Biogeographical Distribution Model of Flowering Plant *Capparis micracantha* Using Support Vector Machine (SVM) and Generalized Linear Model (GLM) and its *Ex-situ* Conservation Efforts

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Abstract— *Capparis micracantha* **is a flowering plant species with a wide range of distributions. It is often used as traditional medicine by local people. This species is often overlooked due to very limited information that reveals about its conservation aspects. This study aims to update the distribution records and predict the potential current distribution of this species. Some new occurrence records were obtained through a direct field survey, plant inventory database, and reliable scientific papers. In order to gain more information about current distribution, Species Distribution Modelling (SDM) was applied to predict the potential current distribution of this species in Indonesia. Two algorithms of machine learning (SVM and GLM) were applied to produce predictive distribution maps. The models were built from occurrence records data and environmental variables (climate and topography). Area Under Curve (AUC) was used to evaluate the model prediction. The AUC value of those models >0.80 means those models have a good performance. The AUC value of those models is stated in SVM (0.86) and GLM (0.824). SVM and GLM have almost similar resulting predictive maps of current distribution. The predictive maps would be useful to give information about the regions in Indonesia that have similar environment characteristics and climate conditions where the species are observably present. This species has also been conserved through ex-situ conservation strategies, but the seedling growth of this species still remains a challenge.**

Keywords— **Biogeographical distribution;** *Capparis micracantha*; *Ex-situ* **conservation; GLM; SVM.**

I. INTRODUCTION

Capparis is a genus of *Capparaceae.* This genus is estimated to have 250 species and is widely distributed in tropic and subtropics. *Capparis micracantha* is one of the plant species that belongs to *Capparaceae* [1]. There are several synonyms of *Capparis micracantha* including *Capparis billardieri* DC; *Capparis callosa* Blume; *Capparis conpicua* Wall; *Capparis odorata* Blanco; *Capparis forsteniana* Miq; *Capparis roydsiifolia* Kurz; *Capparis hainanensis* Oliv; *Capparis myrioneura* Hallier.f .; *Capparis bariensis* Pierre ex Gagnep; *Capparis donnaiensis* Pierre ex Gagnep; *Capparis venosa* Merr; *Capparis liangii* Merr & Chun and *Capparis petelotii* Merr. The local names of this species are Balung, Kledung (Java), and Ketket Kayu Joh (Bali) [2]. It has a relatively wide distribution that stretches from Burma, Yunan, Hainan, Thailand, Vietnam, Malay Peninsula, Philippines, Northern Borneo, Sulawesi, Halmahera, East Nusa Tenggara, Java, and South Sumatra

[2]–[4]. Another report states that this species is also seen in Central Java, East Java, and Madura and rarely in West Java. It is commonly found in tropical rain forests, teak forests, evergreen forests, dry areas (*calcareous soilsa* and *savanna*), roadsides, coastal areas, and mostly in lowland areas with an altitude up to 1400 m above sea level [5]. It is also recorded in Nglanggeran, Gunung Kidul [6]. This area has a tropical monsoon climate (Am) climatic characteristic based on Köppen's climate classification [7], [8]. The characteristics of a tropical monsoon climate are the minimum temperature around 18 ºC and monthly averaged minimum precipitation ≤ 60 mm, which is 4 % higher than annual averaged precipitation [9]. The wide range of *C. micracantha* distribution indicates that it has high adaptability to various gradients of environment.

It is used as a medicinal herbal; its parts are used as medicinal ingredients such as the root and bark of its stem. The bark of *C.micracantha* is used as an anti-inflammatory drug, relieving hot pain symptoms, fever and bruises [10]. A red to purple fruit has a sweet aromatic flavour, but it is unsafe

