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An endemic plant species of East Java, *Smilax nageliana* A.DC (Smilacaceae)

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Abstract. *Smilax nageliana* A.DC (Smilacaceae) is an endemic plant species confined to Ranu Darungan and Mt. Kawi in East Java, Indonesia. The species was last collected in 1980 and is not known to be present at ex situ collections. In the present study, we conducted a field survey in the natural habitats of the species to provide updated information on morphological and ecological characteristics and to evaluate the presence of *S. nageliana* species, including habitat preferences. Using a focused survey method, 307 mature individuals of *S. nageliana* were recorded growing in Ranu Darungan and Mt. Kawi. The morphological character especially in color of the fruit, that found in dark green, while the previous time it was dark purple to black. The ecological character of the *S. nageliana* habitat was different from the previous time, where today was found at an altitude of 670 m above sea level (masl). In Ranu Darungan, the population was found at an elevation range of 670-1200 m, while in Mt. Kawi, the population grows from 1100-1400 masl. This plant grows in places with high relative humidity ranges from 52%-90% and moderate temperatures ranging from 21°C -27.7°C.

1. Introduction

Indonesia is a vast country, with a land area of 1,919,440 km² spread over thousands of islands [1]. Indonesia also has a very high level of plant endemism. A unique geographical position (between two continents and two oceans) with a constellation of large and small islands that stretches from the Oriental region, Wallacea, to Australia, makes Indonesia has very high biodiversity and level of endemism [2–5]. Conservation of Indonesian species is thus challenging and costly. The endemic plant species are usually more vulnerable to anthropogenic threats and natural changes [6] and have a higher risk of extinction. Conservation of these species is a major concern in a global context and in situ protection alone will not guarantee their conservation. Ex situ conservation measures should be taken to support the conservation of this species. A species is considered endemic to grow naturally in one geographical area, which can be narrow in size or relatively large [7], or its existence is unique in one place or region and is not found naturally in other areas. This term is usually applied to the geographical unit of an island or group of islands, but sometimes it can be a country, habitat type or region [8].

Smilax nageliana A.DC. is a plant that is vulnerable to extinction due to its small population size, narrow distribution, and specific environmental conditions. Research showed [9] that the herbarium data records were known to be the last collection status in 1942 and 1980, and there has been no recent evaluation. In fact, the current population study is unknown. At the conservation level, *S. nageliana* has



not been conserved ex-situ, nor in its natural population (in-situ). Alphonso de Candolle described a single specimen, Nagel no 27 in Herbarium Berlin (B) Germany as a newly described species, *S. nageliana*. Since the Herbarium Berlin was destroyed during World War II, the holotype is most likely lost [10]. After careful tracking and observation of herbarium specimens including digital specimens in herbaria such as BM, BO, BR, G, K, L, SING, and US, no potential sources of original material of *S. nageliana* was found. Since there is no original material still in existence or as long as it is missing, a neotype was proposed here (Art. 9.12, the International Code of Nomenclature [11]. East Java has restricted the distribution of *S. nageliana*. The Herbarium Bogoriense (BO) has just two specimen collection numbers, while de Groot & Wehlburg RD52 specimen represents the protologue description [10].

Area in East Java is potential habitat for *S. nageliana*, but few studies were implemented to describe the habitat. Thus, research on *S. nageliana* distribution in mountain areas in East Java will provide significant information for *S. nageliana* conservation strategy. The objectives of the present study were to i) provide updated information on morphological characteristics of the species through photos taken from living plants in the wild. and (ii) evaluate the presence of *S. nageliana* species in their habitat, including habitat preferences.

2. Methods

2.1. Area study

The study was focused at Mt. Semeru and Mt. Kawi in East Java. Field survey was conducted at Ranu Darungan/Ranu Lingga Rekisi, Bromo Tengger Semeru National Park (BTSNP) and Mt. Kawi (figure 1), East Java from August to September 2021.



Figure 1. The location for field survey to assess to recent distribution of *Smilax nageliana* A.DC. in Ranu Darungan in Mt. Semeru, and Mt. Kawi, Malang, East Java.

