ACADEMIA JOURNAL OF BIOLOGY 2021, 43(4): 1–24
DOI: 10.15625/2615-9023/16509

DISTRIBUTION CHARACTERISTICS OF ENDEMIC AND RARE PLANTS ALONG THE ALTITUDINAL GRADIENT IN BAT XAT NATURE RESERVE IN VIETNAM

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Received 1 September 2021, accepted 15 December 2021

ABSTRACT

This study aimed to assess the relationship between distribution, altitude and investigation lines of vascular plants in Bat Xat Nature Reserve, Lao Cai province. Based on the collected specimens added 273 species of vascular plants belonging to 48 genera, 18 families, bringing the total number the currently known species are 1245 species of vascular plants belonging to 649 genera, 174 families and under 6 divisions such as. Of these, and there are 211 endemic and rare species consists have been recorded and 22 rare species 17 endemic species and updated scientific name 14 species added checklist to the Nature Reserve. Topographic, vegetation and distribution maps, changes in diversity and a checklist of endemic and rare species are shown.

Keywords: Distribution, endemism, rare plants, altitudinal gradient, Bat Xat Nature Reserve, Vietnam.

Citation: Bui Hong Quang, Tran Duc Binh, Do Van Hai, Le Ngoc Han, Duong Thi Hoan, Nguyen Thi Thanh Huong, Vu Anh Thuong, Trinh Ngoc Hiep, 2021. Distribution characteristics of endemic and rare plants along the altitudinal gradient in Bat Xat nature reserve in Vietnam. *Academia Journal of Biology*, 43(4): 1–24. https://doi.org/10.15625/2615-9023/16509

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INTRODUCTION

The Bat Xat Nature Reserve (BXNR) lies in Bat Xat district of Lao Cai province in North-West of Vietnam. This Nature Reserve was established in 2016 by the Decision No.1954/QD-UBND of the President of Lao Cai province (DARD, 2016), with an aim to conserve the primary forest ecological systems, especially related to the rare flora and fauna in the Hoang Lien Son range. Besides, this Nature Reserve and buffer zone have a role in supplying cattle food resources, medicinal plant drugs, groundwater enrichment by providing clean water to raise Salmon and Sturgeon fishes, sheltering wild animals, tourism, culturing plants and animals (eg. Cardamom, Bees etc.), and climate change mitigation.

According to the previous literature and our recent research results, a total of 211 endemic and rare species consist of 93 endemic, 125 rare in which there are 7 species including both endemic and rare status, in habit the BXNR. (Orme et al., 2005; Morrone, 2008; IUCN 2019; MOST & VAST, 2007; GOV, 2019). The Nature Reserve is spread in an area of more than 18,000 ha, with altitude ranging from 1,000 to 3,000 m. a.s.l., with some mountain peaks like Ky Quan San (Bach Moc Luong Tu) (3046 m, fourth highest mountain in Vietnam), Nhiu Co San (2965 m) and Lao Than (2860 m) (Figs. 1, 2). The BXNR is included in the North of Hoang Lien Son range, thus exhibiting significantly similarities with Hoang Lien National Park, famous for its rich flora and fauna (Nguyen & Harder, 1996; Nguyen & Nguyen, 1998; Mac et al., 2019; Bui et al., 2020), and both of conservation areas were in Yunnan-Sikang plant area, belonging to Holarctic plant territory (Takhtajan, 1986; Averyanov et al., 2003a, b; Fu et al., 2019). This Nature Reserve is in the North of Vietnam, where in South-East and end of China-Himalaya range and one of the important parts of India – Myanmar area, the richest of biodiversity (Critical Ecosystem Partnership Fund, 2020). With the plant species diversity and subtropical climate, several publications on new species such as *Disanthus ovatifolius* Aver., P.K.Endress, B.H.Quang & K.S.Nguyen (Averyanov et al., 2017), *Primula gracilituba* C.M.Hu & Nuraliev (Nuraliev et al., 2020b) and *Shortia rotata* Gaddy & Nuraliev (Gaddy & Nuraliev, 2017) and the new record (Nguyen et al., 2017; Nguyen et al., 2018; Tran et al., 2018; Lee et al., 2019; Lu et al., 2020; Averyanov et al., 2020a,b; Nuraliev et al., 2020a, b; Bui et al., 2019, 2020, 2021) came out. This supports the view that the BXNR is a suitable place to research fragile flora and their conservation.

The BXNR is located between 22°23'–22°37'N; 103°31'–103°43'E, and lies in the administrative area of 5 communes: Y Ty, Den Sang, Sang Mao Sao, Trung Leng Ho and Nam Pung covering 15,285.05 ha of forest area, and 3,352 ha vacant land area (DARD, 2016). Hitherto, there has been only one documentation available on the biological resources of the nature reserve which primarily recorded 940 species of vascular plants belonging to 550 genera, 156 families, under 6 plant divisions (DARD, 2016). Further, Nguyen (2018) supplemented this with 32 more species to this area. These researches focused mainly on the plant community analysis but unspecified their distribution in the area.

In the present work, we have documented the occurrence of another 273 species based on our field records, and statistics related to the altitudinal gradient of the endemic and rare plant species occurring in the area which will provide the baseline for sustainable use of the national resources, and their conservation.

MATERIALS AND METHODS

Area of study

The topography of BXNR is relatively complicated, created by many high mountains, strongly sporadic, large steep terrain (20−250 m on average), descending to South-East. The area experiences a subtropical and humid temperate subregion climate. The summer sustains from May to October and the winter from November to

April. The average temperature is 15.4 ^{o}C, the average rainfall is 2,819 mm (max is 3,838 mm) and irregular in the months (DARD, 2016; Nguyen, 2018).

Sampling

During the field trips conducted during 2018–2020 (7−10 days per trip) in BXNR, and collected 500 voucher specimens (in duplicate), we investigated from all following the vegetation in 5 altitudinal gradients such as (i) those under 1,500 m, (ii) from 1,500−1,800 m, (iii) 1,800−2,100 m, (iv) 2,100−2,400 m, and (v) more than 2,400 m. On these altitudes, we established the lines according to the forest current status map to investigate all the different ecological systems such as slopes, peaks, people's trails, main streams (UNESCO, 1973, Averyanov et al., 2003a,b). We collected specimens and statistical records of all the vascular plant species in the lines. For each species, we collected 3−6 specimens, took photographs, and noted the coordinates, habitat information, and other necessary data to identify the species.

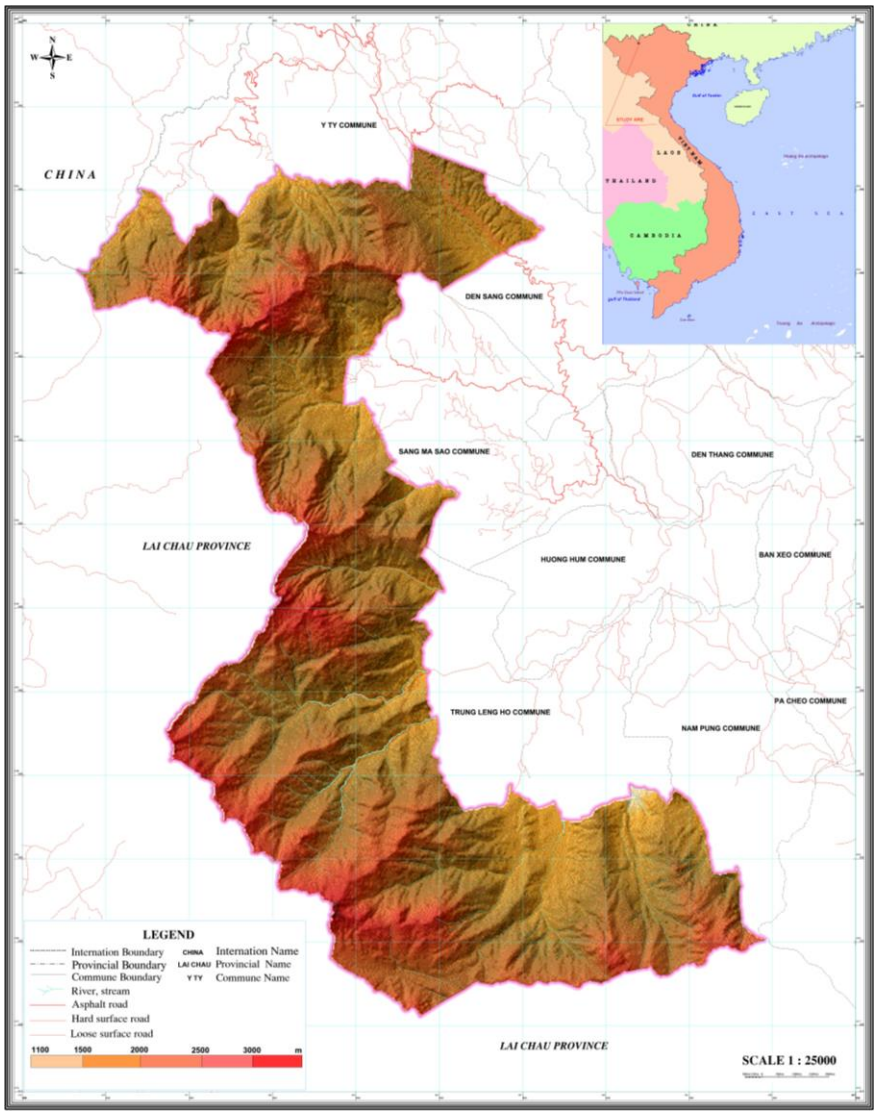

Figure 1. Topographic map of Bat Xat NR

Processing plant samples

Specimens were treated as following the standard protocol (Maden, 2004, Nguyen, 2007) and deposited in the Ha Noi herbaria, Institute of Ecology and Biological Resources (IEBR). The species were identified consulting relevant literature and specimens housed in various herbaria such as P, K, VNM. These specimens were identified using the monographs flora Vietnam. Multiple accessions were consulted for every species and the occurrence and phenological data was recorded. The accepted scientific names were cross checked with online databases such as (APG IV, 2016; IPNI, 2021; POWO, 2021). In the appendix, family names are listed in alphabetical order and each is presented with the following details (MOST & VAST, 2007; IUCN, 2019; GOV, 2019). Threatened status is defined according to the International Union for Conservation of Nature (IUCN, 2019; MOST & VAST, 2007; GOV, 2019). The abbreviations for the categories are as follows: Group IA, Group IIA: and Endemism (E) is defined according to (Ho, 1999, 2000, 2003; Ban et al., 2003, 2005; CRES, 2001; Orme et al., 2005; Morrone, 2008).

