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Research paper

Assemblage and Activity Frequency of Forest Mammals Across Different Landscape Types and Disturbance Levels

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ABSTRACT

This study aims to explore the effects of landscape type and human disturbance level on the composition and activity frequency of forest mammals in Taiwan's low- to mid-altitude areas. The study areas are the Lienhuachih Experimental Forest in the mosaic landscape of central Taiwan and the Fushan Experimental Forest in the continuous natural forest in the northeast. From February 2023 to March 2024, 20 sampling sites were set up in the two forest areas for infrared automatic camera monitoring, and the occurrence frequency (Occurrence Index [OI]) and species composition, as well as the seasonal changes in species OI values, were analyzed. During the study period, a total of 17,931 mammal images were recorded, and a total of 15 species of wild mammals from five orders and 10 families were confirmed. Non-parametric two-way ANOVA showed that the OI values of eight common mammals were significantly different among regions. *Sus scrofa taivanus*, *Paguma larvata*, and *Callosciurus erythraeus thaiwanensis* had higher OI values in Lienhuachih, indicating that these animals preferred the mosaic landscape of Lienhuachih. In addition, *Prionailurus bengalensis* with conservation values was only recorded in Lienhuachih, indicating that the area had critical habitat potential. Forest species, such as *Muntiacus reevesi micrurus*, *Capricornis swinhoe*, *Macaca cyclopis*, and *Melogale subaurantiaca* had significantly higher OI values in Fushan, indicating the importance of continuous natural forests for these species. Some species showed heterogeneous responses to human disturbance, such as *Cal. erythraeus thaiwanensis* preferring high-disturbance environments, while *S. scrofa taivanus* tended to use low-disturbance areas. Most species showed no obvious seasonal activity changes; only *Mel. subaurantiaca* in Lienhuachih had significant different OI values between seasons (summer and autumn). During the study period, *Martes flavigula chrysospila* and *Rusa unicolor swinhoii* were recorded for the first time in Fushan, indicating that the species at higher altitudes had the potential to spread to medium and low altitudes, and their ecological impacts deserve attention. Overall, this study pointed out that landscape type and degree of disturbance have a significant impact on the species composition and habitat use of mammals. Future conservation strategies should consider

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the different ecological needs of species, combine long-term monitoring and habitat management, and improve the habitat sustainability and biodiversity protection of low- to mid-altitude forest mammals.

Keywords: Infrared camera trap, Occurrence index, Lienhuachih Experimental Forest, Fushan Experimental Forest.

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INTRODUCTION

Mammals play crucial ecological roles as indicators, mobile organisms, and apex or mesopredators, making them highly responsive to environmental change and human disturbance (Taig-Johnston et al. 2017). Long-term monitoring provides essential insights into population dynamics, activity patterns, and habitat use; helps identify early signs of biodiversity decline; and informs conservation and habitat-management decisions (Lindenmayer et al. 2022). Systematic, long-term monitoring thus forms the foundation for understanding mammal–environment interactions.

Mammalian distribution and activity are strongly influenced by landscape characteristics (Lindenmayer et al. 1999, Presley et al. 2019). While overall forest cover is important, spatial configuration, continuity, and heterogeneity have even stronger effects on species diversity (Bowers and Matter 1997, Brodie et al. 2015, Magioli et al. 2016). Continuous natural forests generally support stable populations of forest-dependent species, whereas diverse land usage, fragmented forest or mosaic landscapes may restrict species requiring larger intact habitat connectivity but can also provide habitat opportunities for some species.

Beyond physical landscape attributes, human disturbance is another key factor affecting mammals. Recreational activities, such as hiking and tourism, can alter wildlife’s spatial and temporal habitat use (Kangas et al. 2010), reduce survival and reproductive success (Baudains and Lloyd 2007), and ultimately lead to population decline (Bejder et al. 2006). Therefore, comparing mammalian assemblage and activity patterns across landscapes and disturbance gradients is fundamental for informing conservation strategies and achieving a balance between wildlife protection and human activities.

This study focuses on two low- to mid-elevation forest sites in Taiwan that differ markedly in landscape structure and management history: Lienhuachih Experimental Forest in the hilly areas of central Taiwan and Fushan Experimental Forest in the northeast. Lienhuachih exhibits a mosaic landscape shaped by historical land use, comprising natural broadleaf forests and a typical mid-elevation forest ecosystem in central Taiwan. By contrast, Fushan lies within the continuous natural forest of the Xueshan Range, is managed at a level comparable to a protected area, and is known for its high wildlife activity. Although both sites fall within similar elevation ranges, they represent distinct forest landscape types, providing ideal conditions for examining how landscape structure influences mammal communities.

Within the two forests, subzones with differing levels of disturbance can be identified, such as natural forests versus plantation or botanical garden. Using camera-trap data and statistical analyses, this study examines mammalian assemblage, occurrence frequency, and seasonal activity variation across landscape types and disturbance levels. The goal is to determine whether mosaic landscapes can support generalist or conservation-important species, assess the ecological value of continuous natural forests for forest-dependent mammals, and evaluate species-specific responses to disturbance and habitat type to support future habitat management and wildlife conservation strategies.

MATERIALS AND METHODS

Study areas

The research was conducted in the Lienhuachih Research Center and the Fushan Research Center of the Taiwan Forestry Research Institute. The Lienhuachih Experimental Forest (hereafter "Lienhuachih") covers 460 ha, located at 576–925 m elevation, with a mean annual temperature of 21℃ and mean annual precipitation of 2,200 mm. Of this area, 269 ha consist of one of the most intact remaining natural broadleaf forests in the low- to mid-elevation region of central Taiwan. The Fushan Experimental Forest (hereafter "Fushan") covers 1,097.9 ha at 400–1,400 m elevation, with a mean annual temperature of 18.5℃ and mean annual precipitation of 4,125 mm. The southern portion of the forest includes the Hapen Nature Reserve. In Lienhuachih, two sampling zones representing different levels of disturbance were established: (1) Natural Forest Zone: Low human disturbance, consisting of broadleaf forests along the Xinshan forest road, dominated by Fagaceae, Lauraceae, and Theaceae species (Chang et al. 2012). (2) Plantation Zone: High human disturbance, consisting mainly of conifer plantations and secondary succession forests around Huopeikeng Mountain, Da-Ziran Farm, and the Medicinal Plant Garden. Planted conifers include *Calocedrus formosana* (Florin) Florin and *Cunninghamia lanceolata* (Lamb.) Hook. Below the canopy, natural regeneration has occurred, with dominant species, such as *Randia cochinchinensis* (Lour.) Merr., *Engelhardtia roxburghiana* Wall., and various Fagaceae and Lauraceae species (Lee PH, pers. comm.). Similarly, two zones were designated in Fushan: (1) Natural Forest Zone (Hapen Nature Reserve): Low human disturbance, consisting of dominant floodplain tree species, such as *Ficus erecta* var. *beecheyana* (Hook. & Arn.) King and *Phoebe formosana* (Hayata) Hayata. Slopes and uplands are dominated by *Litsea acuminata* (Blume) Sa.Kurata, *Symplocos theophrastifolia* Siebold & Zucc., *Itea parviflora* Hemsl., and *Machilus thunbergii* Siebold & Zucc. (Lu et al. 2010). (2) Botanical Garden Zone: High human disturbance, consisting of the tree exhibition area, forest exploration area, ethnobotanical garden, and gymnosperm trail. Dominant canopy species include *E. roxburghiana*, *Castanopsis cuspidata* var. *carlesii* f. *sessilis* (Hemsl.) T.Yamaz., *Helicia formosana* Hemsl., *M. thunbergii*, *L. acuminata*, *Schefflera octophylla* (Lour.) Harms, and *Pasania harlandii* (Hance *ex* Walp.) Rehder (Lin et al. 1995).

From a landscape perspective, Lienhuachih is characterized by a mosaic of forest patches and agricultural land, with relatively dense roads and natural broadleaf forests remaining as fragmented patches. By contrast, Fushan consists of a continuous natural forest with only a single access road and limited artificial structures concentrated around the botanical garden.

Survey methods

The survey period was from February 2023 to March 2024. In each of the four sampling areas, five sampling sites were selected for camera-trap installation (Figure 1). Sampling site elevation ranged from 614–750 m, with distances between sampling sites > 300 m. Within each sampling sites, five camera sampling points were established and surveyed in rotation, with distances between sampling points > 30 m. Each sampling point was monitored for approximately two months before the camera was retrieved for memory card and battery replacement, after which the camera was moved to the next sampling point.

Two brands of infrared camera traps were used in this study: Browning (BTC-8E-HP5, BTC-5DCL) and Bushnell (CORE DS-4K NO GLOW). Their basic functions were comparable. Cameras were installed at a height of approximately 1–1.5 m with a downward angle targeting the ground 1.5–3 m away from the camera's center view. Depending on the model, cameras recorded either ~10-second videos or

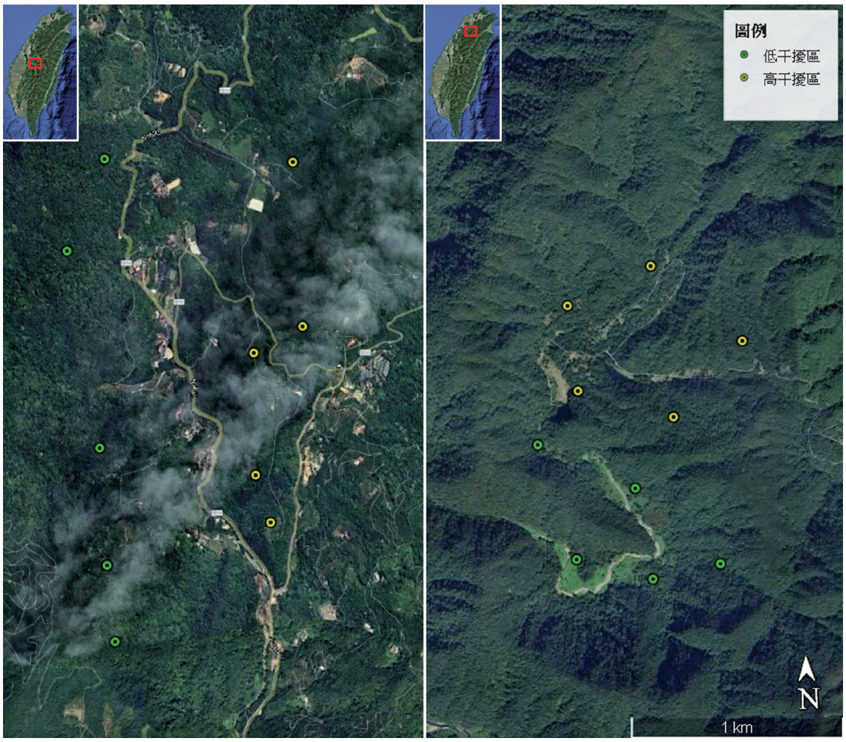

Figure 1. Locations of survey sites in the Lienhuachih Experimental Forest (left) and Fushan Experimental Forest (right). Green circles indicate low-disturbance areas, and yellow circles indicate high-disturbance areas.