2.2. Field survey

A survey was conducted through Focused or “Intuitive”-Controlled Surveys [12] (figure 2). This method focuses the intensity of surveys on areas of high potential habitat for the target species. This method was implemented through the authors' experiences, field intuition, and the preparation of the

surveyor to guide the survey. The determination of areas with high-potential habitats was done by marking potential habitats on a GPS. Survey route planning based on targeted locations in major landscape features/habitat types was established. Prior to the survey, information was collected from local residents who recognized the plant and its presence in the forest. A field survey was carried out on Mt. Kawi and Mt. Semeru to determine the distribution of the sampling area, and target species were determined in an area where *S. nageliana* plants might be found. Survey high-potential habitats of *S. nageliana* in Mt. Kawi and Mt. Semeru was carried out by walking across potential habitats and landscape features (e.g., hilltops, slopes, valleys, etc.). Soil acidity was measured using a pH meter, while air temperature and humidity were measured using a thermo-hygrometer.

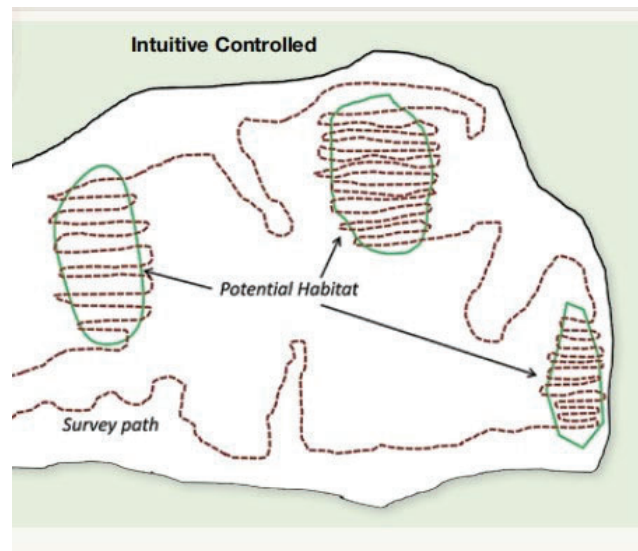


Figure 2. Survey method for vegetation analysis at locations that contain *Smilax nageliana* A.DC. *Intuitive controlled* is a method that focuses the intensity of surveys on areas of high potential habitat for the target species. *Potential habitat* is visiting an area with focus on covering features that influence what kinds of plants grow. *Survey path* is survey high potential habitats by walking across all parts. The presence of seedlings is an indicator that one or more larger individuals of the species are or were somewhere nearby.

2.3. Identification of *S. nageliana*

Determination of *S. nageliana* was carried out using the *Smilax* determination key in Java [9] *Smilax* scientific journals.

Key to the species of Smilacaceae from Java:

- 1a. Stem smooth, thin, prickly-less; stamens 3, connate into a column; tepals connate *Smilax micrantha* 2
- 1b. Stem with prickles; stamens 6, free; tepals free 3
- 2a. Basal petiolar sheaths broad 3
- 2b. Basal petiolar sheaths narrow 4
- 3a. Basal petiolar sheathing portion 25–35 mm long with broadly ovate auricles, 4–15 mm in width, broadly clasping nodes; abaxial leaf green to pale green *Smilax blumei*
- 3b. Basal petiolar sheathing portion 15–20 mm long with weakly incurved, 2–4 mm in width, not clasping nodes; abaxial leaf glaucous *Smilax leucophylla*
- 4a. Branches rough or scabrid due to numerous warts 5
- 4b. Branches smooth or not scabrid, but often ornamented with sparsely spines 6

- 5a. Young stem usually green-coloured; branches spinous with spreading spines, 1–2 mm long *Smilax modesta*
 5b. Young stem usually purple-coloured; branches densely beset with minute spines < 1 mm long *Smilax odoratissima*
 6a. Inflorescence with long peduncle (≥ 3 cm) 7
 6b. Inflorescence with peduncle < 3 cm 8
 7a. Berries globose to broadly obovoid up to 4 cm in diameter, seed 0–3, ≤ 2 mm in diameter *Smilax macrocarpa*
 7b. Berries globose, ca. 2 cm in diameter, seed 1–3, up to 7 mm in diameter *Smilax seminamagnifica*
 8a. Basal leaf rounded to truncate 9
 8b. Basal leaf pointed, rounded or sub-cordate *Smilax zeylanica*
 9a. Apex subacute to attenuate, nerves 5–7 *Smilax nageliana*
 9b. Apex obtuse to retuse, nerves 3 or 5 *Smilax klotzschii*

2.4. Data analysis

To investigate ecological factors with the focus on environmental variables that influenced the occurrence and the establishment of *S. nageliana* in their habitats, we used methods of Principal Component Analysis (PCA).

