The Thesis of the PhD Dissertation

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Gödöllő

2024

Hungarian University of Agriculture and Life Sciences

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ASSESSING THE POTENTIAL APPLICATION OF HUNGARIAN WILDLIFE MANAGEMENT STRATEGIES TO IMPROVE WILDLIFE CONSERVATION TOOL IN MALAYSIA.

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2024

Title: Assessing the Potential Application of Hungarian Wildlife Management Strategies to Improve Wildlife Conservation Tools in Malaysia

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1. BACKGROUND OF THE WORK AND ITS AIMS

1.1. Introduction

Malaysia, renowned for its rich biodiversity, grapples with pressing conservation challenges, including human-wildlife conflict, poaching, illegal wildlife trade, and habitat loss (Xin et al., 2024). Despite governmental and NGO efforts to address these issues, persistent challenges suggest existing strategies may fall short of effectiveness or sustainability (Tong, 2020). Complex socio-economic and cultural factors further complicate conservation efforts, necessitating ecologically sound and culturally appropriate strategies (Pimid et al., 2022). Countries like Hungary have gained international recognition for their practical game management approaches long ago (Nagy & Bencze, 1973). Hungarian strategies blend scientific research, sustainable principles, and community involvement, potentially serving as a model for wildlife conservation improvement (e.g., Nagy & Bencze, 1973; Csányi, 1993; Báldi et al., 2001; Csányi et al., 2010; Anthony & Tarr, 2019). However, directly applying these strategies to countries with different ecological and socio-economic contexts, such as Malaysia, is complex. Adaptation and practical implementation are crucial for success. This study background, therefore, includes the urgent need for enhanced wildlife conservation in Malaysia, the potential lessons to be learned from Hungarian wildlife management strategies, and the broader aspect of global conservation. This study aims to contribute in-depth understanding and more wildlife conservation tools. It sets the platform for a comprehensive exploration of innovative

strategies, cross-cultural learning, and the development of tailored approaches to conserving wildlife.

1.2. Research problems

1.2.1. Increase in human-wildlife conflict in Malaysia

Human-wildlife conflict in Malaysia is increasing due to urbanization, habitat encroachment, and systemic issues. Wildlife like the Asian palm civets (*Paradoxurus hermaphroditus*) are increasingly seen as threats rather than essential parts of Malaysia's natural heritage (Nakashima et al., 2010). Habitat loss from deforestation forces civets into human areas, leading to conflicts that threaten safety and livelihoods (Young et al., 2021; Mekuriaw & Getahun, 2022). These conflicts reduce community support for conservation, complicating efforts to implement sustainable strategies (Pimid et al., 2022).

1.2.2. Inefficiency of existing wildlife management strategies in Malaysia

Wildlife management in Malaysia often needs more localized approaches, making national policies less effective due to the diverse socio-economic and ecological conditions (Melick et al., 2012; DWNP, 2023). Insufficient resources and poor stakeholder engagement, particularly with local communities, hinder effective conservation (Ernest, 2023; Mogomotsi et al., 2020). There is a need for integrated strategies that combine community needs, economic development, and advanced technology to achieve effective wildlife conservation (Zhang,

2019; Casazza et al., 2023).

1.3. Aim and objectives

The primary aim of this study is to determine the possible adaptation of elements of Hungarian wildlife management strategies and assess their potential applicability within the Malaysian context to improve wildlife conservation tools. Specifically, this study aims to a) conduct an extensive comparative analysis between Hungarian and Malaysian wildlife management strategies to identify unique approaches, challenges, and outcomes; b) investigate the extent of human-wildlife conflicts in Malaysia, mainly focusing on the Asian palm civet conflict, and evaluate the current mitigation strategies employed; c) assess local attitudes towards wildlife and their management methods using newly developed attitude indices, such as WAI (Wildlife Attitude Index) and WMMAI (Wildlife Attitude Management Method Index); and d) introduce Geo Wild System (GWS) as a novel wildlife reporting, monitoring, and analyzing system in Malaysia, serving as the integration and implementation of a customized version of the NGMD (National Game Management Database) system that aligns with Malaysia's ecological, cultural and socio-economic contexts.

2. MATERIALS AND METHODS

This chapter presents an integrated methodological approach divided into three parts to achieve the objectives outlined in **Chapter 1.3**. The methods include:

1) Broad Literature Survey: Describes wildlife management strategies in both Malaysia and Hungary.
2) Field-Based Research: Focuses on the human-Asian palm civet conflict and local attitudes towards wildlife and their management methods in Malaysia, utilizing survey and field data collection.
3) Technical-Based Research: Concludes the methodological frameworks with the introduction and initial deployment of a novel "Geo Wild System (GWS)" in Malaysia, a wildlife reporting, monitoring, and analyzing system that utilizes PWA and survey data collection

2.1. Broad literature survey: Wildlife management strategies in Hungary and Malaysia

2.1.1. Literature Survey

This study assessed wildlife management strategies in Hungary and Malaysia, focusing on their impacts on wildlife populations and local communities. It explored differences and commonalities between the two countries' approaches, particularly in response to varying wildlife conflicts and socio-economic environments. Key aspects investigated included management models, ownership, funding, systems, and regulatory frameworks. The strategies were evaluated based on wildlife population trends, economic impacts, and local

community benefits, incorporating a "Triple Bottom Line Analysis" to measure ecological, financial, and social sustainability (Amit et al., 2020). A broad review from 1960 to 2022 used governmental and academic sources to draw parallels and identify key legislation.

