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Survey of Invasive Plants at Hin Nam No National Park, Khammoune Province, Laos

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Abstract: This paper represented the first survey of invasive plants at the Hin Nam No National Park, Khammoune province, Laos. We identified 33 invasive species among 78 alliance species. These invasive species cause an impact on the open habitats of the national park, mostly to the secondary evergreen scrubs, secondary semi-deciduous scrubs, secondary evergreen grasslands, secondary semi-deciduous grasslands, abandoned cultivated lands, residential areas, and sometimes to the regenerating evergreen forest or regenerating semi-deciduous forest. The worst impacting species that were first observed are Lantana (*Lantana camara*), Siam weed (*Chromolaena odorata*), Blackjack (*Bidens pilosa*). The medium-impacting species are Mysore thorn (*Biancaea decapetala*) and Billy goat weed (*Ageratum conyzoides*). This research provides foundational insights to the national park and local stakeholders about biological conservation and potential invasive plant controlling activities, such as focusing on controlling invasive plants in the borders of the national park. It is necessary to conduct a detailed study to identify exactly the impact of each species, including the impacted areas, the impacting pathway, and controlling methods. The research also recommends that Centre for Agriculture and Biosciences International (CABI) change the alliance status of 12 species to native and reconsider Blue porterweed (*Stachytarpheta jamaicensis*) as an alliance species.

Keywords: Hin Nam No, Invasive plant, Lantana, Siam weed, Blackjack, Leucaena, Mysore thorn, Billy goat weed.

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1. Introduction

An invasive species is a plant, fungus, or animal species that is not native to a specific location, and tends to spread to a degree that is believed to cause damage to the environment, human economy, or human health. So that, the invasive species have been noted by a lot of specialists all over the world and the common and biggest group of specialists is the Invasive Species Specialist Group (ISSG) - a global network of scientific and policy experts on invasive species organized under the auspices of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN) in 1994. The ISSG aims to reduce threats to natural ecosystems and the native species they contain by increasing awareness of invasive alien species and of ways to prevent, control, or eradicate them. Currently, the Global Invasive Species Database (GISD) is managed and published by ISSG, which has been using common of the world where an invasive has been showing for native distribution or alien/impacted range and experience to manage them at somewhere (ISSG, 2015). Besides that, in 2001, the Centre for Agriculture and Biosciences International (CABI) developed the Invasive Species Compendium (ISC) as an encyclopedic resource that draws together scientific information on all aspects of invasive species (CABI, 2022). The ISC is an online, open-access reference work covering the recognition, biology, distribution, impact, and management of the world's invasive plants and animals, together with GISD, people can identify whether any organism is an invader.

2. Invasive Records for Laos

According to a report on Invasive Alien Species in the Lower Mekong Basin (MWBP/RSCP, 2006) [1] and Pallewatta et al., (2003) [2], the legal document relevant to invasive and alliance species in Laos: Decree on Prohibition of Wildlife Trade (1986), Decree on the Management & Protection of Wild Animals (1989) Decree on establishment of National Protected Areas (1993) Quarantine Legislation (1994), Forest Law (1996), Water Resources Management Law (1996), Plant Appreciation Legislation (1996), Land Law (1997), Transportation Law (1997), Environment Protection Law (1999), Pesticide Law (2000), National Environment Action Plan and Bio-access draft legislation and the invasive plants was recorded for Laos including only 7 species as Swamp grass (*Echinochloa colonum*) on lowland rice production systems; Water hyacinth (*Eichhornia crassipes*) on slow-flowing rivers, stagnant water; Barnyard grass (*Echinochloa crusgalli*) on lowland rice production systems; Giant Mimosa (*Mimosa pigra*) on upland agricultural systems in northern provinces; Mile-a-minute (*Mikania micrantha*) and Crofton weed (*Ageratina adenophora*) on the northern highland areas of Lao PDR and Siam weed (*Chromolaena odorata*) in abandoned cultivation, along road sides. Currently, the data of ISC – CABI [3] records for Laos with 308 alliance plant species in Laos, among them, there are 3 invasives, including Siam weed (*Chromolaena odorata*), Water hyacinth (*Eichhornia crassipes*) and water primrose (*Ludwigia hyssopifolia*). Besides that, the data of ISSG [4] has recorded 25 plant invasive species impact on Laos. There is no record for Khammoune province in those data and lists.

3. Introduction to Hin Nam No

Hin Nam No[1] is a national park in Laos. It is a natural marvel that spans an area of 94,121 hectares in southeastern Laos. This biodiverse and stunningly beautiful protected zone shelters some of the planet's most spectacular, mysterious, and highly threatened biodiversity and harbors an array of ecosystems, including pristine forests, majestic waterfalls, and intricate cave systems such as the Xe Bang Fai Cave, the

[1] https://hinnamno.org/

largest documented active cave river in the world. Hin Nam No sits in the middle of the rugged Central Annamite Mountains that form the border between Vietnam and Laos. It shares its eastern border with the Natural World Heritage site "Phong Nha-Ke Bang" of Vietnam, and together, they form the world's largest contiguous limestone karst landscapes. The name "Hin Nam No" translates as "mountain crest, spiky as bamboo shoots" and is a testament to this rugged limestone forest landscape's signature sharp spires, formed by 300 million years of geology. Hin Nam No's to-date recorded 173 caves and its spectacular cliffs reach up to 300 meters from secluded, isolated habitats deep inside caves or in secluded valleys where animal species could evolve largely isolated from other populations. Hence, one of the defining features of Hin Nam No National Park is its high level of biodiversity. The National Park is home to an incredible range of species, including many that are found nowhere else on the Earth. These include rare and exotic birds, mammals, reptiles, and plants, making the area a true natural treasure. However, the park is not only a place of natural wonders. It is also a site of cultural and historical significance. The national park is home to several ethnic minority groups, each with unique traditions, customs, and ways of life. Come witness the rich cultural heritage of these communities and the deep connection between people and nature.