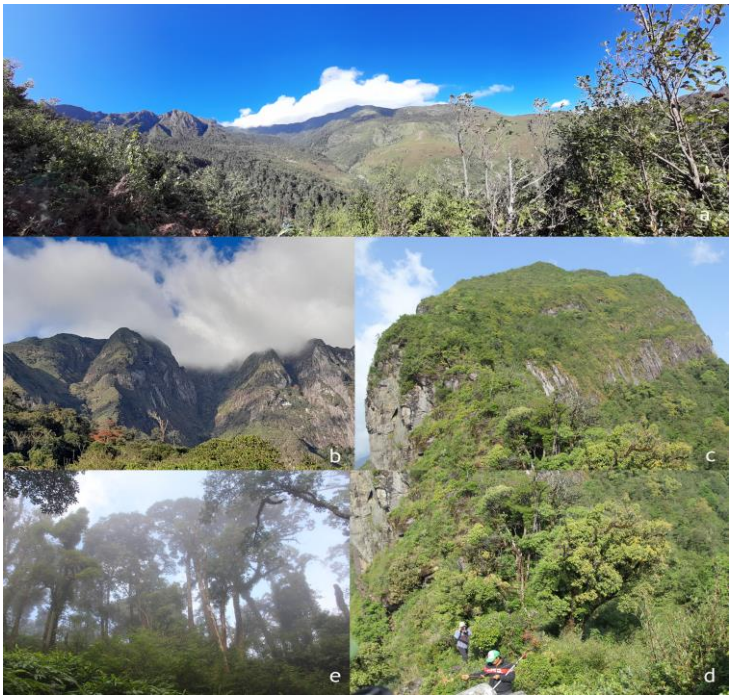

Figure 2. Some representatives of forest vegetation in Bat Xat NR
a, b) Forest vegetation Ky Quan San peak (3,046 m. a.s.l.) in Sang Mao Sao commune;
c) Forest vegetation Cu Nhu San peak (2662 m. a.s.l.); d) Route to Cu Nhu San peak;
e) Forest vegetation at foot of Cu Nhu San peak in Y Ty commune
[*Photos:* Bui Hong Quang & Tran Duc Binh]

RESULTS AND DISCUSSION

The diversity of the flora

Based on published literature and our collection, the flora of the BXNR comprises 1245 vascular plant taxa belonging to 649 genera, 174 families under 6 divisions such as Psilotophyta (1 family, 1 genus, 1 species); Lycopodiophyta (2 families, 5 genera, 11 species); Equisetophyta (1 family, 1 genus, 1 species); Polypodiophyta (22 families, 67 genera, 98 species); Pinophyta (3 families, 6 genera, 6 species); and Magnoliophyta (145 families, 569 genera, 1,128 species) (Table 1).

Table 1. Taxa distribution in divisions in Bat Xat NR

Division	Family		Genus		Species	
	Number	%	Number	%	Number	%
1. Psilotophyta	1	0.57	1	0.15	1	0.08
2. Lycopodiophyta	2	1.15	5	0.77	11	0.89
3. Equisetophyta	1	0.57	1	0.15	1	0.08
4. Polypodiophyta	22	12.64	67	10.36	98	7.90
5. Pinophyta	3	1.72	6	0.93	6	0.48
6. Magnoliophyta	145	83.33	569	87.64	1128	90.56
Total	174	100.00	649	100.00	1245	100.00

Magnoliophyta was found to be the most dominant division comprising 90.56% of the total species found in BXNR. It was followed by Polypodiophyta with 7.9% species (Fig. 3).

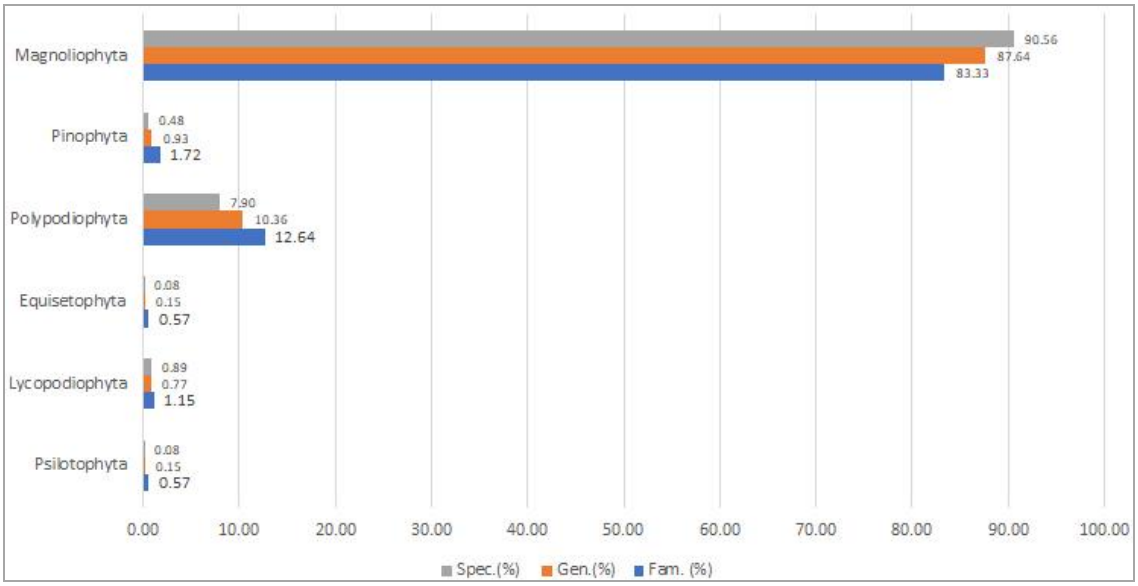

Figure 3. The percentage ratio of taxa in each division in Bat Xat NR

Lycopodiophyta and Equisetophyta are represented by 1 family, 1 genus, and 1 species per division. The present research supplements 273 species to the previous checklist (DARD 2016; Nguyen; 2018). The specimens of the newly recorded species are housed at Ha Noi Herbarium, IEBR, VAST. Table 2 and Figure 4 indicates a significant addition to the floristic record of the Bat Xat NR indicates a significant addition to the floristic record of the BXNR. increased significantly during 2018−2020. The number of families increased to 18 (18 families 10.34%), previous total families such a Elaeagnaceae, Woodsiaceae, Balanophoraceae, Bretschneideraceae, Diapensiaceae,… the number of genera increased to 48 genera (7.11%) previous total genera such a *Shortia, Enkianthus, Erythroxylum, Hylodesmum, Geranium,…* and the number of species increased to 273 species (21.61%) previous total species such as *Shortia rotata* Gaddy & Nuraliev, *Erythroxylum calyptratum* Komada & Tagane, *Geranium homeanum* Turcz., *Disanthus ovatifolius* Aver., P.K.Endress, B.H.Quang & K.S.Nguyen.

