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Expedition and Characterization of the Corpse Flower (*Amorphophallus titanum* Becc.) in West Sumatra

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Abstract

The corpse flower (Amorphophallus titanum Becc.) *is an endemic flora of Indonesia that is naturally found only in Sumatra. The status of A. titanum is endangered because of several factors: deforestation, tuber exploitation, long flowering time, and protogyne. Until now, there has been no research about the population and distribution of A. titanum in West Sumatra. This study aimed to obtain information about the population and distribution of A. titanum in West Sumatra, so this research is essential to learn. The research used roaming and snowball sampling methods in Solok Selatan and Sijunjung Regencies in September–October 2022. The research was conducted by recording the coordinates where A. titanum was discovered, marked using GPS, and collecting morphological characteristics. The results showed that exploration in the Solok Selatan District found 19 corpse flower individuals (18 species of A. titanum and one species of A. gigas). In contrast, exploration in Sijunjung Regency managed to found 25 species of A. titanum. The corpse flowers found were in vegetative, dormant, flowering, and fruiting phases. The results help record the number and distribution of A.titanum in West Sumatra. The ex-situ conservation program will use germplasm as propagation material in the future.*

Keywords: *biodiversity, conservation, endangered, forest, IUCN*

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Introduction

There are 263 species of *Amorphophallus* distributed from West Africa to Southeast Asia and Northern Australia. Indonesia has about 25 of these species, 17 of which are endemic. Sumatra Island has the highest level of *Amorphophallus* species endemism compared to other islands, with 12 species found: *Amorphophallus asper, A. beccarii, A. forbesii, A. gigas, A. gracilis, A. hirsutus, A. manta, A. titanum, A. muelleri, A. paeoniifolius, A. prainii, and A. haemotospadix*. The first eight species are endemic to Sumatra, there are 5 species in Java, 3 in Kalimantan, and 1 in Sulawesi (WCVP, 2024; IUCN Redlist, 2024).

The corpse flower (*A. titanum* Becc.) is an endemic flora that is naturally only found on Sumatra Island and has an endangered status (IUCN Redlist, 2024), It was first discovered by Dr. Odoardo Beccari in 1878 (Hetterscheid & Ittenbach, 1996). The corpse flower's large size is unique, with a flower height that can reach 179.7 cm (Latifah et al., 2015) to 274 cm (Lobin et al., 2007). The recorded locations of *A. titanum* in Sumatra are: Aceh (1 location), North Sumatra (4 locations), West Sumatra (10 locations), South Sumatra (1 location), Bengkulu (6 locations), Jambi (3 locations), and Lampung (3 locations) (Yuzammi et al., 2015).

A. titanum is protected in Government Regulation Number 7/1999 (Appendix PP. Number 7/1999) and Regulation of Environment and Forestry Minister of the Republic of Indonesia Number P.92/MENLHK/SETJEN/KUM.1/8/2018. The population decline was caused by several factors, namely: habitat destruction/deforestation, tuber exploitation for the ornamental plant trade, and besides that, the people thought the porang (*A. muelleri*), reached a long generative phase, and protogyne (Korotkova & Barthlott, 2009; Sudarmono et al., 2016; Yudaputra et al., 2021).

Studies on various aspects of the corpse flower have been carried out in order to support conservation programs, including studies of plant morphology and anatomy, growth and development of the vegetative (spathe) and generative (spadix) parts (Lobin et al., 2007), studies on flower thermogenesis (Korotkova & Barthlott, 2009), prediction of flowering (Latifah et al., 2015), seed germination (Latifah & Purwantoro, 2015), hand pollination (Sudarmono et al., 2016), in vitro culture (Irawati et al., 2017), induction of shoots from peculiar callus (Yuzammi et al., 2018), identification of molecular genetic diversity (Arianto et al., 2018), bioecology (Nursanti et al., 2019), expedition (Yudaputra et al., 2021), habitat vegetation (Yudaputra et al., 2022), and petiole cutting (Setiawan et al., 2023)

Comprehensive studies regarding the existence of *A. titanum* are essential to support conservation programs. Researchers have conducted several studies on expedition,

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exploration, and habitat bioecology. Arianto et al., (2019) found 52 individuals in 3 locations in Bengkulu, consisting of 49 individuals in the vegetative phase and three in the generative phase. In the Kerinci Seblat National Park, Nursanti et al., (2019) reported that 83 individuals found in open areas, river banks, secondary forests, and on the edge of the road. Furthermore, Yudaputra et al., (2021) also found 162 individuals spread from Aceh to Lampung. Naturally, *A. titanum* is widespread over the Sumatra rainforest as understory growth in the calcareous soil below the forest canopy (Yuzammi et al., 2018).

