Population and conservation status reassessment of *Etlingera balikpapanensis* A.D. Poulsen, an endemic ginger in East Kalimantan

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**Abstract.** The Balikpapan ginger (*Etlingera balikpapanensis* A.D. Poulsen) is a ginger species endemic to East Kalimantan Province, Indonesia. Known only from two locations near Balikpapan City, the species is threatened by forest encroachment and forest fires. To provide the most current distribution and population size as well as to reassess its extinction risk based on IUCN Red List Category and Criteria of the species, we therefore carried out a population survey in the intact forest of Balikpapan Botanical Garden and the adjacent areas of Sungai Wain Protected Forest. Using focused or intuitive-controlled survey method, we located 14 clumps of *E. balikpapanensis* with a total of 171 individuals. Based on the occurrence points collected during the survey and additional records from peer-reviewed papers, the calculated extent of occurrence (EOO) and area of occupancy (AOO) of the species were 1,292.265 km² and 20 km², respectively. Therefore, we considered *E. balikpapanensis* as Endangered (EN) under criteria B1+2ab(iii), C2a(i). Under this category, *E. balikpapanensis* was considered to be facing a very high risk of extinction in the wild.

1. **Introduction**

The ginger family (Zingiberaceae) is the largest member of the order Zingiberales comprising approximately 50 genera and more than 1600 species [1]. It is distributed in tropical and subtropical countries with the centre of diversity is in South East Asia [2]. The family is reported to be in an active stage of evolution [3] and therefore, its taxonomy is still poorly known with many new taxa described in the last several years [4-10]. The members of this family are perennial herbs with rhizomatous root. It is usually found in moist shady habitat under the forest canopy, although some species are also able to grow under direct sunlight [11].

The species within the family are commonly found on the forest floor, and prone to habitat loss due to forest conversion and degradation. In total of 627 species of Zingiberaceae has been assessed by IUCN Red List, of which 260 (42.5%) species are threatened with extinction i.e. with Critically Endangered, Endangered and Vulnerable category [12]. The IUCN [12] recorded that the main threats for the taxa are logging and wood harvesting as well as forest conversion into non-timber crop fields and wood and pulp plantation. Most of these threatened gingers are endemic species distributed in Malaysia (103 species) and Indonesia (82 species).

The Balikpapan ginger (*Etlingera balikpapanensis* A.D. Poulsen) is a ginger species endemic to East Kalimantan Province, Indonesia [13,14]. Poulsen [13] stated that the species is known only from
Sungai Wain Protected Forest and Wartokadri Forest located near Balikpapan City, and is threatened by forest encroachment and forest fires. Poulsen and Olander [14] considered the species as Endangered based on the criteria of B2ab(iii) i.e. a small area of occupancy (B2), the number of location ≤5 (a) and a continuing decline in area, extent and/or quality of habitat (iii). However, the assessment was based only on herbarium records and there is no information on the current population status of the species.

Knowledge on distribution and population size of the species is important for management and conservation of a narrowly endemic and threatened plant [15], we therefore carried out a population survey for *E. balikpapanensis*. The aims were to assess geographic distribution, population size and threats of the species as well as to reassess its extinction risk based on IUCN Red List Category and Criteria. We expect that the results of this study can serve as a basis for conservation planning and actions of the *E. balikpapanensis* and its habitat.

2. Materials and Methods

2.1. Study site and species

The survey was carried out in the intact forest of forest zone in Balikpapan Botanical Garden (Figure 1) and the adjacent forest of Sungai Wain Protected Forest in September 2017. The study area is a lowland dipterocarp forest with a gentle topography and elevation ranging from 10 to 55m above sea level (asl) [16]. The soils are classified as acrisols with low nutrient level and have varied pH values from 4.09 to 4.55 [17]. The temperature range and average rainfall is 23-31°C and 2250 mm/year [18], respectively.

![Figure 1](image-url)

**Figure 1.** Location of the study area (grey quare) within Kebun Raya Balikpapan (Balikpapan Botanical Garden) and the adjacent forest of Sungai Wain Protected Forest near Balikpapan City, East Kalimantan.
Firstly described in 2006, *Etlingera balikpapanensis* A.D.Poulsen is an endemic ginger found only in lowland forests of East Kalimantan, Indonesia [13]. It is a rhizomatous herb with leafy shoots of up to 5 m [13] (Figure 2). The generation length of *E. balikpapanensis* is estimated to fall between 5-20 years similar to two other members of Zingiberaceae (i.e. *Amomum petaloideum* and *Curcuma alismatifolia*) with generation length of 5-10 [19] and 20 years [20], respectively. The leaf and rhizome extracts of the species are known to have antioxidant activities [21-22], and additional antibacterial activity is also shown by its leaf extract [23]. Due to threats from wood and pulp plantations, fire and fire suppression as well as from logging and wood harvesting, *E. balikpapanensis* is considered facing a high risk of extinction and categorized as Endangered according to IUCN Red List [14].