3. Result and discussion

Smilax nageliana A.DC. Monogr. Phan 1 (1878): 184 — Type: Java, Malang, Ranoe Daroengan, 19–22 Oct 1942, de Groot & Wehlburg RD52 (Neotype, designated here, BO [1597624]).

Distribution — These species are found in East Java.

Note:

Alphonso de Candolle described a single specimen, Nagel no 27 in Herbarium Berlin (B) Germany, as a newly described species, *S. nageliana*. Since the Herbarium Berlin was destroyed during World War II, the holotype is most likely lost. After careful tracking and observation of herbarium specimens, including digital specimens in herbaria such as BM, BO, BR, G, K, L, SING, and US, no potential sources of original material of *S. nageliana* was found [10].

3.1. Morphology of *S. nageliana*

The de Groot & Wehlburg RD52 herbarium specimen in BO was chosen as the neotype of *S. nageliana* (figure 3) [10], and vegetative characters in figure 4 and figure 5.

Woody climber; stem vines with stipules and verrucae, a cross-section of stem round; branches more or less 4-angular, armed with sparsely triangular prickles 1–2 mm long, internodes terete, 2–4 cm long, 1–2 mm thick; *Leaves* alternate; petioles 9–20 mm long, with narrow basal sheath, sheathing for ca. 4 mm from base; tendrils vestigial on flowering leaves, up to 12 cm on sterile leaves and stems; blades generally oblong to lanceolate, apex subacute to attenuate, rounded-truncate at base, thinly coriaceous, 6–8 × 4–6.5 cm, margin regular, entire, pruinose beneath, adaxial and abaxial leaves green, costas 5 or 7, often stained with dark red, the median 3 united for 4 to 7 mm above the base. *Inflorescences* 3–3.5 cm long, 1-umbellate, on a short common axis, peduncle 0.5 cm long, prophyllate at the base, a cross-section of peduncle round. *Staminate umbels* densely 21-to-23-flowered, receptacles ellips, 4 mm long. *Staminate perianth* green; tepals free, outer tepals oblong, rounded at apex, 4–5 mm long, ca. 1 mm wide, inner ones linear-oblong, obtuse, 0.2–0.4 mm wide, both recurved at anthesis. *Stamens* 6, one third of the perianth, free; filaments slender, 0.6 mm long; anthers lanceolate, 1 mm long, two locules. *Pistillate umbels* 20-flowered; receptacles globose, 6–8 mm across. *Pistillate perianth* ca. 4 mm long; outer tepals elliptic, ca. 1 mm wide, inner ones elliptic-oblong, 0.5 mm wide, subobtusate tip; ovary ellipsoid, ca. 1.5 mm long, 1 mm thick; stigmas ca. 1 mm long; staminodes 3, needle-like, ca. 1 mm long. *Berries* globose to obovoid, 6–8 mm across, dark green at maturity. *Seeds* 1-or 2, green to brown at maturity.

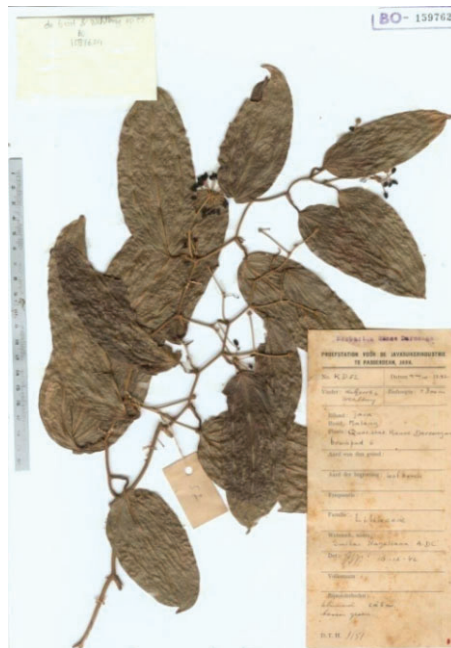


Figure 3. Neotype of *Smilax nageliana* A.DC, de Groot & Wehlburg RD52 (BO) (Photo:[13]).