Table 2. Supplemented taxa for Bat Xat NR flora

No.		Family	%	Genus	%	Species	%
1	Previous list	156	89.66	601	92.89	972	78.39
2	Supplemented taxa	18	10.34	48	7.11	273	21.61
	Total	174	100.00	649	100.00	1245	100.00

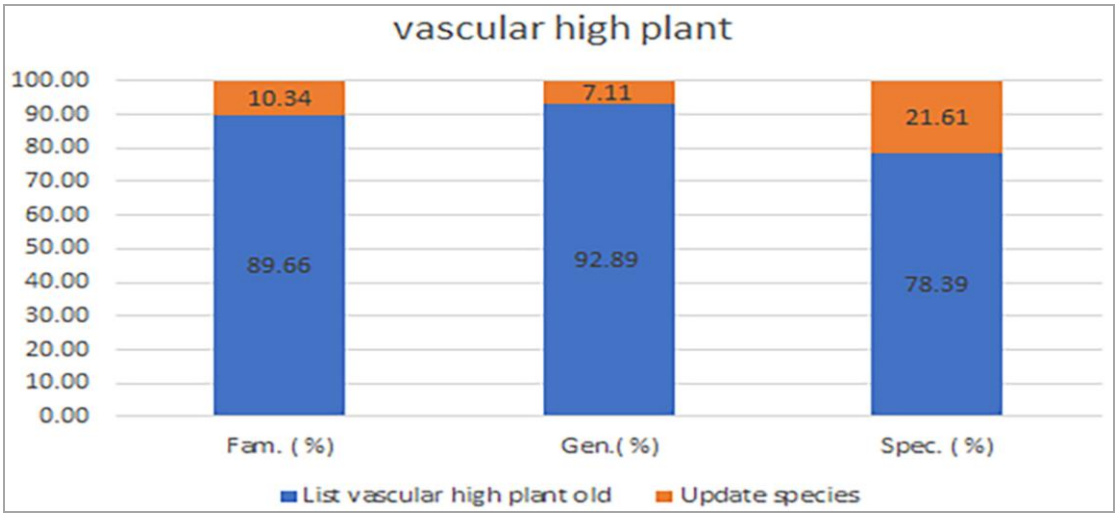

Figure 4. The percentage ratio of supplemented taxa compared to the previous list in Bat Xat NR

Plant distribution in specific regions

According to Table 3 and Figure 5 the number of plant taxa in Bat Xat NR was unequal. Under 1,500 m. a.s.l., vegetation was found to be affected by the anthropogenic pressure 3 vascular plant divisions (50.00%), 53 families (30.46%), 86 genera (13.29%) and 102 species (8.23%) were found. In 1,500–1,800 m. a.s.l., less human interference was observed. The abundance and diversity were more. Species belonging to 4 vascular plant divisions (66.67%), 121 families (69.54%), 315 genera (48.53%) and 436 species (35.08 %) were found (Fig. 6).

Table 3. The number of plant taxa belonging to different elevation range in Bat Xat NR

No.	Elevation	Division		Family		Genus		Species	
		Number	%	Number	%	Number	%	Number	%
1	< 1,500 m	3	50.00	53	30.46	86	13.29	102	8.23
2	1,500–1,800 m	4	66.67	121	69.54	315	48.53	436	35.08
3	1,800–2,100 m	5	83.33	134	77.01	354	54.71	535	42.90
4	2,100–2,400 m	3	50.00	37	21.26	79	12.21	117	9.44
5	> 2,400 m	5	83.33	28	16.09	45	6.80	55	4.35
Total		6	100	174	100	649	100	1245	100

Vegetation in different elevation gradient

Under 1,500 m. a.s.l., vegetation comprises the secondary ecological system. Logging, firewood, cultivation has significantly changed the forest vegetation. Many areas of primary forest have become a secondary forests. The characteristics of this vegetation are regenerated species that fastly grow such a *Macaranga denticulata*,

Mallotus apelta, *Trema orientalis*, *Endospermum chinensis*, *Ampelocalamus patellaris*, *Schizostachyum aciculare*. Vines, wooden vines had been well developed such as *Bauhinia* sp. (Fabaceae), Apocynaceae, Convolvulaceae. Besides, there are subtropical species in Aceraceae, Illiciaceae, Ericaceae, Theaceae, and Fagaceae. In 1,500–1,800 m. a.s.l., vegetation is different, comprising mainly of the secondary forest after farming, less agriculture cropland or almost none. There are some Cardamom (*Amomum aromaticum)* plantation forests. The component of plant species is also diverse. Especially, there were many Gymnosperm species such as *Fokienia hodginsii*, *Podocarpus neriifolius*, *Nageia fleuryi*, *Dacrycarpus imbricatus*, *Cunninghamia konishii*, and *Cephalotaxus manii*. Besides, there were also big trees such as species of *Castanopsis*, *Lithocarpus* (Fagaceae); *Cinamomum*, *Litsea* (Lauraceae); *Maglietia* (Magnoliaceae).

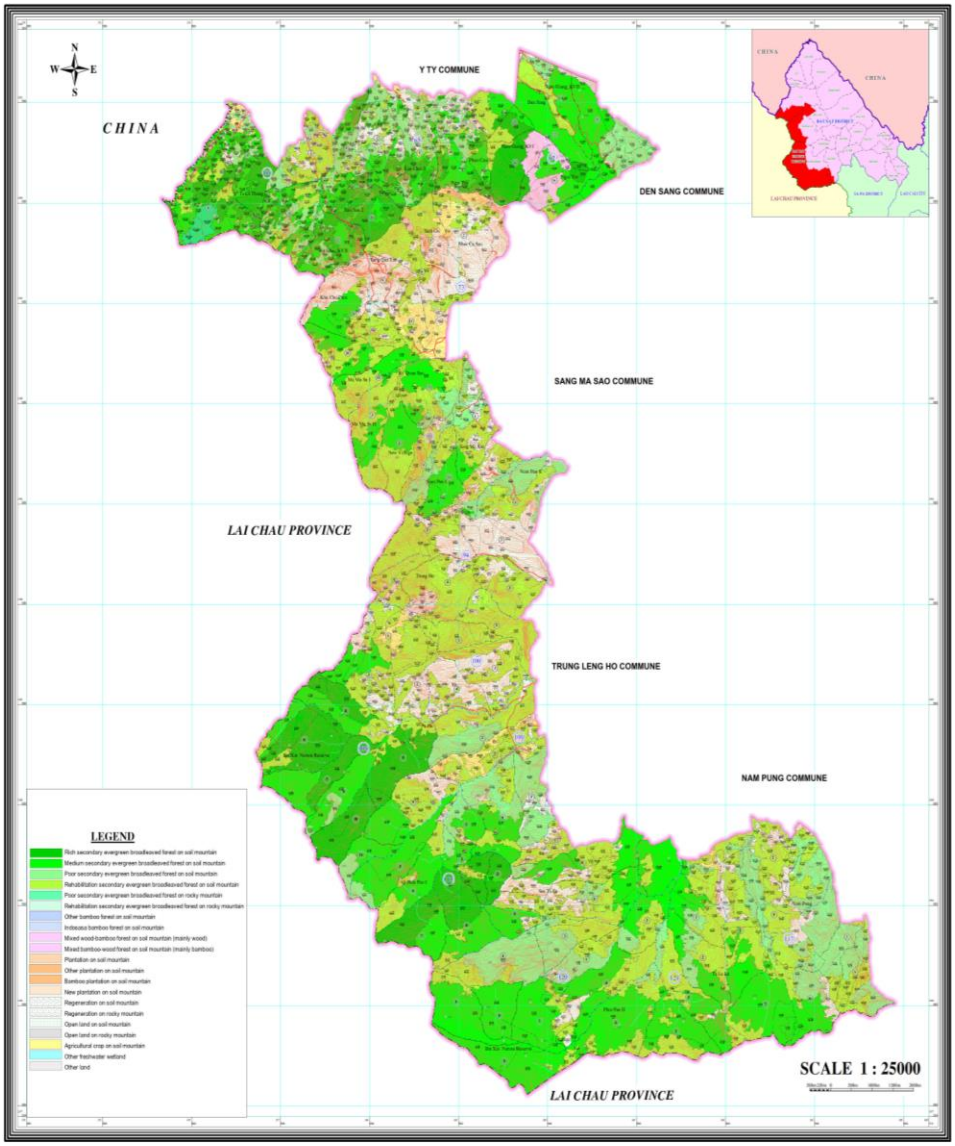

Figure 5. Vegetation map of Bat Xat NR

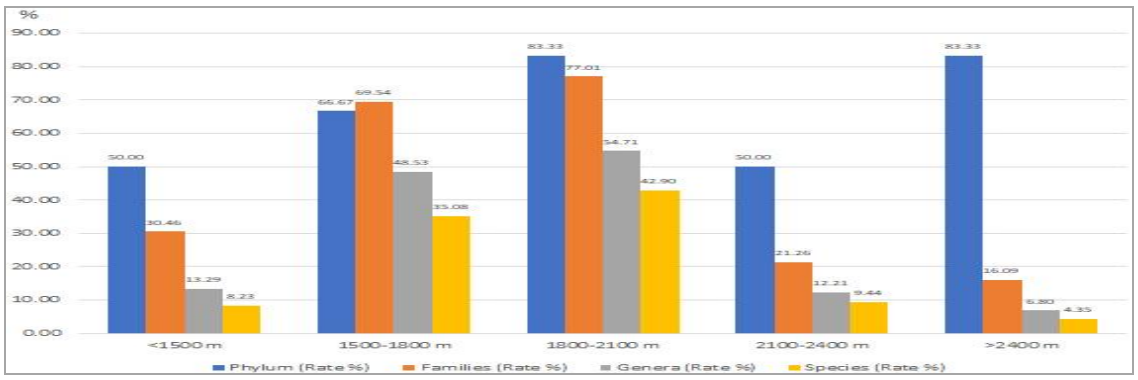

Figure 6. Distribution of taxon in elevation gradient in Bat Xat NR

In 1,800–2,100 m. a.s.l., vegetation is most diverse. There are big trees in Fagaceae, Pinaceae; small trees in Moraceae, Meliaceae, Ebenaceae, Clusiaceae, Myrtaceae, Fabaceae, Lauraceae, and Arecaceae. The small trees and shrubs comprise Rubiaceae, Euphorbiaceae, Melastomataceae, and Acanthaceae. The woody vines like *Bauhinia* (Fabaceae), Annonaceae, Apocynaceae, Asclepiadaceae, and Dioscoreaceae are common. The herbs are mostly from Valeriaceae, Asteraceae, Ranunculaceae, and Orchidaceae. In 2,100−2,400 m. a.s.l., alpine vegetation can be seen. The elements include *Acer* (Aceraceae); *Illicium* (Illiciaceae); *Vacinium, Rhododendron* (Ericaceae); *Rhodoleia* (Hammelidaceae). Besides, there were also shrubs adapted to high altitudes such as *Rubus* (Rosaceae); *Ilex* (Aquifloliaceae); some species of Polypodiophyta are in Selaginellaceae, Dennstaedtiaceae, and Thelypteridaceae. In more than 2,400 m. a.s.l., the vegetation is characterized by dwarf forest, and more of alpine species, mainly small trees in Rubiaceae, Aquifoliaceae, and Fagaceae; shrubs in Rosaceae, Ericaceae, and Melastomataceae; some of Polypodiophyta in Bechnaceae, Polypodiaceae, and Adiantaceae.