2.1.2. Data Analysis

The effectiveness of the wildlife management strategies was assessed in three key areas: wildlife population trends, economic contributions, and support from local communities. Indicators for these categories were quantitatively analyzed. The results were compiled in a Wildlife Management Strategies Indicators table, which used a color-coded system to rank each country's performance, based on established metrics from Pack et al. (2013). This detailed analysis illuminated the complexities of the strategies, fostering cross-country learning and improvement, and emphasized sustainable practices that balanced ecological, economic, and social factors.

2.2.Field-based research: Human-Asian palm civet conflict

2.2.1. Study Area

The research was conducted from August 2021 to December 2022 across six villages in Hulu Langat, Selangor, Malaysia. The area features diverse landscapes such as rolling hills, rivers, dense rainforests, and agricultural lands, contributing significantly to local agriculture (Yusry et al., 2018). The climate is tropical rainforest with high humidity and temperatures ranging from 23°C to 32°C, experiencing the most

rainfall from November to January (Malaysian Meteorological Department, 2022).

2.2.2. Survey data collection

Preliminary surveys started in August 2021 to identify respondents familiar with the human-Asian palm civet conflict, resulting in structured interviews and surveys from July to August 2022 (Drury et al., 2011; Rust et al., 2017). Respondents were selected from six villages based on initial surveys and 2020 census data (Department of Statistics Malaysia, 2022), using semi-structured interviews and questionnaires administered in Malay to explore local perceptions, impacts, and mitigation measures related to the conflict.

2.2.3. Scats data collection

From January to December 2022, 57 scat samples from the Asian palm civet were collected to analyze their diet, which included identifying plant materials and chicken feathers (Perilli et al., 2016; Marassi & Biancardi, 2002). The collection focused on areas known for civet activity, using identification techniques to ensure accurate analysis (Zhou et al., 2008). The frequency of occurrence of different food items was calculated to determine dietary preferences, with analyses conducted using SPSS software version 27 (SPSS, 2020).

2.3. Field-based research: Local attitudes towards wildlife and their management methods

A survey involving 585 Malaysians assessed local attitudes towards wildlife and their management methods. The Wildlife

Attitude Index (WAI) and Wildlife Management Method Attitude Index (WMMAI) were developed to quantify these attitudes. Vaske (2008) suggested that a sample size of 400 is sufficient for generalizing results at a 95% confidence level with a ±5% margin of error.

2.3.1. Survey and data collection

The survey was conducted online via Google Forms from May 18 to May 23, 2021. A total of 585 respondents were selected using multi-stage and simple random sampling techniques based on the 2020 Malaysian Census (Department of Statistics Malaysia, 2022). The questionnaire included 16 Likert-scale items to assess attitudes toward wildlife and management methods, along with socio-demographic information.

2.3.2. Design of questionnaire

The questionnaire was structured to explore the socio-demographic and cognitive factors influencing attitudes toward wildlife and management methods (Tadesse & Kotler, 2016). It was divided into four sections, addressing wildlife experiences, attitudes toward wildlife, preferences for management methods, and demographic details. Feedback from a preliminary survey with 20 students was used to refine the content, and a pilot study ensured reliability through Cronbach's alpha testing (Griethuijsen et al., 2014).

2.3.3. Design of attitude indices

The WAI and WMMAI were developed to systematically measure attitudes toward wildlife and management practices.

These indices were validated for content, face, and construct validity, using expert reviews and statistical analysis (Babbie, 2014). The indices were scored on a scale from 0 to 100, reflecting the range from negative to positive attitudes, and were tested for internal consistency using Cronbach's alpha.

2.3.4. Data analysis

Out of 586 responses, 585 were analyzed. Statistical methods such as chi-square tests, t-tests, ANOVA, and regression models were employed to examine variations in WAI and WMMAI scores across different demographics and regions. The analysis adhered to rigorous statistical standards, ensuring robust insights into local attitudes towards wildlife and management methods.

2.4.Technical-based research: Geo Wild System

This study outlines the deployment, functionality, and analytical processes of the Geo Wild System (GWS), which was developed to manage human-wildlife conflicts in Malaysia. The methodology covers the system's development, data collection processes, GIS-based analysis, and evaluation of user feedback.

