SPECIES RICHNESS AND ABUNDANCE OF RHODODENDRONS ALONG THE MARAI PARAI TO WEST GURKHA HUT TRAIL

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ABSTRACT

A survey conducted from October 6th to 12th, 2023, along the Marai Parai to West Gurkha Hut trails in the Mount Kinabalu area, has revealed important insights into the distribution and abundance of *Rhododendron* species. The survey results show considerable variation in *Rhododendron* populations across different elevations and habitats. Notably, Transect 7 recorded the highest number of individuals (640) and species diversity (4), suggesting this area may serve as a key hotspot for *Rhododendron* diversity. Transect 8 followed closely with 533 individuals and 2 species. In contrast, no *Rhododendron* individuals were detected in Transects 1, 3, and 11, located at elevations of 1,043 m, 1,529 m, and 3,660 m above sea level (a.s.l), respectively. Overall, 15 distinct species were identified in the Marai Parai region, with eight species observed along the trail from Marai Parai to West Gurkha Hut. These findings underscore the ecological significance of the region as a biodiversity hotspot and emphasize the urgent need for targeted conservation efforts to protect these species.

Keywords: *Marai Parai, rhododendron, species, abundance.*

INTRODUCTION

Marai Parai is located atop the Penibukan ridge on the western flank of Mount Kinabalu, above Kiau village. The area is characterized by pioneer vegetation in various stages of succession, particularly on the landslides that occasionally occur there. Despite being surrounded by dense lower montane rainforests at an elevation of 1,600 meters above sea level (a.s.l), Marai Parai exhibits a stunted vegetation profile, more akin to *kerangas* vegetation found on leached acid sandstone plateaux elsewhere in Borneo (van der Ent et al., 2014). This distinct ecological feature sets it apart from the surrounding forest and adds to the region's botanical uniqueness. One of the most striking aspects of Marai Parai's flora is its diversity of rhododendrons, with 16 different species thriving in the area. Rhododendrons are part of the Ericaceae family, which comprises approximately 4,000 species globally, divided into five subfamilies and various tribes. Borneo, an island in Southeast Asia, is home to 55 *Rhododendron* species, with 42 species located in Sabah, Malaysia. Notably, all 15 species found in Marai Parai are endemic to Mount Kinabalu (Argent et al., 2007).

Mount Kinabalu, one of Southeast Asia's tallest peaks, home to a diverse range of plant species including *Rhododendron*, with many endemic species found nowhere else on Earth (Beaman & Beaman, 1998). 26 species of *Rhododendron* recorded across its slopes, four of which are exclusive to the mountain (Argent et al., 2007). The Ericaceae family of Mount Kinabalu has been extensively covered by G. Argent (1996), while Beaman et al., 2001 provide a detailed enumeration of the species and taxa within this family. Despite the ecological significance of Marai Parai and its *Rhododendron* diversity, no comprehensive studies have been conducted to document the *Rhododendron* species along the Marai Parai to West Gurkha Hut trail, highlighting a gap in research that warrants further exploration. This study aims to inventory the rhododendrons along the Marai Parai-Gurkha Hut route. The inventory will help the park authority develop a management strategy for the new climbing route to the Mount Kinabalu summit.

MATERIALS AND METHODS

Data collection

The research was conducted in 12 distinct transects along the Marai Parai to West Gurkha Hut Trail (Figure 1). 12 transects, each 1 km in length, were established. Plant counts and species documentation were conducted within a 5-meter range on both sides of the transect. The study sites were selected based

on their elevations ranging from 938 to 3,986 m above sea level (a.s.l) (Figure 2). The research focused on recording the number of *Rhododendron* individuals, and total species diversity, documenting the distribution, elevation, and habitat of *Rhododendron* species. Species richness and abundance were measured using a simple method by counting the number of *Rhododendron* species and the total number of individuals present in each transect.

Sample collection

An opportunistic sampling of rhododendrons was carried out along the Transect 1 to Transect 12. The collected specimens were curated and identified at the SNP Herbarium (SNP). Floral structure samples were collected and preserved using Bridson & Forman's (2000) standard herbarium technique.