Distribution of major plants

According to our investigation, there are 93 Vietnamese endemic species in Bat Xat NR comprising 7.46% of the total species number and 125 species (9.91%) are found as rare species (Table 4, Fig. 7).

Table 4. Distribution of endemic and rare species in different elevation gradients of Bat Xat NR

No.	Elevation gradient	Endemic species	%	Rare species	%
1	< 1,500 m	9	10.75	5	3.25
2	1,500−1,800 m	30	31.18	58	47.15
3	1,800−2,100 m	40	43.01	56	44.72
4	2,100−2,400 m	12	12.90	2	1.63
5	> 2,400 m	2	2.15	4	3.25
Total		93	100	125	100

Under 1,500 m. a.s.l., because of the anthropogenic pressure, a smaller number of rare species can be seen. We recorded 5 rare species (3.25%) such as *Ardisia silvestris* Pitard (Myrsinaceae), *Gnetum montanum* Margf. (Gnetaceae), *Kadsura coccinea* (Lem.) A.C.Sm. (Schisandaceae), and *Bulbophyllum scabratum* Reichb and *Galeola lindleyana* (Hook & Thomson) Reichb (Orchidaceae).

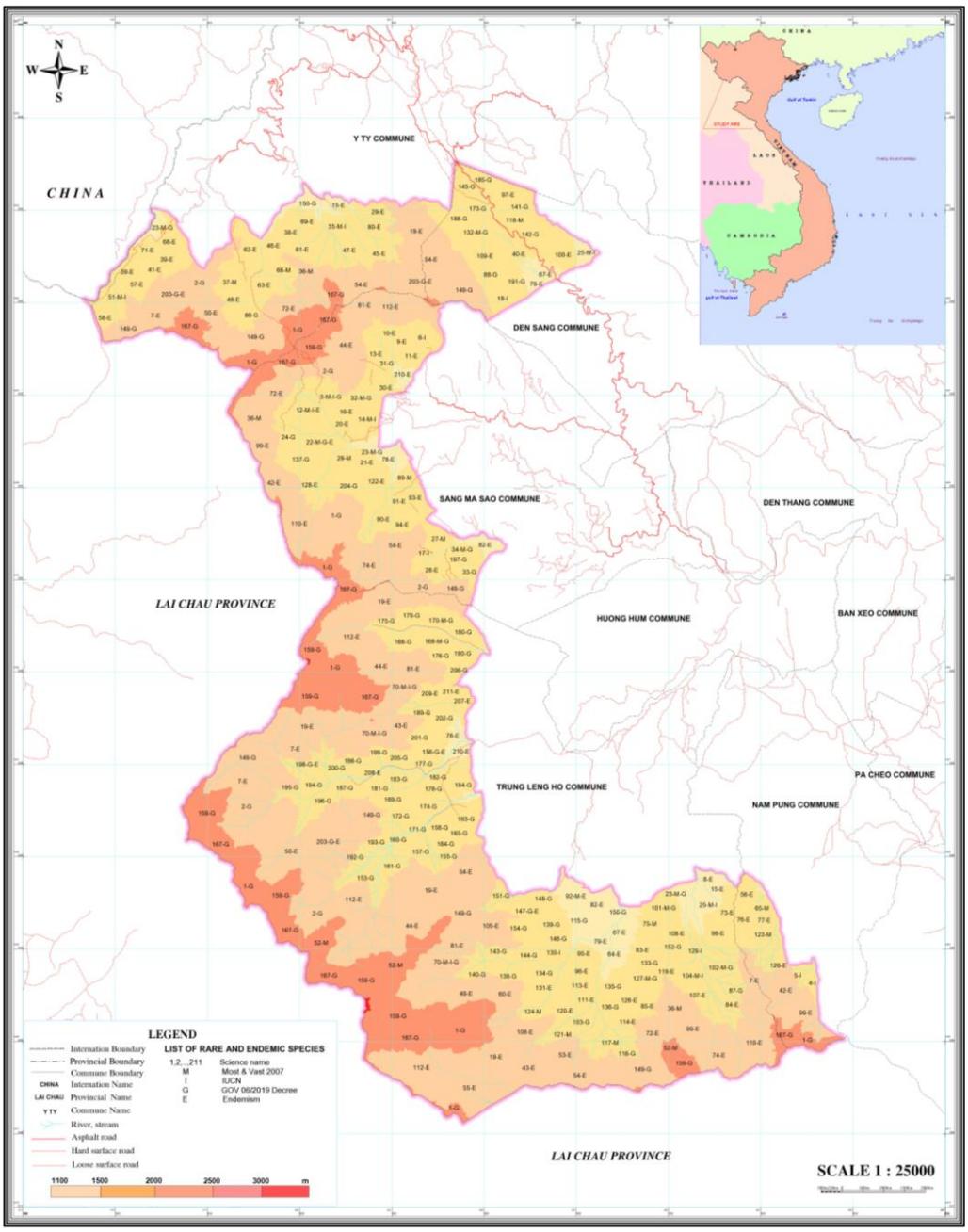

Figure 7. Distribution of endemic and rare plants in Bat Xat NR

Rare plants

In 1,500–1,800 m. a.s.l., the number of rare species is significantly high as of 58 species (47.15%) like *Asarum glabrum* Merr., *Asarum balansae* Franch. (Aristolochiaceae), *Tinospora sagittata* (Oliv.) Gagnep. (Menispermaceae), *Coptis quinquesecta* W.T.Wang., and *Coptis chinensis* Franch. (Ranunculaceae). The rare gymnosperm, *Fokienia hodginsii* (Dunn) A. Henry et H. H. Thomas (Cupressaceae) was encountered at

one location during our survey. In 1,800–2,100 m. a.s.l., the most abundant of rare species were observed as of 56 species (44.72%) like *Rhoiptelea chiliantha* Diels & Hand.-Mazz. (Rhoipteleaceae), *Bretschneidera sinensis* Hemsl. (Bretschneideraceae), *Balanophora laxiflora* Hemsl. (Balanophoraceae), *Lonicera hildebrandiana* Collett & Hemsl. (Caprifoliaceae), *Valeriana hardwickii* Wall., *Valeriana jatamansi* Jones (Valerianaceae), and *Ainsliaea petelotii* Merr. (Asteraceae). In 2,100−2,400 m. a.s.l., the number of rare species was decreased. There were only 2 species (1.63%) viz. *Cibotium barometz* (L.) J. Smith (Dicksoniaceae) and *Codonopsis javanica* (Blume) Hook & Thoms. (Campanulaceae). In more than 2400 m. a.s.l., only 4 rare species (3.25%) were encountered viz. *Lithocarpus cerebrinus* (Hickel et A. Camus) A. Camus (Fagaceae), *Cymbidium floribundum* Lindl., *Dendrobium moniliforme* (L.) Sw. (Orchidaceae), *Cyathea contaminans* (Wall. ex Hook.) (Cyatheaceae) This could be the effect of the topography and high elevation (Figs. 8, 9).