2.4.1. Development and functionality of the Geo Wild System

The Geo Wild System, developed in 2024 by the author and a technology expert, was created to tackle wildlife management challenges in Malaysia, especially those involving endangered species. Beyond mere wildlife tracking, the system actively

involves local communities in conservation efforts. Built with open-source software, GWS integrates advanced GIS tools for mapping and analysis and functions as a Progressive Web Application (PWA), ensuring accessibility across multiple platforms. The system prioritizes data security and complies with Malaysia's Personal Data Protection Regulation Act (Department of Personal Data Protection, 2010), promoting widespread user participation and secure data management.

2.4.2. Initial deployment and data collection

During January to June 2024, wildlife authorities deployed 117 traps across six districts in Peninsular Malaysia: Shah Alam, Hulu Selangor, Sungai Besar, Hulu Langat, Georgetown, and Seberang Prai. These deployments were based on citizen reports of wildlife conflicts, which were submitted through traditional channels such as phone calls and in-person reports. High-risk areas for trap placement were identified using patterns from previous conflict reports, which provided insight into frequent hotspots and species involved in past incidents. The Geo Wild System (GWS) recorded detailed trap data, including GPS coordinates, species captured, and timestamps. Additionally, GWS facilitated real-time data collection from citizens, leading to 24 new wildlife conflict reports during the study period. All data were systematically uploaded and verified for accuracy within the GWS.

2.4.3. GIS-based data analysis

The GWS utilizes advanced GIS tools, including Kernel Density Estimation (KDE), to analyze the spatial distribution

of wildlife conflicts and trapping effectiveness. KDE was used to create heatmaps highlighting conflict hotspots, including those involving species such as long-tailed macaques (*Macaca fascicularis*), wild boars (*Sus scrofa*), and Asian palm civets (*Paradoxurus hermaphroditus*). The analysis involved geocoding traps and citizen-reported data to produce density maps of conflicts across the study area. These heatmaps identified critical hotspots for targeted interventions and allowed for species-specific analysis, aiding wildlife authorities in prioritizing management actions.

2.4.4. User feedback evaluation

The evaluation of user feedback aimed to assess the user experience and effectiveness of the GWS Application. Respondents were selected from those who had used the GWS, ensuring feedback was based on actual experiences. A three-page English questionnaire was administered online via Google Forms from March 10th to 16th, 2024, targeting user experience, system functionality, and overall satisfaction. A simple random sampling technique was used to gather 103 responses: 73 citizens, 24 wildlife officers, five researchers, and one licensed hunter.

Participants provided consent, and the survey-maintained confidentiality. The questionnaire employed a 5-point Likert scale, where respondents rated their experiences from 1 (strongly disagree) to 5 (strongly agree) across different aspects of the app (Likert, 1932), including usability, data entry processes, and effectiveness in supporting wildlife conservation. Responses were analyzed using descriptive

statistics via SPSS version 27, focusing on central tendency and dispersion measures to identify patterns in satisfaction and areas for improvement. Comparative analysis across user roles further informed recommendations for enhancing the system.

3. RESULTS

3.1. Literature survey: Wildlife management strategies in Hungary and Malaysia

3.1.1. Comparison of wildlife management strategies in Hungary and Malaysia

Wildlife management in Hungary and Malaysia exhibits distinct approaches shaped by differing objectives, ownership structures, and practices. In Malaysia, wildlife is entirely state-owned, with conservation efforts focused on charismatic animals to promote ecotourism, funded mainly by government allocations and NGO contributions (DWNP, 2023). The management approach is non-interventionist in protected areas, aiming to preserve habitats for biodiversity, with ecotourism considered a secondary benefit. Community engagement is limited, and wildlife relocations are regularly carried out to maintain demographic balance and genetic diversity. Data management is conducted using the Spatial Monitoring and Reporting Tool (SMART), with access being restricted but generally reliable (SMART, 2019).

In contrast, Hungary's game management involves state-owned wildlife, with private reserves (fenced hunting gardens) established for hunting, which is central to conservation strategies. Game management units must be financially self-sustaining, as external funding is limited and no EU or national subsidies are provided (Csányi & Lehoczki, 2010). Hunting rights belong to landowners, but a minimum of 3,000 hectares is required, promoting professional management and financial viability (Csányi and Lehoczki, 2010). Local involvement can be weak due to conflicts, mainly over agricultural damages

(Katona et al., 2011; Bleier et al., 2012). Wildlife relocation is rare and used only for critical conservation. The National Game Management Database (NGMD) supports monitoring and strategy development with reliable, accessible data (Csányi et al., 2010).

3.1.2. Wildlife management strategies indicators in Hungary and Malaysia

Hungary and Malaysia reflect their distinct socio-economic priorities through their wildlife management strategies. Malaysia ranks higher in the conservation of large mammal populations (67-100%), though this indicates more severe declines due to challenges like human-wildlife conflicts, habitat loss, and poaching (Perhilitan, 2020; DWNP, 2023). In contrast, Hungary's middle-range ranking (34-66%) suggests more stable or increasing populations as a result of effective management practices (NGMD, 2022).

