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DISTRIBUTION OF *ANOECTOCHILUS ROXBURGHII* (WALL.) LINDL IN BACH MA NATIONAL PARK OF CENTRAL VIETNAM

NHI THI HOANG HO[*], AN THIEN TRAN[1], NGOC THI NHU LE[1], HAN NGOC HO AND HAI THI HONG TRUONG[*]

Institute of Biotechnology, Hue University, Hue City, Vietnam

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Abstract

Anoectochilus roxburghii is an endangered medicinal plant with high economic value in Vietnam, but its population is decreasing due to overexploitation and unfavourable conditions. The base line distribution survey of *A. roxburghii* in Bach Ma National Park (BMNP) was carried out for the first time in this study. Survey lines were established through interviews to develop field surveys and collect ecological characteristics. Results showed that the interview method was effective for generating potential lines. In the 9 survey lines out of 20, *A. roxburghii* was found to be represented by 123 individuals in the core of BMNP. Standard plots 05 and 27 were found to have the greatest ecological differences. This species was observed mainly distributed on mountain sides of evergreen and semi-deciduous natural broadleaf wood forests, where the altitude was 300 - 400 m, high humidity and large canopy. Besides, they were groups of 4-15 individuals and could produce flowers and fruits in some standard plots.

Introduction

Anoectochilus roxburghii (Wall.) Lindl is an important medicinal plant belonging to the family Orchidaceae. It grows primarily in the subtropical biome and is native to Assam (India), Bangladesh, China South-Central, China Southeast, East Himalaya, Hainan, India, Laos, Myanmar, Nepal, Thailand, Tibet, Vietnam, West Himalaya (Plants of the World Online 2025). This species contain several bioactive compounds such as polysaccharides, alkaloids, steroidal compounds, organic acids, terpenoids, flavonoids, volatile oils, and glycosides (Yuan *et al*. 2024). They play potential roles in the pharmacological activities such as anti-inflammatory, antidiabetic, antilipemic, antiviral, hepatoprotective, renal protective, immunomodulatory, abirritant, sedative, and anticancer (Ye *et al*. 2017, Śliwiński *et al*. 2022). Recently, it has been classified as a vulnerable or near-threatened species in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Wang *et al*. 2022). This is because of increasing demand, limited growing conditions, severe habitat destruction, slow growth rate, low seed germination rate, and overexploitation (Li *et al*. 2018, Zheng *et al*. 2024).

In Vietnam, *Anoectochilus* has brought a wide economic value for local people with the price of up to 100 USD/1 kg fresh mass (Trinh *et al*. 2020). However, it is listed as an endangered species in group IA according to Decree 84/2021/ND-CP dated September 22nd, 2021 of the Vietnam Government because of deforestation and long-term exploitation. This plant has been conserved in national parks and nature reserves by *in situ* and *ex situ* methods. Although there are many funding resources for *Anoectochilus* conservation, it may be difficult to deploy due to its distribution in difficult terrain or less accessible areas (Do *et al*. 2024).

*Author for correspondence: <hothihoangnhi@hueuni.edu.vn>, <tthhai@hueuni.edu.vn>. [1]Bach Ma National Park, Phu Loc, Hue City, Vietnam.

Bach Ma National Park (BMNP) in Central Vietnam is one of the top-priority biodiversity conservation regions. This is a place with natural conditions that are very suitable for the growth of *A. roxburghii* (Nguyen *et al.* 2020). Several publications showed the presence of *A. roxburghii* in BMNP (Tran and Ziegler 2001, Do *et al.* 2024). Nevertheless, there is currently no published information on the distribution of this species. Therefore, this study was taken to assess the distribution, location and ecological characteristics of *A. roxburghii* in BMNP intending to evaluate reserves and create a scientific basis for well protection, conservation and enhancing natural breeding.