According to Leonid et al., [5], the vegetation of Hin Nam No include: i) Tropical seasonal (monsoon) lowland semideciduous broad-leaved forests on flatland with alluvial soils (at elevation 200–400 m a.s.l.); ii) Tropical seasonal (monsoon) lowland semideciduous broad-leaved forests on flatland with alluvial soils (at elevation 200–400 m a.s.l.); iii) Tropical seasonal (monsoon) lowland and submontane semideciduous and evergreen broad-leaved forests on sandstone (at elevation 400–1200 m a.s.l.); iv) Tropical seasonal (monsoon) montane evergreen broad-leaved, mixed and coniferous forests on sandstone (at elevation 1200–1400 m a.s.l.); v) Tropical seasonal (monsoon) lowland semideciduous and evergreen broad-leaved limestone forests (at elevation 250–500 m a.s.l.); and vi) Tropical seasonal (monsoon) dwarf wind formed semideciduous broadleaved limestone scrub on tops of limestone hills (at elevation 400–600 m a.s.l.). Besides that, the flora was also recorded as 75 families, 755 genera, and 1519 species. Based on previous data on the flora diversity of Hin Nam No, including data from Leonid et al., [6], Newman [7], Lamxay [8], we have counted and updated flora data for Hin Nam No as 1530 species, 955 genera, and 173 families of the vascular plants.

There are various ethnic groups living around the Hin Nam No NPA [10], such as Makong, Tri, Yoy, Phoutai, Kaleung, Vietic, and Salang/Kris. The population is considered not very high, being approximately 7,000 people from 22 villages. There are no villages within the protected area, but most of them are very close to the NP, and there might be more than 10,000 people who are beneficiaries of this protected area. The ethnic groups in the area with distinctive cultures include Salang/Kris in Khet Dou and Makong/Tri in Khet Taplao and Nongma. These groups live in relatively under-developed conditions, with high levels of illiteracy and a lack of sanitation. Most villagers rely on farming, gardening, collecting non-timber forest products (NTFPs), and scrap metal collection for their livelihoods. Slash and burn cultivation, which used to be practiced in Khet Taplao and Nongma is no longer allowed inside the protected area. Livestock raising is also an important contributor to household incomes, and livestock are considered living assets for villagers to sell when they need ready cash. Together with no management system in place, there is an over-harvesting of natural resources, so the current livelihoods pose a considerable risk to the biodiversity of the national park; some plant species are close to local extinction, such as Mai Doulai and Khetsana, and some wildlife species in the area are also highly threatened, such as pangolin, porcupine, some species of turtles, Bengal monitor lizards and it is also

making a chance for invasive species come in, bad impact to the native species and habitat.

4. Methods and Materials

4.1. Materials

Materials for this research includes referred botanical data from Hin Nam No National Park provided by Leonid et al., [6], Vichith Lamxay [8], and plant samples recorded in the field visit report from V. A. Tai recently (2023) [11] stored in the Department of Bio-Geography, Institute of Geography, Vietnam Academy of Science and Technology.

4.2. Methods

The methodology of surveillance of alien species was based on the common species biodiversity survey methods. A list of alien species is prepared before a field survey. The list, according to the GISD [4] and CABI [3] includes impacted/impacting species in Laos. As above mentioned, when a list of alliance plant species for Hin Nam No was built, based on CABI Training Materials, Invasive Species Compendium (ISC) - User Guide [12], the main invasive plant species for Hin Nam No would be identified.

