Soil seed bank of an invasive species, *Cecropia peltata* L. in kapur limestone hills

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Abstract. *Cecropia peltata* is an invasive species which was initially introduced through Kebun Raya Bogor. Research on the presence of *C. peltata* and its effect on plant community are still limited and most were based on above ground vegetation observation. Information on seed storage in the soil is important for understanding the impact of plant invasion on an ecosystem. Aim of this study is to discover and analyze the impact of *C. peltata* in the soil seed bank of Kapur limestone hills. Seedling emergence and seed extraction was used for a method. The result showed 646 seedlings of *C. peltata* in the soil seed bank with seedling density approximately 23.07 ± 33.59 seedlings tray⁻¹. The presence of large amounts of *C. peltata* in the soil seed bank has the potential to push the dominance of this species on the above vegetation which can subsequently cause loss of native species and habitat destruction.

Keywords: seed storage, plant invasion, seedling emergence

1. Introduction

*Cecropia peltata* is a neotropic plant which was included on the list of 75 important invasive species in Indonesia [1]. This species has also been nominated as among 100 of the World's Worst Invasive Alien Species [2]. *C. peltata* was probably first introduced to Indonesia through Kebun Raya Bogor (KRB) as seeds. It was sent by The Royal Botanic Gardens, Kew to KRB for cultivation after 1861 and prior to 1868. Since then *C. peltata* has spread 35–40 km from Bogor region towards Jakarta [3] and appears to have naturalised extensively [4]. Combination between rate of spreading and high fecundity suggests that *C. peltata* can be viewed as invasive in West Java [3]. This species has the characteristics of an invasive species due to several factors, including reproductive potential, seed behaviour, and its ability to remain viable in the soil seed banks [5]. One inflorescence of *C. peltata* can produce seeds in large quantities, which are about 2725 seeds [6]. *C. peltata* seeds are orthodox so they can survive in storage and are able to form persistent soil seed banks [7].

In Bogor area, this species can be found in open and disturbed areas [4] such as Kapur limestone hills, particularly on its steep slopes. Based on current studies, *C. peltata* dominates the vegetation of Kapur limestone hills [8, 9]. Mining in the karst region like Kapur hills have caused various types of
Invasive species such as Chromolaena and Melastoma to grow in locations and can be found in abundant quantities [10]. Invasive species negatively affect karst ecosystems because of their ability to replace native species through a series of competitive processes [11].

Research on the presence of C. peltata and its effect on plant community are still limited and most were based on above ground vegetation observation. A complete description of a plant community must include the soil seed bank, because it’s a part that occur in above ground vegetation [12]. Soil seed banks are a reserve of viable and ungerminated seeds both in the soil and on the surface of a habitat [13, 14]. They are a major component of the life cycle of sexually reproducing species and an important source of plant diversity [12, 15]. The importance of evaluating the soil seed bank of invaded communities has been highlighted in recent studies due to its role in predicting the long-term impact of invasive species on vegetation [16, 17]. This study was done to identify and describe impact of C. peltata in the soil seed bank of Kapur limestone hills.

2. Methods
2.1. The Study Site
This study was conducted in Kapur limestone hills (06°32’59.8” S and 106°41’16.1” E) in Bogor Regency, West Java (Fig. 1). The site was managed by several parties, one of them is State-Owned Forestry Company (Perum Perhutani). The area is a production forest but in some parts of the area there were mining activities that has been started since nineteen eighties. Most of its area is wide slope and narrow ridges. Due to logging, parts of the area has become open with minimal vegetation cover. Daily temperature in Kapur hills is 29–37°C with relative humidity of 53–70%, respectively. Mean rainfall in the area is approximately 255.27±200.04 mm with light intensity 1816–1823x10 lux.

![Figure 1](image)

Figure 1. (a) Map of the study site; (b) Plot sample position (both created using Google Earth); (c) View from Kapur Hills

2.2. Soil Seed Bank Study
A vegetation observation plot (6 x 6 cm) was made. Then, from 10 vegetation area, A total of 30 soil samples were taken plus another 15 sample randomly taken on that site. The size of each soil sample plot was 1 x 1 m with 5–10 cm depth. The plots were chosen purposively and scattered in elevation between 258 and 310 m asl. During the sample collection, the presence of C. peltata in the above ground vegetation was also recorded. In this study we use the seedling emergence and seed extraction
method. The seedling emergence gives information on number of seedlings and seedling density in the soil, while seed viability and seed density information can be provided by seed extraction.