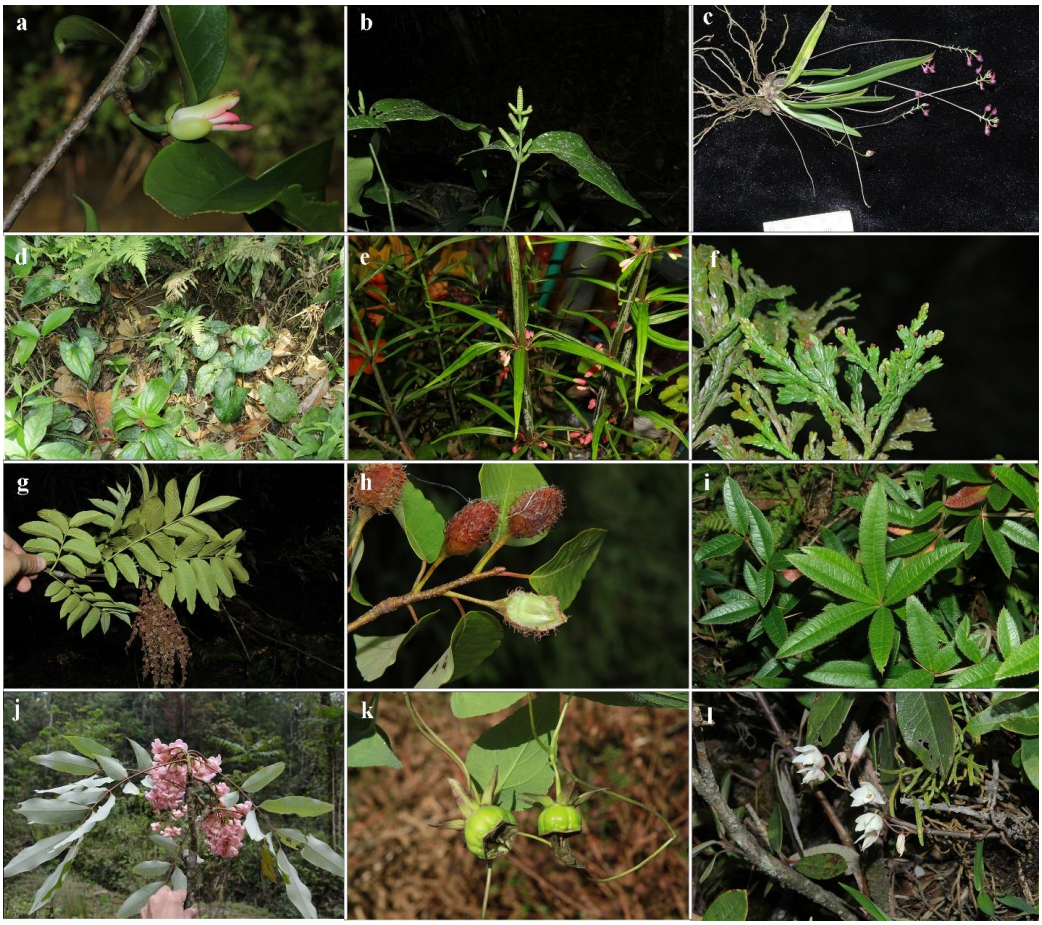

Figure 8. Some rare species in elevation bands in Bat Xat NR
a) *Kadsura coccinea* (Lem.) A.C.Sm.; b) *Gnetum montanum* Margf.; c) *Bulbophyllum scabratum* Reichb; d) *Asarum petelotii* O.C.Schmidt; e) *Polygonatum kingianum* Coll. et Hemsl.; f) *Fokienia hodginsii* (Dunn) A. Henry et H. H. Thomas; g) *Rhoiptelea chiliantha* Diels & Hand.-Mazz.; h) *Fagus longipetiolata* Seemen; i) *Berberis julianae* Schneid.; j) *Bretschneidera sinensis* Hemsl; k) *Codonopsis javanica* (Blume) Hook & Thoms; l) *Dendrobium moniliforme* (L.) Sw [*Photos:* Bui Hong Quang]

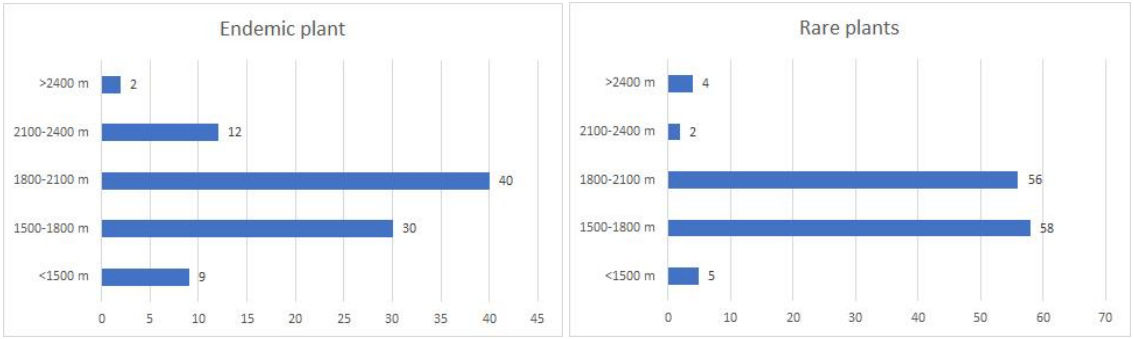

Figure 9. Of rare and endemic species in elevation gradient

Endemic plants

Under 1,500 m. a.s.l., vegetation was found to be affected by the anthropogenic pressure with 10 species (10.75%), mainly shrub and herb species such as Acanthaceae (*Strobilanthes petelotii* Benoist, *Strobilanthes echinata* Nees, *Staurogyne chapaensis* Benoist, *Strobilanthes obesus* Benoist), Theaceae (*Eurya persicifolia* Gagnep.), Lauraceae (*Actinodaphne ellipticibacca* Kosterm.), Violaceae (*Viola tonkinensis* Gagnep.), Zingiberaceae (*Caulokaempferia petelotii* K. Larsen), Melastomataceae (*Blastus multiflorus* (Cogn.) Guillaum., *Sporoxeia sciadophila* W.W. Sm.) were found. In 1,500−1,800 m. a.s.l., less human interference was observed. The abundance of vegetation was high. Species belonging to 30 species (31.18%) such as Apiaceae (*Hydrocotyle petelotii* Tardieu), Cyperaceae (*Eriophorum scabriculme* (Beetle) Raym., *Carex neonelmesii* Raymon), Gesneriaceae (*Didissandra petelotii* Pellegr.), Icacinaceae (*Gomphandra obscurinervia* Merr.), Malpighiaceae (*Aspidopterys glabrifolia* Arènes), Orchidaceae (*Liparis dendrochiloides* Aver., *Peristylus chapaensis* (Gagnep.) Seident. F.), and species of Poaceae, Proteaceae, Rubiaceae,, Rutaceae, Sabiaceae, Sapindaceae. Scrophulariaceae, Theaceae, Tiliaceae, Violaceae, Viscaceae, and Zingiberaceae were found. In 1,800−2,100 m. a.s.l., less human interference was observed. The abundance of vegetation was high. Species belonging to 40 species (43.01%) such as Acanthaceae (*Strobilanthes helicta* T. Anderson, *Strobilanthes patulus* Benoist,…), Aceraceae (*Acer erythranthum* Gagnep., *Acer brevipes* Gagnep., *Acer tonkinense* Lecomte), Berberidaceae (*Podophyllum tonkinense* Gagnep.), Diapensiaceae (*Shortia rotata* Gaddy & Nuraliev), Erythroxylaceae (*Erythroxylum calyptratum* Komada & Tagane), Hamamelidaceae (*Disanthus ovatifolius* Aver., P.K.Endress, B.H.Quang & K.S.Nguyen), *Altingia poilanei* Tardieu), Urticaceae *(Pellionia chapaensis* Gagnep.), and Vitaceae (*Tetrastigma chapaense* Merr.) were found.

In 2,100−2,400 m. a.s.l., less human interference was observed. The abundance and vegetation was more. Species belonging to 12 species (12.9%) such as Loranthaceae (*Taxillus cordifolius* (Wall.) Ban), Araliaceae (*Schefflera hypoleucoides* Harms), Acanthaceae (*Strobilanthes cusia* (Nees) Kuntze), Primulaceae (*Primula gracilituba* C.M. Hu & Nuraliev), Ericaceae (*Vaccinium chapaensis* Merr.), Fagaceae (*Lithocarpus baviensis* (Drake) A. Camus), Hamamelidaceae (*Altingia takhtajanii* T.V. Trung & L.V. Loc), and Ericaceae (*Lyonia chapaensis* (Dop) Merr.) were found. In upper 2,400 m. a.s.l., less human interference was observed. The abundance of vegetation was high. Species belonging to 2 species (2.1%), *Sporoxeia petelotii* C.Hansen (Melastomataceae), *Melanoseris leiolepis* (C. Shih) N. Kilian & J.W. Zhang (Asteraceae) were found (Figs. 9, 10).