Sample Identification

The monographs of Argent et al., 2007 and Beaman et al., 2001 were consulted for species identification. Cross-referencing was then conducted with the Global Biodiversity Information Facility (GBIF), The World Flora Online (WFO), and the KEW World Checklist of Selected Plant Families (WCSP). Flower parts were preserved in ethanol. All materials are deposited in the SNP Herbarium following the standard protocol to ensure that the specimens are stored in a controlled environment, where they can be accessed and re-examined as needed.

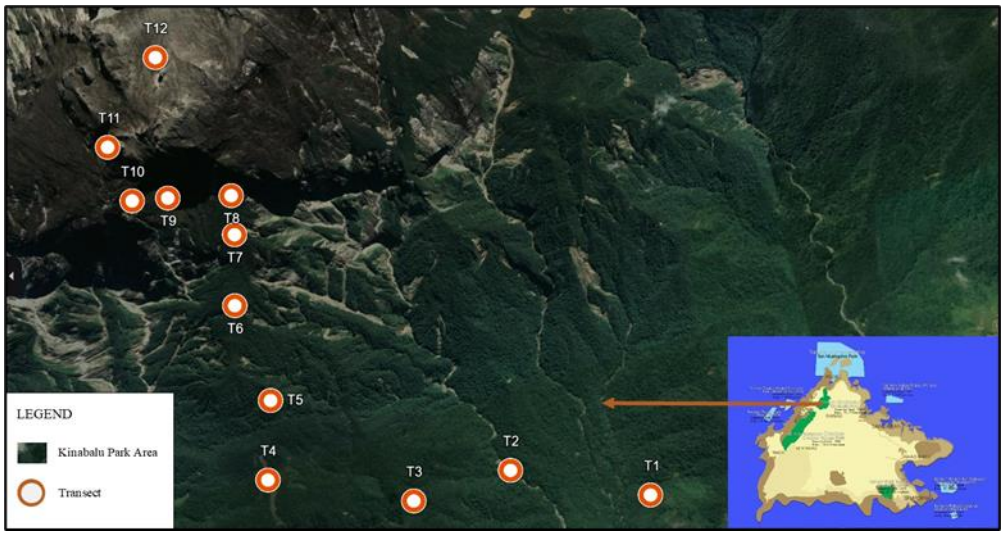

Figure 1. Location of the Transect (T1 to T12) from Kiau Nuluh-Marai Parai-West Gurkha Hut

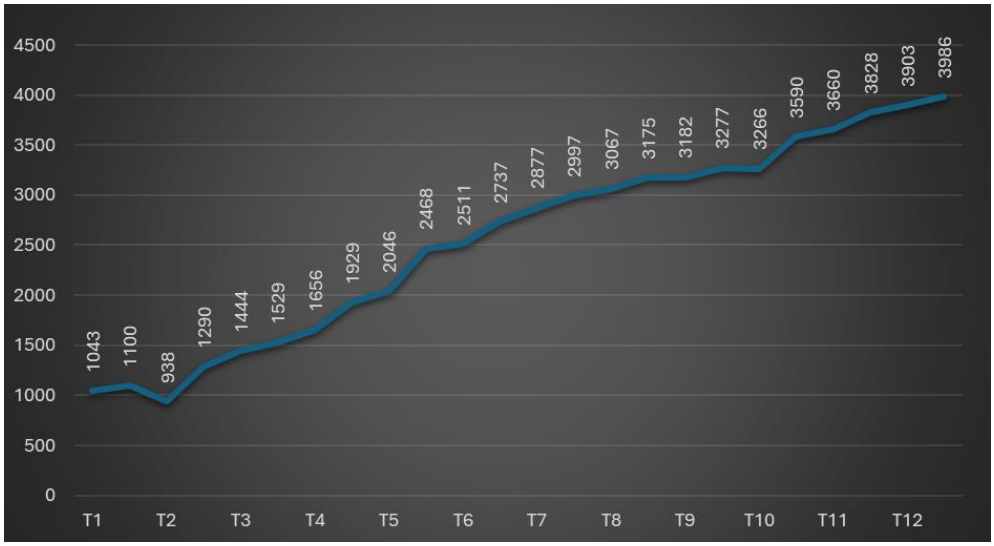

Figure 2. Elevation profile of transect (T1 to T12) locations at Marai Parai to West Gurkha Hut Trail