Materials and Methods

The study was carried out in the Bach Ma National Park (BMNP) in Central Vietnam. The information was collected by the interview method, using a prepared content collection form, which included personal information, reasons for knowing this plant, location, time and morphology when encountered, number of plants, living characteristics, surrounding plants, diseases and uses of *Anoectochilus roxburghii*. There were 10 forest rangers and 10 local citizens living in buffer regions of Nam Dong Province and Phu Loc Province were participated in this survey. Collected information was then used to indicate potential areas for this plant's presence and construct a survey route map.

In the field, species distribution along the predetermined line has been surveyed. The coordinates of starting/ending points of each line were determined. In addition, the average travel speed was 1.5 - 2 km/h and *A. roxburghii* was detected by observing at least 5 m on each side of the road. At the locations where the plant were seen, coordinates and elevation were collected using a Garmin GPS device and a standard plot of 5 m × 5 m was established. Data was recorded to map the species distribution, including altitude, humidity, canopy level, forest state, presence location, species composition growing together, number of individuals encountered, number of regenerated individuals and growing ability (good, medium or poor).

All coordinates were transferred from VN2000 format into UTM Zone 48 North using landlooking.com (accessed December 2nd, 2024). Then, a survey line map and a distribution map were developed based on QGIS software, a BMNP map and satellite images (www.googlemap.com). The correlation between ecological traits and the dispersion of standard spots on the coordinate axes was estimated using PAST v4.06.

Results and Discussion

Interviews to collect information from locals and forest rangers were useful in developing potential survey lines. Based on the knowledge from 10 local people and 10 rangers, some preliminary characteristics of *A. roxburghii* have been summarized. This species was identified with the help of photos, books, literature and scientific reports. The locations encountered were on the edge of the forest, in natural forests, along streams and on the slopes of hills in Huong Loc, Huong Phu, Thuong Lo, Thuong Nhat Communes of Nam Dong District; Loc Tri, Loc Hoa Communes, Phu Loc Town of Phu Loc district. In terms of ecology, this is a shade-demanding plant that grows around herbaceous plants, small wood trees, climbing plants and moss. In addition, *A. roxburghii* is often susceptible to soft rot and is eaten by snails. The roles uses of this plant are found to be decorative and medicinal which is similar to the previous publications reports (Ho *et al*. 2020, Pham and Tangmany 2024).

A survey line map with 20 lines was created based on interview contents to provide a vital basis for the field route. These lines were 2.0 - 5.0 km long, except for the Bach Ma Road line with 16 km, and were distributed throughout BMNP and its buffer zone. The field assessment results communicated that only 9 out of 20 surveyed lines had *A. roxburghii* presence with a total

length of 30.3 km. These lines include line 2 (Do Quyen Trail), line 4 (Tri Sao Trail), line 7 (Thac Phuon), line 9 (Thuong Lo), line 11 (Mo Rang), line 12 (Giang Ong Nhom), line 17 (Ong Gia Road), line 18 (Thac Mo) and line 19 (Thac Truot). Individuals of this species are mainly concentrated in the core of BMNP (Table 1, Fig. 1A). This is because these are strictly protected regions and are difficult for local people to access.

Table 1. Information of 20 lines in the survey line map.