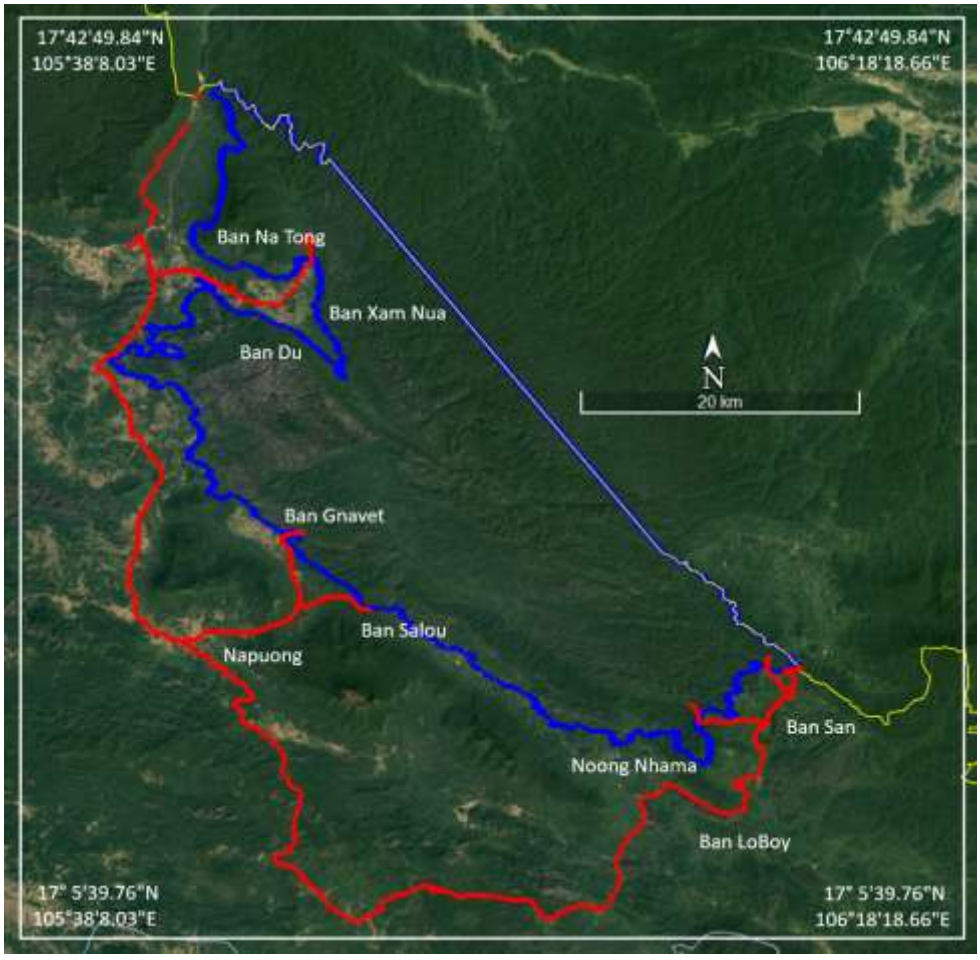

Figure 1. Transects and survey sites for field survey recorded by Gaia App and presented on Google Earth
Note: Red line - Transects; Blue line - Boundary of the national park;
Yellow line - International boundary (Viet Nam and Laos).

A field survey was planned based on the main ecological habitats of the site, and then, some transects as trails and roads were selected through almost all habitats, and it was available to assess any site as a potential habitat of invasive species from the trail or road. In this study, some transects and study sites were selected for the survey, including site 1: Napuong - Ban Loboy - Noong Nhama - Ban San - Viet Laos international boundary (3 transects from the village to the core area of the national park), site 2: Napuong - Gnavet - Ban Salou (1 transect on the boundary of the national park) and site 3: Ban Na Tong - Ban Du - Ban Sam Nua (2 transects, including 1 on the boundary of the national park and 1 to the core area of the national park), see detail on a map on Figure 1.

Plant sample collection: through the transect, the appearance of the plant was observed, and when the plant had fruits or flowers, it could be collected. We also focused on "100 of the World's Worst Invasive Alien Species" additional [12] to record their appearance at checking points. Use a camera to record botanical characteristics and their population. Species identification by morphological comparison method. According to the guidance of N. N. Thin (2004) [14], and CABI's guidance [12], the population of alliance species was observed and preliminary accessed in 1 of 5 categories as i) Absent - species appeared in limited places only, under positive control; ii) Non impacted - species random appeared in the wild, individuals have been not connected (population has been not established); iii) Low level - species appeared in the wild, the population has been established in limited areas, mostly in bare-lands; iv) Medium level - species appeared in the wild, the population has been established in wide areas but not harmful for the native species or habitat; and v) High level - species appeared in the wild, the population has been established in wide areas had given a harmful for the native species or habitat. The final assessment of the level of each species based on their general impact on all habitats of the research area would be used for discussion and conclusion.

5. Results and Discussion

5.1. List of Invasive Plants

Based on the plant list of Hin Nam No [11] with an update from a field survey in May - June and November - December 2022, combined with the data from GISD [4] and CABI-ISC [3], a list of alliance plants was created and presented at Table 1. In this table, 78 species belonging to 34 families were recorded as an alliance for the national park. It included 66 species that can be referred from the previous data of the national park's flora so there are 12 species first recorded for this flora, especially as Blackjack (*Bidens pilosa*) and Lantana (*Lantana camara*), the common invasive species, but has been not included to the flora's data of the national park. The field visit also recorded 42 alliance species. 78 species are mentioned as enhanced by the data of CABI-ISC, but one species was not mentioned alliance to Laos as Blue porterweed (*Stachytarpheta jamaincensis*, Figure 2), while 12 ones are listed as impacted by the data of GISD. In the list, there are only 2 species Giant Mimosa (*Mimosa pigra*) and Siam weed (*Chromolaena odorata*) mentioned in the National Environment Action Plan and Bio-access draft legislation, and the invasive plants were recorded for Laos [1] and only one species was mentioned as invasive for Laos from the data of ISSG [4] as Siam weed (*Chromolaena odorata*). Therefore, based on the species listed for the national park, 12 invasive plant species were recorded by the global data.