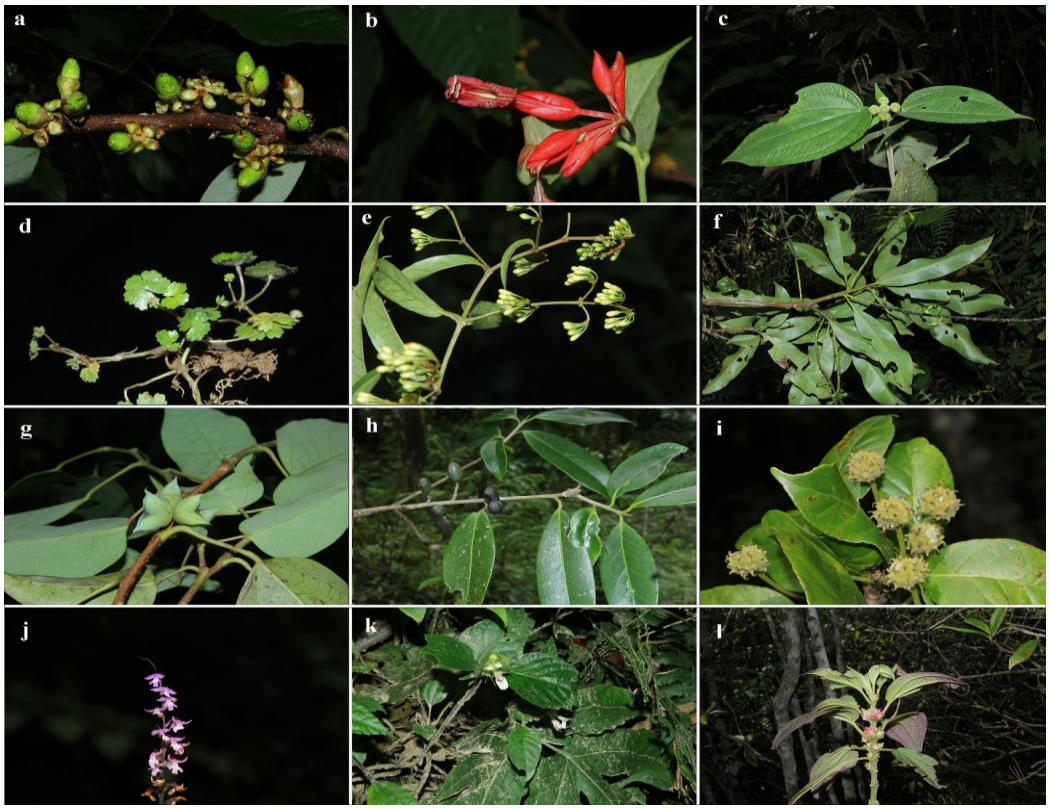

Figure 10. Endemic species in elevation gradient in Bat Xat Nature Reserve
a) *Actinodaphne ellipticibacca* Kosterm.; b) *Aeschynanthus pedunculatus* D.J.Middleton; c) *Phyllagathis longicalcarata* C.Hansen; d) *Hydrocotyle petelotii* Tardieu; e) *Aspidopterys glabrifolia* Arènes; f) *Helicia cauliflora* Merr; g) *Disanthus ovatifolius* Aver., P.K.Endress, B.H.Quang & K.S.Nguyen; h) *Symplocos olivacea* Merr.; i) *Altingia poilanei* Tardieu; j) *Tsaiorchis keiskeoides* (Gagnep.) X.H.Jin, Schuit. & W.T.Jin; k) *Rungia eberhardtii* (Benoist) B.Hansen ; l) *Sporoxeia petelotii* C.Hansen. [*Photos:* Bui Hong Quang]

CONCLUSION

The flora of Bat Xat NR was surveyed six times during 2018−2020. The present work supplements 273 species of vascular plants belonging to 48 genera, 18 families to the earlier checklist, 211 endemic and rare species consist of 93 endemic, 125 rare plant species have been recorded in which there are 7 species including both endemic and rare and updated scientific name 14 species in the check list. Topographic, vegetation and distribution maps, changes in diversity, distribution and check list of endemic and rare species are shown here in this research.

The rare and endemic species were found to be concentrated in 1,500−2,100 m. a.s.l. elevation range. In this elevation, the anthropogenic pressure was less.

The present research documents the diversity and distribution of the rare, endemic and threatened vascular plants of Bat Xat NR in different altitudinal gradient. The study analyzed the suitability of the habitats of vascular plants in multiple altitudinal ranges such as <1500 m. a.s.l., 1,500–1,800 m. a.s.l., 1,800−2,100 m. a.s.l., 2,100−2,400 m. a.s.l. and > 2,400 m. a.s.l. Significant difference was observed in the diversity and distribution of the threatened plants under these ranges. In each band, there were difference of component, number of species and eco-morphological characteristics because of

environmental factors, light intensities, temperature and humidity.

Acknowledgements: This research is supported by the Vietnam Academy of Science and Technology (VAST) (project No. VAST 04.03/20–21). The authors thank the anonymous reviewer for his constructive critical comments that helped improve the manuscript and we are also grateful to Dr. Ritesh Kumar Choudhary from Agharkar Research Institute, India for improving the English text.

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Check list of rare and endemism species in Bat Xat NR

No.	Family	Science name	MOST & VAST 2007	IUCN, 2019	GOV 06/2019	Altitude	Endemism
1	Cyatheaceae	*Cyathea contaminans* Wall. ex Hook.*			IIA	2592	
2	Dicksoniaceae	*Cibotium barometz* (L.) J. Smith*			IIA	2150	
3	Cupressaceae	*Fokienia hodginsii* (Dunn) A. Henry et H. H. Thomas	EN A1a,c,d	VU A2acd; B2ab(ii,iii,iv,v)	IIA	1795	
4	Gnetaceae	*Gnetum montanum* Margf.		LC		1416	
5	Pinaceae	*Tsuga dumosa* (D.Don) Eichler.		LC		1506	
6	Podocarpaceae	*Dacrycarpus elatum* (Roxb.) Wall.		LC		1853	
7	Acanthaceae	*Rungia eberhardtii* (Benoist) B.Hansen**				2146	E
8	Acanthaceae	*Strobilanthes obesus* Benoist**				1420	E
9	Aceraceae	*Acer brevipes* Gagnep.				1904	E
10	Aceraceae	*Acer chapaense* Gagnep.				2132	E
11	Aceraceae	*Acer erythranthum* Gagnep.				1855	E
12	Annonaceae	*Cyathostemma vietnamense* Ban	EN A1a,b,c	LC		1807	E
13	Annonaceae	*Fissistigma petelotii* Merr.**, (***)				2025	E
14	Annonaceae	*Enicosanthellum petelotii* (Merr.) Ban	EN B1+2b,c	LC		1934	
15	Apiaceae	*Hydrocotyle chevalieri* (Chern.) Tardieu**				1362	E
16	Apiaceae	*Hydrocotyle petelotii* Tardieu**				1754	E
17	Apocynaceae	*Wrightia laevis* Hook.f.*		LC		1859	
18	Araliaceae	*Aralia chinensis* L.		VU A2c		1904	
19	Araliaceae	*Schefflera alpina* Grushv. et N. Skvorts.				2138	E
20	Araliaceae	*Schefflera chapana* Harms				1874	E
21	Araliaceae	*Schefflera fantsipanensis* Bui (***)				1852	E
22	Aristolochiaceae	*Asarum balansae* Franch.	EN A1c,d,B1+2b,c		IIA	1649	E
23	Aristolochiaceae	*Asarum glabrum* Merr.	VU A1c,d		IIA	1507	
24	Aristolochiaceae	*Asarum petelotii* O.C.Schmidt*			IIA	1752	
25	Asteraceae	*Achillea millefolium* L.	VU A1a, c, B1+2b,c,d	LC		1503	
26	Asteraceae	*Ainsliaea chapaensis* Merr.				1982	E
27	Asteraceae	*Ainsliaea petelotii* Merr.	VU A1a,c, B2a,b			1989	

28	Balanophoraceae	*Balanophora laxiflora* Hemsl.*	EN B1+2b,c,e			1972	
29	Balsaminaceae	*Impatiens finetii* Tardieu				1600	E
30	Begoniaceae	*Begonia chapaensis* Trmscher sec. Phamh.				1560	E
31	Berberidaceae	*Berberis chingii* Cheng			IA	1939	
32	Berberidaceae	*Berberis julianae* Schneid.	EN A1c,d, B1+2b,c,e		IA	1830	
33	Berberidaceae	*Mahonia nepalensis* DC.			IIA	1885	
34	Berberidaceae	*Podophyllum tonkinense* Gagnep.	EN A1a,c,d		IIA	1979	
35	Bretschneideraceae	*Bretschneidera sinensis* Hemsl.*	CR B1+2e	EN A1c,d		1846	
36	Campanulaceae	*Codonopsis javanica* (Blume) Hook.f. & Thoms.	VU A1a,c,d+2c,d			2168	
37	Caprifoliaceae	*Lonicera hildebrandia* Coll. et Hemsl.	CR B1+2b,c, C2a			1997	
38	Clethraceae	*Clethra chapaensis* Phamh.				1800	E
39	Diapensiaceae	*Shortia rotata* Gaddy & Nuraliev**				1930	E
40	Elaeocarpaceae	*Elaeocarpus petelotii* Merr.**				1878	E
41	Elaeocarpaceae	*Elaeocarpus tonkinensis* A. DC.				1888	E
42	Ericaceae	*Agapetes cauliflora* Merr.				2033	E
43	Ericaceae	*Lyonia chapaensis* (Dop) Merr.				2177	E
44	Ericaceae	*Vaccinium chapaensis* Merr.				2353	E
45	Ericaceae	*Vaccinium tonkinensis* Dop.				1831	E
46	Erythroxylaceae	*Erythroxylum calyptratum* Komada & Tagane**				1859	E
47	Euphorbiaceae	*Breynia subangustifolia* Thin				1670	E
48	Euphorbiaceae	*Sauropus racemosus* Beille				1839	E
49	Fagaceae	*Castanopsis chapaensis* Luong				2079	E
50	Fagaceae	*Castanea phansipanensis* A. Camus				2495	E
51	Fagaceae	*Castanopsis cerebrina* (Hickel & A.Camus) Barnett.(***)	EN A1c,d			2613	
52	Fagaceae	*Fagus longipetiolata* Seemen	EN B1+2b,c,e	VU A1c,d		1842	
53	Fagaceae	*Lithocarpus chevalieri* A. Camus				2035	E
54	Fagaceae	*Lithocarpus elegans* (Blume) Hatus. Ex Soepadmo (***)	EN A1c,d			2088	

