

CHARACTERISTICS OF HABITAT OF TONKIN SNUB-NOSED MONKEY IN QUAN BA WATERSHED FOREST, HA GIANG PROVINCE

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ABSTRACT

The forest habitat of the Tonkin Snub-nosed Monkey (TSM) population in Cao Ma Po, Ta Van and Tung Vai communes (Quan Ba district, Ha Giang province) was surveyed in 2019 – 2022 using line transects and sampling plot methods. The study results show that the habitat includes 4,213.16 ha of natural forest with two forest types: Montane evergreen broad-leaf forest and Limestone evergreen forest. Each forest type has 4 states (rich, medium, poor and rehabilitation) of which 2 states (rich and medium forests) can support the activity of TSM and have an area of 2,560 ha, accounting for 61.48% of the forest area in the study area. Key characteristics of forests in the study area are highlighted including plant species composition (647 species of 364 genera and 129 families), list of TSM food plant species (19 species), the density of trees of $D_{1.3} \geq 5$ cm (1491.3 trees/ha), $D_{1.3}$ size (mean 14.97), basal area (BA) of tree species (average 275.17 cm²/tree and total BA = 41.04 m²/ha) and dominant families and species. In comparison with Khau Ca TSM Conservation Area, the ecological indicators of forests in the study area are lower indicating the forest in the study area was more degraded. It is necessary to have management solutions and silvicultural interventions to improve the forest quality in the study area for the long-term conservation of Quan Ba TSM population.

Keywords: *Habitat, primate, Quan Ba forest, Rhinopithecus avunculus.*

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1. INTRODUCTION

The Tonkin Snub-nosed Monkey (TSM) *Rhinopithecus avunculus* is an endemic primate species of North Vietnam. Historically, the species occurred in five provinces including Yen Bai, Ha Giang, Tuyen Quang, Thai Nguyen and Bac Kan provinces [1]. However, due to excessive illegal hunting and massive habitat loss and degradation, the species is now found only in a few forest areas

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in Ha Giang and Tuyen Quang provinces, with a total number not exceeding 250 individuals [2], [3]. The species was listed as "Critically endangered" (CR) in both the Red Data Book of Vietnam [4] and the IUCN Red List [5]. Quan Ba watershed forest in Ha Giang Province harbors a small population of TSM (about 30 - 35 individuals [6]. It is the second largest population of TSM after the largest population of about 120 individuals found in the Khau Ca TSM Conservation Area, Ha Giang province. This population is highly vulnerable due to illegal wildlife hunting and forest degradation by illegal timber cutting, non-timber product harvesting, and especially, the excessive forest farming of the Cardamon plant *Amomum tsao* [7].

As an arboreal and plant-eating monkey [8], [9], the survival of TSM depends much on the quality of the forest in which they live. Thus, understanding the characteristics of the forest where the TSM population is living is very important for the species conservation. The habitat of TSM in Khau Ca TSM Conservation Area was well studied in many aspects including forest types/states, structure, floral composition, plant community ecological characteristics, TSM food plant species, reserves and phenology, etc. [10], [8], [9]. While the TSM habitat in Quan Ba watershed forest is still poorly studied except for some general information on forest types and the impacts of the forest farming of Cardamon on the habitat quality [7]. Thus, during 2019-2022, we conducted field studies

of TSM habitat in Quan Ba watershed forest, intending to better understand the forest characteristics.

2. METHODS

Study area: This study is focused on an area of about 5,000 ha of natural forests that the TSM population is inhabiting (the study area). The study area is located within the eastern part of Quan Ba district, Ha Giang province, sharing 3 communes (Cao Ma Po, Ta Van and Tung Vai) and a national border with Malipo district of China. The terrain of the study area is characterized by steep limestone mountains with deep narrow valleys, and the altitude ranges from 900 to 1,700 m above sea level. The study area has a humid tropical climate, influenced by monsoon (Quan Ba district statistical Yearbook 2017). There are two distinct seasons: the rainy season from May to October, with the heaviest rain in July and August, with the average rainfall of 246 mm/month. In the dry season from November to April next year, the average rainfall is 44.8 mm/month. The average annual rainfall is 1,768 mm.