Table 1. List of alliance species found in Hin Nam No

No.	Alliance species				Database		(1)	(2)	(3)
	Latin name	Laos name	English name	Family	CABI	SSIG			
1	Achyranthes aspera L.	ໂຄຍງູ	Sevil's horsewhip	Amaranthaceae	EN		x	x	x
2	Adenanthera pavonina L.	ໝາກກ່ຳ	Red-bead tree	Fabaceae	EN		x		
3	Ageratum conyzoides L.		Billy goat weed	Asteraceae	EN		x	x	x
4	Albizia procera (Roxb.) Benth.	ສະຖ່ອນ	White siris	Fabaceae	EN		x		
5	Alternanthera sessilis (L.) R.Br. ex DC.	ໂຄຍງູ	Sessile joyweed	Amaranthaceae	EN	IM	x	x	x
6	Amaranthus spinosus L.	ຜັກຫົມໜາມ	Spiny amaranth	Amaranthaceae	EN		x	x	x
7	Angiopteris evecta (G.Forst.) Hoffm.	ກູດກີບມ້າ	King fern	Marattiaceae	EN		x		
8	Annona muricata L.	ໝາກຂຽບ	Soursop	Annonaceae	EN		x		
9	Arenga pinnata (Wurmb) Merr.	ຕາວ	Sugar palm	Arecaceae	EN		x		
10	Bambusa bambos (L.) Voss	ໄຜ່ບ່າ	Giant thorny bamboo	Poaceae	EN		x		
11	Barleria cristata L.		Philippine violet	Acanthaceae	EN		x		
12	Biancaea decapetala (Roth) O. Deg.	ns	Mysore thorn	Fabaceae	EN	IM	x	x	x
13	Bidens pilosa L.		Blackjack	Asteraceae	EN			x	x
14	Bixa orellana L.		Annatto	Bixaceae	EN		x	x	x
15	Broussonetia papyrifera (L.) Vent.		Paper mulberry	Moraceae	EN		x		
16	Buddleja asiatica Lour.	ດອກຄັບ	Dog tail	Scrophulariaceae	EN		x	x	x
17	Capsicum annuum L.	ໝາກເຜັດ	Bell pepper	Solanaceae	EN		x		
18	Cascabela thevetia (L.) Lippold		Yellow oleander	Apocynaceae	EN			x	
19	Cassia fistula L.	ດອກຄູນ	Indian laburnum	Fabaceae	EN		x		
20	Cassia javanica L.		Pink shower	Fabaceae	EN		x		
21	Centella asiatica (L.) Urban	ຜັກຫນອກ	Asiatic pennywort	Apiaceae	EN		x		
22	Chromolaena odorata (L.) R.M.King & H.Rob.	ຫຍ້າຜະລັ້ງ	Siam weed	Asteraceae	EN	IM	x	x	x
23	Camphora officinarum Nees		Camphor laurel	Lauraceae	EN			x	
24	Clerodendrum japonicum (Thunb.) Sweet	ພວງພີ	Pagoda flower	Lamiaceae	EN		x		

No.	Alliance species				Database		(1)	(2)	(3)
	Latin name	Laos name	English name	Family	CABI	SSIG			
25	Cocos nucifera L.	ໝາກພ້າວ	Coconut	Arecaceae	EN		x		
26	Colocasia esculenta (L.) Schott	ບອນ	Taro	Araceae	EN		x		
27	Crassocephalum crepidioides (Benth.) S.Moore	ຍົນເຫາະ	Redflower ragleaf	Asteraceae	EN		x		
28	Crotalaria retusa L.		Rattleweed	Fabaceae	EN		x		
29	Cynodon dactylon (L.) Pers.	ຫຍ້າແຜງ	Bermuda grass	Poaceae	EN		x	x	x
30	Derris elliptica (Wall.) Benth.		Tuba root	Fabaceae	EN		x		
31	Digitaria fuscescens (J.Presl) Henrard		Yellow crabgrass	Poaceae	EN		x		
32	Dioscorea bulbifera L.		Air potato	Dioscoreaceae	EN	IM	x		
33	Diplazium esculentum (Retz.) Sw.	ຜັກກູດຂາວ	Vegetable fern	Athyriaceae	EN		x	x	x
34	Eleusine indica (L.) Gaertn.		Goose grass	Poaceae	EN		x	x	x
35	Epipremnum pinnatum (L.) Engl.		Centipede tonga vine	Araceae	EN	IM	x		
36	Euphorbia hirta L.		Garden spurge	Euphorbiaceae	EN		x		
37	Ficus benjamina L.	ດື່ອ	Weeping fig	Moraceae	EN		x		
38	Ficus microcarpa L.f.	ດື່ອ	Indian laurel tree	Moraceae	EN	IM	x		
39	Ficus religiosa L.	ໂພໄຊ	Sacred fig tree	Moraceae	EN		x		
40	Flemingia strobilifera (L.) W.T.Aiton	ໜອນໜ່າຍ	Wild hops	Fabaceae	EN			x	
41	Gmelina arborea Roxb.		Candahar	Lamiaceae	EN		x		
42	Heliotropium indicum L.	ດອກງວງຊ້າງ	Indian heliotrope	Bignoniaceae	EN		x	x	x
43	Imperata cylindrica (L.) P.Beauv.	ຫຍ້າຄາ	Cogon grass	Poaceae	EN	IM	x		
44	Ipomoea aquatica Forssk.	ຜັກບົ້ງ	Swamp morning-glory	Convolvulaceae	EN		x		
45	Ixora finlaysoniana Wall. ex G.Don	ດອກເຂັ້ມຂາວ	White jungle flame	Rubiaceae	EN			x	
46	Jasminum multiflorum (Burm. f.) Andrews	ມະລິປ່າ	Star jasmine	Oleaceae	EN		x		
47	Jatropha gossypiifolia L.		Bellyache bush	Euphorbiaceae	EN			x	