In the seedling emergence method, 30 soil samples were composited and then placed in a 44 × 35 × 10 cm germination trays which are filled with 5-7 cm autoclaved sand. The germinating seeds of *C. peltata* in each tray were counted and removed on once a week interval. After there was no seedling emergence for two consecutive weeks in all germination trays, the observation was ended. The number of seedling in each tray was recorded.

In this study we use modified seed extraction method [18]. Every 100 grams from 15 soil samples was immersed in 500 ml of distilled water for 30 minutes. The mixture of distilled water and soil samples was stirred evenly for 15–30 minutes and left for 1 hour to settle. The organic matter that settles is rinsed and filtered using a stratified filter to obtain seeds from soil samples taken. The extracted seeds are counted and observed.

3. Result and Discussion

Succession development in karst ecosystem is relatively slow compared to other ecosystems [19]. In karst ecosystem, restoration after disturbance is relatively slow and this has causes low resistance of the area to invasion. Disturbance in high intensity and long periods of time in karst limestone hills supports the growth and development of invasive species in the area. On the above ground, these species present in the vegetation with a relatively high density and one of them is *C. peltata*. Invasive species such as *C. peltata* can reduce the availability of light on the forest floor and reduce the diversity of non-invasive plants [20]. *C. peltata* is a pioneer tree introduced from the American tropics and subtropics. The tree is common in parts of West Java, Indonesia [21]. This species is a small fast growing tree up to 10 m in height (Fig. 2). The stem is hollow with large alternate leaves and have 7-11 palmate lobes [1]. Seeds are approximately 1.6 – 2.0 cm long (Fig. 2). *C. peltata* grows well in the study site and are able to produce seeds. The number of individuals found in the vegetation observation plot were seven individuals in adult stage. The seven individuals are spread both in open and forested areas, this condition shows that seeds are dispersed widely and are available in the soil.

*Figure 2. Cecropia peltata* tree (inset: seeds)

*Cecropia peltata* is one of 50 plant species that has been successfully germinated from seeds in the soil samples which were tested using the seedling emergence method. The study finds that the total
number of seedlings consist approximately 50% of C. peltata. There are 646 seedlings of C. peltata out of 1280 seedlings in Kapur limestone hills soil seed bank. Domination of C. peltata in the soil proven by high number of C. peltata seedling that can be found in the soil seed bank. The fact that C. peltata seed occurred in numbers greater than other species in the soil seed bank has given a competitive advantage on this species regeneration. [4] stated that their preliminary study in West Java has provided no evidence that Cecropia poses a significant short-term conservation threat. The statement was made based only on the above ground vegetation observation. The finding on the presence and the number of C. peltata in the soil seed bank in this study has provide new information which can help to justify that Cecropia might actually poses a significant conservation threat. Although, this requires further studies on soil seed bank of Cecropia in different area to support the statement.

The number of seedlings in the germination trays varies from 0 to 132 seedlings (Fig. 3) with seedling density approximately 23.07 ± 33.59 seedlings tray⁻¹. There was large variation in number of seedlings tray⁻¹ that probably cause by a non-uniform dispersal of seeds in the soil. The density of C. peltata seeds in the soil sample was 247 seeds m⁻². The number is much lower compared to the density of C. peltata seeds in undisturbed lower montane rain forest soil seed bank in Puerto Rico which were 398 seeds m⁻² [22]. With this number, there are strong probability that in a certain time in the future C. peltata is able to dominate the above ground vegetation of the study area and replace native plants just like what has happened in Cameroon where study finds strong evidence that C. peltata replace native flora of Cameroon [23]. Seed germination of invasive species can potentially encourage the dominance of these species on surface vegetation [17] which can then cause loss of native species through series of competition.

![Figure 3. Number of C. peltata seedling in each observed tray.](image)

Viability of C. peltata seeds in the tested soil samples was approximately 36.49%. This figure is relatively low for seed viability. Study on C. peltata in Kebun Raya Bogor shows that this species has 30-80% of seed viability (Hadiah pers. comm). The two studies were conducted in a nursery while in the forest floor with full light conditions, germination may be as high as 80–90%. The low viability of C. peltata seeds in this study probably occurred due to inadequate environmental condition for germination in the nursery particularly the amount of sunlight. Seeds of C. peltata require full sunlight for successful germination [6]. Observation conducted on the field is necessary to provide accurate
information on seed viability of this species. Unfortunately field observation is time and money consuming. The germination method in this study may not be ideal in providing the seed viability data but it is the most efficient one.