Line transect method: We followed Buckland *et al.* (2007) [11]. In each habitat type, transects with a length of 500 m or more were established, depending on the topography and habitat size. The information/data collected on the transects were canopy structure, tree species name and tree photography. The width of survey transects varied from 5 to 20 m depending the

thickness of forests. A total of 15 transects with a total length of 30.7 km were carried out (Figure 1).

Sampling plot method: According to Brockelman (1987) [12], when studying the habitat of primates, the plots are arranged scattered in the habitat but must be in the most concentrated distribution area of the studied species. Due to the very steep and rugged terrain of the study area, plots of size 10 x 10 m (100 m²) were used. The plots were randomly established on survey transects in different habitat types and at least 500 m apart. In each plot, one sub - plot of size 5 x 5 m was established to survey shrubs and regenerated trees and one sub - plot of size 1 x 1 m to survey herbaceous plants. In the plots, data were collected on trees with breast circumference $C1.3 \geq 19$ cm and height $H_{vn} \geq 5$ m, including common names or local names, breast girth (C1.3) and height (H_{vn}). At the same time, the names of extra-layer plant species were also recorded. In the 5 x 5 m sub-plots, collected data included species names and the height H_{vn} of all trees having $C1.3 < 19$ cm and $H_{vn} < 5$ m. In the herbaceous sub-plots, we identified the species' names and counted the number of plants of each species. A total of 23 sampling plots were established (Figure 1).

Plant species identification and data analysis: Species identification was carried out mostly in the field. For plants that could not be identified in the field, specimens were

collected for later identification at the laboratories (Institute of Ecology and Biological Resources). Key documents used for the species identification include [13], the Flora of Vietnam (MoST and the VAS, multi-volumes) and the Flora of China [14].

The obtained data were stored and analyzed using Word, Excel, MapInfor 10.5 programs. The ecological indicators of the forest are determined according to Bhadra *et al.* (2016) [15]: Plant density (stem/ha) = total number of trees of considered species in all plots/total area of all plots implemented. Dominance of species (cm²) = total basal area (BA) of all trees of considered species in the plots. The basal area of the stem BA (cm²) = $3.1416 \times (D_{1.3}/2)^2$, where $D_{1.3}$ is the diameter at the breast height of the tree. Sorensen similarity index between 2 areas $SI = 2C/(A+B)$. In which: C - number of species occurring in both areas A & B, A - number of species of area A; B - the number of species of area B. Important Value Index $IV(\%) = (RF\% + RDe\% + RDo\%)/3$ [16]. In which, RF(%) - relative frequency, RDe (%) - relative density, RDo(%) - Relative dominance, while $RF(\%) = (\text{number of plots with the considered species}/\text{total number of plots with occurrence of all species}) \times 100$; $RDe(\%) = (\text{total number of plants of considered species}/\text{total number of plants of all species}) \times 100$; and $RDo(\%) = (\text{total BA of considered species}/\text{sum of BA of all species}) \times 100$.

3. RESULTS AND DISCUSSION

3.1. Forest cover

Out of the total 4,563.46 ha of the survey area, 4,213.16 ha (92.3%) is covered by natural forests, and the rest 350.3 ha (7.7%) is non-forest land. There are two main forests including: Montane evergreen broad-leaf

forest and Limestone evergreen forest. Due to the long-term impact of human livelihood activities, these main types of forest have been converted into sub-categories as a rich, medium, poor and rehabilitation forest (Figure 1).

