Khotpathoom et al. (2024). Souphanouvong University Journal of Multidisciplinary Research and Development. ISSN 2521-0653. Volume 10. Issue 2. Apr - Jun. 2024. Page 104 - 112

Dominant Tree of Lime Stone Karst in Habitat of Kha Nyou (*Laonastes Aenigmamus*) at Mouang-Doy Village, Thakhek District, Khammouane Province, Lao PDR

Thananh Khotpathoom[*], Viengsamone Thammavong[1], Houan Vorasane[1], Duoangphachan Souvansay[1] and Bakham Chanthavong[1]

Ecotourism Department, Faculty of Forest Science, National University of Laos, Lao PDR

[*] ***Correspondence:*** *Thananh Khotpathoom, Ecotourism Department, Faculty of Forest Science, National University of Laos, Mobile: +8562022636171, Email: thananh@nuol.edu.la*

Article Info:
Submitted: Jul 31, 2023
Revised: Apr 19, 2024
Accepted: May 27, 2024

Abstract

Dominant tree of limestone karst was carried out to study in the habitat of Kha Nyou or Laotian rock rat (*Laonastes aenigmamus*) in Mouang-Doy Village, Thakhek District, Khammouane Province, central Lao PDR during April and June 2020 using stratified random sampling. Twenty 10x10m sampling plots were placed separately for each forest type (limestone deciduous forest and semi - evergreen forest) within the habitat of Kha Nyou was studied during 2008 and 2010. Tree dominance was considered based on Important Value Index (IVI). A total of 332 individual trees (1660 individual/ha) representing 30 families, 40 genera and 54 species were found. However, three of these species were only classified to a genus (appendix 01 and 02). The dominant trees of limestone karst in habitat of Kha Nyou can be separated based on forest types. In the semi - evergreen forest were *Diospyros rubra* H. Lec., *Memecylon ovatum* Sm. and *Walsura trichostemon* Miq. (mean IVI=51.70, 22.41, 18.65 and 14.55, respectively), while in the limestone deciduous forest were *Sterculia pexa* Pierre, *Spondias pinnata* (L.F) Kurz, *Zanthoxylum cf. myriacanthum* Wall. ex Hk. f. and *Trichilia connaroides* (Wight & Arnott) (mean IVI=81.65, 26.28, 22.97 and 17.23, respectively).

Key words: *Dominance tree, Kha Nyou, Limestone Karst, Khammouane Province and Phou Hin Poun*

1. Introduction

The limestone karst in Lao PDR is distributed throughout country. The largest limestone karst located in central Lao People's Democratic Republic **(**Lao PDR), Khammouane province. Phou Hin Poun National Protected Area (PHP NPA), former called Khammouane Limestone Protected Area (KLPA). Limestone karsts are sedimentary rock outcrops that consist primarily of calcium carbonate (Clements *et al*., 2006). In Lao PDR, the limestone karst in northern is of Permian-Carboniferous age, but Jurassic limestone occurs locally at Luang Prabang Province, while in the central, Permo-Carboniferous limestone is very widespread (Kiernan, 2009).

PHP NPA is known as the habitat of Kha Nyou *Laonastes aenigmamus* (Jenkins *et al*., 2005; Khotpathoom *et al*., 2020), which is existing and only a representative of Diatomyidae (Flynn, 2007), while another has been extinct more than 11 million years ago and the significants primates such as southern white-cheeked gibbon *Nomascus siki* (Duckworth et al., 2010; Phiapalath et al., 2012; Van Tran et al., 2023) and Laotian langur *Trachypithecus laotum* (Souwideth et al., 2021). PHP NPA is also known as home of new and endemic species of wild animal such as limestone rat *(Saxatilomys paulinae)* (Musser et al., 2005), bare-faced bulbul *(Pycnonotus Hualon)* (Woxvold et al., 2009), an amphibian *(Rhacophorus spelaeus)*

(Orlov et al., 2009) and reptile (*Gekko khunkhamensis*) (Sitthivong et al., 2021). For the plants, at least four species was listed in endemic to Indochina (Cambodia, Lao and Vietnam) such as *Cynometra dongnaiensis* Pierre, *Jasminum vidalii* P.S.Green, *Memecylon chevalieri* Guillaumin and *Pothos gigantipes* Buchet ex P.C.Boyce. (Prosperi et al., 2017). However, the limestone habitat or ecology in PHP NPA is limited of study (Timmins, 1997; Steinmetz, 1998).