RESULTS AND DISCUSSION

A total of eight species of *Rhododendrons* have been recorded along the transect. The survey results revealed that Transect 7 had the highest number of *Rhododendrons*, totaling 640 individuals from four species. Transect 8 was followed by 533 individuals from two species, while Transect 10 had 365 individuals from two species, and Transect 12 had 315 individuals from two species. In contrast, Transect 6 had 127 individuals from two species, Transect 5 had nine individuals from two species, Transect 4 had three individuals from one species, and Transect 2 had only one individual from one species. Notably, Transects 1, 3, and 11 had no rhododendrons. The total count across all transects was 2,356 *Rhododendron* individuals (see Figure 3).

A comparison of the number of species richness and abundance of rhododendrons in the twelve study sites is depicted in Table 1. These findings provide valuable insights into the distribution and population of rhododendrons in the study area, expanding knowledge of 15 species in the Marai Parai region, with eight species specifically identified along the Marai Parai to West Gurkha Hut Trail transect (see Appendix).

The geographical distribution of rhododendrons along the Marai Parai to West Gurkha Hut trail was documented based on a study of rhododendrons in various vegetation types by Argent et al., 2007. Through comprehensive field observations, the study unveiled that rhododendrons thrive in six distinct types

of vegetation. These encompass lowland hill forests, lower montane forests, upper montane forests, subalpine forests, upper subalpine forests, and alpine scrub and dwarfs in alpine rock deserts. This research underscores the importance of understanding the ecological requirements of rhododendrons and possible indicators for climate change and it may have significant implications for the management and conservation of natural habitats.

Distribution of Rhododendrons in Varied Vegetation Types Marai Parai to West Gurkha Hut Trail

From Marai Parai to West Gurkha Hut, the diverse altitude range, localized climates, and various soils such as those from the granite dome, ultramafic outcrops, and sedimentary formations - collectively contribute to the region's unique environmental characteristics. The combination of altitude, temperature, rainy seasons, wind, and cloud saturation, together with the topography of the mountain, in combination with the underlying soils, has produced a great diversity of local microclimatic and site variation (Argent et al., 2007). This results in different vegetation (forest) types, supporting different plant communities within each category (Kitayama 1991). This is the main reason for a greater diversity of shrub and herb species, including rhododendrons, in the montane forest, compared to the lowland and hill forests (Argent et al., 2007).

1. Lowland Hill Forest (900 – 1,100 m)

In the lowlands, the mean air temperature is 27°C, with minimum temperatures typically ranging from 20 to 24°C. Kitayama (1991) demonstrated a decrease of 0.55°C in annual mean temperatures per 100 m increase in altitude on Mt. Kinabalu. Kitayama (1991) reported that between the years 1975 and 1983, the lower montane forest at 1,680 m above sea level (a.s.l) exhibited a mean maximum temperature of 22.2°C and a mean minimum temperature of 14.4°C. The temperature decline with elevation is linked to a notable increase in epiphytic vegetation, including orchids and ferns, above 300 m, particularly in the hill regions at 600-800 m above sea level (a.s.l) (Argent et al., 2007). The flourishing of epiphytic rhododendrons is especially in the humid streamside forests, where they start to populate the forest canopy (Argent et al., 2007). In a research expedition carried out at 938 meters above sea level (a.s.l) near the Tahubang River, one species of *Rhododendron* was identified (*R. crassifolium*), which grows as an epiphyte in the forest canopy in Transect 2. No rhododendrons found in Transect 1. Transect 1 is positioned in a secondary forest.