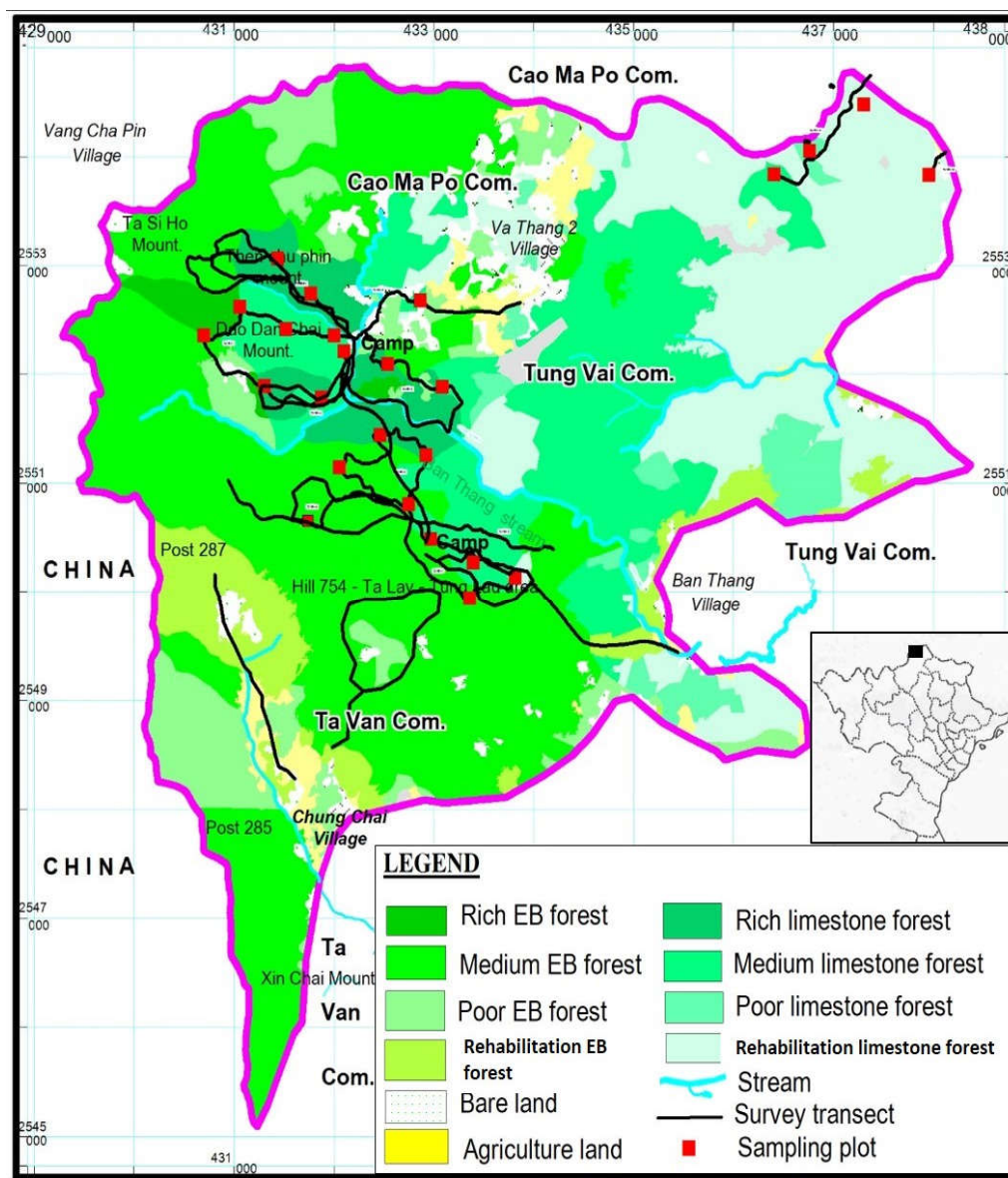


Figure 1. Land-use map of watershed forest in Quan Ba

(EB – evergreen broad-leaf)

The Montane evergreen broad-leaf forest includes rich montane evergreen broad-leaf forest (49.7 ha), medium montane evergreen broad-leaf forest (1,619.99 ha), poor montane evergreen broad-leaf forest (360.03 ha) and rehabilitation montane evergreen broad-leaf forest (250.63 ha). The limestone evergreen forest includes the rich limestone evergreen forest (173.42 ha), medium limestone evergreen forest (746.67 ha), poor limestone evergreen forest (141.98 ha), and rehabilitation limestone evergreen forest (860.74 ha) (Figure 1).