In PHP NPA, some previous researcher briefly described that the habitat was characterized by 2 main forest types of semis - evergreen forest and mixed deciduous forest. There is also patch of low bamboo-dominated secondary growth (Timmins, 1997). Steinmetz (1998) classified vegetation in PHP NPA into 5 sub forest types such as semi - evergreen forest, vine-bamboo forest, dry deciduous forest, mixed deciduous forest and wetlands. However, inventory of vegetation has not been undertaken yet. Thus, the objectives of this study were to distinguish the dominant trees which grown in the limestone karst habitat of Kha Nyou. The expected result in this study will be the fundamental inventory of limestone vegetation in PHP NPA. In addition, the basic information on tree dominance of Kha Nyou's habitat will be helpful for future study and management on habitat and diet of this vegetarian endemic rodent.

2. Materials and Methodology

2.1 Study area

The study was carried out at Mouang-doy Village, Thakhek District, Khammouane Province, Central Lao PDR. This village is known as the first study area of Kha Nyou (Jenkins *et al*., 2005), located at about 21 km north of Thakhek downtown (104˚46′-104˚52′E and 17˚31′-17˚34′N) and encompassed of 21 km^2 area. More than half of area overlapped with PHP NPA. The study area is located at one kilometer to the west of village (Figure 1) within 20 ha. In this study area was separated into 2 forest types such as limestone deciduous forest (9 ha) and semi - evergreen forest (11ha). The climate is tropical and the year is distinctly divisible into rainy season (April to September) and dry season (October to March). According to ten years of climate statistic from 2000 to 2009 of Thakhek Meteorological Station, the average annual rainfall is 2,509.86 mm and the average monthly of air temperatures within annual cycle ranges from 22.58-29.50°c. Semi-evergreen forest and deciduous forest is main plant community in this study area.

2.2 Plot sampling and analyzing

Plant study was carried out during April and June 2010 using stratified random sampling. Twenty 10x10 m sampling plots were placed randomly for separately each forest types (Ten plots for limestone deciduous forest and ten plots for semi - evergreen forest). All trees ≥ 3 m height were measured diameter at breast height (dbh) in all sampling plots and identified in the field. The unidentified trees were photographed and collected to identify at Herbarium of the Faculty of Forestry, National University of Laos. The botanical name was checked by using Lao Plant Name (Lemann et al. 2003; Newman et al., 2007; Inthakoun and Delang, 2008) and Thai Plant Names (Smitinand, 2001).