55	Fagaceae	*Lithocarpus parvulus* (Hickel et A. Camus) A. Camus				2202	E
56	Fagaceae	*Quercus petelotii* A. Camus				1906	E
57	Gentianaceae	*Tripterygium chevalieri* H. Smith sec. Phamh.				1776	E
58	Gesneriaceae	*Didissandra petelotii* Pellegr.				1709	E
59	Hamamelidaceae	*Altingia poilanei* Tardieu[**]				1824	E
60	Hamamelidaceae	*Altingia takhtajanii* T.V. Trung & L.V. Loc				2177	E
61	Hamamelidaceae	*Disanthus ovatifolius* Aver., P.K.Endress, B.H.Quang & K.S.Nguyen[**]				1851	E
62	Illiciaceae	*Illicium difengpi* B.N Chang	VU B1+2b,c,e			1560	
63	Lamiaceae	*Mosla bracteata* Doan				1708	E
64	Lamiaceae	*Scutellaria tonkinensis* Doan				1492	E
65	Lamiaceae	*Scutellaria yunnanensis* Lévl.	CR B1+2a,e			1541	
66	Lamiaceae	*Teucrium petelotii* Doan				1730	E
67	Lauraceae	*Actinodaphne ellipticibacca* Kosterm.[**]				1420	E
68	Lauraceae	*Alseodaphne lanuginosa* Kosterm.				1833	E
69	Lauraceae	*Caryodaphnopsis poilanei* Kosterm.				1841	E
70	Lauraceae	*Cinnamomum parthenoxylon* (Jack.) Meisn.	CR A1a,c,d	LC	IIA	2037	
71	Lauraceae	*Lindera balansae* Lecomte				1776	E
72	Lauraceae	*Neolitsea elaeocarpa* H. Liou				2157	E
73	Lauraceae	*Phoebe petelotii* Kosterm. sec. Phamh.				1790	E
74	Magnoliaceae	*Magnolia baillonii* Pierre[(***)]	VU A1a,c,d			1882	
75	Magnoliaceae	*Michelia chapaensis* Dandy				2025	E
76	Malpighiaceae	*Aspidopterys glabrifolia* Arènes[**]				1725	E
77	Melastomataceae	*Allomorpha arborescens* Guillaum.				1863	E
78	Melastomataceae	*Blastus multiflorus* (Cogn.) Guillaum.				1448	E
79	Melastomataceae	*Phyllagathis longiradiosa* (C. Chen) C. Chen[**,(***)]				1445	E
80	Melastomataceae	*Poilannamia allomorphioides* C. Hansen				1910	E
81	Melastomataceae	*Sporoxeia petelotii* C.Hansen[**]				2441	E

82	Melastomataceae	*Sporoxeia scidophila* W.W. Smith				1475	E
83	Melastomataceae	*Vietsenia scaposa* Hans				1766	E
84	Meliaceae	*Dysoxylum tonkinense* Chev. ex Pellegr.				1731	E
85	Menispermaceae	*Cyclea fansipanensis* Gagnep.				1946	E
86	Menispermaceae	*Stephania brachyandra* Diels			IIA	1579	
87	Menispermaceae	*Stephania hernandiifolia* (Willd.) Spreng.			IIA	1595	
88	Menispermaceae	*Stephania tetrandra* S. Moore			IIA	1622	
89	Menispermaceae	*Tinospora sagittata* (Oliv.) Gagnep.	VU A1c,d			1582	
90	Myrsinaceae	*Ardisia annamensis* Pitard				1672	E
91	Myrsinaceae	*Ardisia perpendicularis* E. Walker				1918	E
92	Myrsinaceae	*Ardisia silvestris* Pitard	VU A1a,c,d+2d			1485	E
93	Myrsinaceae	*Maesa subdentata* A. DC.				1936	E
94	Oleaceae	*Linociera macrothyrsa* Merr.				1767	E
95	Piperaceae	*Piper montium* C. DC.				1708	E
96	Pittosporaceae	*Pittosporum merrillianum* var. petelotii Gowda				1608	E
97	Pittosporaceae	*Pittosporum oblongilimbum* Merr.				1671	E
98	Polygalaceae	*Polygala tricornis* Gagnep. var. *latifolia* Gagnep.				1879	E
99	Primulaceae	*Primula gracilituba* C.M. Hu & Nuraliev**				2230	E
100	Proteaceae	*Helicia cauliflora* Merr.				1725	E
101	Ranunculaceae	*Coptis chinensis* Franch.	CR A1d, B1+2b,c		IA	1758	
102	Ranunculaceae	*Coptis quinquesecta* W.T.Wang.	CR A1d, B1+2b,c		IA	1622	
103	Ranunculaceae	*Thalictrum foliolosum* DC.			IIA	1808	
104	Rhoipteleaceae	*Rhoiptelea chiliantha* Diels & Hand.-Mazz.*	EN B1+2b,c,e	VU B1+2c		1810	
105	Rosaceae	*Eriobotrya elliptica* Lindl. var. *petelotii* Vidal				2242	E
106	Rosaceae	*Rubus idaeifolius* N.V. Thuan				2328	E
107	Rosaceae	*Rubus tonkinensis* F. Bolle				1804	E
108	Rosaceae	*Sorbus brevipetiolata* T.H.Nguyen & Yakovlev**				1967	E

109	Rubiaceae	*Lasianthus fansipanensis* V.S. Dang & Naiki[**]				1713	E
110	Rubiaceae	*Lasianthus caeruleus* Pitard				2078	E
111	Rubiaceae	*Mussaenda baviensis* in Herbier				1741	E
112	Rubiaceae	*Psychotria tonkinensis* Pitard				2143	E
113	Rubiaceae	*Tarenna chavalieri* Pitard				1840	E
114	Rubiaceae	*Wendlandia acuminata* Cowan				1987	E
115	Schisandraceae	*Kadsura coccinea* (Lem.) A.C.Sm.[*]			IIA	1431	
116	Schisandraceae	*Kadsura oblongifolia* Merr.[*]			IIA	1827	
117	Schisandraceae	*Schisandra rubriflora* (Franch.) Rehd. & Wils.	EN B1+2c,e			1939	
118	Scrophulariaceae	*Paulownia fargesii* Franch.	CR B1+2e			1766	
119	Scrophulariaceae	*Torenia scandens* Bonati				1533	E
120	Symplocaceae	*Symplocos olivacea* Merr.				1833	E
121	Theaceae	*Adinandra megaphylla* Hu	VU A1c,d			1529	
122	Urticaceae	*Pellionia chapaensis* Gagnep.				1889	E
123	Valerianaceae	*Valeriana jatamansi* Jones[*]	EN B1+2b,c			1893	
124	Valerianaceae	*Valeriana hardvickii* Wall. in Roxb.	VU B1+2b,c			1891	
125	Violaceae	*Viola petelotii* W. Bechker ex Gagnep.				1537	E
126	Vitaceae	*Tetrastigma chapaense* Merr.				1826	E
127	Convallariaceae	*Polygonatum kingianum* Coll. et Hemsl.	EN A1c,d		IIA	1642	
128	Cyperaceae	*Carex atrivaginata* Nelmes				1854	E
129	Cyperaceae	*Cyperus diffusus* Vahl		LC		1946	
130	Cyperaceae	*Cyperus rotundus* L.		LC		1530	
131	Cyperaceae	*Eriophorum scabriculme* (Beetle) Raym.				1503	E
132	Liliaceae	*Lilium brownii* F.E. Br. ex Mill. var. *viridulum* Baker	EN A1a,c,d		IIA	1784	
133	Orchidaceae	*Arundina graminifolia* (D. Don) Hochr.			IIA	1503	
134	Orchidaceae	*Brachycorythis galeandra* (Reichb. f.) Summ.			IIA	1575	
135	Orchidaceae	*Bulbophyllum abbrevilabium* Carr[(***)]			IIA	1605	

136	Orchidaceae	*Bulbophyllum ambrosia* (Hance) Schlechter			IIA	1878	
137	Orchidaceae	*Bulbophyllum careyanum* (Hook.) Spreng.			IIA	1873	
138	Orchidaceae	*Bulbophyllum flabellum-veneris* (J.König) Aver.(***)			IIA	1748	
139	Orchidaceae	*Bulbophyllum retusiusculum* Reichb.f.			IIA	1684	
140	Orchidaceae	*Bulbophyllum scabratum* Reichb. f.*,(***)			IIA	1459	
141	Orchidaceae	*Calanthe alleizettei* Gagnep.*			IIA	1858	
142	Orchidaceae	*Calanthe angustifolia* (Blume) Lindl.			IIA	1506	
143	Orchidaceae	*Calanthe densiflora* Lindl.			IIA	1703	
144	Orchidaceae	*Calanthe mannii* Hook.f.			IIA	1931	
145	Orchidaceae	*Calanthe davidii* Franch (***)			IIA	1594	
146	Orchidaceae	*Calanthe petelotiana* Gagnep.			IIA	1652	
147	Orchidaceae	*Ceratostylis siamensis* Rolfe ex Downie			IIA	1584	
148	Orchidaceae	*Cleisostoma chapaensis* (Guillaum.) Garay			IIA	1514	E
149	Orchidaceae	*Cleisostoma rostratum* (Lindl.) Garay			IIA	1546	
150	Orchidaceae	*Coelogyne leucantha* W.W.Sm.*			IIA	2070	
151	Orchidaceae	*Galeola lindleyana* (Hook.f. & Thomson) Reichb.f.*,(***)			IIA	1464	
152	Orchidaceae	*Coelogyne lockii* Aver.			IIA	1929	
153	Orchidaceae	*Coelogyne ovalis* Lindl.			IIA	1860	
154	Orchidaceae	*Coelogyne rigida* Parish & Reichb.f.			IIA	1756	
155	Orchidaceae	*Collabium formosanum* Hayata(***)			IIA	1663	
156	Orchidaceae	*Corymborkis veratrifolia* (Reinw.) Blume			IIA	1660	
157	Orchidaceae	*Cryptochilus ctenostachyus* Gagnep.(***)			IIA	1773	E
158	Orchidaceae	*Cymbidium aloifolium* (L.) Sw.			IIA	1667	
159	Orchidaceae	*Cymbidium dayanum* Reichb.f.			IIA	1686	
160	Orchidaceae	*Cymbidium floribundum* Lindl.*			IIA	2607	
161	Orchidaceae	*Cymbidium lowianum* Reichb. f.			IIA	1820	
162	Orchidaceae	*Cymbidium sinense* (And.) Willd.			IIA	1743	
163	Orchidaceae	*Dendrobium chrysanthum* Wallich	EN B1+2e+3d		IIA	1846	