three rapid-fire still images. All retrieved images were examined manually for species identification. Each recognizable species captured was counted as a valid detection. To avoid overestimating occurrences caused by the same individual lingering in front of the camera, images appearing within 30 minutes and not distinguishable as different individuals were considered repeated detections and excluded, with only the first detection retained. If multiple individuals appeared simultaneously, the image with the highest count was used as the valid detection. For each sampling period, camera results were standardized to an Occurrence Index (OI) per 1,000 hr, representing the relative activity frequency of each species, calculated as follows (Pei 1998):

$$\text{OI} = \left(\frac{\text{Number of valid detections of a species at a sampling point}}{\text{Camera's operating hours at that sampling point}}\right) \times 1{,}000 \text{ hr}$$

Data analysis

The OI of each sampling site was obtained by averaging the five camera sampling results. Using R statistical software (version 4.4.3) and the rcompanion package, the “scheirerRayHare” function was applied to perform a non-parametric two-way ANOVA (Scheirer-Ray-Hare test, an extended Kruskal-Wallis test) to examine differences in the major species among survey regions and disturbance levels.

For the two experimental forests, the OI values of major species were calculated for each of the four sampling areas using monthly data. Seasonal comparisons of OI values were then conducted separately for each forest (spring: March–May; summer: June–August; autumn: September–November; winter: December–February). Using the “kruskal.test” function in R, non-parametric multi-sample median tests (Kruskal-Wallis tests) were performed to assess seasonal differences in OI values. When significant differences were detected ($p < 0.05$), post-hoc analyses (Dunn’s test) were conducted using the “dunnTest” function in the Fisheries Stock Analysis (FSA) package (version 0.9.6), with Bonferroni correction applied to adjust *p*-values for multiple comparisons.

RESULTS

Mammal assemblage: During the study period, camera traps captured 17,931 mammal images, of which 15,921 were valid. A total of 15 wild mammal species from five orders and 10 families were recorded, excluding domestic dogs and unidentifiable Muroidea, Soricidae, and Chiroptera. Different in mammalian assemblage between Lienhuachih and Fushan are shown in Table 1. Lienhuachih cameras operated for 2,764 trap days, recording 11 identifiable mammal species (excluding domestic dogs). Mean OI values from highest to lowest belonged to Formosan reeves’s muntjac (*Muntiacus reevesi micrurus*, 45.57 ± 26.10), Formosan wild boar (*Sus scrofa taivanus*, 5.44 ± 4.80), Formosan red-bellied squirrel (*Callosciurus erythraeus thaiwanensis*, 3.05 ± 2.48), masked palm civet (*Paguma larvata*, 2.71 ± 1.36), ferret-badger (*Melogale subaurantiaca*, 2.71 ± 1.98), Formosan crab-eating mongoose (*Urva urva formosana*, 1.96 ± 1.75), Taiwanese macaque (*Macaca cyclopis*, 1.28 ± 1.51), Formosan pangolin (Manis pentadactyla pentadactyla, 0.31 ± 0.15), Leopard cat (*Prionailurus bengalensis*, 0.15 ± 0.15), Formosan sambar (*Rusa unicolor swinhoii*, 0.06 ± 0.14), and Formosan serow (*Capricornis swinhoe*i, 0.03 ± 0.06); additionally, unidentifiable groups included Muroidea (1.94 ± 1.71), Soricidae

Table 1. Mean occurrence index of mammals (number of effective animal detections / working hrs × 1,000 hrs) in each sampling site of Lienhuachih and Fushan Experimental Forests.

Order	Species	Chinese name	Lienhuachih			Fushan		
			Plantation	Natural forest	Mean	Botanical garden	Natural forest	Mean
			OI (n = 5)	OI (n = 5)	OI (n = 10)	OI (n = 5)	OI (n = 5)	OI (n = 10)
Artiodactyla	*Capricornis swinhoei*	臺灣野山羊	0.00 ± 0.00	0.05 ± 0.07	0.03 ± 0.06	4.94 ± 4.00	6.55 ± 2.17	5.75 ± 3.15
	Muntiacus reevesi micrurus	山羌	39.07 ± 17.90	52.06 ± 33.27	45.57 ± 26.10	88.84 ± 34.51	100.49 ± 43.65	94.66 ± 37.64
	Rusa unicolor swinhoii	水鹿	0.00 ± 0.00	0.11 ± 0.19	0.06 ± 0.14	0.08 ± 0.18	0.05 ± 0.07	0.07 ± 0.13
	Sus scrofa taivanus	野豬	2.76 ± 2.14	8.13 ± 5.40	5.44 ± 4.80	0.23 ± 0.12	1.25 ± 0.32	0.74 ± 0.58
Carnivora	*Canis lupus familiaris*	家犬	0.09 ± 0.14	0.08 ± 0.12	0.09 ± 0.12	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	Prionailurus bengalensis	石虎	0.20 ± 0.13	0.11 ± 0.17	0.15 ± 0.15	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	Urva urva formosana	食蟹獴	2.20 ± 1.75	1.71 ± 1.92	1.96 ± 1.75	1.29 ± 0.52	0.90 ± 0.53	1.10 ± 0.53
	Melogale subaurantiaca	鼬獾	3.12 ± 2.34	2.29 ± 1.70	2.71 ± 1.98	8.70 ± 5.86	8.22 ± 7.44	8.46 ± 6.32
	Martes flavigula chrysospila	黃喉貂	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.05 ± 0.12	0.05 ± 0.12	0.05 ± 0.11
	Paguma larvata	白鼻心	3.32 ± 1.42	2.10 ± 1.11	2.71 ± 1.36	0.48 ± 0.71	0.28 ± 0.22	0.38 ± 0.51
	Viverricula indica	麝香貓	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	5.58 ± 2.91	4.72 ± 2.57	5.15 ± 2.63
Chiroptera	--	蝙蝠類	0.11 ± 0.06	0.05 ± 0.10	0.08 ± 0.09	0.19 ± 0.20	0.08 ± 0.19	0.14 ± 0.19
Pholidota	*Manis pentadactyla pentadactyla*	穿山甲	0.30 ± 0.18	0.31 ± 0.15	0.31 ± 0.15	0.17 ± 0.18	0.25 ± 0.26	0.21 ± 0.22
Primates	*Macaca cyclopis*	臺灣獼猴	0.37 ± 0.67	2.19 ± 1.61	1.28 ± 1.51	7.46 ± 3.68	9.03 ± 5.45	8.24 ± 4.46
Rodentia	*Callosciurus erythraeus thaiwanensis*	赤腹松鼠	4.62 ± 2.67	1.49 ± 0.81	3.05 ± 2.48	1.28 ± 0.42	0.29 ± 0.20	0.79 ± 0.61
	Petaurista lena	白面鼯鼠	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.05 ± 0.12	0.03 ± 0.08
	Petaurista grandis	大赤鼯鼠	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.06	0.00 ± 0.00	0.01 ± 0.04
	Muroidea	鼠類	2.85 ± 1.43	1.02 ± 1.54	1.94 ± 1.71	2.35 ± 1.02	3.10 ± 0.31	2.73 ± 0.82
Soricomorpha	Soricidae	鼩鼱類	0.46 ± 0.53	0.05 ± 0.12	0.26 ± 0.42	0.09 ± 0.18	0.24 ± 0.27	0.16 ± 0.23

Note: Values for the sampling sites are mean ± standard deviation.

(0.26 ± 0.42), and Chiroptera (0.08 ± 0.09). Fushan cameras operated for 3,308 trap days, recording 14 identifiable mammal species. OI values from highest to lowest belonged to Formosan reeves's muntjac (94.66 ± 37.64), ferret-badger (8.46 ± 6.32), Taiwanese macaque (8.24 ± 4.46), Formosan serow (5.75 ± 3.15), small Indian civet (*Viverricula indica*, 5.15 ± 2.63), Formosan crab-eating mongoose (1.10 ± 0.53), Formosan red-bellied squirrel (0.79 ± 0.61), Formosan wild boar (0.74 ± 0.58), masked palm civet (0.38 ± 0.51), Formosan pangolin (0.21 ± 0.22), Formosan sambar (0.07 ± 0.13), Formosan yellow-throated marten (*Martes flavigula chrysospila*, 0.05 ± 0.11), white giant flying squirrel (*Petaurista lena*, 0.03 ± 0.08), and red giant flying squirrel (*Petaurista grandis*, 0.01 ± 0.04); additionally, unidentifiable groups included Muroidea (2.73 ± 0.82), Soricidae (0.16 ± 0.23), and Chiroptera (0.14 ± 0.19).

Occurrence frequency

After excluding species with fewer than 30 detections–Formosan sambar, leopard cat, Formosan yellow-throated marten, white giant flying squirrel, red giant flying squirrel, Soricidae, Chiroptera, and domestic dogs–non-parametric two-way ANOVA results for 11 species are shown in Table 2. Across regions, eight species showed significant differences in OI values, with higher values in Lienhuachih for Formosan wild boar, masked palm civet , and Formosan red-bellied squirrel, and higher values in Fushan for Formosan reeves's muntjac, Formosan serow, Taiwanese macaque, ferret-badger, and small Indian civet; no regional differences were observed for Formosan crab-eating mongoose, Formosan pangolin, and Muroidea. Regarding disturbance levels within regions, Formosan wild boar preferred low-disturbance habitats with significant OI difference whereas Formosan red-bellied squirrel preferred high-disturbance habitats with significant OI difference. No significant interaction effects were observed for any of the results.