Sl.No.	Survey line name	Location	Coordinates		Line length (km)
			Starting point	Ending point	
1	Bach Ma Road	Loc Tri, Phu Loc, Thua Thien Hue	16°14'56.7"N 107°52'18.3"E	16°11'44.4"N 107°51'17.1"E	16.0
2	Do Quyen Trail	Loc Tri, Phu Loc, Thua Thien Hue	16°11'44.5"N 107°50'53.8"E	16°11'06.2"N 107°50'58.7"E	2.5
3	Khe Mon	Huong Loc, Nam Dong, Thua Thien Hue	16°09'54.4"N 107°45'15.1"E	16°09'54.3"N 107°45'36.3"E	3.1
4	Tri Sao Trail	Loc Thuy, Phu Loc, Thua Thien Hue	16°13'28.3"N 107°56'01.0"E	16°13'49.5"N 107°51'17.6"E	2.0
5	Da Dung, Da Lien	Loc Tri, Phu Loc, Thua Thien Hue	16°12'33.5"N 107°52'42.4"E	16°13'28.8"N 107°53'02.6"E	2.5
6	Natural Trail (Bach Ma mountain top)	Loc Tri, Phu Loc, Thua Thien Hue	16°11'46.4"N 107°51'20.9"E	16°11'38.7"N 107°51'50.1"E	2.6
7	Thac Phuon	Huong Phu, Nam Dong, Thua Thien Hue	16°11'42.0"N 107°43'53.1"E	16°11'09.1"N 107°45'31.0"E	3.6
8	Khe Ao	Huong Loc, Nam Dong, Thua Thien Hue	16°08'18.3"N 107°47'34.8"E	16°09'18.9"N 107°47'10.8"E	3.3
9	Thuong Lo	Thuong Lo, Nam Dong, Thua Thien Hue	16°06'01.0"N 107°44'41.3"E	16°04'44.8"N 107°45'32.8"E	4.7
10	Nhi Ho, Khe Don	Loc Tri, Phu Loc, Thua Thien Hue	16°14'20.2"N 107°53'44.7"E	16°13'28.7"N 107°53'02.6"E	5.0
11	Mo Rang	Huong Loc, Nam Dong, Thua Thien Hue	16°08'31.5"N 107°49'45.8"E	16°07'53.7"N 107°51'31.8"E	3.6
12	Giang Ong Nhom	Loc Tri, Phu Loc, Thua Thien Hue	16°11'42.2"N 107°50'49.1"E	16°11'25.8"N 107°50'10.9"E	2.1
13	Me Em	Loc Hoa, Phu Loc, Thua Thien Hue	16°15'13.4"N 107°46'23.7"E	16°14'10.9"N 107°44'58.0"E	3.5
14	Ma Rai	Thuong Nhat, Nam Dong, Thua Thien Hue	16°05'21.2"N 107°41'12.6"E	16°03'24.6"N 107°42'22.8"E	5.5
15	Cha Mang	Thuong Nhat, Nam Dong, Thua Thien Hue	16°05'32.3"N 107°42'20.1"E	16°04'21.2"N 107°43'32.6"E	4.2
16	Khe Gu	Thuong Lo, Nam Dong, Thua Thien Hue	16°05'08.5"N 107°44'48.0"E	16°04'40.7"N 107°45'16.9"E	2.0
17	Ong Gia Road	Huong Loc, Nam Dong, Thua Thien Hue	16°08'11.2"N 107°46'36.1"E	16°07'04.9"N 107°47'33.6"E	4.0
18	Thac Mo	Huong Phu, Nam Dong, Thua Thien Hue	16°12'36.9"N 107°43'27.5"E	16°13'17.6"N 107°44'20.1"E	3.0
19	Thac Truot	Huong Phu, Nam Dong, Thua Thien Hue	16°12'07.4"N 107°43'55.4"E	16°11'07.5"N 107°45'26.0"E	4.8
20	Vung Thung	Loc Dien, Phu Loc, Thua Thien Hue	16°13'57.3"N 107°48'47.1"E	16°12'15.0"N 107°50'19.0"E	4.8

Anoectochilus roxburghii distribution is uneven on the survey lines. Lines 7 and 11 are where this species was found most at four locations, while there is one position in lines 2, 4, 12, 17 and 19. The individual frequency of each line was also unequal, the highest was on the Mo Rang line (8.3 individuals/km) and the lowest on the Do Quyen Trail line (1.6 individuals/km). Over a total of 30.3 km of surveyed travel, there were 123 accessions with an average frequency of 4.16 individuals/km (Table 2). This proves that *A. roxburghii* was scarce in Hue City due to war and the conversion of natural forest to plantations for economic development (Pham *et al*. 2022; Cochard et al. 2023). Additionally, *A. roxburghii* grows relatively densely, from 4 to 15 individuals in a small area (Fig. 1C). Most of them were regenerated plants and have flowering and fruiting phenomena at the assessment time. The accessions' growth ability was good to medium, and there were no record of pest and disease invasion (Table 2, Figs 1B and 1C). This may be a vigorous growth stage of *A. roxburghii*. However, it differs from the publication of Li *et al*. (2019) due to differences in geographical location and species origin.