While previous research has extensively highlighted the biological and ecological uniqueness of *A. titanum*, its specific distribution in West Sumatra remains poorly documented. Therefore, this study can fill that gap by presenting the latest data from field surveys. Given the research's limited scope, but the significant and intriguing information it contains, we present our findings in the form of a short communication. This article is designed to provide a comprehensive overview of the main findings in a concise and compact manner. As a short communication, this article does not include the in-depth analysis typically found in full research papers. Instead, we focus on the main findings of our research, including the geographical distribution, ecological conditions supporting the growth of *A. titanum*, and several important field observations. We hope that these findings can serve as a foundation for further research and as valuable information for future conservation efforts. We also hope that presenting these findings as a short communication will facilitate access and understanding by other researchers interested in the conservation of *A. titanum.*

Therefore, this study not only enhances our knowledge of the corpse flower in West Sumatra but also provides a strong basis for more effective conservation efforts. These findings highlight the importance of preserving natural habitats to support the survival of *A. titanum.* The discovered corpse flower can serve as propagation material for conservation programs, potentially fostering the growth of agro-ecotourism areas for recreation, research, and education. In conclusion, we present this short communication as an important contribution to the field of ecology, contribute meaningfully to the scientific knowledge and to support conservation efforts. This study aimed to determine the number and distribution of *A. titanum* in West Sumatra, especially in Solok Selatan and Sijunjung Regencies.

Methods

Study area This research was conducted in September–October 2022. The research locations were Simancuang Village, Nagari Alam Pauh Duo, Pauh Duo District, Solok Selatan Regency, and Buluah Kasok Village, Lubuk Tarok District, Sijunjung Regency, West Sumatra Province (Figure 1).

Procedures The tools used in this study were a global positioning system (GPS), camera, stationery, tape measure, knife, clear plastic, container box, and ArcGIS. Exploration of carrion flowers is carried out by the roaming method using a line (transect line) with a width of 20 m to the right and left of the track. The data was collected on specimens found at the observation site, including species name, plant height, stem circumference, and habitat conditions. The data collected is presented in tables, figures, and maps, and then analyzed descriptively.

Data analysis The data was collected on specimens found at the observation site, including species name, plant height, stem circumference, growth phase, and habitat conditions. Rachis and leaf samples were used as propagation material in the cuttings and tissue culture methods. Data is presented in tables, figures, and maps, then analyzed descriptively.

Results and Discussion

Exploration activities in South Solok Regency found one *A. gigas* and 18 *A. titanum*. The corpse flower is in the vegetative, flowering, fruiting, and dormancy phases. Three