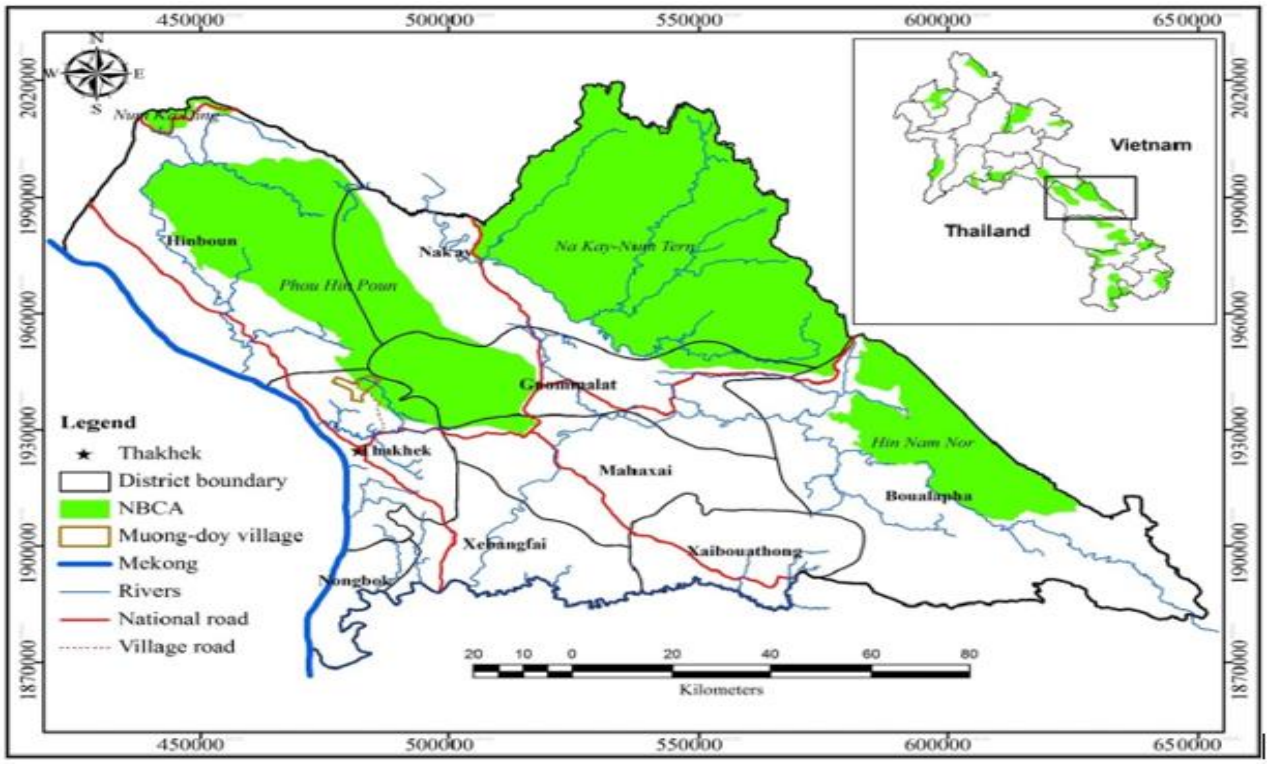

Figure 1: Target study Mouang-doy Village, Thakhek District and NPAs system in Lao PDR

The dominant trees and shrubs were determined using the Importance Value Indices (IVI) which has been used widely in previous researches (Dangol and Shivakti, 2001; Kunwar and Sharma, 2004; Sahu at el., 2012). The IVI was determined by adding the relative density (RD), relative dominance (RDo) and relative frequency (RF) (Mueller-Dombois and Ellenberg, 1974). The RD, RDo, RF and IVI were calculated by using the following formulas:

$$RD = \frac{\text{Density of a species}}{\text{Density of all species in sampling plots}} \text{ X } 100 \quad (1)$$

$$RDo = \frac{\text{Dominance of a species}}{\text{Dominance of all species in sampling plots}} \text{ X } 100 \quad (2)$$

$$RF = \frac{\text{Frequency of a species}}{\text{Frequency of all species in sampling plots}} \text{ X } 100 \quad (3)$$

$$IVI = RD + RDo + RF$$

3. Result

3.1 Limestone karst habitat

The majority of the land in Mouang-doy village is stunning limestone karst, with minimal flora in certain areas (limestone outcrops) but plentiful evergreen trees in others, such as the valley, sinkhole, and mountain base. The limestone karst of this area is home to Kha Nyou and a large number of limestone plants and animals due to the quantity of natural habitats.

Kha Nyou lives in limestone karst with complex crevices or caverns that include boulders varied in size up to numerous meters on steep slopes. The karst formation where Kha Nyou was captured, according to locals, was mostly covered with limestone deciduous trees. The semi-evergreen forest's edge, on the other hand, was confirmed. The limestone karst ecosystem provides safe cover for animals against natural predators and local hunters.

3.2 Vegetation

The vegetations of PHP NPA were briefly described in the 1990s. The limestone karst cliffs and slopes support a small plant community. The primary types of forest are semi-evergreen and mixed deciduous forest which call “Limestone deciduous forest”. Deciduous trees, possibly identified as Sterculia, are common. According to the findings of this study, semi-evergreen

forests are found where valleys are abundant, but mixed deciduous forests are found on karst where soils are scarce. There were 332 individual trees (1660 individuals/ha) spanning 30 families, 40 genera, and 54 species discovered. However, three of these species were only recently classified to a genus (appendix 01 and 02).

3.2.1 Semi-evergreen forest

The semi-evergreen forest community was found between 160-350 m above sea level (55% of total area) in this study location. Both evergreen and deciduous trees covered the ecosystem. Trees grow primarily near the base of mountains, valleys, and sinkholes when deep soil is found. A total of 206 individual trees (2,060 trees/ha) were found, representing 24 families, 32 genera, and 42 species (one species was only identified into genus). This forest type has a greater diversity of tree species than limestone deciduous forest.

3.2.2 Dominance tree

The semi-evergreen forest structure was divided into three stories in this study area. It appeared differently in the dominants tree for each based on the IVI values. *Hopea ferrea* Laness. and *Diospyros rubra* H. Lec. were the leading trees in the first story. *Memecylon ovatum* Sm., and *Walsura trichostemon* Miq. dominated the second story, while *Streblus asper* Lour., *Hydnocarpus ilicifolius* King and *Alphonsea boniana* Finet & Gagnep dominated the third. (Please see Appendix 1). However, because the semi-evergreen forest has been damaged by illegal logging, those prominent trees can be dynamic.

3.2.3 Limestone deciduous forest

This forest type occupied around 45% of the total area and ranged in elevation from 200 to 400 meters above sea level. The majority of the trees were growing on limestone cracks with some soil. During the dry season, they are usually leafless. The limestone deciduous forest is largely made up of deciduous trees and shrubs, but there are some evergreen trees and shrubs as well, such as *Diospyros rubra* H. Lec. and *Radermachera* sp. (Appendex 02). According to the findings of this investigation, 126 individual trees (1,260 trees/ha) comprising 20 families, 20 genera, and 25 species were discovered.