Seasonal variation

After excluding species, such as Formosan sambar, seasonal OI comparisons for 11 species are shown in Table 3. At Fushan, no mammal species exhibited significant seasonal differences. At Lienhuachih, Formosan crab-eating mongoose and ferret-badger showed significant seasonal variation; however, post-hoc tests revealed no significant pairwise differences for Formosan crab-eating mongoose. Consequently, the only species showing clear seasonal difference was ferret-badger, with the lowest OI in summer and the highest in autumn.

DISCUSSION

This year-long camera-trap survey compared two experimental forests at similar elevations but with contrasting landscape configurations. The results revealed notable differences in mammal assemblage, activity frequency, and seasonal dynamics. The two sites did not share identical species lists: Leopard cat was not detected in Fushan, whereas Lienhuachih lacked detections of small Indian civet, Formosan yellow-throated marten, red giant flying squirrel and white giant flying squirrel. The two flying squirrel species are generally difficult to detect using camera traps and are thus not discussed further. At Lienhuachih, Formosan wild boar, masked palm civet, and Formosan red-bellied squirrel exhibited significantly higher OI values than in Fushan, suggesting that these three species readily adapt to agricultural

Table 2. Comparison of the occurrence index (number of effective animal detections / working hrs × 1,000 hrs) of major mammals in relation to area and disturbance level between the Lienhuachih and Fushan Experimental Forests.

Order	Species	Chinese name	Lienhuachih		Fushan		Scheirer-Ray-Hare test			
			Plantation	Natural forest	Botanical garden	Natural forest	Area		Disturb.	
			OI (n = 5)	OI (n = 5)	OI (n = 5)	OI (n = 5)	H	p-value	H	p-value
Artiodactyla	*Capricornis swinhoei*	臺灣野山羊	0	0	3.25	6.19	15.26	**< 0.001**	0.55	0.458
	Muntiacus reevesi micrurus	山羌	35.36	48.33	85.36	121.55	8.48	**0.004**	0.32	0.571
	Sus scrofa taivanus	野豬	2.28	10.00	0.19	1.09	10.62	**0.001**	3.88	**0.049**
Carnivora	*Urva urva formosana*	食蟹獴	1.61	0.96	1.64	0.83	0.70	0.404	1.13	0.289
	Melogale subaurantiaca	鼬獾	3.86	1.95	6.87	6.13	8.26	**0.004**	0.63	0.427
	Paguma larvata	白鼻心	3.08	1.85	0.13	0.29	13.23	**< 0.001**	0.47	0.495
	Viverricula indica	麝香貓	0	0	6.04	3.63	16.31	**< 0.001**	0.08	0.777
Pholidota	*Manis pentadactyla pentadactyla*	穿山甲	0.00	0.00	0.10	0.20	1.29	0.256	0.46	0.496
Primates	*Macaca cyclopis*	臺灣獼猴	0	2.29	7.38	6.77	13.23	**< 0.001**	0.97	0.325
Rodentia	*Callosciurus erythraeus thaiwanensis*	赤腹松鼠	5.38	1.38	1.07	0.27	8.51	**0.004**	5.70	**0.017**
	Muroidea	鼠類	2.54	0.25	2.56	3.02	1.46	0.226	0.46	0.496

Note: Statistical analysis was conducted using the Scheirer-Ray-Hare test, a non-parametric two-way ANOVA. Mammals' occurrence indices (OI) are shown as medians.

mosaic landscapes. All three are commonly regarded as agricultural pests: Wild boar rooting on rhizomes and tubers, while masked palm civet and red-bellied squirrel feed on fruit crops. The availability of orchards and farmlands in mosaic landscapes may increase food resources and local population densities. By contrast, Fushan - a large, contiguous natural broadleaf forest - supported higher OI values for Formosan reeves's muntjac, Formosan serow, Taiwanese macaque, and ferret-badger. The feeding ecology of these species helps explain this pattern: Formosan reeves's muntjac and Formosan serow primarily consume leaves of dicotyledonous plants (Liang 2006, Jiang et al. 2008), while Taiwanese macaque relies heavily on fruits and foliage (Su 1993, Chang 1999); such resources are most diverse and abundant in natural forests. Notably, Taiwanese macaque, despite being a major agricultural pest, did not show elevated abundance in Lienhuachih's agricultural mosaic, suggesting that the mosaic structure of this landscape does not consistently benefit macaques or that local disturbances do not favor higher abundance. For ferret-badger, whose primary diet consists of earthworms and small invertebrates

Table 3. Seasonal variation in the occurrence index (number of effective animal detections / working hrs × 1,000 hrs) of major mammals in the Lienhuachih and Fushan Experimental Forests.

Order	Species	Chinese name	Lienhuachih OI Spring (n = 6)	Lienhuachih OI Summer (n = 6)	Lienhuachih OI Autumn (n = 6)	Lienhuachih OI Winter (n = 5)	Kruskal-Wallis test (p value)	Fushan OI Spring (n = 6)	Fushan OI Summer (n = 6)	Fushan OI Autumn (n = 6)	Fushan OI Winter (n = 6)	Kruskal-Wallis test (p value)
Artiodactyla	*Capricornis swinhoei*	臺灣野山羊	0	0	0	0	0.588	2.58	4.21	2.38	3.48	0.195
	Muntiacus reevesi micrurus	山羌	20.29	28.23	24.51	21.32	0.714	45.57	57.38	45.49	93.49	0.126
	Sus scrofa taivanus	野豬	1.83	1.94	2.79	2.85	0.239	0.18	0.25	0.62	0.27	0.721
Carnivora	*Urva urva formosana*	食蟹獴	0.75[a]	1.56[a]	0.56[a]	1.57[a]	**0.041**	0.81	0.57	0.57	0.37	0.751
	Melogale subaurantiaca	鼬獾	1.36[ab]	0.21[b]	2.47[a]	1.66[ab]	**0.016**	5.38	4.16	2.84	3.46	0.161
	Paguma larvata	白鼻心	1.48	1.84	1.02	2.02	0.725	0.20	0.13	0.10	0.11	0.509
	Viverricula indica	麝香貓	0	0	0	0	-	1.53	2.94	2.62	3.47	0.067
Pholidota	*Manis pentadactyla pentadactyla*	穿山甲	0.20	0.00	0.14	0.00	0.677	0.00	0.11	0.14	0.10	0.583
Primates	*Macaca cyclopis*	臺灣獼猴	0.26	0.42	1.40	0.00	0.590	2.71	5.63	4.61	2.94	0.126
Rodentia	*Callosciurus erythraeus thaiwanensis*	赤腹松鼠	2.53	1.39	1.31	1.62	0.547	0.34	0.09	0.17	0.26	0.371
	Muroidea	鼠類	0.58	0.71	0.58	0.09	0.602	1.22	0.42	0.97	1.29	0.191

Note: Statistical analysis was performed using the Kruskal-Wallis test, followed by Dunn's post-hoc test for pairwise comparisons. Different letters indicate significant differences ($p < 0.05$). Mammals' occurrence indices (OI) are shown as medians.

(Chuang 1994, Tai 2021), the extensive natural forest of Fushan likely provides more stable habitat and food availability. However, because central Taiwan is a rabies-endemic area for ferret-badger, the significantly lower OI in Lienhuachih may also reflect disease impacts.

Additionally, the survey revealed the presence of free-roaming dogs at Lienhuachih, whereas none were detected at Fushan. It has been well documented that free-roaming dogs prey on small mammals, such as Formosan reeves's muntjac, leopard cat, small Indian civet, Formosan pangolin, ferret-badger, and masked palm civet, and can impact the activity of wild carnivores (Ho et al. 2025). The potential effects of dogs on wildlife in Lienhuachih warrant further evaluation. Although the OI values for free-roaming dogs were not particularly high in this study, continued monitoring is recommended given the presence of multiple protected species in the area. Long-term assessment should include population and interspecific dynamics.

Most species exhibited stable OI values

across seasons, suggesting that short-term fluctuations in wild mammal populations are relatively minor, and seasonal migrations are less pronounced than in other taxa, such as birds. The only exception was ferret-badger at Lienhuachih, which displayed significantly higher OI in autumn compared to summer, a pattern not synchronized with that of Fushan, where OI was lowest in autumn. This highlights the need for extended monitoring to gain a better understanding of seasonal patterns.

Below we provide additional notes on the distribution and habitat adaptability of key species under different landscape types and disturbance levels.

1. Leopard cat

Within the 25-hectare forest dynamics plot of Lienhuachih, where the Taiwan Forestry Research Institute has continuously monitored natural broadleaf forests using camera traps, leopard cat has been consistently recorded from 2015 to 2024 (Lee PH, pers. comm.), confirming that this area represents a suitable habitat for the species. In the current survey, leopard cats were detected at six camera stations, occupying both undisturbed broadleaf forests dominated by Lauraceae and Fagaceae and disturbed mixed plantations of conifer and naturally regenerating broadleaf trees. These results suggest that leopard cat is capable of utilizing a diversity of forest types. The species is primarily distributed in the low-elevation foothill forests of Miaoli, Taichung, and Nantou (Weng 2021), typically inhabiting rolling hills with mosaic forest covers and relatively low road density (Lin et al. 2016). In Nantou, leopard cat has been observed in forest types with lower canopy closure and bamboo-broadleaf mixtures (Farng 2016), which is consistent with our findings that the species can adapt to disturbed plantations with mixed broadleaf trees. Nonetheless, the limited extent of suitable habitats, often located on private land and under ongoing development pressure, highlights the importance of habitat conservation (Liu and Lin 2016). Consequently, both the natural broadleaf and mixed conifer-broadleaf forests of Lienhuachih provide stable forest cover within an agricultural forest mosaic, underlining their conservation significance. Long-term monitoring of population dynamics and activity hotspots is recommended, alongside measures to enhance habitat connectivity and manage the surrounding environment. By contrast, leopard cat has only recently been recorded sporadically in Yilan at Dajiaoxi Forest (Chong et al. 2023), and none were detected at Fushan, likely due to the presence of a large, contiguous natural forest rather than mosaic habitats.