Economically, ecotourism contributes 3% to Hungary's GDP and 6.7% to Malaysia's, placing both in the middle range (OECD, 2022; Hungarian Central Statistical Office, 2023). However, hunting contributes significantly more to Hungary's GDP (0.05%) within its agriculture sector (1.12%) compared to Malaysia's less than 0.01%. Employment in tourism is high in both countries, with 9.5% in Hungary and 10.54% in Malaysia, but hunting-related employment is notably higher in Hungary (0.029%) than in Malaysia (0.0002%) (Hungarian Central Statistical Office, 2023; Department of Statistics Malaysia, 2023; DWNP, 2023).

Quantifying local financial benefits from wildlife conservation

remains challenging in both countries due to a lack of detailed empirical data. In Hungary, wildlife management has led to significant agricultural damage costs, estimated between €6-8 million (Csányi, 2018). However, similar data on wildlife-related damages in Malaysia is not empirically verified. Economic and demographic factors, such as population density, growth rates, rural population percentage, protected area coverage, and GDP per capita, further highlight the differences in wildlife management strategies between Hungary and Malaysia (Department of Statistics Malaysia; OECD, 2022; The World Bank, 2023; Biodiversity Information System for Europe, 2024).

3.2. Field – based research: Human-Asian palm civet conflict

3.2.1. Types of damage caused by Asian palm civets

Among the surveyed respondents, the majority were males (81.1%) and most (64.6%) were aged 35–55. 157 respondents had at least primary education, and nearly half (49.5%) were engaged in farming. Additionally, over 75% reported being familiar with and having experience with wildlife, while the remaining 22.2% had no wildlife knowledge. The local communities in Hulu Langat suffered losses due to the consumption of cultivated fruits and poultry attacked by APC. According to the survey findings, consumption of cultivated fruits (59%), attacks on poultry (19%), agricultural (12%), and property damages (10%). Poultry attacks predominantly occurred during dawn and dusk hours. Locals revealed that APC primarily targeted young birds rather than fully grown chickens, and preferred consuming chicken eggs.

3.2.2. Asian palm civet food preferences

The APC's diet includes at least 13 types of fruits, poultry, and rotten fruits (**Table 1**), with durian being the most frequently consumed, making up over 25% of its diet year-round, as evidenced by scat samples across both seasons. During Malaysia's fruit season, from June to August, the APC primarily feeds on fruits, benefiting from the optimal fruiting conditions associated with the Southwest Monsoon, which brings less rainfall (Malaysian Meteorological Department, 2022). Conversely, the wetter conditions of the Northeast Monsoon, from November to January, reduce fruit availability in Selangor, prompting the APC to prey on poultry and consume rotten fruits occasionally.

Table 1. Relative frequency of occurrence, (% O) and frequency of occurrence, (FO) of foods found in 57 scats of APC between dry and wet seasons in Hulu Langat, Selangor.

	Wet season, n=18		**Dry Season, n=39**	
Foods	**FO**	**% O**	**FO**	**% O**
Nephelium lappaceum	-	-	8	20.51
Garcinia mangostana	-	-	2	5.13
Mangifera indica	-	-	2	5.13
Durio zibethinus	5	27.77	10	25.64
Carica papaya	-	-	1	2.56
Ananas comosus	-	-	1	2.56
Musa acuminata	-	-	1	2.56
Psidium guajava	3	16.67	-	-
Syzygium samarangense	-	-	2	5.13
Lansium domesticum	-	-	3	7.69
Artocarpus heterophyllus	-	-	2	5.13
Artocarpus integer	-	-	7	17.95
Theobroma cacao	3	16.67	-	-
Poultry	3	16.67	-	-
Rotten fruits	4	22.22	-	-

3.2.3. Local attitudes towards Asian palm civets

Most respondents showed a positive attitude towards APCs (n = 132, 62.3%), preferring to maintain or increase their population. However, a minority of farmers disliked APCs (n

= 35, 16.5%), desiring a reduction in their numbers. The results revealed that occupation ($\chi 2$= 7.445, p=0.007), gender ($\chi 2$= 7.425, p=0.006), fruits consumed ($\chi 2$= 17.174, p=0.001), and familiarity ($\chi 2$= 4.463, p=0.031) significantly influenced attitudes towards APCs. Male respondents tended to have more negative attitudes compared to females. Moreover, respondents who experienced property damage from APCs exhibited lower tolerance and more negative attitudes towards them. Additionally, locals familiar with APCs held more negative attitudes than those who had not encountered them.