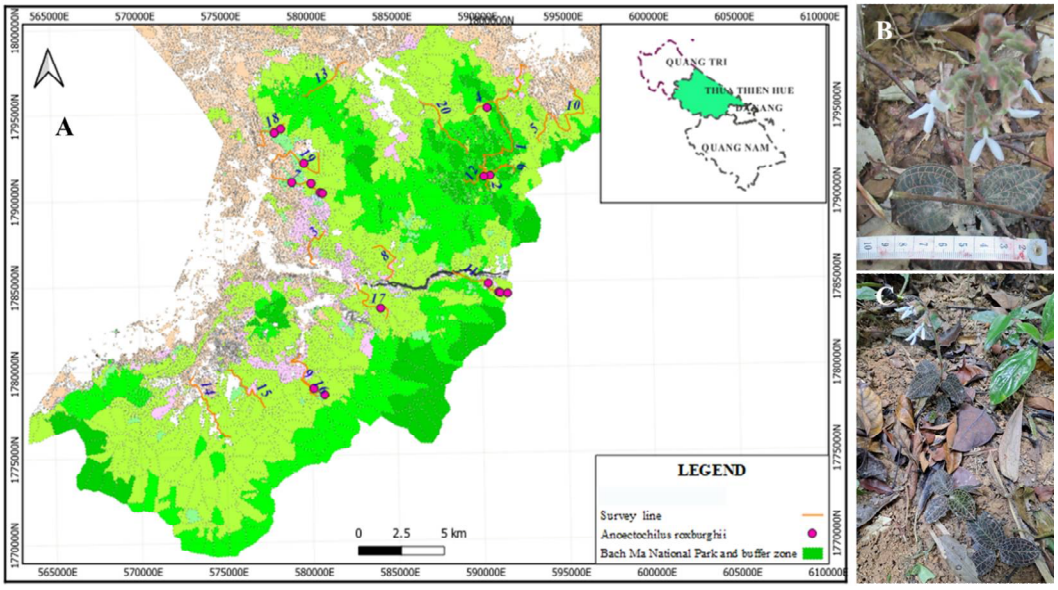

Fig. 1. Map showing distribution and survey lines of *Anoectochilus roxburghii* in BMNP. A: buffer zone and B and C: survey areas. The numbers on the map represent the order of lines.

Anoectochilus roxburghii prefers to grow in humus-rich soils (Refish *et al.* 2015, Li *et al.* 2019) and is a shade-demanding tree that grows densely in areas with high canopy levels and humidity, similar to the study of Trinh *et al.* (2020). In this study, *A. roxburghii* grows close to the ground, clinging to the surface, in places with rich humus, and can grow in humus-rich moist soil holes along streams and trails in the forest. They were mainly found on mountain sides (52.9%), followed by the slope tops (35.2%). Their distribution altitude is from 250 m to 1150 m and most of them are concentrated at 300-400m. Regarding forest state, *A. ruxburghii* is present in poor or medium secondary forests that have been impacted (IIIA1 and IIIA2). The characteristics of this forest are a canopy level from 0.7 to 0.9, a discontinuous canopy layer, wood trees with a height under 25 m and 0.2 - 0.4 m of sparse evergreen shrubs.

Table 2. Distribution and ecology of *Anoectochilus roxburghii* in different survey lines.