In general, there were no morphological differences between *S. nageliana* in Mt. Kawi and Mt. Semeru. *S. nageliana* in Mt. Kawi and Mt. Semeru has apex subacute to attenuate variations. But at Mt. Kawi, its attenuate leaf shape has a slightly sharper tip when compared to the attenuate leaf shape of *S. nageliana* in Mt. Semeru (figure 4).



Figure 4. Left to right leaves *S. nageliana*: apex subacute Mt. Kawi - apex attenuate Mt. Kawi - apex subacute Mt. Semeru - apex attenuate Mt. Semeru.

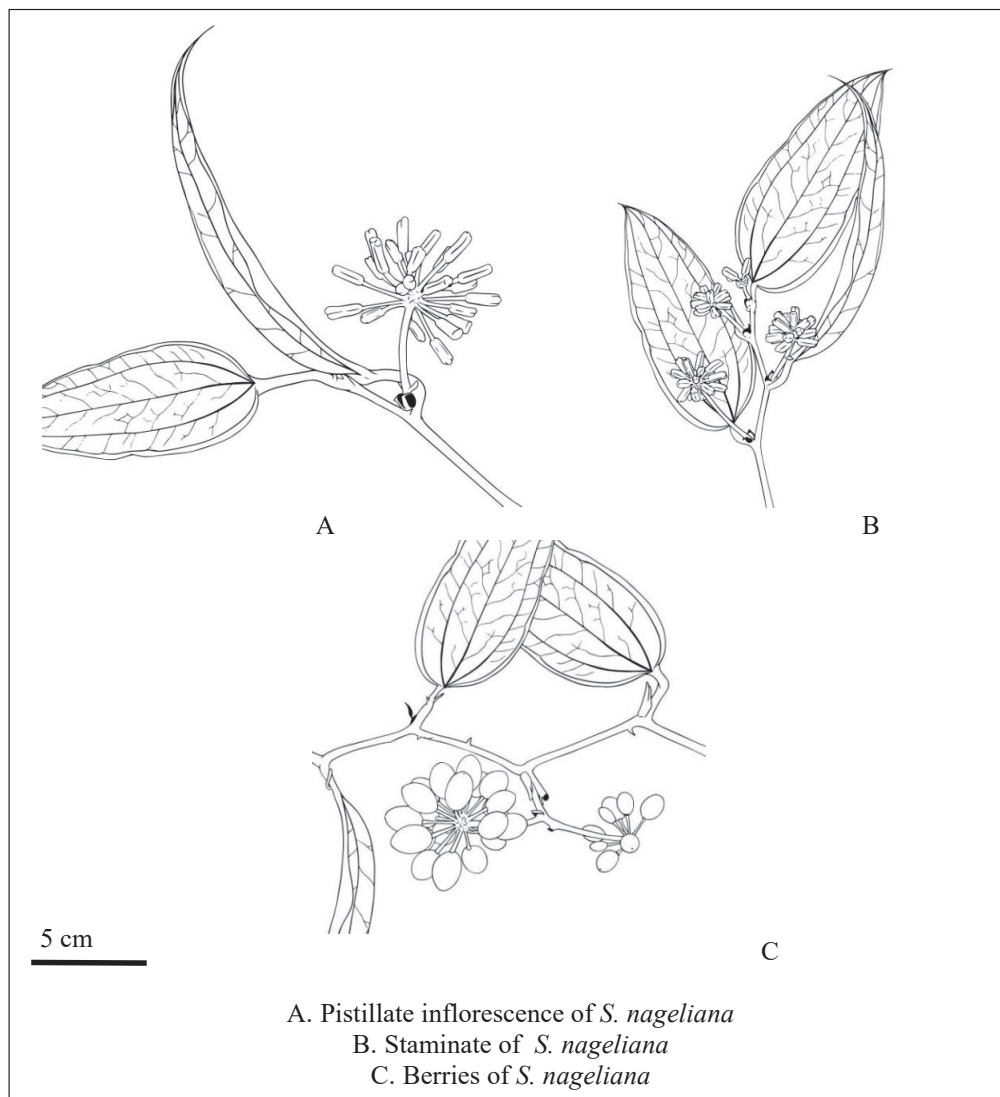


Figure 5. Vegetative characters of *Smilax nageliana* A.DC.