No.	Alliance species				Database		(1)	(2)	(3)
	Latin name	Laos name	English name	Family	CABI	SSIG			
48	Lagerstroemia indica L.		Indian crape myrtle	Lythraceae	EN			x	
49	Lagerstroemia speciosa (L.) Pers.		Pride of India	Lythraceae	EN			x	
50	Lantana camara L.		Wild-sage	Verbenaceae				x	x
51	Leersia hexandra Sw.		Southern cut grass	Poaceae	EN		x	x	x
52	Leucaena leucocephala (Lam.) de Wit	ກະຖິນ	Leucaena	Fabaceae	EN	IM	x	x	x
53	Litsea glutinosa (Lour.) C.B.Rob.	ມໍ່ ມໍ່ເມັ່ນ	Indian laurel	Lauraceae	EN		x	x	x
54	Melastoma malabathricum L.	ເອນອ້ຳ	Banks melastoma	Melastomataceae	EN		x	x	x
55	Melia azedarach L.	ກະເດົ່າຊ້ຳ	Chinaberry	Meliaceae	EN		x	x	x
56	Mimosa pigra L.	ໜາມຂີ້ແຮດ	Giant sensitive plant	Fabaceae	EN		x	x	x
57	Mimosa pudica L.	ໜາມຫຍ້າຫຍຸບ	Sensitive plant	Fabaceae	EN		x	x	x
58	Murraya paniculata (L.) Jack		Orange jessamine	Rutaceae	EN			x	
59	Ocimum gratissimum L.	ກະເພົາ	African basil	Lamiaceae	EN		x	x	x
60	Paederia foetida L.		Skunkvine	Rubiaceae	EN	IM	x	x	x
61	Passiflora foetida L.	ເຄືອຜັກບ້ວງ	Red fruit passion flower	Passifloraceae	EN		x	x	x
62	Phragmites australis (Cav.) Trin. ex Steud.	ອ້ໍ້ນ້ອຍ	Common reed	Poaceae	EN		x		
63	Pistia stratiotes L.	ຜັກຈອກ	Water lettuce	Araceae	EN		x		
64	Pluchea indica (L.) Less.	ໜາດຂາວ	Indian camphorweed	Asteraceae	EN		x		
65	Pteris vittata L.		Chinese ladder brake fern	Pteridaceae	EN		x		
66	Pterocarpus macrocarpus Kurz	ດู่	Burma padauk	Fabaceae	EN		x		
67	Rhodomyrtus tomentosa (Aiton) Hassk.		Downy rose-myrtle	Myrtaceae	EN	IM	x	x	x
68	Senna alata (L.) Roxb.	ດອກຂີ້ລັ່ງໃຫຍ່	Candle bush	Fabaceae	EN		x	x	
69	Sesbania grandiflora (L.) Poiret	ດອກແຄ	Sesbania	Fabaceae	EN			x	
70	Sterculia foetida L.	ໜາກຂຶ້ມໂຮງ	Java olive	Sterculiaceae	EN		x	x	x
71	Stachytarpheta jamaicensis (L.) Vahl		Blue porterweed	Verbenaceae	EN		x	x	x

No.	Alliance species				Database		(1)	(2)	(3)
	Latin name	Laos name	English name	Family	CABI	SSIG			
72	Syzygium cumini (L.) Skeels.	ໝາກຫວ່າ	Black plum	Myrtaceae	EN	IM	x	x	x
73	Tagetes erecta L.	ດອກດາວເຮືອງ	Mexican marigold	Asteraceae	EN		x		
74	Tamarindus indica L.	ໝາກຂາມ	Tamarind	Fabaceae	EN		x	x	x
75	Thunbergia fragrans Roxb.	ໜາມເໝ້ຂາວ	Whitelady	Acanthaceae	EN		x	x	x
76	Toona ciliata M. Roem.	ຍົມຫອມ	Toon	Meliaceae	EN		x	x	x
77	Urena lobata L.	ບໍ່ຂີ້ອ້ົນ	Caesar weed	Malvaceae	EN		x	x	x
78	Vitex trifolia L.		Simple-leaf chaste-tree	Lamiaceae	EN		x	x	x
Total					**78**	**12**	**66**	**42**	**33**

Note: EN: Enhance; IM: Impacted; (1) Referred; (2) Field record; (3) Invasive.