Rich forests remain only on very steep slopes and limestone mountains. The forests have the typical structure of tropical rainforest with 4 canopy layers and forest canopy coverage of more than 70%. Trees have a diameter at breast height ($D_{1.3}$) of 40-60 cm, and a height of 20-40 m. Medium forests has no superior layer (A1 layer) in some places, and the forest canopy has been disrupted in many places due to many tall trees having been removed.

The structure of poor and rehabilitation forests was severely altered due to the falling of large trees. The superior layer (A1 layer) has been removed; the main canopy layer (A2 layer) and lowest woody tree layer (A3 layer) are also strongly impacted, and almost absent in some limestone areas. According to Le Khac Quyet *et al.* (2010) [6] and Nguyen Xuan Dang *et al.* (2019) [7], in the limestone evergreen forests, the TSM is found in rich,

medium forests and occasionally in the poor forest, while in montane evergreen broad-leaf forest, the animals found only in rich and medium forests. Thus, out of a total of 4213.16 ha of natural forest in the study area, the area of habitats suitable for TSM activity is about 2590 ha, accounting for 61.48% of the total forest area. This is much larger than the current activity area of the TSM population (about 1000 ha). In other words, the study area can support the TSN population here to be increased many times more. This is comparable with the fact that in Khau Ca area, the total area of forests suitable for the TSM population is only 816.5 ha [9]) which harbors a TSM population of about 120 individuals.

3.2. Species richness

A total of 647 species of vascular plants belonging to 364 genera, 129 families and 5 phyla have been recorded in the study area. The Magnoliophyta is the most diverse phylum with 106 families, 582 species, accounting for 82.17% of the total families and 89.95% of the total species. The second most diverse Pteridophyta includes 17 families, 52 species (13.18% and 8.04%, respectively). The Pinophyta has 3 families and 7 species, the Lycopodiophyta has 2 families and 5 species, and the Gnetophyta has only one family and one species. Among the families, the species-richest are Orchidaceae (53 species), followed by Lauraceae (36 species), Rubiaceae (31 species), Urticaceae (22 species), Gesneriaceae (19 species), Primulaceae (19

species), Asteraceae (17 species), Fagaceae (16 species), Moraceae (16 species), Rosaceae (13 species), Araceae (12 species), Polypodiaceae (11 species), Asparagaceae (11 species), Apocynaceae (10 species) and Rutaceae (10 species). There are 5 families with 9 species each, 3 families with 8 species each, 3 families with 7 species each, 8 families with 6 species each, 4 families with 5 species each, 16 families with 4 species each, 18 families with 3 species each, 20 families with 2 species each and 36 families with one species each.

There has been no study on the food plants of TSM in the study area. However, based on the list of TSM food plants known in previous studies in Vietnam [1], [10], [8], [9] and our list of 647 plant species found in the study area we have identified 19 species belonging to 11 families are food plant species of TSM in the study area. They are *Litsea baviensis* Lec., *Litsea yunnanensis* Yen C. Yang & P.H. Huang, *Machilus bonii* Lecomte, *Archidendron robinsonii* (Gagn.) L. Niels., *Brassaiopsis stellata* Fang, *Toona sinensis* (Juss.) M. Roem, *Ficus auriculata* Lour, *Ficus hispida* L.f., *Broussonetia papyrifera* (L.) L' Hér. ex Vent., *Canarium album* (Lour.) DC., *Canarium pimela* K. D. Koenig, *Garcinia oblongifolia* Champ. ex Benth., *Caryota urens* L., *Castanopsis tonkinensis* Seemen, *Castanopsis chinensis* (Spreng.) Hance, *Quercus platycalyx* Hickel & A.Camus, *Gnetum montanum* Markgr., *Musa acuminata*

Colla, *Phyllostachys bambusoides* Sieb. & Zucc.

3.3. Physical structure of forests

A total of 612 trees were counted in the 23 plots of the study area. The total plot area covered 0.23 ha, and the density of trees of $D_{1.3} \geq 5$ cm was 1491.3 per hectare. Most of the trees have a $D_{1.3}$ from 5 to 20 cm, accounting for 80.11% of the total number of trees sampled. Species with $D_{1.3}$ from 5 to 9.0 cm accounted for the largest proportion (41.81%) and only 7.61% of the total trees with $D_{1.3} \geq 40$ cm. The highest $D_{1.3}$ value of 91.4 cm was recorded in the *Lithocarpus garrettianus* (Craib) A.Camus. The mean value of $D_{1.3}$ of the trees in the plots is 14.97 cm.