to eat when unripe [10]. In addition, the root is used as a diuretic, stomachic, antipyretic [11], and tonic [12]. In Thailand and the Philippines, its root is also used for traditional medicine for diabetes mellitus [13]. The wood is used for treating biliousness, stomachache, and giddiness. The bark is used as a diuretic to treat bronchitis and nasal ulcerations. The stem is used in the treatment of breast cancer [10]. The stem is crushed with water and applied topically to relieve pain and swelling [12]. In Thailand, this species is used as raw material for herbal medicine, namely Ha-Rak. A previous study about Ha-Rak stated that herbal medicinal properties in the form of lupeol have anticancer activity [14]. Furthermore, Ha-Rak has functional uses for preventing and delaying skin photoaging through restoring redox homeostasis [15].
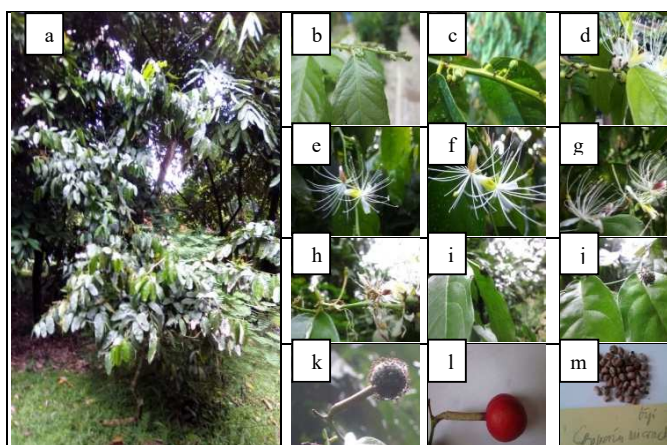

Fig. 1 *Capparis micracantha*, tree (a); development of leaves to flower buds (b-d); blooming flowers (e-g); development of prospective fruits (h - j); young fruit, ripe fruit & seeds (k - m).

According to the records, the locations where this species is present are affected by the natural disaster (Tsunami), such as Panaitan Island, Ujung Kulon (West Java), North coast of Bondowoso (East Java), Palu, Donggala, and Parigi (Central Sulawesi. Furthermore, some habitats in Gorontalo and Bali are threatened by land-use change. Anthropogenic disturbances are also threatening biodiversity in recent times [16], [17]. Although *C.micracantha* is not included on the list of threatened plants and the IUCN Red List has published no global assessment, an effort for updating information about the current distribution of this species would be important since the first conservation effort was started at Teijsmann period around 1873 – 1876 in the Bogor Botanic Gardens. No information about the existence of this species in Bogor Botanic Gardens after that period. The current information that has been stated by Kew Webb, the distribution of *C.micracantha* is scattered in Sumatra, Java, Kalimantan, Sulawesi, Bali, West Nusa Tenggara, East Nusa Tenggara, Maluku Islands and Papua. Another piece of information provided in Jacobs's report is that the distribution records data of *C. micracantha* in Indonesia is too long (55 years ago). However, Jacobs's report is very important as a basic guideline for this investigation. By conserving this species through *ex-situ*, the opportunity to study many aspects of *C. micracantha* for conservation purposes becomes more accessible and easier.

This study aims to update the distribution records based on the current direct field survey, plant inventory databases, scientific journals, and herbarium databases. That presence records data will be used to predict the potential current distribution of *C. micracantha* in unsurveyed locations. It is impossible to survey all regions to obtain the distribution data of this species due to financial limitations and time restrictions. In order to understand the potential distribution of this species in unsurveyed locations, the modeling distribution can be considered as an alternative way. Species distribution modeling (SDM) is now widely used to model and predict the potential distribution of biodiversity in response to global change. It is also an important approach for conservation endeavors [18], [19]. SDM is also used to understand the species response to environmental change [20]. Recent studies stated that SDM was used for many conservation purposes, such as predicting Egyptians medicinal plants distribution [21], predicting the potential distribution of endemic plant *Rosa Arabica* [22], understanding the impact of climate change on the distribution *Paeonia ostii* across china [23], and assessing the cultivation areas of *Scutellaria baicalensis* in China [24]. SDM incorporates the occurrence records and abiotic factors such as topography, climate, and land-use change [25], [26].