3.2. General feature of recent *S. nageliana* habitat

307 mature individuals of *S. nageliana* were recorded growing in Ranu Darungan and Mt. Kawi. *S. nageliana* is a woody climber. *S. nageliana* in Mt. Kawi is mostly found in natural forest areas with an altitude of 1100-1400 meters above sea level (masl), temperature 21°C-27.5°C, and humidity 53%-78%. A natural forest has a rather coarse soil texture, more sand content, and has a porosity value of about 55% [14]. The soil density of the natural forest in this area is 0.9 g cm⁻³ [14] and soil acidity is 6-7. The value of soil organic matter and soil infiltration is relatively high compared to other forests such as pine forests, mixed forests, as well as coffee and sugar cane plantation [14]. Based on this research, the area around the habitat of *S. nageliana* consists of pine plantations that intercrop with coffee plants and vegetable farms. Meanwhile, Mt. Kawi is also a place where religious rituals are carried out, so it is visited by many people, especially at certain times that are considered sacred by the community. Based on the research, it was found that *S. nageliana* grows in the forest area next to the ritual area, where the area is also one of the paths leading to the climb to the top of Mt. Kawi.

Bromo Tengger Semeru National Park (BTSNP), is located on the southern slope of Mt. Semeru at an altitude of 800-3676 masl, the air temperature ranges from 5-22°C [15]. The area of Ranu Darungan is 0.25 Ha, surrounded by forests and cliffs so that the access to there is quite steep. Based on the results

of this study, in Ranu Darungan, *S. nageliana* was found at an altitude of 670-1200 masl, temperature 21.6°C-27.7°C, and humidity 52%-90%.

There are key factors that determine the presence of *S. nageliana* in Ranu Darungan, and this is a study for further ecological research. The formation of the Lake Ranu Darungan ecosystem originating from this caldera eruption makes it a unique habitat where *S. nageliana* grows. Ranu Darungan is one of the aquatic ecosystems owned by BTSNP. Ranu Darungan is a reservoir of cold lava flow until finally the water is flowed by the forest around the lake, therefore forest and aquatic ecosystems in Ranu Darungan turned out to have quite diverse diversity [16]. Several studies [13,17] have shown that the endemic species richness is more in the highlands than in the lowlands, as is the pattern found in the tropical highlands. An increase in ecological isolation with altitude induces speciation isolation at higher evolutionary rates. Figure 6 shows that the habitat of *S. nageliana* is more influenced by environmental factors slope and air humidity. The existence of an isolated area due to this altitude allowed unique and special species to survive under harsh conditions, and supported endemism during a long evolutionary period [18]. Uplands in places such as mountains receive higher rainfall, which allows for a special microclimate, resulting in a unique assemblage of species.