2. Formosan wild boar

Abundance was higher at Lienhuachih compared to Fushan. Wild boar exhibits strong dispersal ability and high reproductive potential, rendering it less susceptible to the effects of habitat fragmentation or forest loss (Virgós 2002). Its diet is highly diverse; Chao and Fang (1988) identified 60 food items through hunter interviews, encompassing seeds of forest trees, roots, stems, leaves, grains, miscellaneous crops, fruits, vegetables, animal matter, and carrion. The mosaic landscape at Lienhuachih, which includes agricultural fields, orchards, and forests, likely provides abundant and varied food resources. This is consistent with findings from the Iberian Mediterranean region, where wild boar effectively exploited agricultural forest mosaics (Virgós 2002). Moreover, Meriggi and Sacchi (2001) highlighted that both food availability and environmental cover are key determinants in habitat selection.

Despite a preference for mosaic landscapes, our study revealed that wild boar avoids highly disturbed areas. This likely reflects differential perceived risk across habitat types. For example, in Hainan Datian Nature Reserve, wild boar selects feeding sites with lower concealment but prefer well-concealed, less-disturbed sites for resting (Teng et al. 2007). Our study suggests that, Formosan wild boar may forage short-term in food-rich but high-risk areas, such as agricultural fields or edges of botanical gardens, while using low-disturbance natural broadleaf forests for longer-term shelter and refuge.

3. Masked palm civet

Relative abundance at Lienhuachih was substantially higher than at Fushan (2.71 vs. 0.38), indicating that foothill mosaic landscapes with multiple land-use types fulfill habitat requirements. Although dietary studies in Taiwan are limited, research from Japan and Mainland China has indicated that the species is omnivorous, with plant-based foods consisting predominantly of fruits (Torii 1986, Zhou et al. 2008). The surrounding landscape at Lienhuachih includes orchards and scattered fruit trees, providing an abundant food supply. Our study further found that local human disturbance did not reduce the OI of masked palm civet; in fact, OI values were higher in disturbed areas than in natural forest at both sites, although not significantly affected. This pattern aligns with previous studies (Cheng and Wang 1993, Chen et al. 2009, Chiang et al. 2012) and corresponds with recent observations of masked palm civet expanding into urban areas (Lim 2023).

4. Formosan red-bellied squirrel

Relative abundance was significantly higher at the mosaic landscape in Lienhuachih compared to Fushan (3.05 vs. 0.79), and it was the only species in this study exhibiting a significant positive response to disturbance. Formosan red-bellied squirrel appears tolerant of human-managed environments and associated changes in soil, vegetation, fauna, sound, or air; rather than being negatively affected, its occurrence increased. This may be attributable to the fact that Formosan red-bellied squirrel is not subject to hunting, and moderate disturbance in natural habitats often enhances resource availability, such as through ecotonal effects between forest and grassland, benefiting generalist species.

5. Formosan reeves's Muntjac

The highest OI values were exhibited among all recorded species, with Fushan showing markedly higher values (mean OI 95) than Lienhuachih (mean OI 46) and substantially exceeding nationwide camera-trap OI averages (8–18) from 2015–2021 (Weng 2021). Both Fushan and Lienhuachih constitute population hotspots, likely reflecting effective habitat protection. Formosan reeves's Muntjac is widely distributed across Taiwan's forests. In a larger spatial scale, Fushan, including the Hapen Nature Reserve, represents one of northern Taiwan's most important continuous natural forests. By contrast, although Lienhuachih contains 269 ha of natural broadleaf forest, its forest is more fragmented. Habitat reduction, fragmentation, and declining habitat quality are major causes of local wildlife decline and extinctions (Andrén 1994, Lindenmayer et al. 1999).

Our results indicated that Formosan reeves's muntjac is a typical forest-dependent species and benefits from extensive, continuous forest cover. Other species–including Formosan serow, Taiwanese macaque, ferret-badger, and small Indian civet–also exhibited higher OI values in Fushan than in Lienhuachih, further supporting the importance of intact natural habitat. Since Fushan (including Hapen) is among Taiwan's earliest ecological reserves with relatively stable habitats, we recommend treating this area as a baseline for long-term monitoring of forest mammal dynamics.

Because Formosan reeves's muntjac showed the highest and most complete OI values in our study, their seasonal activity warrants further discussion. Nonparametric analyses indicated no significant differences across seasons; however, mean OI values revealed a consistent pattern in both Fushan and Lienhuachih, with peak activity in winter and the lowest in spring. This seasonal trend differs from other studies: In the Taosai watershed and Nanhudashan, OI peaked in spring, followed by the values in summer and autumn, with the lowest value in winter (Wang et al. 2012). In Hehuanshan, activity peaked in summer (Yao et al. 2022). In Taimali, peak seasons varied between years (Liu 2014). The nationwide camera-trap monitoring from 2015–2021 showed higher OI in June (Weng 2021). Liang (2010) studied its food quality and then suggested that precipitation-driven new plant growth is the primary driver of population fluctuations. These findings indicated that local climate and resource conditions may strongly influence seasonal activity patterns, underscoring the need for long-term, multi-factor monitoring to interpret the population dynamics of Formosan reeves's muntjac fully.

6. Small Indian civet

Previous studies have indicated that populations of small Indian civet in the foothill regions of central and western Taiwan (Nantou, Miaoli, and Hsinchu) are naturally sparse. In a study conducted by the Forestry Bureau across 179 camera stations in 10 townships of Nantou (including Yuchi Township), only three stations detected small Indian civet, with an occurrence index (OI) of merely 0.03 (Liu and Lin 2016). Consequently, the absence of detections at Lienhuachih in the present study may reflect extremely low local population density. Elsewhere, Yen et al. (2015) synthesized data from Taiwan and reported OI values for small Indian civet as follows: 0.81 in Yangmingshan National Park; < 0.01 in the foothill of Hsinchu-Miaoli; 0.2 in the Nangang mountain system at the eastern edge of the Taipei Basin; 0.73 in the Chachayalai wildlife habitat; and potentially regionally extinct in Kenting National Park.

By contrast, all 10 camera stations in Fushan (including Hapen and the Fushan Botanical Garden) recorded small Indian civet, with a mean OI of 5.15–substantially higher than other regions–indicating that Fushan represents a population hotspot. The species appears widely across Taiwan, from lowland forests in Danongdafu Forest Park (Lin 2018) up to 2,800 m on Línzhǐ Mountain (Liberty Times Net 2024), tolerates human disturbance, and may even coexist with free-roaming dogs (Yen et al. 2015) . Lienhuachih is likely a suitable habitat, but whether the species is absent or exists at extremely low density requires further long-term monitoring.

7. Formosan yellow-throated marten

Aside from small Indian civet, Formosan yellow-throated marten was also detected in Fushan but not in Lienhuachih. Previous mammal surveys in Fushan have reported no Formosan yellow-throated marten (Lee LL, pers. comm.; Koh 2007, Chang et al. 2024). Our study detected the species at only two of 10 camera stations. Formosan yellow-throated marten primarily inhabits natural forests at elevations ranging from 300 to 3,900 m, appearing more frequently in mid-elevation forests, with the majority of recent records concentrated in the central and eastern sectors of the Central Mountain Range (Chiang 2019). Nationwide camera-trap data have indicated that populations below 1,000 m have shown a gradual increase in abundance from 2015 to 2021 (Weng 2021). In the Xueshan Range, the species may have been regionally extinct, with the first recent photographic record only in 2010 at Qilan, yielding an extremely low OI of 0.01 (Chen et al. 2015). These observations suggest that Formosan yellow-throated marten may have recently expanded into lower-elevation areas around Fushan. Based on OI values recorded in this study, the current population in Fushan is likely still small, although future population growth is possible. Although not detected in the present Lienhuachih dataset, long-term monitoring of the permanent plot (2015–2024) recorded Formosan yellow-throated marten for the first time in October 2023 (Lee PH, pers. comm.), indicating a potential similar pattern of downward expansion from higher elevations. If populations at both sites indeed represent expansion fronts from higher-elevation core habitats, continued monitoring of population trends and potential interactions with other mammal species (e.g., muntjac) is strongly recommended.

8. Formosan sambar

The mean OI for Formosan sambar in Lienhuachih was 0.06. A 2014–2016 camera-trap survey conducted by the Forestry Bureau in the lower-elevation mountain areas of Nantou recorded Formosan sambar at low OI values (0.39-3.69) and noted the existence of sambar farms in some townships, suggesting that some detections may have involved escaped domestic individuals (Liu and Lin 2016). Whether the Formosan sambar observed in Lienhuachih represents wild populations or escaped stock remains uncertain, though the local population appears smaller than in the referenced survey.

In the parallel survey, the mean OI for Formosan sambar in Fushan (including Hapen and the Botanical Garden) was 0.07. Previous mammal surveys have reported no Formosan sambar records in Fushan (Lee LL, pers. comm.; Koh 2007, Chang et al. 2024), making the present study the first documented record in this experimental forest. Whether these individuals originate from wild populations or escaped stock remains uncertain. Nationwide camera-trap data from 2015–2020 have shown a gradual increase in Formosan sambar OI, particularly above 2,000 m (Weng 2021). If populations continue expanding into mid- and low-elevation areas, potential impacts on local vegetation–especially in the Hapen Nature Reserve–could be significant. We therefore recommend close monitoring of Formosan sambar abundance, along with the development of predictive distribution models and risk assessment frameworks to manage potential vegetation disturbances preemptively.

CONCLUSIONS AND SUGGESTIONS

1. The Lienhuachih and Fushan Experimental Forests differ in geographic location and landscape structure, leading to variations in mammal assemblages. Among the 11 species common to both sites, Formosan reeves's muntjac, Formosan serow, Taiwanese macaque, and ferret-badger exhibited higher activity levels in continuous natural forests. By contrast, Formosan wild boar, masked palm civet, and Formosan red-bellied squirrel were more abundant in the mosaic landscapes

of Lienhuachih, which combine forest patches with agricultural land and plantations. These findings provide guidance for habitat management tailored to species-specific preferences.

2. Species exhibited heterogeneous responses to human disturbance. For example, Formosan red-bellied squirrel showed a preference for mosaic landscapes, with its OI positively correlated with disturbance, whereas Formosan wild boar also used mosaic habitats but had OI negatively correlated with disturbance, indicating preference for less-disturbed natural forests. These results highlight the need for differentiated conservation strategies based on species habits and its sensitivity to environmental changes.
3. Stable habitats and long-term monitoring are critical for conservation. The consistent presence of leopard cat and small Indian civet in Lienhuachih and Fushan, respectively, underscores the importance of maintaining long-term protected habitats at these sites. Furthermore, the apparent downslope expansion of mid- to high-elevation species, such as Formosan yellow-throated marten and Formosan sambar, along with seasonal activity fluctuations in certain species, emphasizes the necessity of long-term monitoring and adaptive management frameworks.
4. The detection of newly arrived species Formosan yellow-throated marten and Formosan sambar at Fushan and Formosan yellow-throated marten at Lienhuachih may have future implications for local mammal and plant communities, ecosystem structure, and ecological balance. These events represent important ecological dynamics, warranting continued monitoring and further research to inform conservation planning.