According to the data of CABI-ISC [3], *Pterocarpus macrocarpus* was listed as enhanced to Laos, it is a wrong record because, in the detailed description of the species, *Pterocarpus macrocarpus* was recorded as a native species to Laos and also to Indochina. It is similar to *Adenanthera pavonina, Ageratum conyzoides, Albizia procera, Alternanthera sessilis, Amaranthus spinosus, Angiopteris evecta, Annona muricata, Arenga pinnata, Bambusa bambos, Barleria cristata, Bixa orellana, Broussonetia papyrifera, Buddleja asiatica, Biancaea decapetala, Capsicum annuum, Cascabela thevetia, Cassia fistula, Cassia javanica, Centella asiatica, Chromolaena odorata, Cinnamomum camphora, Clerodendrum paniculatum, Cocos nucifera, Colocasia esculenta, Crassocephalum crepidioides, Crotalaria retusa, Derris elliptica, Digitaria fuscescens, Dioscorea bulbifera, Diplazium esculentum, Epipremnum pinnatum, Ficus benjamina, Ficus microcarpa, Ficus religiosa, Flemingia strobilifera, Gmelina arborea, Imperata cylindrica, Ipomoea aquatica, Ixora finlaysoniana, Jasminum multiflorum, Phragmites australis, Pistia stratiotes, Pluchea indica, Pteris vittata, Senna alata, Sesbania grandiflora.* According to the data of CABI-ISC [3], ISSG [4] and Illustrations Flora of Vietnam [15], the Flore du Laos et du Vietnam [16], Flore générale de l'Indo-Chine [17], The World Flora Online Plant List [18], those species were recorded as native to Southeast Asia or at least to Indochina, that means, those species have been not recorded as alliance to Laos. It is recommended that the CABI-ISC should remove them and add Blue porter weed (*Stachytarpheta jamaicensis*, Figure 2) in the alliance plant species list of Laos.

Figure 2. Blue porterweed (*Stachytarpheta jamaincensis*) in the core area, needs to be add in CABI's data as alliance to Laos.

In addition, 5 alliance species were also recorded for the flora of the national park that were not mentioned before, including *Cascabela thevetia* (Apocynaceae), *Jatropha gossypiifolia* (Euphorbiaceae), *Lagerstroemia indica* and *L. speciosa* (Lythraceae) and *Murraya paniculata*

(Rutaceae). All of them are ornamental species, that were introduced to plant somewhere at the national park's buffer zone and tourist and headquarters places and have been not naturally growing in the wild.

Table 2. Impact level recorded for invasive in habitats of Hin Nam No

No.	Latin name	Impacted levels in Habitats								
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Achyranthes aspera	-	-	-	-	L	-	L	L	L
2	Ageratum conyzoides	-	-	-	-	L	-	M	L	M
3	Alternanthera sessilis	-	-	-	-	-	-	L	L	L
4	Amaranthus spinosus	-	-	-	-	L	-	L	L	L
5	Biancaea decapetala	L	-	M	L	M	L	M	L	M
6	Bidens pilosa	L	-	M	H	M	L	H	M	H
7	Bixa orellana	-	-	-	L	-	L	L	L	L
8	Buddleja asiatica	-	-	L	-	L	-	L	L	L
9	Chromolaena odorata	L	-	H	M	H	M	H	M	H
10	Cynodon dactylon	-	-	L	-	L	-	L	L	L
11	Diplazium esculentum	L	-	L	-	L	-	L	-	L
12	Eleusine indica	-	-	-	-	L	-	L	-	L
13	Heliotropium indicum	-	-	L	-	L	-	L	-	L
14	Lantana camara	-	-	H	M	H	M	H	M	H
15	Leersia hexandra	-	-	L	-	L	-	L	L	L
16	Leucaena leucocephala	-	-	-	-	-	-	L	L	L
17	Litsea glutinosa	-	-	L	-	L	-	L	-	L
18	Melastoma malabathricum	-	-	L	L	L	L	L	-	L
19	Melia azedarach	L	-	L	-	L	-	L	L	L
20	Mimosa pigra	-	-	L	L	L	L	L	L	L
21	Mimosa pudica	-	-	L	-	L	-	L	L	L
22	Ocimum gratissimum	-	-	L	L	L	L	L	L	L
23	Paederia foetida	-	-	L	-	L	-	L	-	L
24	Passiflora foetida	-	-	L	-	L	-	L	-	L
25	Rhodomyrtus tomentosa	-	-	L	-	L	-	L	-	L
26	Sterculia foetida	-	-	L	-	L	-	-	-	L
27	Stachytarpheta jamiacensis	-	-	L	L	L	L	L	-	L
28	Syzygium cumini	-	-	L	-	L	-	-	-	L
29	Tamarindus indica	L	-	L	L	L	-	L	L	L
30	Thunbergia fragrans	L	-	L	-	L	-	L	-	L
31	Toona ciliata	-	L	-	L	-	L	-	L	L
32	Urena lobata	-	-	L	L	L	L	L	L	L
33	Vitex trifolia	L	-	L	-	L	-	L	-	L

Notes: Habitats including (1) Regenerating evergreen forest; (2) Regenerating semi-deciduous forest; (3) Secondary evergreen scrubs; (4) Secondary semi-deciduous scrubs; (5) Secondary evergreen grasslands; (6) Secondary semi-deciduous grasslands; (7) Abandoned cultivated lands; (8) Residential areas; (9) Whole National Park. Impact levels include L - Low level; M - Medium level; H - High level.