For finding a reliable predictive current distribution map, machine learning algorithms are widely used to address the impact of climate dynamics on biodiversity distribution. Some algorithms are well tested to predict the current distribution of *Guetarda speciosa* [27]. Furthermore, those algorithms are also applied to predict the potential distribution of invasive species *Caliandra calothyrsus* in Bali [28]. SVM (Support Vector Machine) is a machine learning algorithm that belongs to a family of generalized linear classifiers. The basis work of SVM is a discriminative classifier defined by a separating hyperplane (the line divides a plane into two different parts of class). SVM, an algorithm of machine learning, is commonly used as a tool for classification. It produces high accuracy and reproducibility performance [29]. SVM is recently used to estimate the species range of parapatric species [30]. Support Vector Machine (SVM) is one of the machine learning algorithms that outperformed the prediction of *Eusideroxylon zwageri* with AUC value >0.80 and TSS value (0.74) [31]. In addition, SVM showed an outstanding performance in predicting habitat suitability of *Morina persica* L. [32].

GLM is often used to determine the distribution pattern of species [33] [34]. GLM is also considered a proper tool for agricultural activities and environmental protection [35]. In a previous study, GLM and MaxEnt were used to understand the effect of grain size on the predicted distribution area [36]. The predictive current distribution map would be useful to provide information about other regions that are suitable for this species. By understanding the predictive potential of current distribution, the conservation strategies of this species become more efficient and effective. This study also provides brief information about the conservation efforts of this species in Bogor Botanic Gardens, including seeds germination, seedling growth, flowering, and fruiting aspects.

II. Materials and Methods

A. Study Species

Erect shrub-shaped plant and slightly bent, 1 - 6 m high, greyish-green stems, thorns, branching appears not far from the ground. Single leaf, oval, leaf 6-25 cm in length, leaf width around 3-10 cm, rounded leaf tip, flat-leaf edge, pointed leaf base, shiny green upper leaf blade, whitish-green lower leaf blade, short petiole brownish green. Single flowers, appearing in branches, near the axillary leaves lined 4 - 6 flowers, rounded flower buds, green petals, white flower crowns, when blooming one flower crown with yellow or purple spots on the bottom of the flower crown, many stamens (16-25), green pistil 1, white pistil (many rudimentary pistils). Buni fruit, round to oval shape, green when young, red when ripe, and contains many seeds wrapped in aryl between the seeds, kidney-shaped seeds, grayish-brown - blackish brown.

B. Species Distribution Modelling

The occurrence records of *Capparis micracantha* were derived from direct field survey, plant inventory database, herbarium database, and reliable scientific papers. The direct field survey was conducted in several islands of Indonesia. It has been taken around two years of data collection. There are 129 occurrence records of *C. micracantha* were recorded on this study. Seven bioclimatic variables and elevation data were used as a predictor of the model. The bioclimatic variables were extracted from the global climate database (https://www.worldclim.org/; [37]. These bioclimatic variables were Annual Mean Temperature, Isothermality, Temperature Seasonality, Annual Precipitation, Precipitation of Wettest Month, Precipitation of Driest Month, Precipitation Seasonality (Coefficient of Variation). Bioclimatic variables were derived from the monthly temperature and rainfall values to generate more biologically meaningful variables. The elevation data of Indonesia was derived from SRTM Elevation data. Both bioclimatic and elevation data are available at 2.5 minutes spatial resolution (approximately 5 km grid cell sizes at the equator) [38].

Two machine learning algorithms were used to predict the potential current distribution of *C. micracantha* in Indonesia. Support Vector Machine (SVM) and Generalized Linear Model (GLM) were selected based on their performances in predicting the distribution model in several previous studies. A package "dismo" was used as a method for species distribution modelling [39]. Both presence and absence (pseudo-absence) occurrence records were used as input of the models. The 200 random points of pseudo absence data were chosen to represent the absence occurrence records of *C. micracantha* in Indonesia. The data was then split into training data and testing data with the proportion of 75% : 25% (using 4 k-fold data partition). The Area Under Curve (AUC) was used to evaluate the model prediction performance. The output of those two models is predictive current distribution maps of *C. micracantha* in Indonesia.

C. Ex-situ Conservation Efforts

The multi propagation of this species has been conducted by germinating the seeds in growing media (sand). The seeds were derived from a plant living collection that has been producing fruits. The germination process and seedling growth observation were conducted in the plant nursery building IX of Bogor Botanic Gardens. The flowering and fruiting process observation has been conducted toward several plant living collections.