![Figure 2. Mature individual of *Etlingera balikpapanensis* showing leafy shoots (left) as well as rhizome and flower buds (right)](image)

2.2. Population survey

To assess population size and geographic distribution of *E. balikpapanensis*, focused or intuitive-controlled survey method was used [15]. The method focuses the intensity of surveys on areas of high potential habitat for the species. When a clump of *E. balikpapanensis* was found, the total number of individual within the clump, height of each individual and wide of the clump i.e. the longest distance between individual were measured. The geographical position of each clump was recorded using a GPS receiver. In addition, the following environmental variables were also recorded at each clump: elevation, slope, aspect and canopy cover. The last variable was measured by taking a canopy picture from the middle of the clump. The picture was then analysed using an image processing and analysis software ImageJ [24].

The threat to *E. balikpapanensis* from forest conversion and degradation was estimated by calculating tree cover loss using the Global Forest Watch website (https://www.globalforestwatch.org/). The calculation used 30% as the minimum tree cover canopy density and was made for East Kalimantan Province from 2001 to 2019.

2.3. Conservation status reassessment

The extinction risk of *E. balikpapanensis* was reassessed using IUCN Red List Category and Criteria [25]. The assessment used five quantitative criteria (A-E) based on information on: i) declining population (criterion A), ii) geographic range size, and fragmentation, decline or fluctuations (criterion B), iii) small population size and fragmentation, decline, or fluctuations (criterion C), iv) very small population or very restricted distribution (criterion D), and v) quantitative analysis of extinction risk
(criterion E). For criterion B, the extent of occurrence (EOO) and area of occupancy (AOO) of the species were estimated using Geospatial Conservation Assessment Tool (GeoCAT) [26]. The application is freely available in the website http://geocat.kew.org/. Additional records from protologue of *E. balikpapanensis* [13] and Hadiah *et al.* [27] were also used for this analysis. Based on the results of this assessment, the species was then assigned into one of the following eight categories: Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in The Wild (EW), and Extinct (Ex).

3. Results and Discussion

3.1. Population status and distribution

During the survey, we located 14 clumps of *E. balikpapanensis* with a total of 171 individuals. As the species is capable of reproduction through rhizome, each individual is considered as one reproductive unit [28]. Therefore, the population size of *E. balikpapanensis* in the study site is equal to 171 individuals. A more recent survey by Hadiah *et al.* [27] in Telen Subdistrict, around 200 km north of Balikpapan City, found 150 individuals of the species. Using systematic sampling, they were recorded at 29 out of 50 plots (2x2m) established by the authors. With this additional number of individuals from Telen Subdistrict, the total population size of *E. balikpapanensis* is estimated to be 321 individuals.

Most of the located individuals were within the height class of 3-3.9m with the highest up to 5.5m (Figure 3). The height of the species was higher compared with other lowland Kalimantan *Etlingera*, such as *E. aurantia* (3.5m), *E. brachychila* (3m), *E. sessilanthera* (3m), and *E. brevilabrum* (3m) [13]. It was, however, lower compared with *E. elatior* [29] and *E. coccinea* [13] which their leafy shoots can reach up to 7m height.

![Figure 3. Population structure of Etlingera balikpapanensis](image)

In the study site, clumps of *E. balikpapanensis* were composed by 4 to 26 individuals with the average number of 12.2±2.1 individuals/clump (Table 1). The wide of a single clump ranged from 0.9 to 14.9m. The species was found at an elevation range of 38.4-49.8m asl. Although Hadiah *et al.* [27] did not describe the habitat of *E. balikpapanensis* in their study, through investigation of their study site map we found that the clumps in Teleng Subdistrict were found from 70 to 100m altitudes, higher than of the clumps in our study site. Furthermore, *E. balikpapanensis* in our study site preferred habitats with gentler slopes (11.4±2.04°), partially open canopy cover (15.8-45.7%), and east-related aspects (east, southeast and northeast). This microhabitat information can be used to support optimum
condition for propagation and cultivation of the species. For the canopy cover where *E. balikpapanensis* found (72.6 ± 3.1%), it was close with the optimum canopy cover for growth (65%) and reproduction (75%) of *E. elatior* [30].

| Clump | ∑Individual | Wide (m) | Elevation (m asl) | Slope (°) | Canopy gap (%) | Aspect |
|-------|-------------|----------|------------------|-----------|----------------|--------|
| 1     | 12          | 4.6      | 45.4             | 18        | 17.8           | South  |
| 2     | 23          | 6.2      | 39.3             | 4         | 21.3           | East   |
| 3     | 17          | 5.8      | 38.5             | 5         | 35.7           | Southeast |
| 4     | 13          | 7.2      | 38.4             | 6         | 36.7           | Northeast |
| 5     | 4           | 1.8      | 49.4             | 1         | 23.5           | Southeast |
| 6     | 4           | 4.7      | 49.8             | 5         | 26.3           | Southeast |
| 7     | 8           | 2.9      | 46.2             | 13        | 32.9           | Southeast |
| 8     | 4           | 14.9     | 47.2             | 12        | 15.8           | Northeast |
| 9     | 12          | 8.4      | 47.6             | 13        | 45.7           | Northeast |
| 10    | 4           | 0.9      | 39.9             | 13        | 17.9           | East |
| 11    | 24          | 5.2      | 42.6             | 12        | -              | Northeast |
| 12    | 26          | 3.7      | 42.9             | 32        | -              | Northwest |
| 13    | 10          | 3.6      | 47.7             | 12        | -              | East |
| 14    | 10          | 3.0      | 47.1             | 14        | -              | Northwest |
| Range | 4-26        | 0.9-14.9 | 38.4-49.8        | 1-32      | 15.8-45.7      | -      |
| Mean  | 12.2±2.1    | 5.2±0.9  | 44.4±1.1        | 11.4±2.04 | 27.4±3.1       | -      |