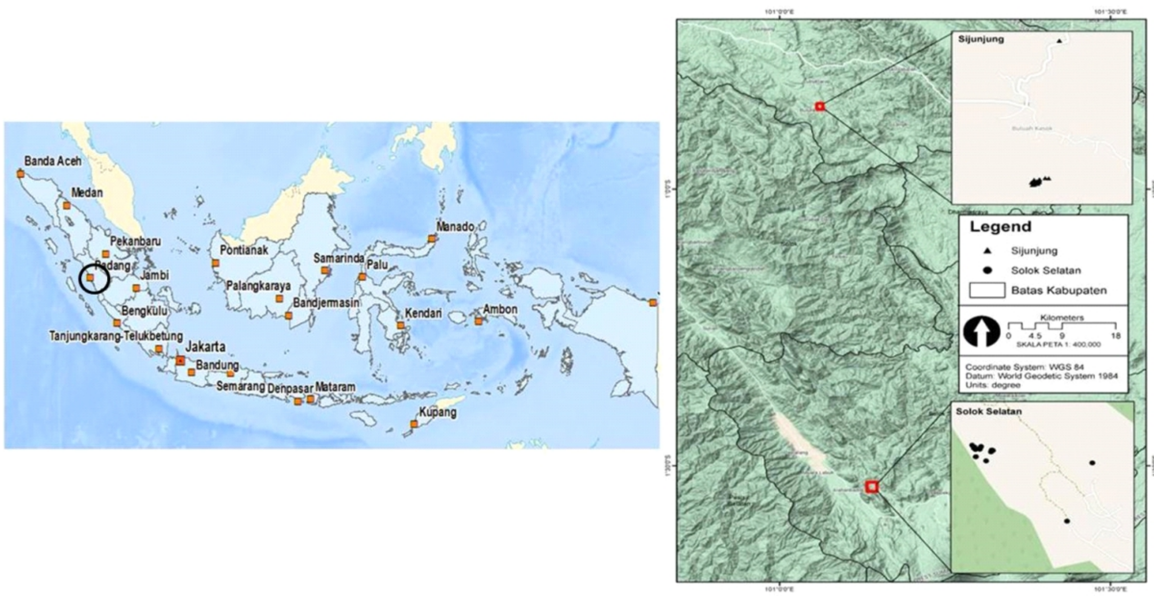

Figure 1 Location of corpse flower expedition in Solok Selatan and Sijunjung Regencies.

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individuals were in the dormancy phase, two in the flowering phase, one in the fruiting phase, and 13 in the vegetative phase (Table 1).

In Sijunjung, only 24 individuals of *A. titanum* species were found, 22 individuals in the vegetative phase, one in the flowering phase, and one in the fruiting phase (Table 2). The

Table 1 Characterization data and coordinates of the corpse flower in Solok Selatan

No	Petiole height (cm)	Petiole circumference (cm)	Growth phase	Habitats	Coordinates	
					Latitude	Longitude
1	-	-	Dormancy	Open field	-1.541265	101.14150
2	160	26	Vegetative	Forest	-1.534357	101.13543
3	130	18	Vegetative	Forest	-1.534398	101.13540
4	200	50	Vegetative	Forest	-1.534445	101.13538
5	246	52	Vegetative	Forest	-1.534539	101.13533
6	177	33	Vegetative	Forest	-1.534369	101.13537
7	300	60	Vegetative	Forest	-1.534408	101.13549
8	150	37	Vegetative	Forest	-1.534230	101.13437
9	187	54	Vegetative	Forest	-1.534208	101.13444
10	204	32	Vegetative	Forest	-1.534280	101.13441
11	320	80	Vegetative	Forest	-1.534009	101.13453
12	270	65	Vegetative	Forest	-1.534173	101.13393
13	200	50	Vegetative	Forest	-1.533885	101.13380
14	410	85	Vegetative	Open field	-1.534068	101.13400
15	170*	55**	Flowering	Open field	-1.534312	101.13406
16	-	-	Fruiting	Forest	-1.535001	101.13411
17	-	-	Dormancy	Forest	-1.535014	101.13409
18	-	-	Dormancy	Forest	-1.535409	101.13493
19	270*	42**	Flowering (*A. gigas*)	Shrubs	-1.535611	101.14355

Note: - = dormancy/fruiting phase, * = flower stalk height, ** = circumference of flower stalks

Table 2 Characterization data and coordinates of the corpse flower in Sijunjung

No	Petiole height (cm)	Petiole circumference (cm)	Growth phase	Habitats	Coordinates	
					Latitude	Longitude
1	66	4	Vegetative	Forest	-0.8541116	101.06134
2	115	10	Vegetative	Forest	-0.8540912	101.06117
3	66	4	Vegetative	Forest	-0.8542483	101.06087
4	125	12	Vegetative	Forest	-0.8541700	101.06088
5	150	10	Vegetative	Forest	-0.8543500	101.06086
6	92	9	Vegetative	Forest	-0.8543333	101.06086
7	270	56	Vegetative	Forest	-0.8542883	101.06074
8	204	20	Vegetative	Forest	-0.8542800	101.06083
9	45*	35**	Flowering	Forest	-0.8543883	101.06076
10	200	36	Vegetative	Forest	-0.8543371	101.06072
11	138	15	Vegetative	Forest	-0.8543466	101.06072
12	85	8	Vegetative	Forest	-0.8543467	101.06067
13	45	6	Vegetative	Forest	-0.8544433	101.06078
14	-	-	Fruiting	Forest	-0.8544113	101.06069
15	215	30	Vegetative	Forest	-0.8545000	101.06060
16	110	8	Vegetative	Forest	-0.8543100	101.06061
17	139	28	Vegetative	Forest	-0.8543933	101.06058
18	166	20	Vegetative	Forest	-0.8542046	101.06060
19	113	8	Vegetative	Forest	-0.8543467	101.06061
20	49	5	Vegetative	Forest	-0.8544383	101.06059
21	44	4	Vegetative	Forest	-0.8544383	101.06059
22	190	40	Vegetative	Forest	-0.8545083	101.06052
23	97	11	Vegetative	Open field	-0.8544850	101.06054
24	200	50	Vegetative	Open field	-0.8458102	101.06189