III. Result and Discussion

The principal reason for using several bioclimatic variables instead of all bioclimatic variables is to take some of those relevant to Indonesia. Bioclimatic variables and elevation are chosen as the model's inputs because the study area covers quite a large region of Indonesia. In order to understand the environmental factors that affect the distribution of plant distribution, some environmental factors such as land use, soil type, and biotic interaction can be excluded if the study area belongs to a regional scale domain (200 – 2000 km). Even though dispersal history and spatial barriers are also considered important factors [40], these can also be excluded if the study scale is relatively wide.

Both algorithms of machine learning have the Area Under Curve (AUC) value > 0.80, which indicates both models are categorized into good models in predicting the potential current distribution of *C. micracantha*. The classification of the model based on the AUC Value is stated as the following: model with AUC in range 0.9-1 (excellent), 0.8-0.9 (good), 0.7-0.8 (fair), 0.6-0.7 (poor), and 0.5-0.6 (fail) [41]. The area under the curve (AUC) is a perfect performance metric for ROC curve. The higher the AUC value, the better performance of the model. SVM model has an AUC value of 0.86, while GLM has AUC value of 0.824. Those models distinguish between the presence and absence of the resulting predictive maps. According to the direct field survey and other sources, the occurrence records of this species are most likely centered in Java Island and scattered to some islands such as Sumatra, Kalimantan, Sulawesi, and Bali. According to the presence points, most of this species is found in areas close to the sea (coastal areas) and small islands, and some of them are found far away from the coastal.
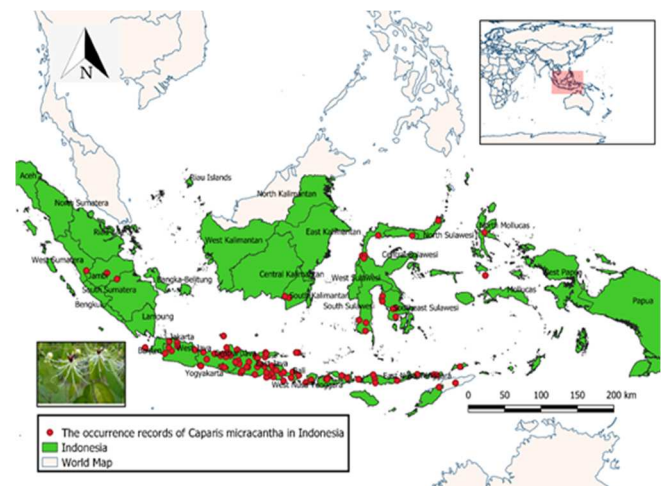

Fig. 2 The occurrence records of *Capparis micracantha* that are collected from direct field survey, plant inventory database, herbarium specimen and other sources (scientific journals and reports).
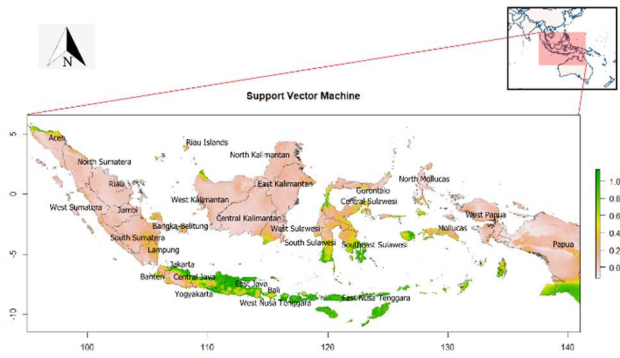
Fig. 3 Predictive map of current potential distribution of *Capparis micracantha* using Support Vector Machine (SVM).
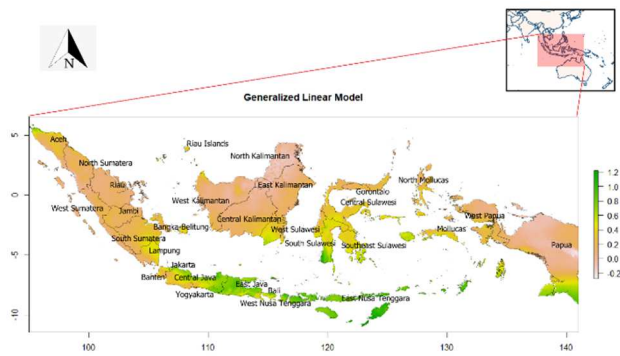

Fig. 4 Predictive map of current potential distribution of *Capparis micracantha* using Generalized Linear Model (GLM).