**Table 1.** Clumps of *Etlingera balikpapanensis* and their habitat conditions.

3.2. *Threats to the species*

According to Global Forest Watch [31], East Kalimantan lost 2,665,210 ha of tree cover from 2001 to 2019, equivalent to a 23% decrease in tree cover since 2000. Figure 4 shows that in this period, the highest tree cover loss was observed in 2016 (314,117 ha) whereas the lowest was in 2003 (37,082 ha). Total forest loss across the range of *E. balikpapanensis* between 2001–2019 was about 2,500 ha- a loss of 49% over 18 years [31], which is about one generation of this species. The main driver of deforestation in Kalimantan was oil palm plantations, followed by forest conversion to grassland/shrubland and small scale agriculture and plantations [32].

![Figure 4. Tree cover loss in East Kalimantan from 2001 to 2019 according to Global Forest Watch [31]](image-url)
3.3. Conservation status reassessment and implications

Based on tree cover loss in East Kalimantan from 2001 to 2019 and declination in EOO, *E. balikpapanensis* was suspected to experience at least 49% population reduction in the last three generations. It is believed that forest conversion and degradation as the main threats for the species are still continuing. Based on this information, the species is qualified for Vulnerable (VU) category under criterion A2c i.e. the population reduction is close to 30% (criterion A2) based on a decline in area AOO, EOO and/or habitat quality (subcriterion c).

Using occurrences from the present study, the study by Hadiah et al. [27] and protologue of the species [13], GeoCAT estimated that the EOO and AOO of *E. balikpapanensis* were 1,292.265 km² and 20 km², respectively (Figure 5). Therefore, the species was considered Endangered under criterion B1+2ab(iii) i.e. EOO less than 5,000 km² (criterion B1), AOO less than 500 km² (criterion B2), number of location ≤ 5 (subcriterion a), and an inferred continuing decline in area, extent, and/or quality of habitat (subcriterion b(iii)).

![Figure 5](image_url)

**Figure 5.** The extent of occurrence (EOO) and area of occupancy (AOO) of *Etlingera balikpapanensis* calculated by GeoCAT [26].

Since the information on population size was available (321 individuals), *E. balikpapanensis* could be assessed under criteria C (small population size and decline) and D (very small or restricted population). For criterion C, we considered the species as Endangered under criterion C2a(i) i.e. the number of mature individuals less than 2,500 (criterion C), inferred continuing decline in area, extent, and/or quality of habitat (subcriterion C2), and the number of mature individuals in each subpopulation ≤ 250 (subcriterion a(i)). Under criterion D, *E. balikpapanensis* was qualified for VU D1 as its number of mature individuals was less than 1000.

Under criterion E (quantitative analysis), the species was considered Data Deficient (DD) as we did not have enough data to conduct any quantitative analyses to estimate the probability of extinction in the wild. The criterion requires high quality, specific data, and adequate familiarity with existing methods of population viability analysis, and thus has seldom been used in the extinction risk assessment of species [33,34].

Based on results of the present study, *E. balikpapanensis* was qualified for VU A2c, EN B1+2ab(iii), EN C2a(i), VU D1 and DD under criterion E. As the species should be listed under the
highest category of threat [28], we proposed Endangered (EN) B1+2ab(iii), C2a(i) as the new conservation status for E. balikpapanensis. There are additional B2 and C2a(i) criteria compared to the current status of EN B2ab(iii) applied by Poulsen and Olander [14].

Under this category, E. balikpapanensis is considered to be facing a very high risk of extinction in the wild. Immediate and comprehensive conservation actions are needed in order to protect the species and its habitat. Sites management and protections are among immediate actions that need to be conducted to conserve the species. Ex-situ conservation by planting the living collection at botanical gardens and storing viable seeds at seed bank facilities is also an important measure that needs to be conducted. These ex-situ collections can serve as buffer collections to avoid the species going extinct if their wild populations are lost. They also can be used as source of materials for recovery programs of the species in the future.

4. Conclusion
Using focused or intuitive-controlled survey method, the present study located 14 clumps of E. balikpapanensis with a total of 171 individuals. The main threats to the species are habitat conversion and degradation, which are mainly caused by oil palm plantations, forest conversion to grassland/shrubland and small scale agriculture and plantations. Based on the collected data and additional records from peer-reviewed papers, we proposed Endangered (EN) B1+2ab(iii), C2a(i) as the new conservation status for the species. The category implies that E. balikpapanensis has a very high probability of extinction in the future unless there are conservation action interventions applied to the species.

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