



“*Brighamia insignis*” an Hawaiian Endangered Species, Current Status and Future Prospects: A Review

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Abstract: Plants are serving human beings through various aspects of life. But these natural servers are not out of danger. They are facing high alerts for the red zone category. This review is highlighting the critically endangered Hawaiian plant species *Brighamia insignis* belonging to the family Campanulaceae. Here is also a discussion about some of the threats to *Brighamia insignis* and its conservation methods to prevent it from extinction.

Keywords: Endangered Species, *Brighamia insignis*, Hawaiian

1. INTRODUCTION

Nature is serving human beings from the beginning of life. It includes both plants and animals. Approximately 320,000 plant species exist on this planet. Out of which 26000–29000 plants are seed-bearing belonging to either gymnosperms or angiosperms. These plants not only provide us with a significant proportion of oxygen but also fulfill the necessities of human beings [1].

Extinction has been always a major part of life. Any living species have some threats of extinction if it is facing some unfavorable environmental conditions. Plants all over the world are not out of danger. These are facing different rates of extinction around the world. This extinction may be because of human activities or some hazardous environmental factors. IUCN has classified plants into various following categories depending upon threat of extinction; Extinct, Critically Endangered, Extinct in wild, Vulnerable, Endangered, Near Threatened, and Least Concern.

About 3654 plant species, 17 % of all known plants have been listed as endangered by International Union for Conservation of Nature (IUCN). Similarly, 99 subspecies and 101 plant varieties were listed as endangered by IUCN [2].

Critically endangered species face a high risk of extinction [3]. A total of 6147 plant species are considered critically endangered. A species is considered critically endangered if Population size is reduced to 90 % with population cover at less than 100 km² and less than 50 numbers of individuals.

Here discussion is about the Hawaiian *Brighamia* genus belonging to family Campanulaceae family. This genus is named after William Tufts Brigham. About 130 endemic plant species belonging to this family are found in the Hawaiian Islands having about of plants. In recent years, the *Brighamia Insignis*, has gained much interest, particularly among succulent plants due to its caudiciform habit [4] unique among family Lobelioideae. This genus comprises two species known as *B.insignis* and *B. rockii*. Both species are similar in morphology. These plants are halophytes [5]. Swollen stem with a crown of tightly packed leaves is characteristics of this genus. [4]. A mature plant of this genus may attain a height of 1-2.5 normally [6].

A complete monograph of the genus *Brighamia* was prepared by St. John (1969) as shown in Figure 1. In which *Brighamia insignis* has special importance. He was unable to find out this specimen from Moloka ‘i. But he selected Remy’s sheet as its

lectotype from Ni'ihau. So this name was limited to Ni'ihau plants while those plants which belong to Moloka'i, were distinct from Ni'ihau plants and are named *B. rockii* [7].

2. Taxonomic position of *Brighamia insignis*

Kingdom: Plantae

Order: Asterales

Family: Campanulaceae

Genus: *Brighamia*

Species: *Brighamia insignis*

Hawaiian name of *Brighamia Insignis*, is *Alula or Ōlulu* [8]. While it is commonly known as Vulcan palm, cabbage on a stick, and Hawaiian Palms. Species name *insignis* is derived from the Latin word *insignia*, which means outstanding in plant appearance.

3. *Brighamia insignis* biodiversity status

Brighamia plants belonging to the family *Campanulaceae* are considered rare plants of Hawaiian plant diversity. Both species of this genus are endangered listed federally [6]. *Brighamia insignis* is a critically endangered plant species endemic to Hawaiian. About five populations of this species were reported in 1994 by the United States Fish and Wildlife Service. There were only 45 to 65 individuals of this plant species in 1994. So they listed it as endangered species. But in 2014 only one individual of this species was reported. So

today, this species is extinct in the wild [9]. IUCN considered it as a critically endangered plant of Hawaiian flora.

4. Plant Description

4.1 Distribution of plant

B. insignis Natural Range is Kaua'i and Ni'ihau. In Kaua'i range its populations were found at Waiahuakua and Ho'olulu valleys. These valleys are found along the coastal regions of Nā Pali.

4.2 Plant Abundance

The population number is rapidly decreasing. *B. insignis* is found along NāPali Coast, Ha'upu Range of Kaua'i island, and Hono O Nā Pali boundaries [12]. Once a population was found on Ni'ihau, but this population is also disappeared since 1947. Now it is believed that there is the complete absence of a wild population of *B. insignis* in Kaua'i and Ni'ihau. While fewer than five plants and fewer than 10 plants are found at Waihuakua and Ho'olulu respectively [12].