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研究報告

不同地景類型與干擾度下森林哺乳動物之群聚組成與活動頻度

陳一銘[1]、李佾玲[1]、葛兆年[1]

摘 要

本研究旨在探討地景類型與干擾程度對臺灣中低海拔森林哺乳動物組成與活動頻度的影響。研究區域為林業試驗所位於臺灣中部鑲嵌型地景之蓮華池試驗林與東北部連續天然林之福山試驗林。2023年2月至2024年3月間，於兩林區共設置20個樣區架設紅外線相機進行監測，分析出現頻度(OI值，Occurrence Index)、物種組成，以及物種OI值在季節間的變動。研究期間共記錄哺乳動物影像17,931張，總共確認5目10科15種野生哺乳動物。非介量雙因子變異數分析顯示，有8種常見動物的OI值在地區間具顯著差異，野豬(*Sus scrofa taivanus*)、白鼻心(*Paguma larvata*)與赤腹松鼠(*Callosciurus erythraeus thaiwanensis*)在蓮華池的OI值較高，顯示這些動物較偏好蓮華池的鑲嵌地景，另僅在蓮華池記錄具保育價值的石虎(*Prionailurus bengalensis*)，顯示該區仍具關鍵棲地潛力。森林性物種如山羌(*Muntiacus reevesi micrurus*)、臺灣野山羊(*Capricornis swinhoe*)、臺灣獼猴(*Macaca cyclopis*)與鼬獾(*Melogale subaurantiaca*)在福山的OI值顯著較高，顯示連續天然林對此類物種之重要性。部分物種對人為干擾有不同的反應，如赤腹松鼠偏好高干擾環境，野豬則傾向利用低干擾區域。大部分物種無明顯季節性活動變化，僅蓮華池鼬獾在季節間(夏秋)出現頻度具顯著差異。研究期間在福山首次記錄黃喉貂(*Martes flavigula chrysospila*)與水鹿(*Rusa unicolor swinhoii*)，顯示較高海拔物種具擴散至中低海拔的潛勢，值得關注其生態影響。整體而言，本研究指出地景類型與干擾程度對哺乳動物的物種組成以及對棲地的利用有顯著影響，未來保育策略應考量物種對生態的不同需求，結合長期監測與棲地管理，提升中低海拔森林哺乳動物的棲地永續性與生物多樣性保護效能。

關鍵詞：紅外線自動相機、出現頻度、蓮華池試驗林、福山試驗林

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前言

哺乳動物在生態系中扮演關鍵角色，具有指標性、遷移性與食物鏈頂層等特性，能反映環境變遷與人為干擾對生態系的影響(Taig-Johnston et al. 2017)。透過長期監測，不僅可掌握族群動態、活動變化與棲地利用趨勢，亦有助於早期發現生物多樣性衰退的徵兆，作為保育政策與棲地管理的科學依據(Lindenmayer et al. 2022)。長期且系統性的監測，能為理解哺乳動物與環境互動關係建立基礎。

哺乳動物的分布與活動，受地景特性深刻影響(Lindenmayer et al. 1999, Presley et al. 2019)。整體森林覆蓋率雖然重要，但其空間配置、連續性與異質性更對物種多樣性具有關鍵影響(Bowers and Matter 1997, Brodie et al. 2015, Magioli et al. 2016)。連續的天然林可支持較多森林性物種的穩定生存，而土地利用多元、森林斷裂或鑲嵌型地景則可能限制對棲地連續性需求較高的物種，卻也可能提供部分物種利用的棲息環境。

除了地景本身的物理條件，來自人類的干擾也是影響哺乳動物的重要因素。人類活動例如遊憩、健行等對野生動物造成的干擾，可能導致棲息地時空利用發生改變 (Kangas et al. 2010)，生存和繁殖能力下降 (Baudains and Lloyd 2007)，並最終導致族群數量下降 (Bejder et al. 2006)。因此，比較不同地景特性與干擾程度下哺乳動物的組成與活動特徵，是制定保育策略與棲地管理的基礎，有助於在保育與人類使用之間尋求平衡。

本研究選擇兩處位於臺灣中低海拔區域，但地景與經營管理特性差異顯著的林業試驗所試驗林地作為監測樣區：位於中部丘陵地區的蓮華池試驗林，以及位於東北部山區的福山試驗林。前者受人為利用歷史影響，呈現出土地利用型態鑲嵌交錯的景觀格局，部分區域保留天然闊葉林，具有中部中低海拔森林生態系代表性；後者則位於雪山山脈連續天然林中，地景完整，採行保護區等級經營方式，亦為野生動物活動的熱區。兩者位處類似的海拔帶，但分別代表臺灣森林地景的不同型態，為比較分析地景結構對哺乳動物相影響提供理想條件。

在這兩處試驗林中，皆可進一步區分為干擾程度高低不同的子樣區，例如原始天然林與經人為開發利用後的園區及造林地。本研究透過自動相機調查與統計分析，從地景尺度與干擾梯度兩個層面，分析哺乳動物群聚組成及出現頻度，並探討季節變化下的活動差異。期望藉由本研究，比較不同地景特徵及干擾度下哺乳動物在空間與時間環境條件的差異，進一步說明鑲嵌型地景是否具支持一般性或保育關注物種的潛力，以及連續天然林對森林性物種之保育價值，同時評估物種對於人類干擾及棲地類型的不同反應，作為未來棲地經營與野生動物保育策略的重要參考。

材料與方法

調查地區

研究地點包括林業試驗所蓮華池研究中心及福山研究中心之試驗林。蓮華池試驗林(以下簡稱蓮華池) 460 ha，海拔576-925 m之間，年平均氣溫21℃，年平均雨量2,200 mm，其中269 ha為中部中低海拔地區僅存最完整之天然闊葉樹林。福山試驗林(以下簡稱福山) l,097.9 ha，海拔400-1,400 m之間，年平均氣溫18.5℃，年平均雨量4,125 mm，試驗林南段為哈盆自然保留區。在蓮華池分別設置不同干擾程度的兩個樣區：(1)天然林樣區：新山林道旁闊葉林，人為干擾低，以殼斗科、樟科、山茶科植物為主(Chang et al. 2012)，(2)造林樣區：多為針葉樹造林及次生演替林，包含火培坑山周圍、大自然農莊以及藥用植物標本園等區域，人為干擾高，種植肖楠(*Calocedrus formosana* (Florin) Florin)、杉木(*Cunninghamia lanceolata* (Lamb.) Hook.)等針葉樹，主冠層以下已天然更新，天然更新之優勢種包括茜草樹(*Randia cochinchinensis* (Lour.) Merr.)、黃杞(*Engelhardtia roxburghiana* Wall.)以及殼斗科、樟科等植物(Lee PH pers. comm.)。同時在福山分別設置不同干擾程度的兩個樣區：(1)天然林樣區：哈盆自然保留區，人為干擾低，氾濫平原

以牛奶榕(*Ficus erecta* var. *beecheyana* (Hook. & Arn.) King)、臺灣雅楠(*Phoebe formosana* (Hayata) Hayata)為主喬木、邊坡高地以長葉木薑子(*Litsea acuminata* (Blume) Sa.Kurata)、山豬肝(*Symplocos theophrastifolia* Siebold & Zucc.)、小花鼠刺(*Itea parviflora* Hemsl.)、紅楠(*Machilus thunbergia* Siebold & Zucc.)為優勢喬木(Lu et al. 2010)，(2)植物園樣區，包含樹木展示區、森林探索區、民俗植物區及裸子步道，人為干擾高，喬木層的優勢樹種為黃杞、鋸葉長尾栲(*Castanopsis cuspidata* var. *carlesii* f. *sessilis* (Hemsl.) T.Yamaz.)、山龍眼(*Helicia formosana* Hemsl.)、紅楠、長葉木薑子、鵝掌柴(*Schefflera octophylla* (Lour.) Harms)、短尾葉石櫟(*Pasania harlandii* (Hance *ex* Walp.) Rehder)等(Lin et al. 1995)。

從地景上來看，蓮華池為森林與農耕鑲嵌地景，道路較密集，天然闊葉林保護區為殘存地景區塊(patch)。福山則為連續的天然林，僅有單一道路，植物園樣區有局部的人工設施。

調查方法

本研究調查時間為2023年2月到2024年3月，在以上4個樣區各選5個小樣區架設自動相機(Figure 1)，小樣區的海拔高度介於614-750 m，小樣區之間距離 > 300 m，每個小樣區內有5處相機取樣點並採輪流調查，取樣點之間距離 > 30 m，1處取樣約持續2個月後回收、更換記憶卡與電池，並移動相機至下個取樣點進行調查。

本研究採用的紅外線自動相機型號有Browning (BTC-8E-HP5、BTC-5DCL)以及Bushnell (CORE DS-4K NO GLOW) 2種牌子，其基本功能皆相似，相機架設高度約1-1.5 m，原則上拍攝中心點地面與相機距離約1.5-3 m，俯視拍攝，視相機型式紀錄約10 sec動態影像或靜態3連拍。收回的影

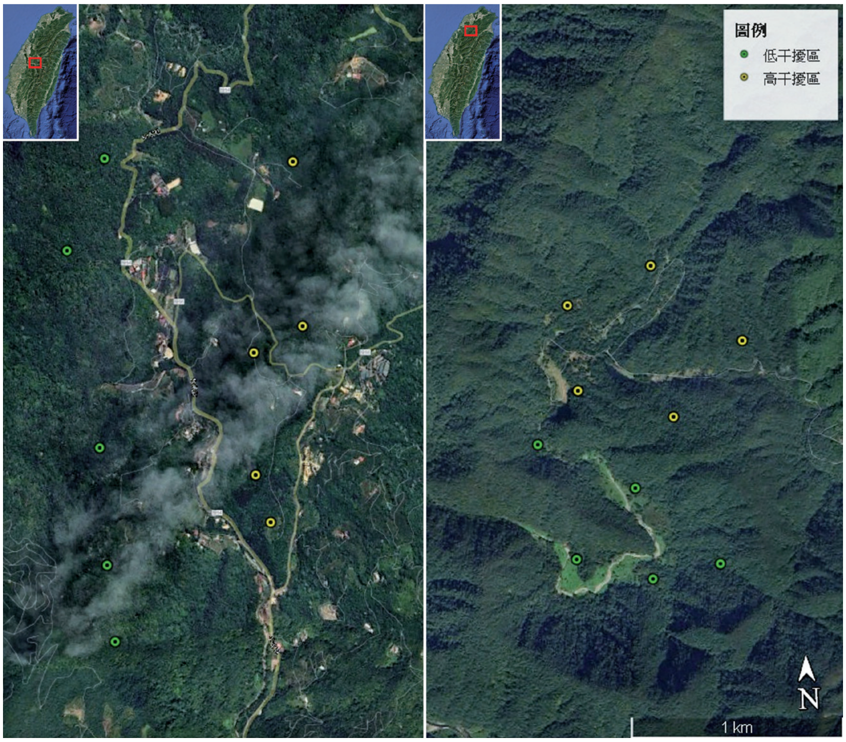

Figure 1. Locations of survey sites in the Lienhuachih Experimental Forest (left) and Fushan Experimental Forest (right). Green circles indicate low-disturbance areas, and yellow circles indicate high-disturbance areas.