3.2.4 Dominance tree

The Limestone deciduous forest structure was divided into two stories in this study area. Based on the IVI values, it appeared differently in the dominant trees for each. *Sterculia pexa* Pierre, *Spondias pinnata* (L.F) Kurz, *Shorea siamensis* Miquel, *Terminalia calamansanay* (Blanco) Rolfe and *Bombax anceps* Pierre dominated in the first story, while *Sterculia pexa* Pierre, *Zanthoxylum cf. myriacanthum* Wall. ex Hk. f., *Trichilia connaroides* (Wight & Arnott) and *Dracaena cochinchinensis* (Lour) S.C. dominated in the second story (Appendix 2).

4. Discussion

There were several endemic species of plants and animals found in the limestone karst ecosystem. Research on the flora in the limestone karst at PHP NPA in Khammuoan Province, Lao PDR, has recently been limited (Timmins, 1997; Steinmetz, 1998; Khotpathoom, 2011; Souvannakhoummane et al., 2021). However, there has been some research on the fauna (Douangboupha et al., 2009, Hautier and Saksiri, 2009; Scopin et al., 2011, Khotpathoom et al., 2020), and some endemic and new species have been discovered (Jenkins et al., 2005; Musser et al., 2005; Woxvold et al., 2009; Orlov et al., 2009, Sitthivong et al., 2021).

The vegetations of PHP NPA are generally described in the 1990s (Timmins, 1997; Steinmetz, 1998). The two types of forest found at PHP NPA are Semi-evergreen and Mixed deciduous (also known as limestone deciduous), which are similar to the limestone karst found on the left bank of the Mekong River in Thailand (Nangngam et al., 2011). due to the short study period and inventory methods, the richness of vegetation species at PHP NPA in this study is much lower (54 species) than that of Limestone Mountain in Thung Salaeng Luang National Park

(129 species), Phitsanuloke Province of Thailand (Nangngam et al., 2011). In this study, there were differences in the diversity of tree species between the two types of forests. Due to significant differences in soil quality and nutritional status, semi-evergreen forests were discovered in greater numbers than limestone deciduous forests.

The dominating species at PHP NPA differ barely between the two types of forests. In semi-evergreen forest was dominated by *Hopea ferrea* Laness., *Diospyros rubra* H. Lec., *Memecylon ovatum* Sm. and *Walsura trichostemon* Miq. which different with the past research in 1990s dominated by Lagerstroemia (Timmins, 1997), while limestone deciduous forest was covered by *Sterculia pexa* Pierre, *Spondias pinnata* (L.F) Kurz, *Zanthoxylum* cf. *myriacanthum* Wall. ex Hk. f., and *Trichilia connaroides* (Wight & Arnott). Steinmetz et al. (1998) also showed that Sterculia combined with cycads was abundant in mixed deciduous forest.

The dominant evergreen trees in the limestone karst are likewise distinctive to each place. Evergreen trees in Doi Tung, northern Thailand dominated by *Capparis sabiifolia* Hk. F. & Th., *Glycosmis cochinchinensis* (Lour.) Pierre ex Engl., *Agapetes megacarpa* W.W. Sm., and *A. lobbii* Cl. (Maxwell, 2007). They appeared distinct in this study at PHP NPA, Khammouane Province, central Lao PDR. However, in the Catba National Park in northeast Vietnam, the main evergreen tree is quite similar to our study, such as *Diospyros* spp., *Streblus macrophyllus*, and *Streblus ilicifilius* (Jong-Won and Nguyen Nghia, 1998).

The karst limestone environment provides excellent natural predator protection (Scopin et al., 2011), but it is not as safe from local hunters (Vongsa, 2010; Khotpathoom et al., 2021). Illegal logging and non-timber forest product harvesting have had a significant impact on the ecosystem of limestone karst in the study site and its surrounds. Valleys and slightly slope were also cut and burned for agricultural purposes. Some large hardwoods were cut, including Hopea ferrea Laness and Afzelia xylocarpa (Kurz) Craib. These acts had an influence on both plant species diversity and animal survival. Human disturbance, according to Larpkern et al. (2011), can have an effect on the density of trees in a community.

