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Notes on endemic and endangered plants of *Eugenia* genus from kalakad mundanthurai tiger reserve (KMTR), southern western Ghats

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Abstract
The plants are basic resource for the living of almost all the organism in the world. Extinction risk is highly noticed with greatest percentage in every country. Conserving the Endangered species to maintain ecological balance of forest is very important. The study is designed to explore endemic and endangered *Eugenia* species distributed in Kalakad Mundanthurai Tiger Reserve (KMTR) is a required to develop conservation practices. In entire Southern Western Ghats, *Eugenia* species collectively documented with nine species only from KMTR hills within particular geographical area. Noticeably these species are endangered namely, *E. singampattiana* Bedd., *E. floccosa* Bedd. *E. discifera* Gamble, *E. mabaeoides* Wight and *E. indica* (Wight) Chithra. The vulnerable species are *E. calcadensis* Bedd. and *E. rottleriana* Wight & Arn. The *Eugenia* diversity in KMTR is considerably high with much number of species which are in endangered condition. These species should be conserved by developing various monitoring plans and projects.

Keywords: endangered plants, *Eugenia* genus, KMTR

Introduction
The plant diversity is always contractedly different based on topographical and climatic features (Brianskaia *et al*., 2021) [1]. According to recent findings, the planet holds more than 430,000 plant species distributed in various climatic conditions. Each country encompasses higher than 1000 endemic species recognized as climate-sensitive. The endemic and endangered plants are at risk of extinction without proper assessment and conservation. in several biodiversity hotspots of the world (Kougioumoutzis *et al*., 2021) [12]. The unawareness and limited studies about endangered plants in particular areas restrict the further protection of plants from extinction. The deficiency in the periodical assessment of global IUCN red lists became the reason for more adverse circumstances. Global warming and climate change are the two phenomenal causes affecting species extinction all over the world. The insufficient funds and non-objective research studies in many countries increased the downfall of long-term conservation practices. Regional conservation practices are recommended for threatened species to minimize biodiversity loss (Heywood, 2019) [9].
The family Myrtaceae comprises more than 5000 species is well known for its medicinal usages in many countries. The family is identified as Gondwanic distribution of the southern region and these can be identified by comparison by many fossil records. The phylogenetic relationship among these species is still being a puzzle in many genera without proper compilations (Ladiges *et al*., 2003) [13]. These aromatic plants are very famous for tasty fruits and products developed from Myrtaceous plants. The many plants of *Eugenia* recorded the enormous phytochemicals, minerals, vitamins utilized for human wellness. The genus *Syzygium*, *Eucalyptus*, *Myrtus*, *Callistemon*, and *Eugenia* is famous plants used by native peoples of all the country (de Paulo Farias *et al*., 2020) [4]. In many studies, wet evergreen forests are dominant with Myrtaceae family species and elucidated as a noticing group of plants to conserve the evergreen forest in many countries. Already many evergreen forests are disappearing and plants are also facing extinction problems. Documenting endemic and endangered species are essential for future prospective studies (Mori *et al*., 1983) [15].
The Myrtaceae is considered a controversial family having taxonomical nomenclature problems all the time in history. The species *Eugenia* is well confessed and has not solved existing everlasting complications in taxonomical society (Schmid, 1972) [17]. The species *Eugenia* occupies one-third of species in the Myrtaceae family which are highly valuable in many aspects. The native of this genus is recognized as Brazil and distributed in Africa and India. Most plants are trees, shrubs with tasty edible fruits having plenty of pharmacological and medicinal importance (de Souza *et al*., 2018) [15]. In India, the taxonomists recently concentrating on the *Eugenia* genus are explored and discovered with new species and varieties in Southern Western Ghats. The species *E. velliangiriana*, *E. megamalayana*, and *Eugenia kalamii* are from Southern Western Ghats. Highlighting the need to study the plants thoroughly in a specific location is essential (Shareef *et al*., 2018; Maruthakkutti *et al*., 2019; Murugan & Arumugam, 2019) [14, 16, 18]. Hence, the present work objected to studying endemic and endangered plants distributed in Kalakad Mundanthurai Tiger Reserve, India to establish clear knowledge on *Eugenia* genus distribution.