Sl. No.	Line name	Standard plot name	Coordinates	Altitude above sea level (m)	Humidity (%)	Presence location	Forest state	Canopy level	Growing ability	No. individuals	No. regenerated individuals	Individuals frequency (No. individuals/ km)	No. individuals with flowers and fruits
1	Line 2	05	16°11'36.2"N 107°50'56.5"E	1150	85	Stream bank	IIIA1	0.77	Good	4	4	1.6	0
2	Line 4	07	16°13'45.4"N 107°50'53.2"E	400	60	Mountainside	IIIA2	0.8	Good	5	5	2.5	0
3	Line 7	12	16°11'29.4"N 107°44'26.1"E	335	80	Mountainside	IIIA1	0.8	Medium - good	5	3	5.8	2
4		13	16°11'26.7"N 107°45'04.1"E	332	70	Mountainside	IIIA1	0.7		3	3		0
5		14	16°11'09.4"N 107°45'21.5"E	331	75	Mountainside	IIIA1	0.8		9	5		4
6		15	16°11'08.1"N 107°45'26.4"E	332	75	Mountainside	IIIA2	0.83		4	4		0
7	Line 9	18	16°04'58.1"N 107°45'02.4"E	250	79	Slope top	IIIA2	0.7	Good	5	4	2.6	1
8		19	16°04'45.9"N 107°45'23.2"E	340	72	Slope top	IIIA2	0.7		7	5		2
9	Line 11	23	16°08'12.4"N 107°50'49.0"E	334	70	Slope top	IIIA2	0.7	Medium - good	3	3	8.3	0
10		24	16°07'55.4"N 107°51'09.0"E	373	75	Mountainside	IIIA1	0.8		8	8		0
11		25	16°07'54.2"N 107°51'12.3"E	385	75	Mountainside	IIIA2	0.8		15	12		3
12		26	16°07'53.1"N 107°51'26.4"E	367	75	Mountainside	IIIA2	0.88		4	4		0
13	Line 12	27	16°11'34.5"N 107°50'44.2"E	1167	82	Mountainside	IIIA2	0.88	Medium - good	13	13	6.2	0
14	Line 17	36	16°07'27.9"N 107°47'16.4"E	457	65	Slope top	IIIA2	0.8	Good	7	5	1.8	0
15	Line 18	37	16°13'04.1"N 107°43'53.6"E	250	67	Mountain foot	IIIA1	0.7	Medium - good	11	11	5.7	0
16		38	16°13'03.9"N 107°44'50.9"E	259	67	Mountainside	IIIA2	0.8		6	6		0
17	Line 19	39	16°12'06.5"N 107°44'50.6"E	300	70	Mountainside	IIIA1	0.8	Good	14	9	2.9	5
Mean				250-1167	73.06			0.78		7.24	6.12	4.16	1

IIIA1 is an evergreen and semi-deciduous natural broadleaf wood forest, a poor secondary forest type that has been impacted. IIIA2 is an evergreen and semi-deciduous natural broadleaf wood forest, a medium secondary forest type that is impacted but has recovered well.