5. Conclusion

The habitat of the Kha nyou, also known as the Laotian rock rat (*Laonastes aenigmamus*), was restricted to limestone karst with cracks and bounders. These areas were primarily covered by semi-evergreen forest and limestone deciduous forest. The dominating trees for each forest type differed slightly based on important value index. *Hopea ferrea* Laness., *Diospyros rubra* H. Lec., *Memecylon ovatum* Sm. and *Walsura trichostemon* Miq. dominated the semi-evergreen forest (IVI=51.70, 22.41, 18.65 and 14.55, respectively), while *Sterculia pexa* Pierre, *Spondias pinnata* (L.F) Kurz, *Zanthoxylum cf. myriacanthum* Wall. ex Hk. f. and *Trichilia connaroides* (Wight & Arnott) (IVI=81.65, 26.28, 22.97 and 17.23, respectively). Human activities have disturbed the semi-evergreen forest in this study area, which may have an impact on the structure of forest, particularly the dominant tree species.

6. Conflict interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

7. Acknowledgement

This study was supported by a grant from Thailand International Cooperation Agency (TICA). I would like to express my sincere thank you very much to the TICA.

8. References

Clements, R., Sodhi, N.S., Schilthuizen, M., & Peter, K.L.NG. (2006). Limestone karsts of Southeast Asia: Imperiled arks of biodiversity. *BioScience, 56*(9), 733-742.

Bunyavejchewin. S., La Frankie, J.V., Baker, P.J., Davies, S.J., & Ashton, P.S. (2009). *Forest Trees of Huai Kha Khaeng Wildlife*

Sanctuary, Thailand: Data from the 50-Hectare Forest Dynamics Plot. Graphicmania Co., Ltd., Bangkok.

Dango, D.R., & Shivakoti, G.P. (2001). Species composition and dominance of plant communities in Western Chitwan, Nepal. *NJ of Science and Technology* 3: 69-78.

Douangboupha, B., Khamphoukeo, K., Herbreteau, V., Cornette, R., Hugot, J.P., & Morand, S. (2009). New pieces of information about the Kha-Nyou, the recently discovered enigmatic rodent from the Lao PDR. *The Lao Journal of Agriculture and Forestry,* (20), 48-54.

Duckworth, J.W., Boonratana, R., Robichaud, W.G., & Timmins, R. J. (2010). A Review of François' Leaf Monkey Trachypithecus francoisi (sensu lato) in Lao PDR. *Primate Conservation*, *25*(1), 61–79. https://doi.org/10.1896/052.025.0111

Flynn, L.F. (2007). Origin and evolution of the Diatomyidae, with clues to paleoecology from the fossil record. *Bulletin of Carnegie Museum of Natural History* 39 (1): 173-181.

Hautier, L., & Saksiri, S. (2009). Masticatory muscle architecture in the Laotian rock rat Laonastes aenigmamus (Mammalia, Rodentia): new insights into the evolution of hystricognathi. *Journal of Anatomy*, 315: 401-410.

Inthakoun, L., & Delang, C.O. (2008). *Lao Flora. A Checklist of Plants Found in Lao PDR with Scientific and Vernacular names*. Lulu Enterprises, Inc. Morrisville, USA.

Jenkins, P.D., Kilpatrick, C.M., Robinson, M.F., & Timmins, R.J. (2005). Morphological and molecular investigations of a new family, genus and species of rodent (Mammalia: Rodentia: Hystricognatha) from Lao PDR. *Systematic and Biodiversity, 2*(4), 419-454.

Jong-Won, K., & Nguyen Nghia, T. (1998). Vegetation of the Catba National Park in Vietnam. *Korean J. Ecol*, *21*(2), 139-149.

Khotpathoom, T., Bhumpakphan, N., Sukmasuang, R., & Bumrungsri, S. (2011). *Home range and bibitat utilization of Kha Nyou (Laonastes aenigmamus Jenkins, Kilpatrick, Robinson & Timmins, 2005) in Phou Hin Poun national biodiversity conservation area, Central Lao PDR.* Kasetsart University, Bangkok, Thailand.

Khotpathoom, T., Vu, T. T., Bhumpakphan, N., Sukmasuang, R., & Bumrungsri, S. (2020). Using radiotelemetry to identify the home range and daily movement of a "living fossil": The Laotian rock rat (Laonastes aenigmamus). *Mammalian Biology*, *100*(4), 377–384. https://doi.org/10.1007/s42991-020-00039-5

Kiernan, K. (2009). Distribution and character of karst in the Lao PDR. *Acta Carsologica, 38*(1), 65-81.

Kunwa, R.M., & Sharma, S.P. (2004). Quantitative analysis of tree species in two community forests of Dolpa district, mid-west Nepal. *Himalayan Journal of Sciences, 2*(3), 23-28.

Larpkern, P., Totland, Q., & Moe, S.R. (2011). Do disturbance and productivity influence evenness of seedling, sapling and adult tree species across a semi-deciduous tropical forest landscape? *Oikos,* 120, 623-629.