Out of a total of 343 sampled timber trees, 131 species belonging to 79 genera and 48 families have been identified for a ratio of about 2.6 plants per species and 2.7 species per family. The largest BA area of 8869.19 cm² was recorded in *Castanopsis chinensis* (Spreng.) Hance and the average BA area for all trees was 275.17 cm². The area of plots sampled is 23,000 m², a total BA of all species is 9.44 m². Therefore, the total BA per hectare is 41.04 m².

Out of 48 sampled families, the family Fagaceae has the highest number of trees (37 trees, accounting for 10.82% of the total number of trees), followed by Lauraceae (26 plants, 7.60%), Fabaceae (23 trees, 6.73%),

Araliaceae (22 trees, 6.43%), Illiciaceae (22 trees, 6.43%), Icacinaceae (20 trees, 5.85%), Taxaceae (20 trees, 3.51%). These seven (7) families have 170 trees, accounting for 47.37% of the total sampled trees. In terms of BA area, Fagaceae has the largest BA (30035.83 cm²), accounting for 31.82% of the total BA of sampled trees. Next are the Magnoliaceae (7884.12 cm², 8.35%), Elaeocarpaceae (7141.31 cm², 7.57%), Araliaceae (5493.40 cm², 5.82%), Lauraceae (4943.02 cm², 5.24%), Fabaceae (4846.06 cm², 5.13%), Theaceae (4265.66 cm², 4.52%). These seven families have a total BA accounting for 68.45% of the total BA of all sampled trees.

Species *Archidendron robinsonii* (Gagnep) I. Nielsen was the most common species in terms of number of trees (21 trees, accounting for 6.14% of the total number of trees). Followed by the *Gomphandra mollis* Merr (20 trees, 5.85%), *Machilus bonii* Lecomte (16 trees, 4.68%), *Castanopsis tonkinensis* Seemen (11 trees, 3.22%), *Garcinia gracilis* Pierre (11 trees, 3.22%), *Amentotaxus yunnanensis* H. L. Li (10 trees, 2.92%). In

terms of BA area, *Castanopsis chinensis* (Spreng.) Hance was the most common species (8869.19 cm², accounting for 9.4% of the total BA of the species). Next are the *Castanopsis tonkinensis* Seemen (6548.16; 6.94%), and *Archidendron robinsonii* (Gagnep) I. Nielsen (4751.16; 5.03%). In the sampled plots, there are no species with IV $\geq$ 5%, there are 4 species with IV $\geq$ 4%, namely *Archidendron robinsonii* (Gagnep) I. Nielsen (4.65%), *Castanopsis chinensis* (Spreng.) Hance (4.53%), *Castanopsis tonkinensis* Seemen (4.51%) and *Gomphandra mollis* Merr. (4.44%).

Khau Ca TSM Conservation Area in Vi Xuyen district, Ha Giang province is home of the largest population of TSM today [7]. Therefore, comparing the forest factors of study area with those of Khau Ca area will have suggestions for the management solutions to protect the habitats of TSM in Quan Ba watershed forest. The key forest ecological factors of tree communities between the two areas are listed in table 1 and figure 2.

Table 1. Comparison of factors of two tree communities in the study area and Khau Ca TSM Conservation Area

Factor	Study area	Khau Ca area*
Species composition	131 species, 48 families	136 species, 49 families
Ratio of tree per species and species per family	2.6 trees/species; 2.7 species/ family	3.7 tree/species; 2.8 species/family.