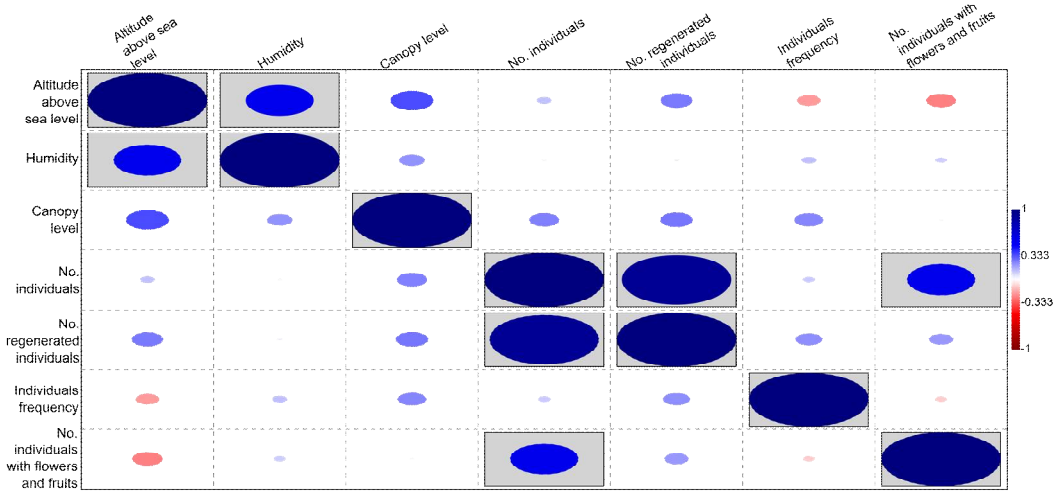

Fig. 2. Correlations between seven quantitative ecological traits. Blue circles represent forward correlations, red circles are reverse correlations, and rectangles indicate significant correlations ($p<0.05$).

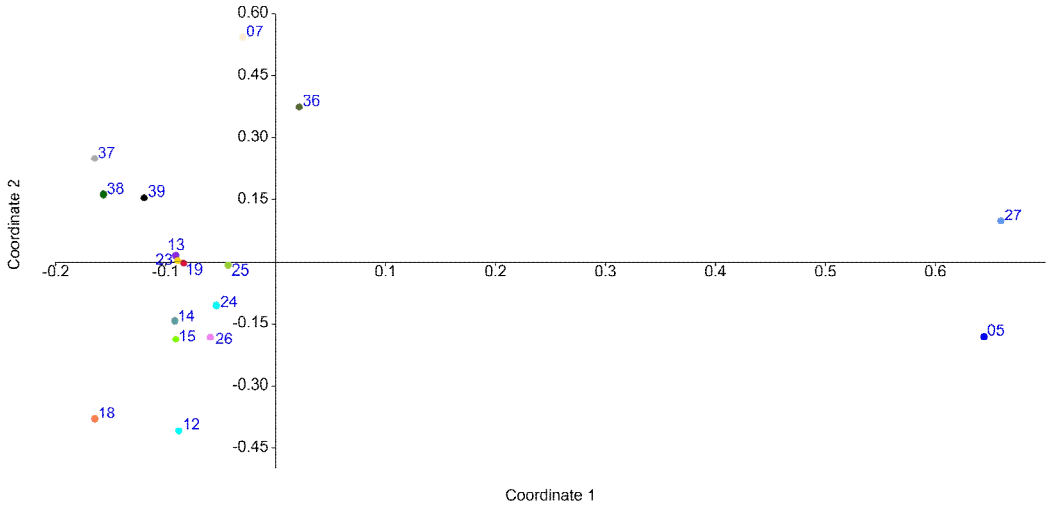

Fig. 3. Dispersion of standard spots on two principal coordinates.

Furthermore, *A. roxburghii* is distributed in a diverse ecosystem. Species living around this plant include wood trees, shrubs, vines and low vegetation. They could be separated based on two forest types: tropical evergreen rainforest in the lowland belt below 900 m and tropical evergreen monsoon forest in the lowland belt above 900 m (upto 1712 m). Among the standard plots established, plot 2 and 12 are located at an altitude above 900 m. Therefore, to conserve and develop this species, some solutions are proposed as follows: (1) increase the conservation of natural forest areas, (2) develop breeding processes and build models for planting *A. roxburghii* under natural forest canopies, and (3) minimize the impact of local people on *A. roxburghii* and natural forests through advocacy and improve their livelihoods under the critical governance of the village (Iwanaga *et al.* 2019).

Significant correlation between ecological traits occur between humidity and altitude, between the number of individuals and the number of regenerating individuals or the number of individuals having flowers/fruits. Most ecological traits have the positive correlation. Meanwhile, the altitude of standard plots is negatively correlated with individual frequency and the number of individuals bearing flowers and fruits (Fig. 2). Besides, standard plots where *A. ruxburghii* presented have a large dispersion on two main coordinates. In particular, standard plots 5 and 27 possess the largest dispersion, which show their ecological difference (Fig. 3). This is due to large altitude and humidity differences. Specifically, these two plots have the highest humidity (82% and 85%) and an altitude of over 1100 m while the remaining ones are below 500 m (Table 2).

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