像以人工進行物種影像判視，每次拍攝到可辨識的物種，計為有效影像。為避免同一隻動物在相機前徘徊造成後續出現頻度高估，30 min以內出現且無法判定為不同個體的影像皆視為重複拍攝而忽略，只以第1張出現的動物隻數為有效影像。若同時有複數個體出現，則以拍攝到最多隻數的影像作為有效影像。單一相機每次取樣結果皆經標準化轉換為1000 hr之OI值(Occurrence Index)，代表各物種的相對活動頻率，計算方式如下(Pei 1998)：

$$\text{OI值} = \left(\frac{\text{各物種在該樣點之拍攝到的有效隻數}}{\text{該樣點之相機工作hr}}\right) \times 1{,}000\ \text{hr}$$

資料分析

每個小樣區的OI值乃以5筆相機取樣資料取平均值而得。使用R統計軟體(版本 4.4.3)的rcompanion套件中「scheirerRayHare」函數分別進行非介量(non-parametric)的雙因子變異數分析(Scheirer-Ray-Hare檢定，擴展型Kruskal-Wallis檢定)，檢視主要動物在調查區域及干擾度之間的差異。

兩處試驗林收回的資料，依4個樣區的每月資料分開計算主要物種的OI值，再根據每個季節(春季3-5月、夏季6-8月、秋季9-11月、冬季12-2月)進行資料分類，最後進行試驗林季節之間的比較。使用R統計軟體的「kruskal.test」函數進行非介量的多樣本中位數差異檢定(Kruskal-Wallis H test)，比較季節之間OI值是否具有差異，若有顯著差異($p < 0.05$)，再使用FSA套件(版本0.9.6.)中「dunnTest」函數進行後測分析(Dunn's test) 應用邦弗朗尼校正(Bonferroni)方法對多重比較的p值進行校正。

結果

哺乳動物組成：本研究調查期間，自動相機拍攝到的哺乳動物影像數量為17,931張，其中有效影像數量為15,921張，共記錄到5目10科15種野生哺乳動物(不包含家犬及無法辨識物種的鼠類、鼩鼱類及蝙蝠類)，自動相機調查動物組成差異如Table 1。蓮華池共拍攝2,764天，記錄到可辨識之哺乳類物種11種(不含家犬)，平均OI值由高至低分別為：山羌(*Muntiacus reevesi micrurus*, 45.57 ± 26.1)、野豬(*Sus scrofa taivanus*, 5.44 ± 4.8)、赤腹松鼠(*Callosciurus erythraeus thaiwanensis*, 3.05 ± 2.48)、白鼻心(*Paguma larvata*, 2.71 ± 1.36)、鼬獾(*Melogale subaurantiaca*, 2.71 ± 1.98)、食蟹獴(*Urva urva formosana*, 1.96 ± 1.75)、臺灣獼猴(*Macaca cyclopis*, 1.28 ± 1.51)、穿山甲(*Manis pentadactyla pentadactyla*, 0.31 ± 0.15)、石虎(*Prionailurus bengalensis*, 0.15 ± 0.15)、水鹿(*Rusa unicolor swinhoii*, 0.06 ± 0.14)以及臺灣野山羊(*Capricornis swinhoei*, 0.03 ± 0.06)，此外為鼠類(Muroidea, 1.94 ± 1.71)、鼩鼱類(Soricidae, 0.26 ± 0.42)及蝙蝠類(Chiroptera, 0.08 ± 0.09)。福山共拍攝3,308天，記錄到可辨識之哺乳類物種14種，OI值由高至低分別為：山羌(94.66 ± 37.64)、鼬獾(8.46 ± 6.32)、臺灣獼猴(8.24 ± 4.46)、臺灣野山羊(5.75 ± 3.15)、麝香貓(*Viverricula indica*, 5.15 ± 2.63)、食蟹獴(1.10 ± 0.53)、赤腹松鼠(0.79 ± 0.61)、野豬(0.74 ± 0.58)、白鼻心(0.38 ± 0.51)、穿山甲(0.21 ± 0.22)、水鹿(0.07 ± 0.13)、黃喉貂(*Martes flavigula chrysospila*, 0.05 ± 0.11)、白面鼯鼠(*Petaurista lena*, 0.03 ± 0.08)、大赤鼯鼠(*Petaurista grandis* 0.01 ± 0.04)，此外為鼠類(2.73 ± 0.82)、鼩鼱類(0.16 ± 0.23)及蝙蝠類(0.14 ± 0.19)。

出現頻度

排除出現隻次數低於30的物種，包括水鹿、石虎、黃喉貂、白面鼯鼠、大赤鼯鼠、鼩鼱類、蝙蝠類及家犬後，對11種動物之OI值進行非介量的雙因子變異數分析結果如Table 2。在地區之間，有8種動物的OI值差異顯著，其中野豬、白鼻心及赤腹松鼠以蓮華池之OI值較高，山羌、山羊、臺灣獼猴、鼬獾及麝香貓以福山之OI值較高，食蟹獴、穿山甲及鼠類在兩個地區間OI值沒有差異。在區內干擾度的比較上，野豬偏好出現

Table 1. Mean occurrence index of mammals (number of effective animal detections / working hrs × 1,000 hrs) in each sampling site of Lienhuachih and Fushan Experimental Forests.

Order	Species	Chinese name	Lienhuachih			Fushan		
			Plantation	Natural forest	Mean	Botanical garden	Natural forest	Mean
			OI (n = 5)	OI (n = 5)	OI (n = 10)	OI (n = 5)	OI (n = 5)	OI (n = 10)
Artiodactyla	*Capricornis swinhoei*	臺灣野山羊	0.00 ± 0.00	0.05 ± 0.07	0.03 ± 0.06	4.94 ± 4.00	6.55 ± 2.17	5.75 ± 3.15
	Muntiacus reevesi micrurus	山羌	39.07 ± 17.90	52.06 ± 33.27	45.57 ± 26.10	88.84 ± 34.51	100.49 ± 43.65	94.66 ± 37.64
	Rusa unicolor swinhoii	水鹿	0.00 ± 0.00	0.11 ± 0.19	0.06 ± 0.14	0.08 ± 0.18	0.05 ± 0.07	0.07 ± 0.13
	Sus scrofa taivanus	野豬	2.76 ± 2.14	8.13 ± 5.40	5.44 ± 4.80	0.23 ± 0.12	1.25 ± 0.32	0.74 ± 0.58
Carnivora	*Canis lupus familiaris*	家犬	0.09 ± 0.14	0.08 ± 0.12	0.09 ± 0.12	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	Prionailurus bengalensis	石虎	0.20 ± 0.13	0.11 ± 0.17	0.15 ± 0.15	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	Urva urva formosana	食蟹獴	2.20 ± 1.75	1.71 ± 1.92	1.96 ± 1.75	1.29 ± 0.52	0.90 ± 0.53	1.10 ± 0.53
	Melogale subaurantiaca	鼬獾	3.12 ± 2.34	2.29 ± 1.70	2.71 ± 1.98	8.70 ± 5.86	8.22 ± 7.44	8.46 ± 6.32
	Martes flavigula chrysospila	黃喉貂	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.05 ± 0.12	0.05 ± 0.12	0.05 ± 0.11
	Paguma larvata	白鼻心	3.32 ± 1.42	2.10 ± 1.11	2.71 ± 1.36	0.48 ± 0.71	0.28 ± 0.22	0.38 ± 0.51
	Viverricula indica	麝香貓	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	5.58 ± 2.91	4.72 ± 2.57	5.15 ± 2.63
Chiroptera	--	蝙蝠類	0.11 ± 0.06	0.05 ± 0.10	0.08 ± 0.09	0.19 ± 0.20	0.08 ± 0.19	0.14 ± 0.19
Pholidota	*Manis pentadactyla pentadactyla*	穿山甲	0.30 ± 0.18	0.31 ± 0.15	0.31 ± 0.15	0.17 ± 0.18	0.25 ± 0.26	0.21 ± 0.22
Primates	*Macaca cyclopis*	臺灣獼猴	0.37 ± 0.67	2.19 ± 1.61	1.28 ± 1.51	7.46 ± 3.68	9.03 ± 5.45	8.24 ± 4.46
Rodentia	*Callosciurus erythraeus thaiwanensis*	赤腹松鼠	4.62 ± 2.67	1.49 ± 0.81	3.05 ± 2.48	1.28 ± 0.42	0.29 ± 0.20	0.79 ± 0.61
	Petaurista lena	白面鼯鼠	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.05 ± 0.12	0.03 ± 0.08
	Petaurista grandis	大赤鼯鼠	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.06	0.00 ± 0.00	0.01 ± 0.04
	Muroidea	鼠類	2.85 ± 1.43	1.02 ± 1.54	1.94 ± 1.71	2.35 ± 1.02	3.10 ± 0.31	2.73 ± 0.82
Soricomorpha	Soricidae	鼩鼱類	0.46 ± 0.53	0.05 ± 0.12	0.26 ± 0.42	0.09 ± 0.18	0.24 ± 0.27	0.16 ± 0.23

Note: Values for the sampling sites are mean ± standard deviation.

