E. translucens, E. tubilabrum, E. urophylla, E. xanthantha,* and *E. yessiae.* Sulawesi is located in the western part of Wallacea region. It is interesting upon this study, that the distribution of *E. megalocheilos* based on biogeographical designation has expanded from Sundaland to Wallacea. In addition, it is strongly assumed that this species also occurs in Papua.

Conservation concerns

The population of *E. megalocheilos* was reported scarce by Bakhuizen (1968), but it has been observed in several very open habitats and considers it rather resilient to disturbance (Poulsen 2007). The latest assessment by Chimera (2016), its conservation status was categorized as Least Concern (LC) with WRA score of 3.0; which means it is not considered as a red-listed category. It may actually have expanded since this species has broad climate suitability, reproduced by vegetative fragmentation but sometimes by seed as well, seeds and propagules possibly dispersed by deer and intentionally by people. However, it has low risk on the environment; no reports of invasiveness or negative impacts. It has limited evidence of cultivation or naturalized outside its native range.

Figure 4. Comparison of the inflorescence. A. *E. megalocheilos* from Sulawesi, median red and yellow edged labellum (this study), B. *E.littoralis* from Thailand, bright red and yellow labellum (Chongkraijak et al. 2013), and C. *E.* coccinea from Philippines, broad yellow center and red involute margins labellum (Naive et al. 2018)

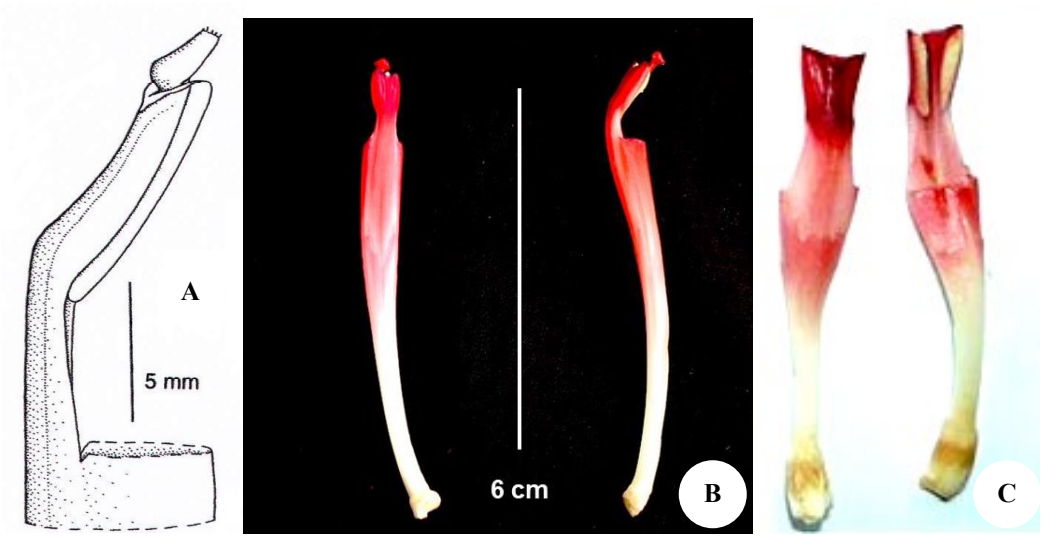

Figure 5. Comparison of the stamen. A. *E. megalocheilos* from Borneo, stamen with angled filament *ca.* 135° (Poulsen 2006); *E. megalocheilos* from Sulawesi, stamen with angled filament *ca.* 135°-160° (this study), B. *E. littoralis* from Thailand, stamen quite erect with very slight angled filament *ca.* 10°-15° (Chongkraijak et al. 2013)

Figure 6. Comparison of the fruits. A. *E. megalocheilos* from Peninsular Malaysia courtesy by Forest Research Institute Malaysia (FRIM), (Chongkraijak et al. 2013), B. *E. littoralis* from Thailand (Chongkraijak et al. 2013), and C. *E. coccinea* from the Philippines (Naive et al. 2018)

Table 1. Some chemical compounds from different material sources of *E. megalocheilos*