The observation on the soil seed bank was conducted for approximately eleven months. This study was unable to elaborate more on persistent soil seed bank of *C. peltata* due to time limitation. Based on previous study, seed banks of *C. peltata* could last more than five years [5]. *C. peltata* seeds is orthodox, seeds stored on the forest floor retained viability for only two to three months while in laboratory could lasted for approximately six months. The lower viability under natural conditions shows that a constant addition of seeds to the soil seed bank is necessary for rapid and successful colonization of a forest gap [6]. In some locations flowering and fruiting occur year-round and in others it is seasonal with a peak in either the wet or the dry season depending on location [24]. Therefore, viable seeds are present continuously and abundantly in the soil. These seeds will then form persistent seed bank in the soil and will remain dormant as long as the environment prevents germination. After the environment provide factors that can stimulate germination, the seeds which in correct physiological state will germinate and grow in the disturbed karst hills. If nothing is done about the accumulation of the seeds in the soil, the more likely there will be extensive and prolonged recruitment of new *C. peltata* plant that will require more resources to solve the invasive species problem in Kapur limestone hills.

### Conclusion

*Cecropia peltata* has become dominant in the soil and might actually pose a significant conservation threat based on its presence in the soil seed bank of the study site. *C. peltata* will most likely to dominate the above ground vegetation and replace native plants in the coming time due to its high seed density in the soil.

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### References

[1] Titrosoedirdjo S S, Mawardi I, Titrosoedirdjo S 2018 75 Important Invasive Plant Apecies in Indonesia Bogor: SEAMEO BIOTROP

[2] Lowe S, Browne M, Boudjelas S, De Poorter M 2004 100 of the World’s Worst Invasive Alien Species A selection from the Global Invasive Species Database Italia: ISSG

[3] Conn B J, Hadiah J T, Webber B L 2012 *Blumea* 57 136–42.

[4] Sheil D and Padmanaba M 2011 *Plant Ecol Divers* 4(2-3) 279–88.

[5] Webber B L, Born C, Conn B J, Hadiah J T, Zalamea P C 2011 *Plant Ecol Divers* 4(2-3) 289–93.

[6] Silander S R and Lugo A E 1990 *Cecropia peltata* L. *Yagrumo hembra*, Trumpet-tree. In: *Silvics of North America. Volume 2: Hardwoods. Agriculture Handbook* 634 Washington, DC: U.S. Department of Agriculture, Forest Service pp 250–57.

[7] Binggeli P 2005 *Crop Protection Compendium* Wallingford: CAB International.

[8] Ridwan M T 2016 *Cecropia peltata* L. at Karst of Gunung Cibodas, Bogor: Invasion Degree, Association of Diagnostic Species, and its Advantages for Human and Environment. Thesis. Bogor Agricultural Institute.

[9] Putri W U, Qayim I, Qadir A 2017 *J. Trop. Life. Science* 7(3) 224–36.

[10] Satyanti A, Kusuma Y W C 2010 *Biotropia* 17(2) 115–29.
[11] Rogers H M and Hartemink A E 2000 J Trop Ecol 16 243–51
[12] Fenner M W 1985 Seed Ecology Netherlands: Springer
[13] Roberts H A 1981 Seed banks in the soil. Cambridge, Academic Press. 55p.
[14] Baskin C C and Baskin J M. 2001. Seeds: Ecology, biogeography, and evolution of dormancy and germination San Diego: Academic Press.
[15] Chesson P, Gebauer R L, Schwinning S, Huntly N, Wiegand K, Ernest M S, Sher A, Novoplansky A, Weltzin J F 2004 Oecologia 141 236–53.
[16] Fourie S 2008 S. Afr. J. Bot. 74 445–53.
[17] Gioria M and Osborne B 2010 Biol. Inv. 12 1671–83.
[18] Price J N, Wright B R, Gross C L, Whalley W R D B 2010 Methods Ecol Evol. 1 151–57
[19] Chen X, Su Y, He X, Wei Y, Wei W 2012 World J Microbiol Biotechnol 28 205–13.
[20] Whitten T, Soeriaatmadja RE, Afiff SA 1996 The Ecology of Java and Bali Singapore: Periplus Editions.
[21] MacDougall A S and Turkington R 2005 Ecology 86(1) 42–55.
[22] Burns R M and Honkala B H 1990 Agriculture Handbook Silvics of North America 2 Washington DC: Forest Service USDA
[23] McKey D 1988 Biotropica 20 262–64.
[24] Binggeli P 1999 Cecropia peltata L. (Cecropiaceae). Woody Plant Ecology retrieved from http://members.lycos.co.uk/WoodyPlantEcology/docs/web-sp3.htm