Table 2. Comparison of the occurrence index (number of effective animal detections / working hrs × 1,000 hrs) of major mammals in relation to area and disturbance level between the Lienhuachih and Fushan Experimental Forests.

Order	Species	Chinese name	Lienhuachih Plantation OI (n = 5)	Lienhuachih Natural forest OI (n = 5)	Fushan Botanical garden OI (n = 5)	Fushan Natural forest OI (n = 5)	Scheirer-Ray-Hare test Area H	Area *p*-value	Disturb. H	Disturb. *p*-value
Artiodactyla	*Capricornis swinhoei*	臺灣野山羊	0	0	3.25	6.19	15.26	**< 0.001**	0.55	0.458
	Muntiacus reevesi micrurus	山羌	35.36	48.33	85.36	121.55	8.48	**0.004**	0.32	0.571
	Sus scrofa taivanus	野豬	2.28	10.00	0.19	1.09	10.62	**0.001**	3.88	**0.049**
Carnivora	*Urva urva formosana*	食蟹獴	1.61	0.96	1.64	0.83	0.70	0.404	1.13	0.289
	Melogale subaurantiaca	鼬獾	3.86	1.95	6.87	6.13	8.26	**0.004**	0.63	0.427
	Paguma larvata	白鼻心	3.08	1.85	0.13	0.29	13.23	**< 0.001**	0.47	0.495
	Viverricula indica	麝香貓	0	0	6.04	3.63	16.31	**< 0.001**	0.08	0.777
Pholidota	*Manis pentadactyla pentadactyla*	穿山甲	0.00	0.00	0.10	0.20	1.29	0.256	0.46	0.496
Primates	*Macaca cyclopis*	臺灣獼猴	0	2.29	7.38	6.77	13.23	**< 0.001**	0.97	0.325
Rodentia	*Callosciurus erythraeus thaiwanensis*	赤腹松鼠	5.38	1.38	1.07	0.27	8.51	**0.004**	5.70	**0.017**
	Muroidea	鼠類	2.54	0.25	2.56	3.02	1.46	0.226	0.46	0.496

Note: Statistical analysis was conducted using the Scheirer-Ray-Hare test, a non-parametric two-way ANOVA. Mammals' occurrence indices (OI) are shown as medians.

在干擾較少的棲地環境，赤腹松鼠則相反，偏好出現在干擾較多的環境，以上結果交互作用皆不顯著。

季節變化

排除水鹿等動物後，11種動物OI值的季節變動比較如Table 3，福山所有的哺乳動物種類的OI值在季節間皆無顯著差異。而蓮華池有食蟹獴與鼬獾在季節間表現出顯著差異，不過其中食蟹獴在後測並無顯著的差異配對。因此本研究結果顯示僅有蓮華池的鼬獾在夏季的OI值最低，秋季最高，兩季節間差異顯著。

討論

本研究透過1年的調查，對比兩個海拔相仿但不同地景的試驗林，有效偵測到哺乳動物群聚、活動頻度與季節波動的差異變化。兩區域之間的野生哺乳動物種類不完全相同，其中福山未記錄石虎，而蓮華池未記錄麝香貓、黃喉貂、大赤鼯鼠及白面鼯鼠，其中2種鼯鼠並不容易被自動相機偵測，因此後續不加討論。蓮華池的野豬、白鼻心與赤腹松鼠顯著高於福山，顯示這3種動物適應農業鑲嵌的棲地。這3種哺乳動物一般也都被視為有害於農作物，其中野豬掘食根莖類、白鼻心與赤腹松鼠則會取食果樹，其覓食特性可能

Table 3. Seasonal variation in the occurrence index (number of effective animal detections / working hrs × 1,000 hrs) of major mammals in the Lienhuachih and Fushan Experimental Forests.

Order	Species	Chinese name	Lienhuachih				Kruskal-Wallis test (p value)	Fushan				Kruskal-Wallis test (p value)
			Spring (n = 6)	Summer (n = 6)	Autumn (n = 6)	Winter (n = 5)		Spring (n = 6)	Summer (n = 6)	Autumn (n = 6)	Winter (n = 6)	
			OI					OI				
Artiodactyla	*Capricornis swinhoei*	臺灣野山羊	0	0	0	0	0.588	2.58	4.21	2.38	3.48	0.195
	Muntiacus reevesi micrurus	山羌	20.29	28.23	24.51	21.32	0.714	45.57	57.38	45.49	93.49	0.126
	Sus scrofa taivanus	野豬	1.83	1.94	2.79	2.85	0.239	0.18	0.25	0.62	0.27	0.721
Carnivora	*Urva urva formosana*	食蟹獴	0.75[a]	1.56[a]	0.56[a]	1.57[a]	**0.041**	0.81	0.57	0.57	0.37	0.751
	Melogale subaurantiaca	鼬獾	1.36[ab]	0.21[b]	2.47[a]	1.66[ab]	**0.016**	5.38	4.16	2.84	3.46	0.161
	Paguma larvata	白鼻心	1.48	1.84	1.02	2.02	0.725	0.20	0.13	0.10	0.11	0.509
	Viverricula indica	麝香貓	0	0	0	0	-	1.53	2.94	2.62	3.47	0.067
Pholidota	*Manis pentadactyla pentadactyla*	穿山甲	0.20	0.00	0.14	0.00	0.677	0.00	0.11	0.14	0.10	0.583
Primates	*Macaca cyclopis*	臺灣獼猴	0.26	0.42	1.40	0.00	0.590	2.71	5.63	4.61	2.94	0.126
Rodentia	*Callosciurus erythraeus thaiwanensis*	赤腹松鼠	2.53	1.39	1.31	1.62	0.547	0.34	0.09	0.17	0.26	0.371
	Muroidea	鼠類	0.58	0.71	0.58	0.09	0.602	1.22	0.42	0.97	1.29	0.191

Note: Statistical analysis was performed using the Kruskal-Wallis test, followed by Dunn's post-hoc test for pairwise comparisons. Different letters indicate significant differences (p < 0.05). Mammals' occurrence indices (OI) are shown as medians.

會因農耕地而受益而使族群量增加；相對的，連續天然闊葉林地景的福山則以山羌、山羊、獼猴及鼬獾OI值顯著較高。從草食動物的食性也可以看出一些趨勢，山羌、山羊都是以雙子葉植物的葉子為主食(Liang 2006, Jiang et al. 2008)，臺灣獼猴則以果實及樹葉為主食(Su 1993, Chang 1999)，這類資源於天然林中最為多樣。從本研究結果來看，森林與農地鑲嵌地景的蓮華池並沒有支持較大的獼猴族群，區域性的干擾也沒有正面影響。臺灣獼猴為重要害獸之一，但此結果顯示其族群似乎並未因農地而受益。至於鼬獾，其最主要食物為蚯蚓與小型無脊椎動物(Chuang 1994, Tai 2021)，我們認為福山大面積天然林能提供鼬獾穩定的棲地及食物來源是可以確定的。不過臺灣中部為鼬獾狂犬病疫區，因此蓮華池的鼬獾族群顯著較福山低，也有可能受疾病因素的影響。

另外，調查結果顯示蓮華池有遊蕩犬出沒，福山則否。遊蕩犬對山羌、石虎、麝香貓、穿山甲、鼬獾以及白鼻心等小型哺乳類都有明確的獵殺報導，已知對野生食肉目動物的活動造成衝擊(Ho et al. 2025)，這對蓮華池野生動物的影響需要進一步評估。目前蓮華池的遊蕩犬出現OI值並不算太高，但有鑑於本區為多種保育物種之棲地，建議應持續監測其族群變動以及與其他物種的消

長趨勢。

本研究結果發現大多數動物在不同地區的OI值並沒有明顯的季節性變動，我們認為野生動物的短期族群量變化原本相對穩定，季節性遷移也不若其他動物(如鳥類)明顯，因此這樣的觀測結果應屬合理。目前僅蓮華池鼬獾秋季的OI值顯著高於夏季，且與福山不同步(秋季最低)。這個現象需要更長期的監測數據加以驗證，才有可能尋求進一步的解釋。

以下針對重要物種分別對分布以及在不同地景、干擾度的適應性做進一步的補充。

(一) 石虎

林業試驗所在蓮華池試驗林的25 ha天然闊葉林設置森林動態樣區架設自動相機，2015-2024年已持續穩定紀錄到石虎(Lee PH pers. comm.)，故已知為石虎的適生棲地。而本調查在蓮華池的監測中，亦有6個樣區拍攝到石虎，分屬於樟科、殼斗科為主的天然闊葉林(無干擾)以及混雜自然演替闊葉樹的人工針葉林(受干擾)，說明石虎棲地可能的多樣樣態。石虎主要分布在苗栗、臺中、南投一帶的淺山森林(Weng 2021)，棲地為低海拔連綿的和緩丘陵地，有一定森林覆蓋的鑲嵌環境且道路密度不能太高(Lin et al. 2016)。南投地區石虎則會利用樹冠層鬱閉度低的區域及竹闊混合林類型的林相(Farng 2016)，本研究結果也呼應這樣的認知，石虎能適應干擾較大，闊葉樹混雜的人工林。不過南投地區石虎可利用棲地面積少又多位於私有地，持續有開發的壓力，棲地保存十分重要(Liu and Lin 2016)。因此，蓮華池試驗林不論是天然闊葉林或針闊葉混生林，為農林鑲嵌地景中穩定的森林環境，在石虎的保育上應有其重要性，建議持續進行本區石虎族群與活動熱區的長期監測，並強化棲地連結性及周邊環境管理。至於宜蘭的石虎僅近年在大礁溪林場出現零星紀錄(Chong et al. 2023)，而福山試驗林未偵測到石虎，可能是因福山為連續大面積的天然林，與前述鑲嵌狀的棲地型態不同。

(二) 野豬

蓮華池的豐量比福山高。野豬具有良好的移動力及繁殖力，比其他哺乳動物更不容易受到棲地破碎化及森林縮減的影響(Virgós 2002)，加上其食性廣泛，Chao and Fang (1988)訪談獵人列出60種食物種類，包括林木種實、根、莖、葉、穀物、雜糧、水果、蔬菜以及動物、腐物等。在地景上鑲嵌有多種土地利用型態例如農田、果園、森林等的蓮華池可能提供了多種食物資源，產生類似Virgós (2002)在伊比利亞地中海區域研究發現野豬(*Sus scrofa*)能適應及利用森林、農田交雜地景的效果。另外Meriggi and Sacchi (2001)指出，野豬選擇棲地的重要考量因素包括食物資源與環境的遮蔽。