A different color ramp represents the predictive maps on the map. The darker green color represents the region's best predicted as the distribution of *C. micracantha*. While the color of pink indicates the area that less suitable for the distribution of *C. micracantha*. Support Vector Machine (SVM) algorithm predicts almost regions in Java, Bali, West Nusa Tenggara, East Nusa Tenggara, Aceh, West Kalimantan, South Kalimantan, Central Sulawesi, South Sulawesi, Southeast Sulawesi, Moluccas, and Southern part of Papua as the high suitable area for the distribution of *C. micracantha* based on bioclimatic variables and elevation. Another region indicates the area that less suitable for the distribution of *C.micracantha*. Generalized Linear Model (GLM) predicts almost regions in Java, Bali, West and East Nusa Tenggara, Northern part of Aceh, Lampung, South Sumatra, South Sumatra, South Sulawesi, West Sulawesi, Southeast Sulawesi, Moluccas, and Southern part of Papua. Although SVM and GLM are not precisely predicting the same all regions regarding the distribution of *C. micracantha* on the predictive map, some regions are similarly predicted on the distribution maps from both SVM and GLM. These algorithms predict another region compared to the observation records. These algorithms predict some parts of Aceh, West Kalimantan, Moluccas, and Southern Papua. The predictive maps most likely show the coastal area as the suitable predicted habitat of this species. It is similar to the location where the species found based on the observation data. Java is predicted as the distribution center for *C.micracantha* from both two models. The predictive map of Java shows that the distribution area of this species is not only in coastal area but also in other areas throughout Java. The predictive map of potential current

distribution shows another region with similar environmental characteristics to the location where the species are found.

Predictive maps that are resulted from this study could give general information about the potential distribution of this species based on bioclimatic variables and topography only. The real distribution may be different from the predictive maps because some variables that are not being considered may affect the distribution. Some species are probably tolerant of climatic variation and resist the habitat change where they are initially found. Using two types of algorithms is to convince that the resulting predictive maps are relevant and robust. Those two predictive maps could be compared in terms of predicted locations of potential distribution.

D. Ex-situ conservation strategies.

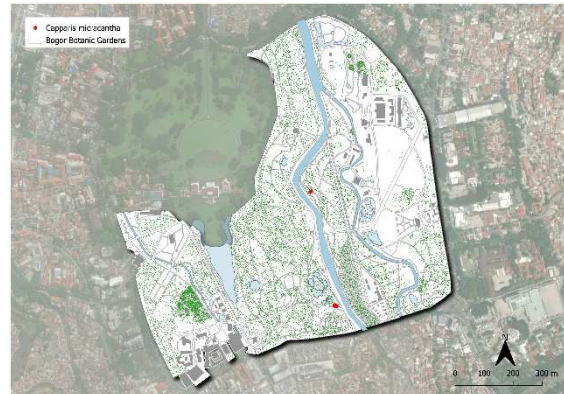
Fig. 5 The occurrence points of *Capparis micracantha* in Bogor Botanic Gardens.

The genus Capparis has been conserved in Bogor Botanic Garden. Several conservation programs in Botanic Gardens include plant expedition, cultivation, research and development, utilization and dissemination of conservation activities. [42]. It has been carried out since at the beginning reconstruction of Bogor Botanic Garden. According to the herbarium specimen preserved in Bogor Botanic Gardens and catalogue database, C. micracantha was recorded as plant living collection in 1866 [43]. Information regarding the living collection of *C.micracantha* at the period of Teijsmann and the following periods is very limited. The plant living collections in Botanic Gardens are very constant change, some species may be die due to the age of plant living collections. Another may be fall and get physical damage due to pest, disease and environment fluctuation [44]. According to the plant living collection database, *C. micracantha* is recorded back in 2008 and 2019. The living collection of *C. micracantha* are collected from Sumbawa Island, Panua Nature Reserve (Gorontalo), and Bali. This plant living collection has been completely identified as *Capparis sp*. After entering the flowering phase, this plant has been completely identified as *C. micracantha*. The same situation also happened in Purwodadi Botanic Gardens in which plant living collections from Annonaceae family remained unidentified at the first time of collection. Those were then completely identified as certain species name based on their morphological appearances [45], [46]. Six plant living collections of *C.micracantha* are recorded, four of those have been entering flowering phase, and two individuals have been producing fruits. The study related to plants' reproductive