4.3 Plant Location

B. insignis locates at 748 meters from sea level. It is found in the terrestrial habitat where annual rainfall is less than 170 cm. It is mostly seen growing in cracks of rocks. *Artemisia species*, *Euphorbia celastroides*, *Hibiscus kokio*, *Lipochaeta*

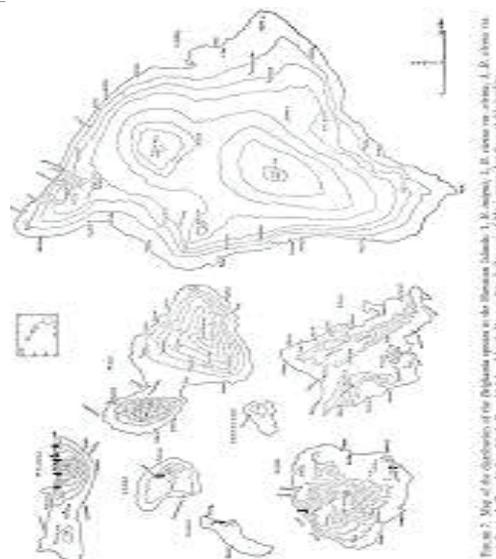


Fig. 1. Monograph of Genus *Brighamia*

succulenta, *Munroidendron racemosum*, and *Sida fallax* are found growing in its surroundings.

5. Plant Morphology

Morphology of *B. insignis* is shown in Figure 2 (A).

5.1 Stem Morphology

B. insignis has an un-branched succulent stem. The stem is bulbous from the base towards the top having tapering ends. The stem top bears fleshy leaves. It usually ranges from 1 m to 2 m in height. Maximum height can be 5 m [10].

5.2 Leaf Morphology

Plant leaves have bright green to dark green appearance. These are semi-succulent. These are compactly arranged in a rosette manner. Leaf size may be 6.5 to 11cm wide and 12 to 20 cm long [12].

5.3 Flower Morphology

The flower is of a showy type and yellow as shown in Fig 2B. These are arranged in groups of three to eight in leaf axils. Petals are fused forming a tube of 7 to 14 cm long. This tube helps in outcrossing through hawk moths. Their blooming period is from September to October.

5.4 Pollen structure

B. insignis bears tricolporate pollen. The outer wall of pollen grains has a triangular shape. It has 3 furrows.

5.5 Fruit Morphology

The fruit of *B. insignis* is capsule-shaped. Its length is about 13 to 19 mm. It contains many viable Pale coloured and egg-shaped seeds. These are 0.8-1.2 mm long [11]. Fruit matures after 6-8 weeks of pollination. It has been noted that there is very low genetic variability [5] between *Brighamia insignis* and *Brighamia rockii*. But *B.insignis* varies from *B.rockii* as shown in Table 1.

6. Photochemistry of *Brighamia insignis*

It has been documented experimentally that 13 organic compounds are present in *B.insignis* [12]. These have been identified by comparing its retention times and mass spectra with standard substances. Linalool and benzyl alcohol are considered dominant volatiles. Linalool has an emission of 41 % during the day and 35 % during the night. Benzyl alcohol has 47 % emission at day and 54 % at night. Here is a table showing the proportion of volatile organic compounds day and night [12]. Detail are given in Table 2.

7. Threats to *Brighamia insignis*

In 1992, the Ālula species was destroyed by the ‘Iniki’ hurricane. This setback was done along the NāPali Coast of Kaua‘i. In this destruction, 60-70 plants were destroyed. Similarly, this hurricane caused the destruction of 10 individuals from Hā‘upu [14].

Here are some of the threats which lead to the extinction of *B. insignis*:



Figure 2A. Morphology of *Brighamia insignis*



Figure 2B. Morphology of *Brighamia insignis* flower

Table 1. Comparison of *Brighamia insignis* and *Brighamia rockii*.

Plant name	Distribution	Flower color	Common name	Maximum height
<i>Brighamia insignis</i>	Ni'ihau an island of Hawaii	Yellow	Ālula	16Ft
<i>Brighamia rockii</i>	Moloka i, an island of Hawaii	White	<i>Pua'ala</i>	16Ft

Table 2. Phytochemicals found in *B.insignis*.