164	Orchidaceae	*Dendrobium chryseum* Rolfe			IIA	1683	
165	Orchidaceae	*Dendrobium devonianum* Paxt.			IIA	1842	
166	Orchidaceae	*Dendrobium henryi* Schlechter			IIA	1674	
167	Orchidaceae	*Dendrobium lituiflorum* Lindl.			IIA	1914	
168	Orchidaceae	*Dendrobium moniliforme* (L.) Sw.*			IIA	2623	
169	Orchidaceae	*Dendrobium nobile* Lindl.	EN B1+2b,c,e		IIA	1706	
170	Orchidaceae	*Dendrobium sociale* J.J. Smith			IIA	1585	
171	Orchidaceae	*Dendrobium wardianum* R. Warner	VU B1+2e		IIA	1799	
172	Orchidaceae	*Epigeneium amplum* (Lindl.) Summ.			IIA	1869	
173	Orchidaceae	*Eria acervata* Lindl.			IIA	1862	
174	Orchidaceae	*Eria clausa* King et Pantl.			IIA	1859	
175	Orchidaceae	*Eria corneri* Reichb.f.			IIA	1502	
176	Orchidaceae	*Eria gagnepainii* Hawkes et Heller			IIA	1549	
177	Orchidaceae	*Galeola faberi* Rolfe*			IIA	1874	
178	Orchidaceae	*Galeola nudiflora* Lour.			IIA	1577	
179	Orchidaceae	*Gastrochilus pseudodistichus* (King et Pant) Schlechter			IIA	1668	
180	Orchidaceae	*Goodyera procera* (Ker.-Gawl.) Hook.			IIA	1813	
181	Orchidaceae	*Habenaria arietina* Hook.f.			IIA	1862	
182	Orchidaceae	*Habenaria limprichtii* Schlechter			IIA	1817	
183	Orchidaceae	*Habenaria malintana* (Blanco) Merr.			IIA	1634	
184	Orchidaceae	*Habenaria petelotii* Gagnep.			IIA	1772	
185	Orchidaceae	*Holcoglossum lingulatum* (Aver.) Aver.			IIA	1715	
186	Orchidaceae	*Liparis averyanoviana* Szlach.			IIA	1510	
187	Orchidaceae	*Liparis bootanensis* Griff.			IIA	1829	
188	Orchidaceae	*Liparis caespitosa* (Thouars) Lindl.			IIA	1803	
189	Orchidaceae	*Liparis clypeolum* (G.Forst.f.) Lindl.			IIA	1936	
190	Orchidaceae	*Liparis dendrochiloides* Aver.			IIA	1555	
191	Orchidaceae	*Liparis mannii* Reichb. f.			IIA	1838	
192	Orchidaceae	*Liparis sootenzanensis* Fukuy.*			IIA	1820	

193	Orchidaceae	*Liparis stricklandiana* Reichb.f.*			IIA	1884	
194	Orchidaceae	*Luisia morsei* Rolfe in Forbes & Hemsl.			IIA	1934	
195	Orchidaceae	*Oberonia ensiformis* (Smith) Lindl.			IIA	1711	
196	Orchidaceae	*Oberonia variabilis* Ker.-Gawl.			IIA	1509	
197	Orchidaceae	*Peristylus chapaensis* (Gagnep.) Seident.f.			IIA	1728	E
198	Orchidaceae	*Peristylus prainii* (Hook.f.) Kraenzl.			IIA	1528	
199	Orchidaceae	*Phajus tankerivilae* (Banks ex L. Her.) Blume			IIA	1801	
200	Orchidaceae	*Pholidota chinensis* Lindl.			IIA	1796	
201	Orchidaceae	*Tainia angustifolia* (Lindl.) Benth. et Hook.f.			IIA	1865	
202	Orchidaceae	*Tainia macrantha* Hook.f.(***)			IIA	1723	
203	Orchidaceae	*Tsaiorchis keiskeoides* (Gagnep.) X.H.Jin, Schuit. & W.T.Jin**			IIA	2025	E
204	Orchidaceae	*Uncifera acuminata* Lindl.*			IIA	1838	
205	Orchidaceae	*Yoania prainii* King. & Pantl.*			IIA	1837	
206	Orchidaceae	*Vanda pumila* Hook.f.			IIA	1944	
207	Pandanaceae	*Pandanus tonkinensis* Martelli ex Stone				1933	E
208	Smilacaceae	*Smilax petelotii* T.Koyama*	CR B2b, 3d			1838	
209	Zingiberaceae	*Amomum lacteum* Ridl.				1655	E
210	Zingiberaceae	*Caulokaempferia petelotii* K. Larsen**				1445	E
211	Zingiberaceae	*Zingiber eberhardtii* Gagnep.				1704	E

Note: GOV Decree 06 (2019) = Decree No 06/2019/ND-CP by the Government of Vietnam on the management of endangered wild. Group IA: prohibited exploitation and use for commercial purpose and Group IIA: limited exploitation and use for commercial purpose; MOST & VAST (2007) = MOST & VAST Vietnam red data book (Ministry of Science and Technology of Vietnam, 2007. Vietnam red data book part II. Plants. Descriptions of nationally endangered species of wild Plants. CR = Critically Endangered, EN = Endangered, VU = Vulnerable; IUCN (2019) = The IUCN Red List of Threatened Species. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LC= Least Concern;E= Endemism is the state of a species being native to a single defined geographic location, such as an island, state, nation, country or other defined zone; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere. (Orme et al. 2005, Morrone 2008); * = Species added (Rare) 22 species (*) and 17 (endemic) to Vietnam (**) species in Bat Xat NR to the previous lists. (DARD, 2016 and Nguyen, 2018). According to publications MOST & VAST (2007), Ho P. H. (1999–2003) and GOV Decree 06 (2019). The scientific names of 14 species used have become synonyms (table below). For this study we have changed and used the accepted scientific name updated according to (Averyanov, 2003c; POWO, 2021) in the check list of rare and endemism species in BXNR = (***).

Updated scientific name in the check list of rare and endemism species in BXNR

Synonym	Accepted name
Araliaceae	
Schefflera hoi (Dunn) R. Vig. var. *fansipanensis* (Bui) Shang =	*Schefflera fantsipanensis* Bui(***)
Annonaceae	
Disepalum petelotii (Merr.) D.M.Johnson =	*Fissistigma petelotii* Merr.(***)
Fagaceae	
Lithocarpus cerebrinus (Hickel et A. Camus) A. Camus =	*Castanopsis cerebrina* (Hickel & A.Camus) Barnett.(***)
Lithocarpus finetii (Hickel et A. Camus) A. Camus =	*Lithocarpus elegans* (Blume) Hatus. Ex Soepadmo(***)
Magnoliaceae	
Paramichelia baillonii (Pierre) S.Y. Hu=	*Magnolia baillonii* Pierre(***)
Melastomataceae	
Phyllagathis longicalcarata C.Hansen =	*Phyllagathis longiradiosa* (C. Chen) C. Chen(***)
Orchidaceae	
Cirrhopetalum lepidum Schlechter =	*Bulbophyllum flabellum-veneris* (J.König) Aver.(***)
Cirrhopetalum retusiusculum (Reichb. f.) Hemsl. =	*Bulbophyllum retusiusculum* Reichb.f.(***)
Epicranthes abbrevilabium (Carr.) Garay & Kittredge =	*Bulbophyllum abbrevilabium* Carr(***)
Calanthe pachystalix Reichb.f. ex Hook.f. =	*Calanthe davidii* Franch(***)
Mischobulbum macranthum (Hook.f.) Rolfe =	*Tainia macrantha* Hook.f. (***)
Collabiopsis formosanum (Hayata) S.S. Ying =	*Collabium formosanum* Hayata(***)
Cryptochilus ctenostachya Gagnep. =	*Cryptochilus ctenostachyus* Gagnep.(***)
Cyrtosia lindleyana Hook.f. & Thomson =	*Galeola lindleyana* (Hook.f. & Thomson) Reichb.f.(***)