Lemann, L., Greijmans, M., & Shenman, D. (2003). *Forest and Trees of the Central Highlands of Xieng Khouang, Lao P.D.R***.** DANIDA, Danish International Development Agency, Vientiane.

Maxwell, J.F. (2007). Vegetation of Doi Tung, Chiang Rai Province, Northern Thailand. *Maejo International Journal of Science and Technology, 1*(1), 10-63

Mueller-Dombois, D., & Ellenberg, H. (1974). *Aims and Methods of Vegetation Ecology*. John Wiley & Sons, New York.

Musser, G.G., Smith, A.L., Robinson, M.F., & Lunde, D.P. (2005). *Description of a new genus and species of Rodent (Murinae, Muridae, Rodentia) from the Khammouane Limestone National Biodiversity Conservation Area in Lao PDR*. American Museum Novitates. Available source: http://digitallibrary.amnh.org/dspace/handle/2246/5666, February 15, 2009.

Nangngam, P., Kridsanatorn, S., Wasun, P., Suchat, W., & Charat, C. (2011). Vegetation of Limestone Mountain in Thung Salaeng Luang National Park, Phitsanuloke Province. *NU Science Journal*, *8*(10), 72-86.

Newman, M., Ketphanh, S., Svengsuksa, B., Thomas, P., Khamphone, S., Lamxay, V., & Armstrong, K. (2007). *A checklist of the Vascular Plants of Laos PDR*. Royal Botanic Garden Edinburgh, Scotland, UK.

Orlov, N.L., Ghophanxay, S., Phimminith, T., & Phomphoumy, K. (2009). A new species of Rhacophorus GENUS (AMPHIBIA: ANURA: RHACOPHORIDAE: RHACOPHORINAE) from Khammouane Province, Lao PDR. *Russian Journal of Herpetology* 16 (4): 295-303.

Perez-Garcia, E.A., A.C. Sevilha, J.A. Meave and Scariot, A. (2009). Floristic differentiation in limestone outcrops of Southern Mexico and Central Brazil: A beta diversity approach. *Bol.Soc.Bot.Mex. 84: 45-58***.**

Phiapalath, P., Bousa, A., & Insua-Cao, P. (2012). *The status and distribution of Gibbons in Phou Hin Poun National Protected Area, Khammouane Province. Fauna & Flora International/IUCN Lao PDR., Vientiane Lao PDR.*

Prosperi, J., Lamxay, V., Hallé, F., Bompard, J.-M., Blanc, P., Ramesh, B.R., Ayyappan, N., & Cardinal, S. (2017). New records in the Flora checklists of Laos, resulting from a Survey of Phou Hin Poun national biodiversity conservation area. *edinburgh Journal of Botany*, *75*(1), 91–106. https://doi.org/10.1017/S0960428617 00035x

Sahu, S.C., Dhal, N.K., & Mohanty, R.C. (2012). Tree species diversity, distribution and population structure in a tropical dry deciduous forest of Malyagiri hill ranges, Eastern Ghats, India. *Tropical Ecology*, *53*(2), 163-168.

Scopin, A.E., Saveljev, A.P., Suntsova, N.A., Gnophanxay, S., Tikhonov, A.N., & Abramov, A.V. (2011). Digestive system of the Laotian rock rat *Laonastes aenigmamus* (Rodentia: Diatomyidae) from the evolutionary viewpoint. *Proceedings of the Zoological Institute RAS* 315 (1): 3-18.

Smitinand, T. (2001). *Thai Plant Names* (Second edition), The Forest Herbarium, Royal Forest Department, Thailand.

Sitthivong, S., Van Lo, O., Nguyen, T.Q., Thi Ngo, H., Khotpathoom, T., Le, M.D., Ziegler, T., & Luu, V.Q. (2021). A new species of the Gekko japonicus group (Squamata: Gekkonidae) from Khammouane Province, central Laos. *Zootaxa*, *5082*(6), 553–571. https://doi.org/10.11646/zootaxa.5082.6.3

Souvannakhoummane, K., Soulivanh, L., & Leonid, V.A. (2021). *Seven new species and seven new records of Begonia L.* (Begoniaceae) in the flora of Laos, Turczaninowia, *24*(2), 99-119.

Souwideth, J., Phiapalath, P., Thanh, H. D., Brakels, P., Van, T. P., & Luiselli, L. (2021). *Ecology and Conservation of the Laotian langur Trachypithecus laotum in a Protected Area of Laos* (Southeast Asia). *Diversity*, *13*(6), 231. https://doi.org/10.3390/d13060231

Steinmetz, R. (1998). *A Survey of Habitat and Mammals in and around Khammouane Limestone National Biodiversity Conservation Area***.** Rep. 1998. 45p.