雖然野豬偏好農田與森林鑲嵌的地景，但我們的研究結果顯示，在地區內野豬還是有明顯避開干擾的傾向。這或許是野豬對不同結構棲地有不同安全風險的反應，例如海南大田自然保護區的野豬的取食地隱蔽程度較低，而臥息地則選擇隱蔽程度較好、遠離人為干擾的地點(Teng et al. 2007)。本研究中，野豬可能也是以食源豐富但高風險的農耕地或植物園區周邊為短期覓食地，而以干擾較低的天然闊葉林作為較長時間的躲避休息環境。

(三) 白鼻心

本研究中白鼻心在蓮華池的相對豐量極顯著高於福山(2.71 vs. 0.38)，代表有多元土地利用型態鑲嵌的淺山地景能符合其對於棲地的需求。白鼻心的食性在臺灣有關研究不多，日本與中國的研究都顯示其為雜食性，而植物性食物幾乎都為果實(Torii 1986, Zhou et al. 2008)。蓮華池周邊的淺山地景中不乏果園與散生果樹，可能提供白鼻心充足的食物。本研究也發現地區性人為干擾對白鼻心的OI值沒有影響，甚至兩地區在干擾環境的OI值都高於天然林，雖然並未達顯著差異。這結果符合其他白鼻心研究(Cheng and Wang 1993, Chen et al. 2009, Chiang et al. 2012)，也呼應了近年白鼻心族群遷入都會區的生態現象 (Lim 2023)。

(四) 赤腹松鼠

赤腹松鼠相對豐度以鑲嵌環境的蓮華池極顯著高於連續天然林的福山(3.05 vs. 0.79)，同時也是本研究唯一發現對干擾有正向反應的物種。赤腹松鼠似乎不會逃避人為經營伴隨而來多種環境變化，包括土壤、植被、動物、聲音、空氣等可能變動，反而出現率變高。我們推測一來松鼠並非人類狩獵的對象，也不致因此而改變牠的行為模式；二來自然環境經過適度干擾常能產生更多資源，例如森林與草原的邊際效應可能對於松鼠這種廣適性物種帶來好處。

(五) 山羌

為本研究中OI值最高的動物，而福山平均OI值95極顯著高於蓮華池平均OI值46，又明顯高於全台各地相機監測在2015-2021年所得OI平均值(介於8-18之間)(Weng 2021)。福山與蓮華池顯然是山羌的熱區，可能與環境受到良好保護有關。山羌為全島森林普遍分布的物種，大尺度來看，福山包含哈盆自然保留區，是北部最重要的連續天然林的核心；相對的，蓮華池雖然也包含了269 ha的天然闊葉林，但是從純森林棲地的角度來看較屬破碎化。許多研究都顯示，棲息地面積的縮小、破碎化，以及棲地品質的下降，是造成野生動物區域性大量減少甚至滅絕的最主要原因(Andrén 1994, Lindenmayer et al. 1999)。

研究結果顯示山羌為典型森林性物種，且大面積連續森林對於此類物種具有明顯的效益。其他如山羊、獼猴、鼬獾、麝香貓在福山OI值也明顯高於蓮華池，這也佐證連續自然棲地的重要性。由於福山研究中心(含哈盆)為臺灣最早成立的生態保護區之一，且棲地狀態相對穩定，本研究建議可將本區視為臺灣森林性哺乳動物長期動態變化的基準，並持續監測。

本研究中山羌的OI值最高也最完整，可進一步討論。非介量統計顯示，山羌季節性OI值並沒有顯著差異，不過若從平均值來檢視，可以看出在福山與蓮華池呈現一致性的變動，都是冬季最高、春季最低。這樣的變動趨勢與其他研究結果不同，值得探討。陶塞溪流域與南湖山區的山羌，其OI以春季最高，夏秋二季次之，冬季最低(Wang et al. 2012)；合歡山山羌在夏季有明顯的活動高峰(Yao et al. 2022)；此外太麻里山區18個月的監測資料顯示不同年間的波峰期並不一致(Liu 2014)；2015-2021年全台各地相機監測則發現山羌在6月有較高的OI值(Weng 2021)。Liang (2010)研究山羌的食物品質則指出降雨量影響的新生植物量才是影響族群量變化的主要因子。承上，山羌數量的季節變動或許因局部地區的氣候或資源條件而有不同，因此需要更長期的監測以及納入更多因子才能清楚解讀。

(六) 麝香貓

前人研究顯示，南投、苗栗、新竹等中西部淺山地區族群量原本就稀少。如林務局在南投縣淺山地區包括魚池鄉等10個鄉鎮市設置179個相機樣點，僅在其中3個樣點拍攝到麝香貓，OI值僅0.03 (Liu and Lin 2016)。因此本研究中蓮華池未偵測到麝香貓也有可能是其數量極低之故。在其他地區，Yen et al. (2015)調查陽明山國家公園及整理臺灣地區麝香貓調查文獻顯示，陽明山平均出現指數0.81，新竹苗栗淺山地區整體出現指數小於0.01，在臺北盆地東緣南港山系出現指數為 0.2，茶茶牙賴山野生動物重要棲息環境之出現指數為0.73，墾丁國家公園則可能已經區域性滅絕。

相較於前述類似調查方法的地區，本研究於福山試驗林(含哈盆自然保留區及福山植物園區) 10個樣點皆有紀錄，且其平均OI值達5.15，相對比其他地區高出很多，是麝香貓族群的熱點。事實上麝香貓分布廣泛，其海拔自平地的大農大富平地森林園區(Lin 2018)到2,800 m的麟趾山(Liberty Times Net 2024)皆有紀錄，也能適應人類的干擾，甚至與遊蕩犬共域(Yen et al. 2015)，猜測蓮華池應屬麝香貓適生棲地，在蓮華池無分布或是數量極低？這一點有待進一步監測確認。

(七) 黃喉貂

除了麝香貓之外，尚有黃喉貂是福山試驗林有而蓮華池試驗林未偵測到的。然而，比對福山

試驗林過去的哺乳動物調查資料，並未有黃喉貂紀錄(Lee LL pers. Comm., Koh 2007, Chang et al. 2024)，而本次調查僅在10個相機樣點中的兩個樣點偵測到。黃喉貂主要分布在海拔 300 m 到 3,900 m 干擾較少的天然森林，但以中海拔出現較為頻繁，目前以中央山脈中南部與東部發現記錄較多(Chiang 2019)。全台相機監測則顯示海拔1,000 m以下的黃喉貂族群豐量在2015-2021年呈現逐漸上升的趨勢(Weng 2021)。黃喉貂在雪山山系早期可能是區域滅絕，一直到2010年才於棲蘭山紀錄1筆影像，OI值甚低僅0.01 (Chen et al. 2015)，因此推測黃喉貂極有可能是近年才擴散至福山這一帶較低海拔山區。而由本研究偵測到的OI值，我們判斷目前福山的族群量應該是相當稀少，但並不排除未來數量可能持續增加。

另外在蓮華池地區，本研究並未紀錄到黃喉貂。但林業試驗所的蓮華池永久樣區2015-2024的長期監測已於2023年10月首次發現(Lee PH pers. comm.)，顯示可能也是較高海拔的族群向低海拔擴散的現象。針對福山與蓮華池兩處試驗林的黃喉貂皆為主棲地往低海拔擴散而來且族群可能持續擴大的假設，建議持續收集其族群量資料，並關注其與其他哺乳類動物(例如山羌)的消長情勢。

(八) 水鹿

本次在蓮華池試驗林監測所得水鹿的OI平均值為0.06，而林務局於2014-2016年在南投淺山地區進行紅外線相機監測，偵測到少量水鹿，OI值介於0.39及3.69之間，同時指出南投有些鄉鎮有水鹿養殖場，故推測這些拍攝到的水鹿可能是養殖逃逸個體(Liu and Lin 2016)。本研究蓮華池出現的水鹿不能確定是否為逃逸個體，不過相比於上述之調查，此地之水鹿族群量是較低的。

同步調查中福山(含哈盆及植物園)的水鹿OI平均值為0.07，但比對福山過往調查記錄(Lee LL pers. comm., Koh 2007, Chang et al. 2024)，並未偵測到水鹿，故本研究為水鹿在福山試驗林的首次記錄，惟目前無法確定是否來自野生族群或逃逸個體。全台相機監測網資料顯示2015-2020年水鹿OI值逐年上升，尤其以海拔2,000 m以上更為明顯(Weng 2021)，其族群是否會逐漸往中低海拔擴散，對福山當地植被尤其是哈盆自然保留區的原生植被造成影響，建議密切關注水鹿豐量的變化，建立動態分布預測與衝突熱區評估系統，對未來可能的植被干擾預先部署控管。

結論及建議

(1) 蓮華池試驗林與福山試驗林因地理位置及地景類型之差異，動物相有些不同。兩地區共通之11種哺乳動物在相對豐度差異表現顯示，在地景尺度上，山羌、山羊、臺灣獼猴及鼬獾較適連續型天然林棲地；野豬、白鼻心以及赤腹松鼠則較適農林鑲嵌地景，此結果可作為野生動物棲地經營之參考。

(2) 部分物種對人為干擾有異質的反應：赤腹松鼠明顯偏好鑲嵌地景且OI值與干擾呈正相關，野豬則也適應鑲嵌地景但OI值與干擾成負相關，即偏好干擾較低的天然林。此結果顯示保育策略須依據物種習性與對環境的反應進行差異化設計。

(3) 穩定棲地與長期監測為未來保育關鍵：石虎與麝香貓分別穩定出現於蓮華池與福山，顯示兩地區應有相對應的長期棲地保育作為；而黃喉貂與水鹿等較高海拔物種擴散趨勢，以及部分物種的季節性活動變化，皆指向應強化長期動態監測與調適性管理機制。

(4) 本研究在福山至少偵測到黃喉貂與水鹿兩種新進遷入的物種，以及蓮華池的黃喉貂，皆有可能在未來對當地動植物族群、結構或生態平衡上帶來改變。我們認為這是很重要的生態事件，值得有關單位持續進行監測並尋求進一步的研究。

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