Chemical compounds	Concentration (%)			
	Rhiz.[1]	Leaf[1]	Rhiz.[2]	Rhiz. & root[3]
(E)-anethole	1.4	0.7	-	-
(E)-methyl isoeugenol	37.7	58.1	-	-
1,8-cineole	1.8	0.3	-	-
1-dodecanol	-	-	-	15.9
1-Naphthalene-pentanoic acid	-	-	7.4	-
2-heptyl acetate	3.8	1.7	-	-
4,4-Dimethyl-heptanedioic acid	-	-	7.1	-
Aromadendrene	-	-	8.9	-
Aromadendrene oxide	-	-	24.8	24.8
Azulene	-	-	3.0	-
Borneol	-	-	-	4.7
Camphene	0.1	0.6	-	-
Camphor	-	-	4.4	-
Caryophyllene	-	-	4.3	0.5
Caryophyllene oxide	-	-	5.7	-
Elemicin	-	-	-	35.6
Lauryl aldehyde	-	-	-	7.9
Methyl eugenol	0.9	0.9	-	-
Myrcene	0.6	0.1	-	-
Oxygenated diterpenes	-	-	14.3	-
Oxygenated monoterpenes	-	-	28.6	-
Oxygenated sesquiterpenes	-	-	28.6	-
p-cymene	0.1	0.1	-	-
Sabinene	0.3	<0.05	-	-
Sesquiterpene hydrocarbons	-	-	21.4	-
Spathulenol	-	-	5.6	-
Terpinen-4-ol	1.1	0.3	-	-
Terpineol oxide	-	-	13.0	-
Verbenol	-	-	3.1	-
α-gurjunene	-	-	3.3	-
α-phellandrene	0.1	0.2	-	-
β-caryophyllene oxide	-	-	-	1.2
β-phellandrene	8.6	2.8	-	-
β-pinene	30.4	3.2	-	-
γ-terpinene	0.5	0.1	-	-
δ-selinene	-	-	-	1.2
δ-3-carene	-	0.1	-	-

Reff.: 1) Wong et al. 2011; 2) Vairappan et al. 2012; 3) Nagappan et al. 2017

Potential uses and future prospects

The local name of *E. megalocheilos* is called Tuis by local people in Sulawesi (Data Record from Registration Unit of Purwodadi Botanic Garden), Tepus by Sundanese (Heyne 1927), Tepu by Malaysian (Noweg et al. 2003; Lim 2014), Tepus Kampong by Ibanic Dayak group, West Kalimantan (Dewi 2016) and Pua by community in Jambi, Sumatra (Novinovrita 2016). This species was not cultivated by local peoples, but the fruits are searched from the wild populations and edible (Heyne 1927). In Sabah (Malaysia), the hearts of young shoots, flower buds, and fruits are eaten (Noweg et al. 2003; Lim 2014); the aril is tasted sweet and sour (Lamb et al. 2013). It has prospects as outdoor ornamental ginger due to its red conspicuous flowers (Gobilik and Limbawan 2010).

Some bioprospecting studies on *E. megalocheilos* to search for its medicinal and other commercially valuable compounds have been conducted. Findings showed that leaves, rhizomes, stems, inflorescences and fruits of *E. megalocheilos* contain essential oils, volatile and non-volatile compounds which exhibited antioxidant, cytotoxicity and microbial activities (Chan et al. 2007; Sivasothy 2008; Wong et al. 2010; Vairappan et al. 2012; Nagappan et al. 2017). Some chemical compounds have been identified (Table 1) and its potential usefulness has been known; the rests have not been known yet. Further bioprospecting studies are necessary to conduct. With promising medicinal properties and activities, the species has great potential to be developed into natural preservatives and herbal products, applicable to the food, cosmetics, and nutraceutical industries.

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REFERENCES

BKSDA Sulteng. 2018. Cagar Alam Pangi Binangga Provinsi Sulawesi Tengah. Balai Konservasi Sumber Daya Alam Sulawesi Tengah, Palu. http://www.bksdasulteng.com/Cagar-Alam-Pangi-Binangga. [Indonesian] [Accessed 2 April 2018]

Bakhuizen van Den Brink RC. 1968. Zingiberaceae. In: Backer CA, Backhuizen van den Brink RC. Flora of Java, vol. 3. N.V.P. Noordhoff, Groningen, The Netherlands.

Burt BL, Smith RM. 1986. *Etlingera*: the inclusive name for *Achasma, Geanthus* and *Nicolaia* (Zingiberaceae). Notes R Bot Gard Edin 43: 235-241.

Chan EWC, Lim YY, Omar M. 2007. Antioxidant and antibacterial activity of leaves of *Etlingera* species (Zingiberaceae) in Peninsular Malaysia. Food Chemistry 104: 1586-1593.

Chimera C. 2016. Assessment report of *Etlingera megalocheilos* (Griff.) A.D. Poulsen. http://plantpono.org/files/Etlingera%20megalocheilos.pdf. [Accessed 22 March 2018]

Chongkraijak W, Ngamriabsakul C, Poulsen AD. 2013. Morphological diversity and distribution of *Etlingera littoralis* (König) Giseke (Zingiberaceae) in Southern Thailand. Walailak J Sci Technol 10 (6): 643-656.