Note: - = dormancy/fruiting phase, * = flower stalk height, ** = circumference of flower stalks

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corpse flower is found in habitats with moist soil conditions covered with leaf litter, shrubs, cinnamon cultivation land, river banks, and mostly on forest slopes with dense vegetation. Hidayat and Yuzammi (2008) reported that corpse flowers grow heavily on soil with a litter layer of up to 10 cm and keep the soil moist. Nursanti et al., (2019) reported that corpse flowers are found at an altitude of 301–341 m asl, land slope of 25–45%, a latosol soil type, the humid habitat, and temperatures ranging from 24–25 °C with an average relative humidity ranging from 80–83%. Additionally, Yudaputra et al. (2021) also reported that corpse flowers are often found in moist soil conditions, on forest slopes, and on river banks.

The vegetative phase begins with seed germination, emergence of the petiole (pseudo-stem), rachis and leaves above the soil surface (Figure 3a). Petioles were dark green and had irregular white blotches (Figure 2a and Figure 3b). The corpse flowers found in Solok Selatan have petiole height range 150–410 cm with stem circumferences range 18–85 cm (Table 1) and in Sijunjung ranging from 44–270 cm with stem circumferences ranging from 4–56 cm (Table 2). Latifah et al., (2015) reported that the vegetative phase from leaf bud to fully opened leaf lasted 88 days. The process of photosynthesis will occur during the vegetative phase which produces photosynthate and is stored in the tubers as a food reserve for the flowering and fruiting phases.

According to Graham and Hadiah (2004), the vegetative phase can result in tuber growth reaching up to 100 kg in weight. This phase usually begins at the beginning of the rainy season. It lasts 6–12 months, followed by a dormant cycle for 1–4 years before entering the flowering cycle, which is irregular. In addition, tuber weight can reach 117 kg, tuber diameter 83 cm, and tuber height 37 cm (Lobin et al., 2007).

The dormancy phase can be seen in the condition of the petioles and leaves, which begin to wither and rot. The flowering phase lasts 2–7 days, and the flowers will then wither. The flowers of *A. gigas* are higher than those of *A. titanum* (Figure 2b), but the tusks and petals of *A. titanum* are broader than *A. gigas* (Figure 2c, Figure 3c). Lobin et al. (2007) reported that the flowering phase, from the appearance of the bud to the opening of the spathe, ranges from 25–46 days, with flower heights varying from 1.66–2.74 m. Latifah et al. (2015) also reported that bud inflorescence to spathe