3.2.4. Locals' preference for mitigating measures of human-Asian palm civet conflict

Most locals employed passive methods or left the APC undisturbed before and after incidents involving them. Most did not take action or implement measures (pre-measures: n=97, 45.28%, post-measures: n=102, 48.11%). For active methods, most locals used firecrackers to drive away the APC (n=47, 22.17%), and around 10% set traps. However, a small number resorted to using poison (n=11, 5.2%) as a last resort to mitigate economic losses from APC damage to fruits, poultry, agriculture, and property. After incidents, most respondents covered fruits (n=70, 33.02%) and called wildlife control (n=40, 18.87%) to capture and relocate the problematic civets.

3.2.5. Locals' knowledge of population changes in Asian palm civets

Many respondents (n =151, 71.2%) stated that the population of APC had increased over the past decade. On the other hand, a minority of respondents (n =61, 28.8%) believed that the

population of APC had decreased during the same period. During the survey, locals mentioned that they formed their opinions based on the following evidence, namely: (1) the frequency of seeing APC, (2) frequency of encountering APC scats, and (3) the occurrence of APC conflicts. The respondents attributed the growth in the APC population to inadequate population control measures and poor wildlife management. Nevertheless, specific data for the APC in Malaysia are currently undocumented. However, globally, according to the IUCN Red Lists data, the population of APC is experiencing a decline (Duckworth et al., 2016).

3.3. Field – based research: Local attitudes towards wildlife and their management methods

3.3.1. Local socio-demographic information

The majority of the surveyed respondents were (N = 317, 54.2%) females; more than 60% (N = 358, 61.2%) belonged to the 25–34 age group, and (N = 122, 20.8%) belonged to the 18–24 age group. A total of 585 respondents participated, 59.8% of whom were urban people (compared to rural), and 41.0% of the respondents had a secondary level of education. Most respondents engaged in hiking activities (N = 397, 68.0%), fishing (N = 159, 27.1%), hunting, and other activities. However, 0.2% (N = 1) of the respondents stated they did not engage in any natural activities. Some respondents (42.6%) reported having experience with wildlife (familiarity), and others did not have any experience with wildlife (57.4%).

3.3.2. Validation of attitude indices

The WAI included six items and resulted in a Cronbach's alpha

coefficient of 0.71, whilst the WMMAI had seven items and recorded a coefficient of 0.73.

Table 2. Reliability analysis for attitude index of wildlife and their management methods.

Items	Mean	*Sd.*	Inter-Item Correlation	(*α*)
Attitude toward wildlife (WAI)				
Wildlife should be conserved for a future generation.	4.69	0.75	0.46	
Wildlife contributes to the local economy.	2.85	1.18	0.83	
Wildlife is not a threat to the local community.	3.42	1.14	0.51	
Wildlife is responsible for more damage to local property than they are worth.	3.17	1.05	0.79	0.71
The risk of being injured by wildlife is high.	3.97	1.16	0.34	
Wildlife is a nuisance.	2.97	1.23	0.37	
Attitude toward wildlife management methods (WMMAI)				
Use regulated hunting to manage wildlife numbers.	3.41	1.26	0.36	
Euthanize wildlife that repeatedly causes problems for people.	2.98	1.21	0.44	
Capture and relocate wildlife from human areas.	3.64	1.02	0.48	
Educate the locals about human–wildlife conflict.	4.66	0.65	0.55	0.73
Remove attractants from human areas (garbage, bird feeder, etc.).	3.71	1.04	0.85	
People do not have to manage wildlife.	3.98	1.07	0.71	
Wildlife is properly managed in Malaysia.	3.18	1.06	0.53	

3.3.3. Local experiences and attitudes toward costs and benefits associated with wildlife

Most respondents (93.7%) were familiar with wildlife in their area, with over half (54.7%) reporting recent sightings. A significant portion (34.5%) had observed multiple wildlife with offspring. Respondents were more inclined to call for wildlife control if animals were seen numerous times near their property (41.4%) or caused damage, either once (37.1%) or repeatedly (54.5%). However, 35% admitted they would do nothing if wildlife were spotted only once near their property. Less than 10% were unsure in all situations. Over 40% believed wildlife caused more damage than they were worth. Despite 97% supporting wildlife conservation, 63.8% felt the risk of wildlife-related injury was high. Regarding economic

contribution, 63% believed wildlife did not benefit the local economy.

3.3.4. Local acceptability of wildlife management methods in Malaysia

More than 70% (70.9%) of local respondents agreed that people do not have to manage wildlife and that nature should be allowed to take its course. One-tenth (10.1%) disagreed with this statement, while 19.0% were neutral. Concerning the locals' attitude toward (a) supporting or (b) opposing management, five factors were ranked by their level of acceptability. For both issues, humane treatment appeared to be the most essential factor. Wildlife management methods were also more likely to be accepted if proven effective. Management methods that do not involve any direct killing (non-lethal), such as education (93.7%), were considered the most acceptable among the locals. Lethal methods were ranked as the least sufficient. For example, one-third of the sample population (34.8%) considered euthanasia unacceptable in some or all cases. In comparison, the corresponding figure for using regulated hunting to manage wildlife numbers was only 22.3%. Remarkably, hunting was the most acceptable lethal method (50.2%), proving it was almost as satisfactory as the commonly practised capture and relocation method, and more acceptable than the euthanasia of wildlife (34.7%).