2. Lower Montane Forest (1,444 – 1,529 m)

The lower montane forest in this region features a dominant presence of three plant species, *Calamus gibbsiae* (Arecaceae) and *Drosera ultramafica* (Droseraceae) in Transect 3 and *Tetraria pilisepala* (Cyperaceae) in Transect 4. These species have successfully acclimated to the challenging environmental conditions of the site (van der Ent et al., 2014). The Transect 4 is characterized by a graminoid community, consisting of grasses and sedges, and is surrounded by marshy areas. *Rhododendron retivenium* is the sole species of *Rhododendron* identified in Transect 4.

3. Upper Montane Forest (1,929 – 2,737 m)

The upper montane forest where the study of Transect 5 and Transect 6 is carried out contains soil derived from erosion of the igneous granite. Featuring a canopy height of up to 20 meters, the upper montane forests are distinguished by a dense herb layer and an abundance of mosses adorning tree trunks, branches, and roots across numerous areas. Within this region, two species of rhododendrons exist, namely *Rhododendron crassifolium* and *R. nervolusum.*

4. Lower Subalpine Forest (2,877 – 3,266 m)

The closed-canopy forest, typically characterized by coniferous dominance, features a canopy height ranging from 6 to 15 meters, along with sparse undergrowth and moss cover, commonly thriving in sheltered gullies (Argent et al., 2007). The soils are derived from erosion of the igneous granite dome of Mt. Kinabalu. Three transects, namely Transect 7, Transect 8, and Transect 9, were surveyed in this specific area. A total of five species of rhododendrons were recorded: *Rhododendron acuminatum*, *R. ericoides*, *R. lowii*, *R. rugosum*, and *R. buxifolium*.

5. Upper subalpine forest (3,590 – 3,600 m)

Within this forest, the uppermost layer of vegetation varies in height, occasionally reaching an impressive 6-10 meters. The canopy is intertwined with open granite rock slopes and boulder rock vegetation, resulting in a distinct and captivating environment. A thorough survey along Transects 10 revealed the presence of only two species of rhododendrons, *Rhododendron buxifolium* and *R. ericoides*.

6. Alpine Scrub and Dwarf Scrub in Alpine Rock Desert

The vegetation forms are found as mosaics where soil has accumulated and are just 2-3 m tall. They are dominated by ericaceous scrub

containing *Rhododendron buxifolium*, *Vaccinium stapfianum* and some dwarfed *Leptospermum recurvum* (Argent et al., 2007). Characterized by frequent ground frost, high winds, and prolonged dry spells, these sites hinder plant development, leading to the growth of extremely stunted vegetation. Water runoff from the rock formations flows into the scrub areas (Argent et al., 2007), fostering the growth of mosses that support orchids, small alpine herbs, and certain *Rhododendron* species, notably the dwarfed *Rhododendron ericoides*. Two transects, designated as Transect 11 and Transect 12, were surveyed in the specified area. Transect 11, situated in a rocky barren area, yielded no records of *Rhododendron*. Conversely, Transect 12 documented the presence of two *Rhododendron* species: *R. buxifolium* and *R. ericoides.*

Possible Indicators of the Impact of Climate Change

Rhododendron species have been suggested as possible indicators of climate change because they are sensitive to environmental conditions and are found across various regions (Cao et al., 2011). These flowering plants respond strongly to changes in temperature, precipitation, and other climatic factors, making the *Rhododendron* valuable indicators of the impacts of climate change on ecosystems (Parmesan, 2006).

Research indicates that *Rhododendron* species are moving towards the Earth's poles due to rising temperatures, much like many other plant species (Parmesan, 2006). For instance, a study on the distribution of *Rhododendron ponticum* in the western United States revealed that its range has expanded northward by up to 150 km over the past century, likely in response to warming temperatures (Waring & Running, 2007). Apart from shifting ranges, *Rhododendron* species are also sensitive to changes in temperature and precipitation patterns, which can impact their growth, flowering, and fruiting (Cao et al., 2011). For example, a study on the growth and flowering of *Rhododendron* in the Himalayas found that warmer temperatures and altered precipitation patterns are affecting the plant's ability to flower and set seed, potentially impacting its population growth and distribution (Bhattacharyya et al., 2014).