Materials and methods
Study area
Southern Western Ghats runs through three Indian states namely Karnataka, Kerala and Tamil Nadu covers nearly 22,600 square kilometer serve as home for many endemic and endangered flora. Due to varied climatic conditions

35% of plants are endemic to the ecoregion mostly evergreen trees are observed to be abundantly distributed. The study area Kalakkad Mundanthurai Tiger Reserve (KMTR) is the oldest and second largest protected area in Tamil Nadu, India (Location co-ordinates: N 08 37. 462 and E 077 14.868). The KMTR total land cover area is approximately 895 km^2 ranges 40 to 1,800 m in elevation with more than 10 rivers and streams. The Plant collection took place in the Mundanthurai range of KMTR which holds many higher elevations more importantly famous Karayar and Servalam water reservoirs.

Field visit

The study area has been explored from March 2018 to March 2020 covering various seasons. Several field trips were conducted approximately 8-10 days/per trip to the study area to observe the plant seasons and climatic changes. The digital camera with zoom lens, field notebook, gloves, hand lens (10x), blotting papers, marker, pencil, stickers, zip-lock covers, tags, field press, stapler, wood cutters, ethanol, formalin and mercuric chloride were used for collection and preservation of plant materials from the study area.

Plant collection and identification

The fresh plants were collected and photographed using wood cutter or cutters and information like associated plant species, topography, vegetation type, flowering and fruiting seasons are recorded in the field notebook. The specimen is recognized using family and genus key character mentioned in earlier literatures Flora of the Presidency of Madras and available online platforms like India Biodiversity Portal, Biotik (Graphical identification system of the trees species), The plant list for correct naming of plant name and HIFP (French Institute of Pondicherry). The extra flowered twigs are needed for identification purposes so collection more flowers and preserving it in FAA (Formalin Acetic Acid) are advisable for taxonomical research. The bark and stem samples also collected freshly and preserved it with FAA and collected specimens are labeled using sticker tapes.

Herbarium preparation

The non-damaged fresh twigs are selected, poisoned and kept on blotting sheet for complete press using presser. The large specimens may fold into N or W shape and let it for complete dry by changing the sheets periodically. The dried specimens mounted on standard herbarium sheets (41 x 29cm) using glue and stitching is recommend for long lasting mounting. The mounted materials are sprayed with 2% mercuric chloride for better preservation to keep the specimen from fungi free. A label should stick to the bottom right corner indicating locality, collection date, habit, habitat, name of the collector, scientific name, identification tips and description.

Result and Discussion

The study area Kalakad Mundanthurai Tiger reserve is recognized for having more endemic plants. Especially Agasthiyamalai range included as one of the five biodiversity-rich centers of India (Ganesh *et al*., 1996) [7, 8]. The species *E. floccosa* Bedd., *E. mabaeoides* Wight, *E. agasthiyamalayana* Gopalan & Murugan, and *E. discifera* Gamble present in the Agashiyamalai range due to unique conditions of their landscape and climatic conditions. Most of the *Eugenia* plants are evergreen shrubs distributed alongside the rivers and rocky slopes. Entire India documented with 25 *Eugenia* species connectively KMTR alone harbors nine endemic and endangered species (Shareef & Santhosh Kumar, 2020) [18]. The endangered species richness of some locations is an indication of the accumulation of closely related species diversity.