3.3.5. Attitudes of locals toward wildlife and their management methods in Malaysia

A linear regression analysis was conducted to assess the factors influencing the WAI and the WMMAI. The model for WAI

was significant (F (4585) = 42.73, p < 0.001), with a 32% goodness of fit. The analysis revealed that urban residents and older individuals tended to have more positive attitudes toward wildlife. In contrast rural residents with more familiarity with wildlife exhibited more negative attitudes, likely due to frequent human-wildlife conflicts in areas bordering forests.

The WMMAI model was also significant (F (7585) = 503.98, p < 0.001), with a 79% goodness of fit. Positive attitudes toward wildlife management methods were higher among rural residents, individuals with higher education, older age, and those with greater familiarity with wildlife. In contrast, urban residents and those highly engaged with nature showed lower WMMAI scores. **Tables 3** and **4** summarize the results of these regression analyses.

Table 3. Regression analysis of Wildlife Attitude Index (WAI).

Variable	***B***	***SE***	**β**	***t***	***p***
Wildlife Attitude Index (WAI)	18.76	3.88	0.00	4.72	<0.001
Age	0.83	0.15	0.37	8.80	<0.001
Urban area	6.21	1.60	0.19	3.88	<0.001
Rural area	−3.67	0.85	−0.19	−3.88	<0.001
Familiarity (experience)	−7.26	0.34	−0.62	−21.67	<0.001

Note. $F_{(4585)}$ = 42.73, p < 0.001, R^2 = 0.32.

Table 4. Regression analysis of Wildlife Management Method Attitude Index (WMMAI).

Variable	***B***	***SE***	**β**	***t***	***p***
Wildlife Management Method Index (WMMAI)	8.76	3.84	0.00	4.42	<0.001
Age	1.23	0.05	0.87	42.15	<0.001
Education	2.88	0.56	0.21	5.54	<0.001
Familiarity	1.69	0.38	0.88	4.76	<0.001
Rural area	2.19	0.42	0.09	4.85	<0.001
Urban area	−7.32	−0.37	−0.62	−19.56	<0.001
Gender	−2.32	0.35	−0.20	−8.61	<0.001
Nature engagement	−1.37	0.64	−0.05	−2.24	<0.001

Note. $F_{(7585)}$ = 503.98, p < 0.001, R^2 = 0.79.

3.4.Technical – based research: Geo Wild System

3.4.1. Initial deployment and GIS-based analysis of wildlife conflict hotspots

During the initial deployment of the Geo Wild System (GWS) from January to June 2024, a total of 117 traps were set across the six districts in Peninsular Malaysia: Shah Alam, Hulu Selangor, Sungai Besar, Hulu Langat, Georgetown, and Seberang Prai under study, resulting in the capture of 88 wildlife individuals, including 85 long-tailed macaques (*Macaca fascicularis*), two wild boars (*Sus scrofa*), and one Asian palm civets (*Paradoxurus hermaphroditus*).

Figure 1 presents a heatmap generated through Kernel Density Estimation (KDE), showing the distribution of *Macaca fascicularis* conflict hotspots. This analysis indicates that areas such as Hulu Langat, and Shah Alam are critical hotspots requiring targeted intervention.

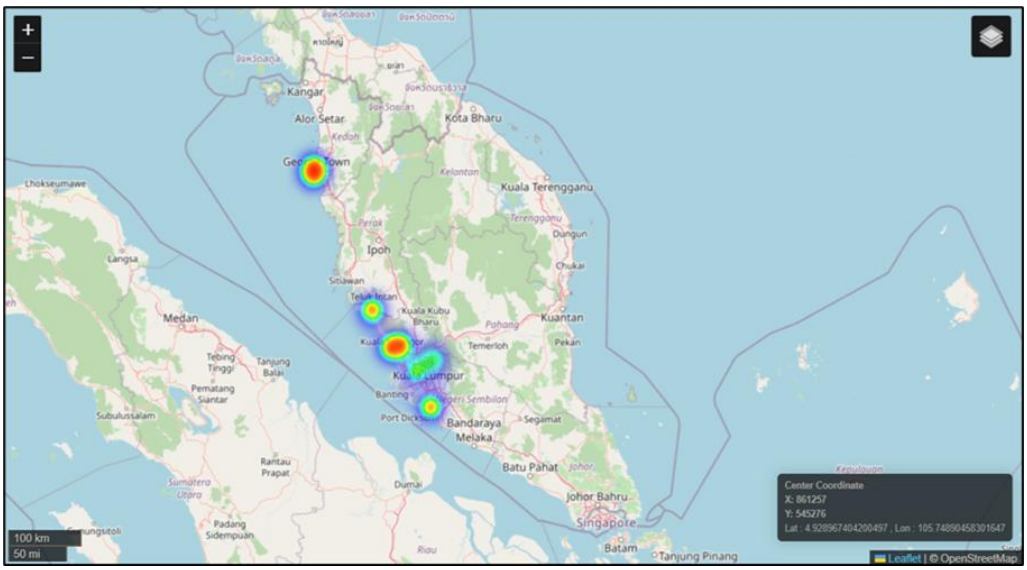

Figure 1. Heatmap of *Macaca fascicularis* (long-tailed macaques) conflict hotspots in Peninsular Malaysia (n=85) generated using Kernel Density Estimation in Geo Wild System from January to June 2024.