Timmins, R.J. (1997). *Note on wildlife and Habitats in Khammouane Limestone National Biodiversity Conservation Area, Khammouane Province, Lao PDR*. Rep. 1994-1996. 27p.

Van Tran, D., Le, T.T., Vu, T.T., Nguyen, D.D., Khotpathoom, T., Van Phung, K., Tran, H.D., Van Le, N., & Le, T.C. (2023). A review on the status and modeling of suitable habitats of the southern white-cheeked gibbon. *Primates*. https://doi.org/10.1007/s10329-022-01047-4

Vongsa, U. (2010). *Distribution, Natural History and Threat of Kha Nyou (Laonastes aenigmamus).* M.S. Thesis, National University of Laos. (In Lao).

Woxvold, I.A., Ducworth, J.W., & Timmins, R.F. (2009). *An unusual new bulbul (Passeriformes: Pycnonotidae) from the limestone karst of Lao PDR*. Forktail, 25: 1-12.

Zhu, H., Wang, H., Li, B., & Sirirugsa, P. (2003). *Biogeography and florisic affinities of the limestone flora in Southern Yunnan, China*. Ann. Missouri Bot. Gard. 90, 444-465.

Appendix 01:

Importance Value Indices (IVI) tree community in Semi - evergreen ecosystem

Family	Botanical name	RD	RF	Rdo	IVI	Habit
Dipterocarpaceae	*Hopea ferrea* Laness.	5.83	6.96	38.92	51.70	T
Ebenaceae	*Diospyros rubra* H. Lec.	6.80	5.22	10.40	22.41	T
Melastomataceae	*Memecylon ovatum* Sm.	8.25	6.96	3.44	18.65	S
Moraceae	*Streblus asper* Luor.	10.19	5.22	2.74	18.15	S
Annonaceae	*Alphonsea boniana* Finet & Gagnep.	8.25	6.96	1.96	17.17	T
Meliaceae	*Walsura angulata* Craib	6.31	6.96	3.77	17.04	T
Meliaceae	*Walsura trichostemon* Miq.	6.31	5.22	3.02	14.55	T
Flacourtiaceae	*Hydnocarpus ilicifolia* King	4.85	3.48	6.06	14.39	T
Lythraceae	*Lagerstroemia calyculata* Pierre	4.37	5.22	2.59	12.18	T
Dipterocarpaceae	*Shorea siamensis* Miquel	0.97	1.74	5.64	8.35	T
Meliaceae	*Trichilia connaroides* (Wight & Arnott)	2.91	3.48	1.63	8.02	T
Fabaceae	*Afzelia xylocarpa* (Kurz) Craib	2.91	2.61	1.51	7.03	T
Euphorbiaceae	*Drypetes hoaensis* Gagnep.	1.94	3.48	0.71	6.13	T
Sapotaceae	*Mudhuca* sp.	3.40	1.74	0.85	5.99	T
Annacardiaceae	*Anacardium occidentale* L.	2.43	2.61	0.92	5.96	T
Moraceae	*Ficus altissima* Blume	1.46	1.74	2.67	5.86	S
Fabaceae	*Antheroporum glaucum* Z. Wei	2.43	2.61	0.26	5.30	T
Guttiferae	*Garcinia xanthochymus* Hook. f. ex T. Anderson	1.94	1.74	0.57	4.25	T
Apocynaceae	*Wrightia arborea* (Dennst.) Mabb.	1.94	1.74	0.26	3.94	S/T
Fabaceae	*Erythrina stricta* Boxb.	1.46	1.74	0.71	3.90	S/T
Lythraceae	*Lagerstroemia cf. villosa* Wall. Ex Kurz	1.94	1.74	0.17	3.85	T
Burseraceae	*Canarium subulatum* Guill.	0.49	0.87	2.26	3.62	T
Meliaceae	*Chukrasia tabularis* A. Juss.	0.49	0.87	2.26	3.62	T
Sterculiaceae	*Pterospermum diversifolium* Blume	0.97	0.87	1.67	3.51	T
Moraceae	*Streblus ilicifolius* (Vidal) Corner	1.46	1.74	0.24	3.43	S
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	0.97	1.74	0.31	3.02	T
Annonaceae	*Alphonsea tonkinensis* A. DC.	0.97	1.74	0.14	2.85	S/T
Fabaceae	*Saraca declinata* (Jack) Miquel	0.97	0.87	0.97	2.81	T
Verbenaceae	*Vitex tripinnata* (Loureiro) Merrill	0.49	0.87	0.59	1.94	T
Sterculiaceae	*Sterculia pallens* (Wall. ex King) Stearn	0.49	0.87	0.42	1.78	T