The sensitivity of *Rhododendron* species to climate change makes these plants useful indicators of the impacts of climate change on ecosystems in the Kinabalu Park area. By monitoring the distribution, growth, and flowering of *Rhododendron* species, researchers can gain insights into the effects of climate change on plant populations and ecosystems and develop strategies for mitigating these impacts.

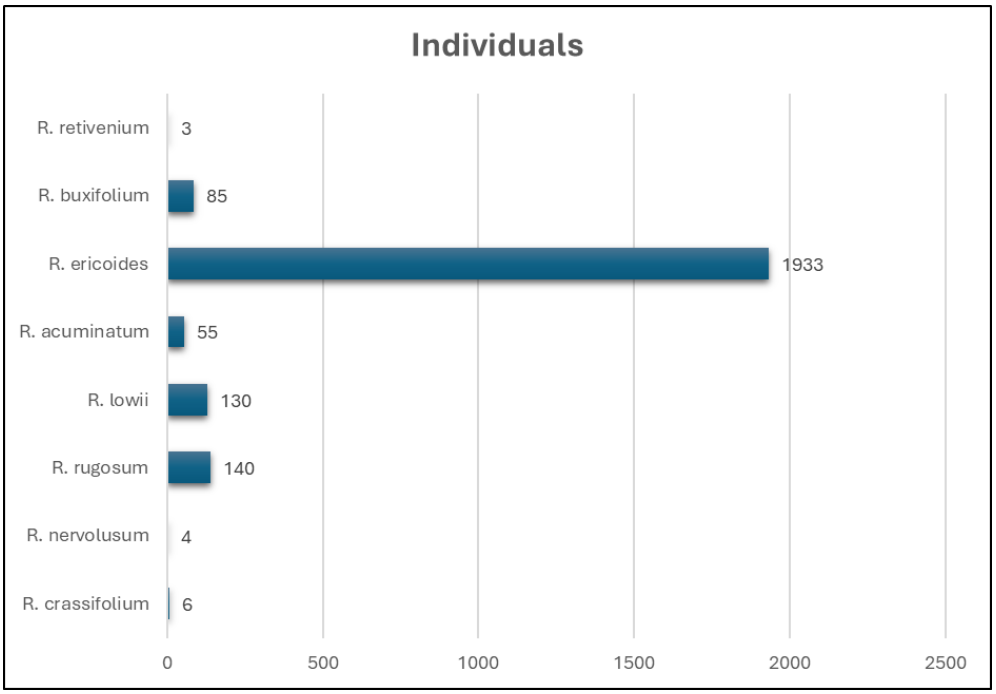

Figure 3. Species individual counts of *Rhododendron* along the Marai Parai to West Gurkha Hut Trail

Table 1. Comparison of the number of species and abundance of rhododendrons in the twelve study sites from lowland hill forest to alpine scrub and dwarf in the alpine rock desert

Transect Number	Total number of species	Total number of individuals	Elevation (m)	Habitat
T1	0	0	1,043-1,100	Lowland hill forest
T2	1. *R. crassifolium*	1	938-1,290	Lowland hill forest to Lower montane forest
T3	0	0	1,444-1,529	Lower montane forest
T4	1. *R. retivenium*	3	1,656-1,929	Lower montane forest to upper montane forest
T5	1. *R. crassifolium* 2. *R. nervolusum*	5 4	2,046-2,468	Upper montane forest
T6	1. *R. rugosum* 2. *R. lowii*	10 117	2,511-2,737	Upper montane forest
T7	1. *R. acuminatum* 2. *R. rugosum* 3. *R. ericoides*	55 130 450	2,877-2,997	Subalpine forest

	4. *R. lowii*	5		
T8	1. *R. ericoides* 2. *R. lowii*	525 8	3,067-3,175	Subalpine forest
T9	1. *R. ericoides* 2. *R. buxifolium*	328 35	3,182-3,277	Subalpine forest
T10	1. *R. ericoides* 2. *R. buxifolium*	325 40	3,266-3,590	Upper subalpine forest
T11	0	0	3,660-3,828	Upper subalpine forest – Alpine scrub and dwarf in alpine rock desert
T12	1. *R. ericoides* 2. *R. buxifolium*	305 10	3,903-3,986	Alpine scrub and dwarf in alpine rock desert
	TOTAL	**2,356**		