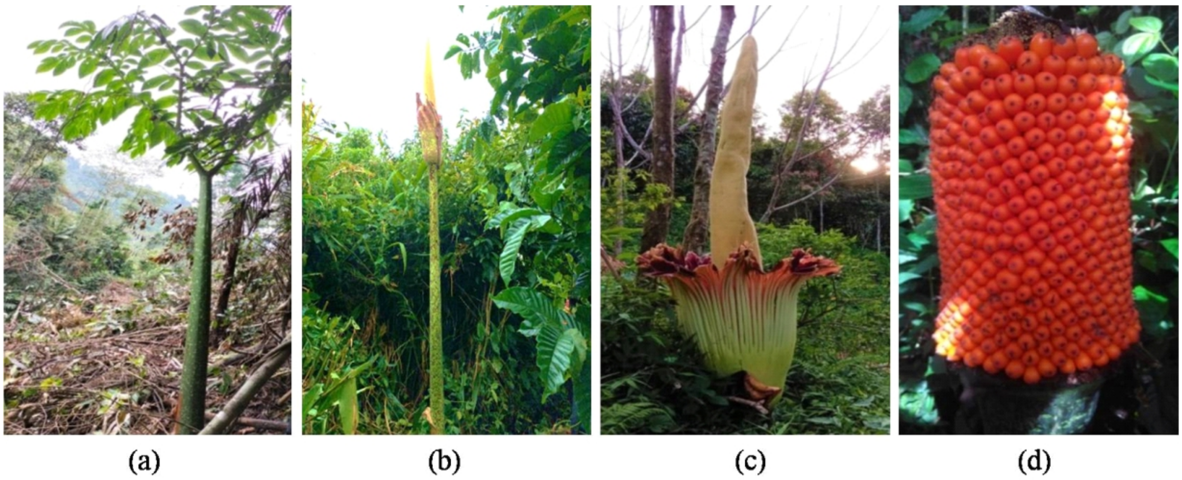

Figure 2 The corpse flower found in Solok Selatan Regency, (a) vegetative phase of *A. titanum*, (b) flowering phase of *A. gigas*, (c) flowering phase of *A. titanum* (d) fruiting phase of *A. titanum.*

Figure 3 The corpse flower in Sijunjung Regency, a) seedling phase, b) vegetative phase, c) flowering phase, d) fruiting phase.

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opening needs 67.6 days.

From observations, the fertilization process was unsuccessful, so the fruit was not formed at both locations. In Solok Selatan, one individual is in the fruiting phase. The reddish-orange fruit adheres to fruit bunches under extremely constrained conditions (Figure 2d, Figure 3d). Fruit length ranges from 0.8–4.1 cm, diameter ranges from 0.4–2.2 cm, the number of fruits reaches 315 fruits/bunch, and each fruit contains 1–2 blackish brown seeds with a pointed tip. In Sijunjung Regency, one individual was also found in the fruiting phase. The fruit is reddish-orange with a length ranges from 0.7–3.9 cm and a diameter of 0.4–2.1 cm. The number of fruits reaches 283 fruits/bunch, and each fruit contains 1–2 blackish brown seeds with a pointed tip. Fruit sizes found at both locations were also small compared to the study by Sudarmono et al. (2016) ranging from 2–5 cm and a diameter of 1.5–3 cm.

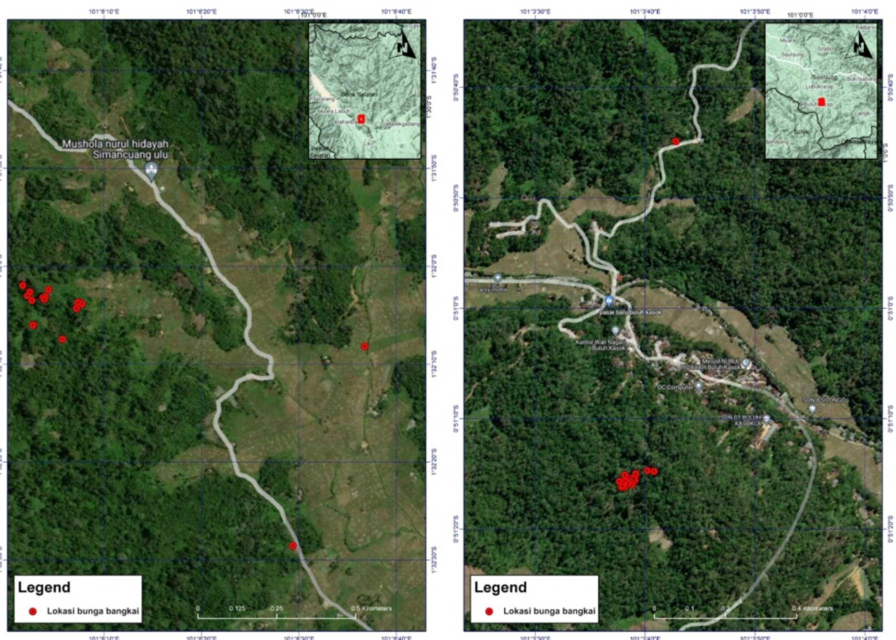
Lobin et al. (2007) stated that the generative phase from flower blooming to ripe fruit takes 177 days. The density of fruit on bunches in Sijunjung was less frequent than in Solok Selatan (Figure 3d). The percentage of successful pollination and fertilization processes is the main factor determining fruit density in bunches. It is suspected that not all ovules were successfully fertilized, so seeds and fruit were not formed.