Myrtaceae	*Syzygium cinereum* (Kurz) Chantar. & J. Paren.	0.49	0.87	0.35	1.71	T
Datiscaceae	*Tetrameles nudiflora* R. Br. & Benn	0.49	0.87	0.26	1.61	T
Bignoniaceae	*Radermachera ignea* (Kurz) Steenis	0.49	0.87	0.26	1.61	S
Anacardiaceae	*Semecarpus cochinchinensis* Engl.	0.49	0.87	0.26	1.61	T
Sterculiaceae	*Sterculia parviflora* Roxb. Ex G.Don	0.49	0.87	0.21	1.57	S
Combretaceae	*Terminalia calamansanay* (Blanco) Rolfe	0.49	0.87	0.21	1.57	T
Ebenaceae	*Diospyros glandulosa* Lace	0.49	0.87	0.19	1.54	T
Dipterocarpaceae	*Hopea recopei* Pierre	0.49	0.87	0.19	1.54	T
Sonneratiaceae	*Duabanga grandiflora* (Roxb. Ex DC.) Walp.	0.49	0.87	0.14	1.50	T
Bombacaceae	*Bombax anceps* Pierre	0.49	0.87	0.12	1.47	T
Moraceae	*Ficus microcarpa* Linnaeus	0.49	0.87	0.12	1.47	S
Moraceae	*Ficus vasculosa* Wall. ex Mi.	0.49	0.87	0.05	1.40	S
Total		100	100	100	300	

Note: S= Shrub**,** ST= Shrubby Tree and T = Tree

Appendix 02:

Importance Value Indices (IVI) of different trees in the limestone deciduous forest

Family	Scientific Name	RD	RF	Rdo	IVI	Habit
Sterculiaceae	*Sterculia pexa* Pierre	26.19	13.33	42.13	81.65	T
Anacardiaceae	*Spondias pinnata* (L.f.) Kurz	4.76	6.67	14.85	26.28	T
Rutaceae	*Zanthoxylum cf. myriacanthum* Wall. ex Hk. f.	7.94	8.00	7.03	22.97	T
Dipterocarpaceae	*Shorea siamensis* Miquel	2.38	4.00	13.36	19.74	T
Meliaceae	*Trichilia connaroides* (Wight & Arnott)	7.14	6.67	3.42	17.23	T
Combretaceae	*Terminalia calamansanay* (Blanco) Rolfe	5.56	9.33	2.08	16.97	T
Dracaenaceae	*Dracaena cochinchinensis* (Lour) S.C. Chen	6.35	4.00	1.23	11.58	S/ST
Bombacaceae	*Bombax anceps* Pierre	4.76	5.33	2.57	12.66	T
Acanthaceae	*Xylycanthus Laotica* Aver. & S.K. Nguyen.	4.76	8.00	0.97	13.73	S
Apocynaceae	*Wrightia arborea* (Dennst.) Mabb.	5.56	4.00	1.27	10.82	T
Lauraceae	*Phoebe* sp.	3.17	5.33	0.82	9.33	S
Fabaceae	*Erythrina stricta* Boxb.	3.17	2.67	2.01	7.85	S/T
Araliaceae	*Schefflera arboricola* (Hayata) Merrill	2.38	2.67	2.27	7.32	T
Euphorbiaceae	*Euphorbia antiquorum* L.	2.38	4.00	0.48	6.86	S/ST
Sterculiaceae	*Sterculia pallens* Wall. ex Hochr.	2.38	2.67	0.86	5.90	S
Moraceae	*Ficus religiosa* L.	1.59	1.33	1.90	4.82	S
Verbenaceae	*Vitex tripinnata* (Loureiro) Merrill	1.59	1.33	0.93	3.85	T
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	1.59	1.33	0.48	3.40	T
Ebenaceae	*Diospyros rubra* H. Lec.	1.59	1.33	0.37	3.29	S/T
Melastomataceae	*Memecylon ovatum* Sm.	0.79	1.33	0.37	2.50	S
Moraceae	*Ficus microcarpa* Linnaeus	0.79	1.33	0.15	2.28	S
Moraceae	*Ficus vasculosa* Wall. ex Mi.	0.79	1.33	0.11	2.24	S
Meliaceae	*Walsura trichostemon* Miq.	0.79	1.33	0.11	2.24	T
Bignoniaceae	*Radermachera* sp.	0.79	1.33	0.11	2.24	S
Moraceae	*Ficus altissima* Blume	0.79	1.33	0.11	2.24	S
Total		100	100	100	300	

Note: S= Shrub**,** ST= Shrubby Tree and T = Tree