3.4.2. Integration of citizen-collected data

In addition to trap data, GWS collected real-time monitoring data from citizens, which is crucial for a comprehensive understanding of wildlife conflicts. Between January and June 2024, citizens reported 24 incidents, primarily involving *Macaca fascicularis* (19 reports), followed by *Sus scrofa* (3 reports), and *Paradoxurus hermaphroditus* (2 reports).

3.4.3. Species-specific heatmap analysis

The citizen-reported data were analyzed to create species-specific heatmaps, providing a clearer view of spatial patterns in wildlife conflicts. These heatmaps, revealed that *Macaca fascicularis* had high-density conflict areas in urban and suburban regions, particularly in Hulu Langat and Shah Alam, closely matching trap data hotspots. In contrast, *Paradoxurus hermaphroditus* reports were fewer and more isolated, primarily in Georgetown and Sungai Besar, indicating less frequent conflicts. *Sus scrofa* incidents were concentrated in suburban areas, with significant activity in Hulu Langat and Shah Alam.

3.4.4. Correlation of citizen reports with trap data: KDE Analysis

Kernel Density Estimation (KDE) was used to compare the density of citizen-reported incidents with trap locations and captures. **Figure 2** shows significant overlap between high-density areas from citizen reports and successful trap sites, indicating that citizen data is a reliable tool for identifying conflict hotspots and guiding trap placement.

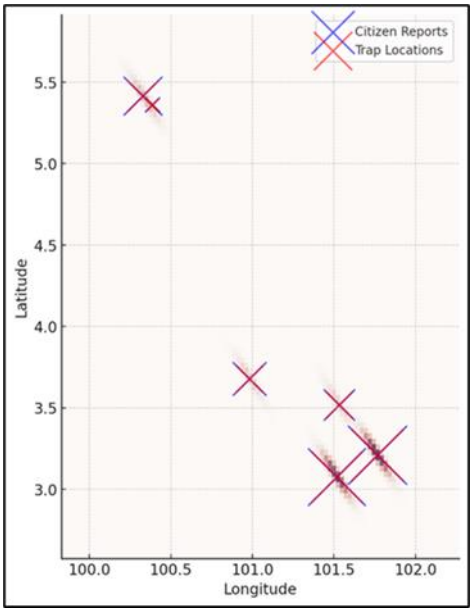

Figure 2. KDE comparison of citizen-reported incidents and trap data from January to June 2024, with the size of the X's representing the relative frequency of reports at each location in Peninsular Malaysia.

3.4.5. User feedback evaluation

User feedback from 103 participants, including 72 citizens, 24 wildlife officers, five researchers, and one licensed hunter, revealed high satisfaction with the Geo Wild System Application, particularly among wildlife officers and citizens. The app's functionality, especially in adding or deleting data and uploading information, was well-received. However, some variability in citizen ratings suggests potential areas for improvement in performance and user interface. Wildlife officers and researchers, being more familiar with similar applications, reported greater ease of use, pointing to a need for enhanced training or more intuitive design for broader user comfort. The likelihood of future use for reporting wildlife incidents was rated highly across all user groups, reinforcing the app's effectiveness and utility in wildlife management.

4. DISCUSSION

4.1. Literature survey: Wildlife management strategies in Hungary and Malaysia

4.1.1. Comparison of wildlife management strategies in Hungary and Malaysia

Malaysia's wildlife management is state-owned mainly, relying heavily on government funding and ecotourism, which often needs more support to maintain effective conservation due to minimal intervention and financial instability (DWNP, 2023). Ecotourism, while crucial for funding and employment, faces challenges such as fluctuating tourist numbers and uneven benefits distribution, with local communities often receiving limited direct financial rewards (Samal & Dash, 2023). The top-down management approach in Malaysia indirectly benefits to locals, with limited proactive community engagement, although some success has been seen in Community-Based Tourism (CBT) initiatives (Kayat & Zainuddin, 2016; Kunjuraman, 2020).