The endangered and Vulnerable species *E. calcadensis* Bedd., *E. singampattiana* Bedd., *E. floccose* Bedd. *E. discifera* Gamble, *E. mabaeoides* Wight, *E. indica* (Wight) Chithra endemic to Agasthiyamalai range of KMTR (Table-1). The habitats of endemic plants should be protected and managed to conserve the flora of appropriate countries (Dobson *et al*., 1997) [6]. The endangered species of many countries are decreasing at a higher rate due to various influencing factors. Hence, developing and monitoring tropical forest species to conserve the species diversity is necessary. The proper research plans are needed to execute in desired places to recover the endangered plants (Cracraft, 1985; Crisp *et al*., 2001) [2, 3]. The altitude choices of the *Eugenia* species always remain from 700 to 1600 altitude in the present study (Table-2). The KMTR previously assessed with mid-elevation biodiversity richness is highly correlated with conducted research (Ganesh *et al*., 1996) [7, 8].

The Eugenia species are exclusively present in the Southern Western Ghats of India. Particularly the species such as *E. singampattiana* Bedd., *E. floccosa* Bedd., *E. mabaeoides* Wight, *E. calcadensis* Bedd., *E. agasthiyamalayana* Gopalan & Murugan, *E. discifera* Gamble, *E. mooniana* Wight, *E. rottleriana* Wight & Arn. and *E. indica* (Wight) Chithra only found in Agasgthiyamalai range of KMTR hills, Tamil Nadu. Hence, KMTR hills are a "Hot Spot" for Eugenia species and other Myrtaceous members in Southern Western Ghats. The geographical richness of a particular gene in a specific region of a country is associated with historical evolution and past vegetation patterns (Jetz *et al*., 2004) [11]. Detailed relationship studies about molecular framework to understand the evolutionary history of *Eugenia* in India is recommended.

Table 1: Endemic and Endangered Eugenia genus plants of KMTR (Kalakad Mundanhurai Tiger Reserve)

S. NO	Plant Name	Endemic status	IUCN status
1	*E. mooniana* Wight	Endemic to SWG	No Data
2	*E. calcadensis* Bedd.	Endemic to ABR	Vulnerable
3	*E. rottleriana* Wught & Arn.	Endemic to SWG	Vulnerable
4	*E. singampattiana* Bedd.	Endemic to ABR	Endangered
5	*E. floccosa* Bedd.	Endemic to ABR	Endangered
6	*E. discifera* Gamble	Endemic to ABR	Endangered
7	*E. mabaeoides* Wight	Endemic to ABR	Endangered
8	*E. indica* (Wight) Chithra	Endemic to ABR	Endangered
9	*E. agasthiyamalayana* Gopalan & Murugan	Endemic to ABR	No Data

- SWG – Southern Western Ghats * ABR– Agasthiyamalai Biosphere Reserve – KMTR.

Table 2: Average elevation choices of the *Eugenia* plants in KMTR

S. NO	Plant Name	Below 1000 Altitude	Above 1000 to 1500 Altitude
1	*E. mooniana* Wight	+	-
2	*E. calcadensis* Bedd.	+	-
3	*E. rottleriana* Wught & Arn.	+	+
4	*E. singampattiana* Bedd.	+	
5	*E. floccosa* Bedd.	-	+
6	*E. discifera* Gamble	-	+
7	*E. mabaeoides* Wight	-	+
8	*E. indica* (Wight) Chithra	-	+
9	*E. agasthiyamalayana* Gopalan & Murugan	-	+

Fig 1: Habit of *Eugenia sp*.

a. *E. floccosa* Bedd.,
b. *E. agasthiyamalayana* Gopalan & Murugan.,
c. *E. rottleriana* Wught & Arn.,
d. *E.singampattiana* Bedd.,
e. *E. mabaeoides* Wight.,
f. *E. discifera* Gamble

Fig 2: Study area of *Eugenia sp*.

Conclusion

The rare and endangered plants are disappearing on a large scale due to various environmental factors and anthropogenic pressure. Conservation and monitoring the species from extinction is the phenomenal duty of every human. The forest officials should be aware of the knowledge about the endemic plants of particular regions. The Agasthiyamalai range in KMTR hills is needed severe conservation measurements. These forests are suitable for many endemic species with absolute climatic conditions naturally for surviving Myrtaceous members.

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