LIMITATION

The impact of climate change on montane ecosystems is a pressing concern, and the *Rhododendron* populations on Mount Kinabalu are indeed vulnerable to these changes. The Intergovernmental Panel on Climate Change (IPCC) has highlighted the potential consequences of climate change on biodiversity, including changes in species distribution, abundance, and extinction risk (IPCC, 2019).

Research on the impact of climate change on *Rhododendron* species on Mount Kinabalu is limited. However, studies on other mountain ecosystems have indicated that increasing temperatures and altering precipitation patterns can result in changes in species composition, phenology, and distribution (Körner, 2003; Walther et al., 2002). For instance, a study on the alpine flora of the European Alps revealed that rising temperatures and precipitation changes have caused shifts in the distribution and abundance of alpine plant species (Grabherr et al., 1994).

To address the limitations of existing research, further studies are needed to investigate the effects of climate change on *Rhododendron* species on Mount Kinabalu. This could involve monitoring changes in species composition, abundance, and distribution over time and conducting experiments to examine the effects of different climate scenarios on *Rhododendron* growth and survival. Additionally, developing strategies for conserving and managing *Rhododendron* populations on Mount Kinabalu will require a better understanding of the potential impacts of climate change on these ecosystems.

CONCLUSION

The study conducted on the Marai Parai to West Gurkha Hut Trail route has concluded that the trail has a significant presence of rhododendrons. The existence of these flowers along the trail route enhances its overall attraction and would be a significant factor in attracting tourists to the area. *Rhododendron buxifolium* seems to thrive due to its adaptability, while *R. retivenium's* scarcity raises conservation concerns or points to specific habitat preferences. *R. ericoides*, on the other hand, appears to dominate the population due to its higher individual count. These observations can provide valuable insights into the ecology and distribution of these species in the region. It's crucial to consider conservation efforts for species like *R. retivenium* to ensure their survival and understand the factors contributing to the success of species like *R. buxifolium* and *R. ericoides* as discussed by Beaman J.H. 2001 on the conservation status and efforts related to the flora of Mount Kinabalu.

ACKNOWLEDGEMENT

We thank Sabah Parks for their unwavering support in our *Rhododendron* research along the Marai Parai Trail to West Gurkha Hut. Special thanks to the Director, Deputy Director, Assistant Director of Kinabalu Park, Coordinator of the Research and Education Division, Coordinator of the Botanical Unit, and all members of the committee involved for their invaluable support. We also appreciate the assistance of the mountain guides and porters from Kg. Kiau Nuluh, Kota Belud, and duly acknowledge the access license from Sabah Biodiversity Council Ref. JKM/MBS.1000-2/4/1 (326-328).

FUNDING

This research was fully funded by The Board of Trustees of The Sabah Parks.

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APPENDIX

The Checklist of Rhododendrons occurring in the Marai Parai area to West Gurkha Hut, Mount Kinabalu

MPA = Marai Parai Area, MPWGH = Marai Parai to West Gurkha Hut Trail

No	Species	Location
1	*Rhododendron acuminatum*	MPWGH
2	*Rhododendron javanicum*	MPA
3	*Rhododendron buxifolium*	MPWGH
4	*Rhododendron crassifolium*	MPWGH
5	*Rhododendron cuneifolium*	MPA
6	*Rhododendron ericoides*	MPWGH
7	*Rhododendron exuberans*	MPA
9	*Rhododendron lowii*	MPWGH
10	*Rhododendron nervulosum*	MPWGH
11	*Rhododendron retivenium*	MPWGH
12	*Rhododendron rugosum*	MPWGH
13	*Rhododendron stenophyllum*	MPA
14	*Rhododendron suaveolens*	MPA
15	*Rhododendron maxwellii*	MPA