Phytochemicals	Volatile organic compound	Proportion at night	Proportion at day
Aliphatic compounds	3-Hexen-1-ol	0.009	0.015
	1-Hexanol	0.016	0.021
	Heptyl butyrate	0.008	0
	3-Nonenol	0.006	0.003
	Decanal	0	0.002
Aromatic compounds	Benzyl alcohol	0.545	0.466
	Methyl salicylate	0.011	0.021
	delta-3-Carene	0.002	0.003
Monoterpenoids	Linalool	0.349	0.412
	1,8-Cineole	0.005	0
	Linalool oxide furanoid	0.001	0.001
Nitrogenous Sesquiterpene	Indole	0.026	0.026
	Nerolidol	0.020	0.29

Above data of table is extracted from the study of Wlash *et al.*, (2019) [12]

- Hawk moth is considered as the only pollinator of *Brighamia insignis*. But now this Hawk moth is extinct [12] due to which *B. insignis* is unable to reproduce itself.
- Grazing animals from steep areas also destroyed this plant. There has been noticed a massive loss of leaves by an insect called *Tetranychus cinnabarinus*. This insect destroyed both cultivated and wild plants [12].
- Landslides and Hurricanes also caused the removal of this plant from this area.
- Exotic and invasive species also dominated the area and reduced its survivorship due to tough competition.

8. Methods to Conserve *Brighamia insignis*

The basic goal to conserve a plant is to protect the existing population from extinction. USFWS has made various actions for the recovery of this plant species. National Tropical Botanical Garden is taking action for increasing seed set by using

manual pollination methods. Newly produced seeds are shifted to greenhouses where these are kept under specialized conditions for the survival of plant species. There are many plants of *B.insignis* at McBryde and Limahuli Gardens but unfortunately, only one individual is found in wild conditions [5]. One of the plants is preserved in Royal Botanical Kew Garden as shown in Figure 3.

Here are two common methods which are used for the conservation of *B.insignis*.

- 1) It has been reported that there is a very low level of genetic variability among both *Brighamia species*. This may be due to repeated bottleneck effects and less number of individuals in a population [16]. These results can be used for the conservation of *B.insignis* [5]. For example, genetic variation among organisms can be increased by ex-situ conserving along with those plants having a maximum level of genetic variability.

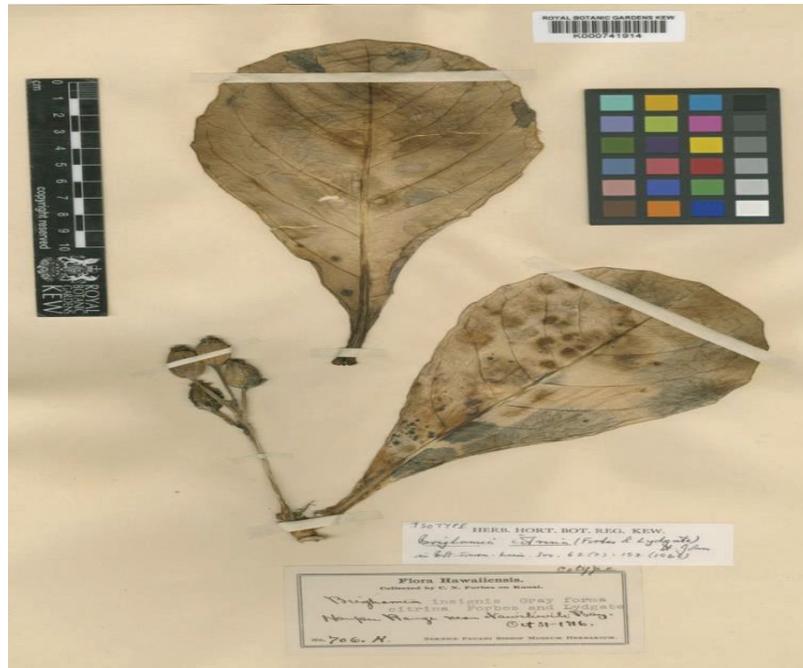


Figure 3. *Brighamia insignis* preserved in Royal Botanical Kew Garden.

2) As Hawk moth, the only pollinator of *Brighamia insignis*; is extinct due to which *B. insignis* is unable to reproduce itself. So to conserve plants manual pollination can be done under specialized conditions *B. insignis* species growing in Waiahuakua can be used for hand-pollinating because it possesses those alleles at Est not found in any other population. This artificial pollination can help in increasing plant individuals.

For conservation of *B. insignis*, some other actions can also be done:

- There should be a survey of the historic land of the plant to survive the remaining populations.
- There should be the establishment of ex-situ stocks which must have a complete description of remaining plant individuals.
- Monitoring of plants to protect them from pathogenic diseases.

9. CONCLUSION

Brighamia insignis belonging to the family Campanulaceae is native to Hawaiian Islands. Its Natural Range is Kaua'i and Ni'ihau. *Brighamia insignis* is considered a critically endangered species of Hawaiian

flora. In 2014, only one individual of this species was reported. Now it is believed that there is the complete absence of a wild population of *B. insignis* in Kaua'i. Major factors toward its extinction include extinction or removal of its pollinator Hawk moth from the Hawaiian Islands, grazing animals, other invasive flora. Artificial pollination and ex-situ conservation are helpful for the conservation of this species.

10. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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