Through the field survey, 46 alliance species have been found as random grows in the study area, mostly controlled areas such as gardens, and cultivated areas, or only individual plants were found growing in open habitats that seem to have no negative impact on the habitat or species, some of them were introduced to the study area as planting trees for ornamental,

vegetable or fruit such as *Annona muricata, Capsicum annuum, Cassia javanica, Cinnamomum camphora, Cocos nucifera,* etc. Finally, 33 species were found that naturalized in one or more habitats inside or surrounding the national park, which belongs to 19 families of vascular plants and among them, the Fabaceae family has the largest number of species (6 species), see Table 2.

5.2. Record Impacts on the Habitats

Habitats were recorded for the Hi Nam No national park area including: Primary evergreen monsoon and moisture broad-leaved, primary semi-deciduous monsoon and dry forest, secondary evergreen monsoon and moisture broad-leaved forest (regenerating evergreen forest), secondary semi-deciduous monsoon and dry forest (regenerating semi-deciduous forest), secondary evergreen monsoon and moisture scrubs (secondary evergreen scrubs) after logging or road construction, secondary semi-deciduous monsoon and dry scrubs (secondary semi-deciduous scrubs) after logging or road construction, secondary evergreen monsoon and moisture grasslands (secondary evergreen grasslands) after grazing, secondary semi-deciduous monsoon and dry grasslands (secondary semi-deciduous grasslands) after grazing, secondary evergreen monsoon and moisture scrubs or grassland on abandoned cultivated lands (abandoned cultivated lands) and artificial vegetation (Residential areas) including gardens, cultivating fields (mostly for wet rice, cassava, corn).

Among that, invasive species were found in 8 habitats (Table 2) including i) Regenerating evergreen forest; ii) Regenerating semi-deciduous forest; iii) Secondary evergreen scrubs; iv) Secondary semi-deciduous scrubs; v) Secondary evergreen grasslands; (vi) Secondary semi-deciduous grasslands; vii) Abandoned cultivated lands; and viii) Residential areas. They were not found naturalized in the primary forest.

Based on the observation, the impact of invasive species was recorded as 3 types, including low impact (L) when the species exit in the wild but population density is low, individuals have been not concentrated growing; medium impact (M) when the population exists in the wild and individuals tend to grow close together but it does not completely prevent moving, food looking or any normal behaviors of the native animals or does not prevent to dispersal, germination of the native plants; and high impact (H) when the population exists in the wild and make a severe impact to the human life, native habitat, species, including completely prevent moving, food looking or any normal behaviors of the native animals or preventing to dispersal, germination of the native plants.

Table 2. Location recorded for the main invasive species of Hin Nam No

No	Species	Date	Location		Impacted level
			Latitude	Longtitude	
1.	Ageratum conyzoides	29-Nov-22	17°14'48.1"N	106°09'10.5"E	Medium
2.	Ageratum conyzoides	30-Nov-22	17°16'27.3"N	106°10'20.7"E	Medium
3.	Ageratum conyzoides	02-Dec-22	17°20'28.7"N	105°49'56.4"E	Medium
4.	Ageratum conyzoides	03-Dec-22	17°31'03.1"N	105°49'40.4"E	Medium
5.	Ageratum conyzoides	03-Dec-22	17°31'27.0"N	105°49'23.7"E	Medium
6.	Ageratum conyzoides	04-Dec-22	17°33'45.1"N	105°50'35.6"E	Medium
7.	Ageratum conyzoides	05-Dec-22	17°32'24.6"N	105°47'18.6"E	Medium
8.	Biancaea decapetala	02-Dec-22	17°19'31.1"N	105°52'33.5"E	Medium
9.	Biancaea decapetala	04-Dec-22	17°33'22.5"N	105°50'40.2"E	Medium