biology is considered an important aspect in plant conservation. It provides many information for artificial breeding at botanic gardens [42]. The flower development, flowering phases, and fruiting periods are examples of the study tightly related to reproductive biology [47]–[49]. The period of flowering and fruiting this species has been observed throughout the year. In its natural habitat, it is known that this species is capable of flowering more than once a year [50]. This species has two type of flowers including complete flower and incomplete flower. The number of incomplete flowers is higher than the complete flowers, so the number of fruits that are formed in each season is only 0-4 (very rare). The development process from prospective fruit until ripe fruits requires around 3 month 10 days. The shape of fruit is round, the young fruit has green color and turn to red when the fruits ripe. The ripe fruit has a sweet taste and many seeds. The seeds are relatively small with kidney-like appearance. Multi propagation of this species has been conducted since several years ago in Botanic Gardens. The species has been multi propagated through the seeds. The seeds are germinated in small polybags or plastic pots. The germination process of this species is relatively simple and easy.
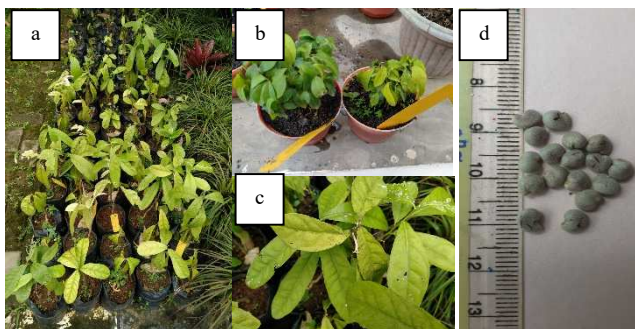

Fig. 6 Multi propagation of *Capparis micracantha* through the seeds: a). seedlings of *C. micracantha*, b). seedling grows in plastic pots, c). leaves of seedling, d). Seeds of *C. micracantha*

The ripe fruits of *C. micracantha* have red skin color. If the fruit opens, it will be seen white flesh wrapping many seeds. The flesh of fruits has sweet taste. The number of seeds per fruit are around 20 – 40 seeds. The seed has a like kidney appearance, brown creamy color. The seeds have a size around 1 – 1.5 mm and 1 mm width. The seeds are relatively hard structure and can be able to germinate after storing during a week in plastic bag at room temperature. The seeds are produced in numerous numbers, whitish, slimy and sweet pulp. The seeds of *C. micracantha* are germinating well in sand growing media. After seven days planting the seeds in growing media, the seeds will germinate completely in the day of 15. The seeds are recalcitrant in which it is not be able to store in long period time. The type of germination is a hypogeal. The period required to grow from the first leaf to the second and subsequent leaves is very slow. The growth are also relatively slow when the seedlings are removed to the polybag. The plants are still small, with 20–35 cm high and 5-7 leaves after 3 years from its first germination. The problem of this species is related to the seedling growth. The seedlings are not growing well in multi propagation media. The seedlings take many years to grow to become mature

individuals. The multi propagation of this species still remains a challenge.

IV. CONCLUSION

SVM and GLM produce almost similar predictive distribution map of *Capparis micracantha*. The predictive maps of those models show some parts of Aceh, West Kalimantan, Moluccas, and Southern part of Papua are predicted as potential distribution areas of *C. micracantha* based on climatic variable and elevation as predictors of the model. The *ex-situ* conservation of *C. micracantha* has an obstacle in seedling growth. The growth rate of seedlings is relatively slow.

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