Dewi AP. 2016. Ethnobotany of Dayak Iban-Village in Sintang District West Kalimantan Province: Species Diversity and Anatomy of Woven Plant Fiber. [Thesis]. School of Graduates, Bogor Agricultural University, Bogor, Indonesia. [Indonesian]

Gobilik J, Limbawang S. 2010. Notes on species composition and ornamental gingers in Tawau Hills Park, Sabah. J Trop Biol Conserv 7: 31-48.

Griffith W. 1851. Notulae ad plantas Asiaticas, vol. 3. Calcutta

Heyne K. 1927. Zingiberaceae. In: De nuttige planten van Nederlandsch Indie 1. 2nd edition. Department van Landbouw, Nijverheid en handel in Nederlandsch Indie.

Holtum RE. 1950. The Zingiberaceae of the Malay Peninsula. Gard Bull Sing 13: 1-249.

Ibrahim H, Setyowati FM. 1999. *Etlingera* Giseke. Record from Proseabase. In: de Guzman CC, Siemonsma JS (Editors). PROSEA (Plant Resources of South-East Asia) Foundation, Bogor, Indonesia.

Khaw SH. 2001. The genus *Etlingera* (Zingiberaceae) in Peninsular Malaysia including a new species. Gard Bull Sing 53: 191-239.

Lamb A, Gobilik J, Ardiyani M, Poulsen AD. 2013. A Guide to Gingers of Borneo. Natural History Publications (Borneo) Sdn. Bhd. Kota Kinabalu, Sabah, Malaysia.

Lim TK, 2014. Edible Medicinal and Non-Medicinal Plants Vol. 7, Flowers. Springer, The Netherlands.

Nagappan T, Yatau MH, Salim JM, Vairappan C. 2017. Diversity in volatile chemicals and antibacterial activity among selected genus of *Cinnamomum*, *Etlingera* and *Schizostachyum* from Sabah. J Sustain Sci Manag 12 (2): 26-33.

Naive MK, Pabillaran RO, Ecrupulo IG. 2018. *Etlingera coccinea* (Blume) S. Sakai and Nagam. (Zingibearaceae - Alpinieae): an addition to the Flora of the Philippines, with notes on its distribution, phenology and ecology. Biosci Discov 9 (1): 107-110.

Novinovrita M. 2016. Ginger species of Zingiberaceae family from Lekuk 50 Tumbi Lempur area. Tarbawi 1 (2): 1-10. [Indonesian]

Noweg T, Abdullah AR, Nidang D. 2003. Forest plants as vegetables for communities bordering the Crocker Range national Park. Asean Rev Biodiv Environ Conserv (ARBEC). January-March 2003: 1-18. Available at http://www.arbec.com.my/pdf/art3janmar03.pdf. [2 April 2018]

Poulsen AD. 2006. *Etlingera* of Borneo. Natural History Publications (Borneo) Sdn. Bhd., Kota Kinabalu, Malaysia & Royal Botanic Garden Edinburgh, Scotland.

Poulsen AD. 2007. *Etlingera* Giseke of Java. Gard Bull Sing 59 (1&2): 145-172.

Poulsen AD. 2012. *Etlingera* of Sulawesi. Natural History Publications (Borneo) Sdn. Bhd., Kota Kinabalu, Sabah, Malaysia.

Purwodadi Botanic Gardens, Indonesian Institute of Sciences. Recent Weather Data at Purwodadi Botanic Gardens. http://koleksi.krpurwodadi.lipi.go.id/pages/datacuaca. [2 April 2018]. [Indonesian]

Ridley HN. 1899. The Scitamineae of the Malay Peninsula. J Straits Branch R Asiatic Soc 32: 85-184.

Sivasothy Y. 2008. Phytochemical investigation on some species from the Genera *Elettariopsis* and *Etlingera*. [Dissertation]. School of Chemical Sciences, University of Sains Malaysia, Pinang, Malaysia

Smith RM. 1986. A review of Bornean Zingiberaceae: II (Alpineae, Concluded). Notes R Bot Gard Edin 43: 439-66.

Vairappan CS, Nagappan T, Palanivebo K. 2012. Essential oil composition, cytotoxic and antibacterial activities of five *Etlingera* species from Borneo. Nat Prod Commun 7 (2): 239-242.

Wong KC, Sivasothy Y, Boey PL, Osman H, Sulaiman B. 2010. Essential oils of *Etlingera elatior* (Jack) R. M. Smith and *Etlingera littoralis* (Koenig) Giseke. J Essential Oil Res 22 (5): 461-466.

Yeats H. 2013. The history and cultivation of *Etlingera*-The torch gingers-at the Royal Botanic Garden Edinburgh. Sibbaldia J Bot Gard Hortic 2: 71-86.