No	Species	Date	Location		Impacted level
			Latitude	Longtitude	
10.	Bidens pilosa	29-Nov-22	17°14'49.3"N	106°08'53.9"E	Medium
11.	Bidens pilosa	29-Nov-22	17°16'52.6"N	106°11'01.6"E	High
12.	Bidens pilosa	30-Nov-22	17°15'01.2"N	106°09'58.1"E	High
13.	Bidens pilosa	30-Nov-22	17°16'48.1"N	106°10'00.6"E	High
14.	Bidens pilosa	02-Dec-22	17°19'34.0"N	105°50'33.5"E	High
15.	Bidens pilosa	03-Dec-22	17°31'03.1"N	105°49'40.4"E	Medium
16.	Bidens pilosa	03-Dec-22	17°31'27.0"N	105°49'23.7"E	Medium
17.	Bidens pilosa	04-Dec-22	17°33'22.5"N	105°50'40.2"E	High
18.	Bidens pilosa	04-Dec-22	17°33'45.1"N	105°50'35.6"E	Medium
19.	Bidens pilosa	05-Dec-22	17°32'24.6"N	105°47'18.6"E	Medium
20.	Chromolaena odorata	29-Nov-22	17°14'45.0"N	106°08'21.7"E	High
21.	Chromolaena odorata	29-Nov-22	17°14'49.1"N	106°07'44.7"E	High
22.	Chromolaena odorata	29-Nov-22	17°16'52.6"N	106°11'01.6"E	High
23.	Chromolaena odorata	02-Dec-22	17°19'31.1"N	105°52'33.5"E	High
24.	Chromolaena odorata	02-Dec-22	17°19'47.7"N	105°51'51.5"E	High
25.	Chromolaena odorata	02-Dec-22	17°19'54.1"N	105°50'07.3"E	High
26.	Chromolaena odorata	03-Dec-22	17°31'03.1"N	105°49'40.4"E	Medium
27.	Chromolaena odorata	04-Dec-22	17°33'22.5"N	105°50'40.2"E	Medium
28.	Chromolaena odorata	04-Dec-22	17°33'45.1"N	105°50'35.6"E	High
29.	Chromolaena odorata	04-Dec-22	17°34'44.2"N	105°49'41.6"E	Medium
30.	Chromolaena odorata	05-Dec-22	17°32'24.6"N	105°47'18.6"E	High
31.	Lantana camara	29-Nov-22	17°14'49.1"N	106°07'44.7"E	High
32.	Lantana camara	29-Nov-22	17°16'52.6"N	106°11'01.6"E	High
33.	Lantana camara	30-Nov-22	17°15'01.2"N	106°09'58.1"E	High
34.	Lantana camara	30-Nov-22	17°16'48.1"N	106°10'00.6"E	High
35.	Lantana camara	02-Dec-22	17°19'54.1"N	105°50'07.3"E	Medium
36.	Lantana camara	02-Dec-22	17°20'28.7"N	105°49'56.4"E	Medium
37.	Lantana camara	03-Dec-22	17°31'03.1"N	105°49'40.4"E	Medium
38.	Lantana camara	03-Dec-22	17°31'27.0"N	105°49'23.7"E	Medium
39.	Lantana camara	04-Dec-22	17°33'22.5"N	105°50'40.2"E	Medium
40.	Lantana camara	04-Dec-22	17°33'45.1"N	105°50'35.6"E	Medium
41.	Lantana camara	05-Dec-22	17°32'24.6"N	105°47'18.6"E	Medium

Through the observation in the field, location of the main impacting species was present in the Table 3. Therefore, the impact of 3 species was recorded at impacted high-level invasive species, including Lantana (*Lantana camara*, Figure 3), Siam weed (*Chromolaena odorata*, Figure 4), and Blackjack (*Bidens pilosa*, Figure 5) and 2 others in impacted medium-level as Mysore thorn (*Caesalpinia decapetala*), and Billy goat weed (*Ageratum*

conyzoides) while 26 other species was recorded as low impacted level. Among them, Blackjack population was observed as expanding from dozens of square meters (5 sites, medium impacted level) to hundreds of square meters (6 sites, high impacted level) in a total of 11 surveyed sites and this species was also observed impacting in 8 habitats (high impacted in 3 habitats, medium impact in 3 other habitats and low impact in 2 ones, see detailed in Table 3) of the national park. The situation is similar with Lantana, considering in drier habitats (semi-deciduous forest, scrubs, and grasslands), the population of Lantana was widespread (4 in high impacted and 3 in medium impacted). Especially with Siam weed, the species was named for the terrestrial lands of Laos and Thailand also, exit and expanding to all sites, high impacting to 4 habitats, medium impacting to 3 habitats, and low impacting to 1 habitat, the population was mostly in hundreds of square meters. The populations of Billy goat weed and Mysore thorn were observed in a dozen square meters, in limited habitats as abandoned cultivated lands, scrubs, and residential areas outside of the national park's boundary (Billy goat) or all the opening areas on the boundary of the national park (Mysore thorn).

Figure 3. Lantana (*Lantana camamra*, left) and their wide population (right) in the core area of the national park.

Figure 4. Siam weed (*Chromolena odorata*) is very common at secondary habitats of the national park, including in core (left) and buffer zone (right) areas.

Figure 5. Blackjack (*Bidens pilosa*, left) and their wide population (right) in the core area of the national park.

6. Conclusion

By surveying invasive plants at the Hin Nam No National Park, Khammoune province, Laos, 33 invasive species among 78 alliance species were identified and reported. These invasive species cause an impact to the open habitats of the national park, mostly to the secondary evergreen scrubs, secondary semi-deciduous scrubs, secondary evergreen grasslands, secondary semi-deciduous grasslands, abandoned cultivated lands, residential areas, and sometimes to the regenerating evergreen forest or regenerating semi-deciduous forest. The worst impacting species that were first observed are Lantana (*Lantana camara*), Siam weed (*Chromolaena odorata*), Blackjack (*Bidens pilosa*). The medium-impacting species are Mysore thorn (*Biancaea decapetala*) and Billy goat weed (*Ageratum conyzoides*). This research provides foundational insights to the national park and local stakeholder about biological conservation and potential invasive plant controlling activities, such as focusing on controlling invasive plants in the borders of the national park. It is necessary to conduct a detailed study to identify exactly the impact of each species, including the impacted areas, the impacting pathway, and controlling methods. The research also recommends that Centre for Agriculture and Biosciences International (CABI) change the alliance status of 12 species to native and reconsider Blue porterweed (*Stachytarpheta jamaicensis*) as an alliance species.

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