Tree density	1491 trees / ha	882 trees /ha
Maximum $D_{1.3}$ t	91.4 cm	134.3 cm
Trees of $D_{1.3}$ from 6 to 40 cm	97.24% total tree number	95.7% total tree number
Trees of $D_{1.3}$ from 6 to <10 cm	41.98% total tree number	34.4% total tree number
Trees of $D_{1.3} \geq 40$ cm	2.76% total tree number	4.3% total tree number
Mean $D_{1.3}$	15.0 cm	17.4 cm
Maximum BA	8869.19 cm ²	15546.54 cm ²
Mean BA per tree	275.17 cm ² /tree	393.90 cm ² /tree
Total BA per hectare	41.04 m ² /ha	34.77m ² /ha

Notes: *After Dong Thanh Hai (2011)

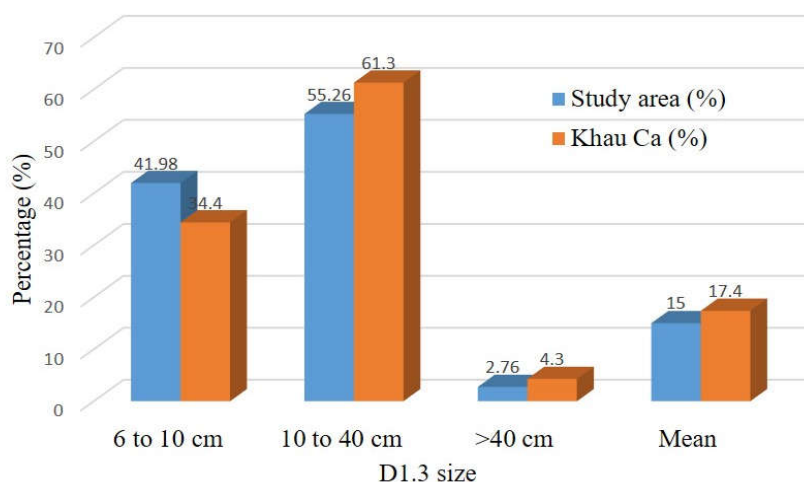


Figure 2. Percentage of trees by $D_{1.3}$ size in study area and Khau Ca area

In table 2, data on tree species than in Khau Ca area (23 plots versus 58 composition and species/family ratios did not differ much between the two regions. tree species composition in the study area. However, taking into account that the number of sampling plots in study area is much less than in Khau Ca area (23 plots versus 58 plots), it is possible to predict a more diverse tree species composition in the study area. This is also consistent with the data on density and $D_{1.3}$ size of the trees. In general, tree

density in study area was higher (1491.3 trees/ha compared with 882 trees/ha) and $D_{1.3}$ of trees in study area was smaller than in Khau Ca (average $D_{1.3}$ in study area was 14.97 cm compared to 17.4 cm in Khau Ca area). The average and maximum BA values per tree were lower in study area than in Khau Ca area. However, total BA per ha of the study area is larger than those in Khau Ca (41.04 m²/ha compared to 34.77 m²/ha). This is due to higher tree density in study area than in Khau Ca (1491.3 trees/ha versus 882 trees/ha). In general, the ecological indicators of plant communities in study area were lower than in Khau Ca area indicating the forest in study area was more degraded than in Khau Ca area (fewer large trees). Therefore, in order to ensure long-term conservation of TSM populations in the study area, it is necessary to have management solutions and silvicultural interventions to improve the forest quality in study area.

4. CONCLUSION

The forest habitat of TSM in Quan Ba district includes 4,213.16 ha of natural forest with two forest types: Montane evergreen broad-leaf forest and Limestone evergreen forest. Each forest type has 4 states: rich, medium, poor and rehabilitation. The forests that are suitable for TSM activity (rich and medium forests of both types) cover an area of

about 2560 ha, accounting for 61.48% of the total forest area in the study area.

Key characteristics of forests in study area include plant species composition (647 species of 364 genera and 129 families), list of TSM food plant species (19 species), the density of trees of $D_{1.3} \geq 10$ cm (1491.3 trees/ha), $D_{1.3}$ size (mean 14.97), basal area (BA) of tree species (average 275.17 cm²/tree and total BA = 41.04 m²/ha) and dominant families and species.

In comparison with Khau Ca TSM Conservation Area, the ecological indicators of forests in the study area are lower indicating the forests in the study area was more degraded. It is necessary to have management solutions and silvicultural interventions to improve the forest quality in study area for the long-term conservation of the TSM population here.

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