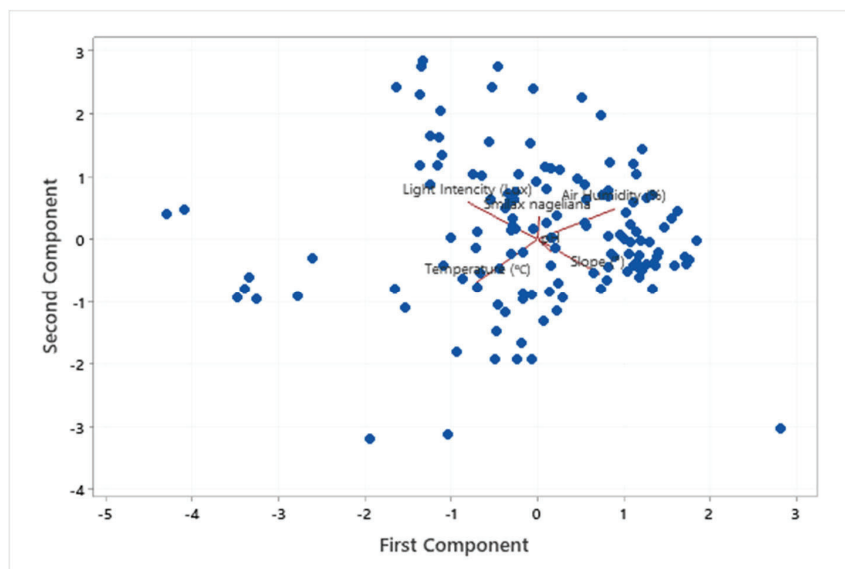


Figure 6. Results of Principal Component Analysis (PCA) of environmental factors on *S. nageliana* habitat in Mt. Kawi and Ranu Darungan.

The habitat of *S. nageliana* (figure 7a). From the diversity of plant species in Indonesia, there are many species that only live and spread in certain areas. Plant species that can only be found in a certain place and cannot be found in other areas are called endemic plants. Endemic plants are considered important not only because their populations are very small but also because these populations are very limited geographically. Several things affect the spread of endemic plants, such as temperature, rainfall, soil type, and topography [19].

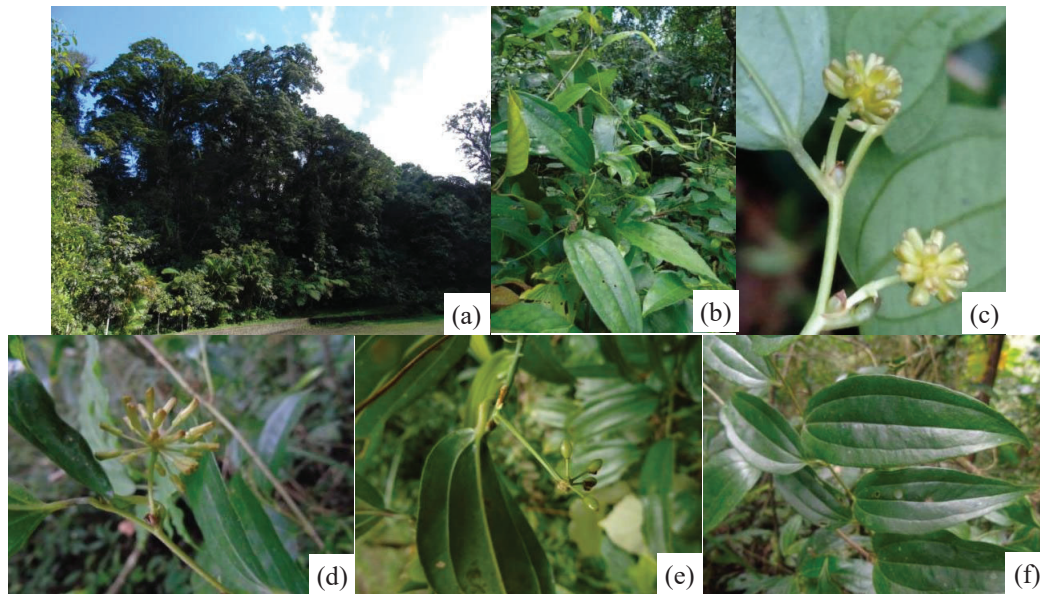


Figure 7. *S. nageliana* (a) habitat, (b) habitus in their habitat, (c) staminate (photo by Dwi Narko), (d) pistillate inflorescence, (e) berries, (f) leaves.

4. Conclusion

S. nageliana is an endemic plant of East Java, which was recorded almost eighty years ago. Currently, *S. nageliana* has a fairly good habitat in Mt. Semeru and Mt. Kawi. Mature individuals of *S. nageliana* were recorded growing in Ranu Darungan and Mt. Kawi. This plant likes places with high relative humidity, which ranges between 52%-90%, and moderate temperatures ranging from 21°C-27.7°C. Environmental factors that influence *S. nageliana* individuals are slope and air humidity. There needs to be more in-depth research on the population and its conservation status to strive for the conservation of *S. nageliana* in East Java so that it does not become extinct.

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