A. titanum has two separate flowering phases: a female flowering phase during the first evening and night after the opening of the spathe and a male flowering phase the following night. The pollination process is aided by insects attracting the pungent scent when the spathe opens. The compounds methyl thioacetate, trimethylamine, and isovaleric acid (Shirasu et al., 2010), dimethyl tetrasulfide, dimethyl trisulfide, and dimethyl disulfate (Kite & Hetterscheid, 2017), methanethiol, and 3-methyl butanal (Kang et al., 2023) are responsible for the rotten smell.

The most volatile compounds released in the flowering night were dimethyl disulfide and dimethyl trisulfide. However, the content of both compounds significantly decreased on the second day of the *A. titanum* flower opening. This is due to the large amount of energy consumed by the flowering, which releases a large amount of heat through respiration (Liu et al., 2023). Pollination and fertilization processes are also determined by temperature in male and female flowers (thermogenesis). Lamprecht and Seymour (2010) reported that the temperature of the inflorescence on the night of flowering can reach above 36 °C. In addition, the temperature of male flowers at anthesis is 39.5 °C while the temperature of other parts of the spathe, including female flowers, is around 26 °C (Korotkova & Barthlott, 2009). On the other hand, a higher temperature is conducive to the emission of volatile compounds. Some studies believe that heat generation is an essential component of 'cheating' insects, and plants that produce heat and odors simultaneously are more likely to attract pollinators than plants that produce odors alone.

The distribution of corpse flowers is clustered in the same area. In the South Solok Regency (Figure 4a) and the Sijunjung Regency (Figure 4b), we found only two individuals separated. Arianto et al. (2019) also reported the same results, finding a clustered spread of corpse flowers. The spread of these clusters is caused by the force of gravity and the flow of water on the soil surface, which carries the seeds spread over the same area. Until now, the spread of carrion flowers is thought to have been assisted by hornbills (Hidayat & Yuzammi, 2008). Nursanti et al. (2019) found that the rhinoceros hornbill (*Buceros rhinoceros*) was active in the corpse flower habitat.

This opinion differs from what was found during observations, especially on individuals bearing fruit, and no



(a) (b)

Figure 4 Map of the corpse flower discovery, a) Solok Selatan Regency, b) Sijunjung Regency.

hornbill activity was found as a vector for dispersing corpse flower seeds. In addition, Hancock (2014) reported that the plant species used as a food source for six species of hornbills found in Sumatra are *Oncosperma horridum* (Arecaceae), *Litsea* sp. (Lauraceae), *Aglaia spectabilis, Chisocheton ceramicus* (Meliaceae), *Horsfieldia tomentosa, Myristica elliptica* (Myristicaceae*),* and *Sterculia* sp. (Sterculiaceae), and none of the literature mentions the food source of the corpse flower. Besides that, ecologically, hornbills live in the highest forest canopy and never on the forest floor.

Conclusion

The research concludes with the presence and distribution of *A. titanum* and *A. gigas* in Solok Selatan and Sijunjung Regencies. Specifically, 18 individuals of *A. titanum* and one individual of *A. gigas* were identified in Solok Selatan, while in Sijunjung, 24 individuals of *A. titanum*. These findings provide important insights into the life cycle stages of the corpse flowers, which were observed in vegetative, dormant, flowering, and fruiting phases. The distribution pattern of the corpse flower in both locations was notably clustered, indicating specific areas where these plants thrive. This clustering may suggest the presence of suitable microhabitats or environmental conditions that support the growth and reproduction of these rare species. Understanding these patterns is crucial for informing future conservation efforts and developing targeted strategies to protect and preserve these unique and ecologically significant plants. The study underscores the need for ongoing monitoring and conservation initiatives to ensure the sustainability of *A. titanum* and *A. gigas* populations.

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