In contrast to Malaysia's passive conservation approach, Hungary actively manages wildlife through sustainable hunting, fee-hunting, and game meat sales to control game populations and fund conservation efforts (Csányi & Lehoczki, 2010; Myronenko, 2015). Hungary's integration with the EU provides financial support for environmentally friendly farming practices that benefit wildlife habitats (Báldi & Faragó, 2007; Kleijn et al., 2009). The country's long-established hunting tradition, regulated by quotas and licenses, generates significant revenue for conservation (Csányi, 1994; Myronenko, 2015). However,

Hungary faces challenges with invasive species, expanding big game populations causing conflicts, and declining small game populations, underscoring the need for a balanced wildlife management strategy (Faragó et al., 2012; Markolt et al., 2012; Schally et al., 2022).

While Malaysia emphasizes passive conservation with limited direct benefits for locals, Hungary integrates community engagement and sustainable use into its wildlife management, offering direct financial incentives. Each country's approach reflects its unique socio-economic and ecological context, highlighting the importance of tailoring strategies to local needs and conditions.

4.1.2. Technological and community involvement

Hungary's NGMD system successfully integrates traditional hunting practices with modern conservation, fostering strong local community involvement and data-driven management (Csányi et al., 2010). This participatory approach enhances data accuracy and stakeholder engagement, contributing to more effective conservation strategies.

In contrast, Malaysia's SMART system focuses on real-time monitoring and enforcement against poaching but lacks robust community involvement, potentially limiting its long-term effectiveness (Trelstad & Bonnie, 2022). While SMART is technologically advanced, its reliance on technology without sufficient community integration can lead to gaps in data and support.

The comparison underscores the need for wildlife management strategies to balance technological tools with community

engagement. Malaysia's system, while effective in monitoring, could benefit from greater local involvement to ensure sustainability and cultural relevance in conservation efforts. Integrating local knowledge and participation will enhance the effectiveness and durability of wildlife management in Malaysia, creating a more holistic and inclusive framework.

4.2.Field-based research: Human-Asian palm civet conflict

4.2.1. Human-Asian palm civet conflict

The study found that over half of the locals in Hulu Langat experienced conflicts with Asian palm civets (APC), particularly those involved in farming, whose crops and poultry were damaged. Negative attitudes toward APC are more common among those familiar with the damage they cause, which hampers conservation efforts (Dai et al., 2019). These conflicts, primarily involving the consumption of cultivated fruits and poultry predation, directly impact livelihoods, leading to heightened sensitivity and negative perceptions among affected locals (Su et al., 2020). Raising awareness and educating communities are crucial for improving APC protection and fostering coexistence.

4.2.2. Causes of human-Asian palm civet conflict

Locals attribute the rise in human-APC conflict to a perceived increase in the APC population, driven by ineffective management and insufficient population control. However, they are often unaware of the global decline in APC numbers (Duckworth et al., 2016). Habitat loss due to urbanization,

tourism, and infrastructure development exacerbates conflicts by pushing APCs into closer contact with humans (Yasuma & Andau, 2000; Shevade et al., 2017). Civets' foraging habits, particularly during seasons when preferred food sources are scarce, lead to property damage and increased predation on poultry, reflecting their opportunistic feeding behavior.

4.2.3. Human-Asian palm civet conflict mitigation measures

Most locals currently prefer passive conflict resolution methods, but some resort to poisoning, which negatively impacts APC conservation. Proactive strategies like targeted trapping and relocation, alongside compensation for damages, can foster tolerance and reduce conflict. Malaysia has yet to implement a comprehensive compensation mechanism for wildlife-related crop and property damage, which would be crucial for encouraging local support for APC conservation (Karamanlidis et al., 2011; Karanth et al., 2013). While government schemes exist for compensating injuries and fatalities, they are often insufficient and slow, leading to frustration among locals (Gao et al., 2023).

To address these issues, it is essential to engage local communities in conflict mitigation efforts and implement modern deterrent systems, such as infrared-triggered alarms, fencing, and non-lethal repellents (Ahmad et al., 2022; Montero-Botey & Perea, 2023). Educating locals on coexistence strategies and enhancing habitat conservation can further reduce conflicts and support APC survival. However, this study's findings are specific to Hulu Langat and may not fully apply to other regions.

Future research should explore APC behavior in less human-impacted areas to better understand the effects of human activities on these animals.

4.3.Field-based research: Local attitudes towards wildlife and their management methods

4.3.1. Wildlife experience affects locals' attitudes

This study found that most locals preferred active wildlife management methods over a passive "leave wildlife alone" approach. While only a few had limited experience with wildlife, they felt that fair protective measures were necessary. Preferences varied notably between those who frequently observed wildlife and those who did not. Direct encounters with wildlife positively influenced locals' attitudes (Basak et al., 2022; Liordos et al., 2020), with familiarity often increasing tolerance and support for management methods (Pinheiro et al., 2016).

Conversely, more than half of the respondents lacked wildlife experience, resulting in neutral or negative attitudes and lower tolerance (Kang et al., 2019). Those with more experience generally supported wildlife conservation and management practices (Odebiyi et al., 2015). Areas with frequent human-wildlife conflicts, especially involving property damage, were associated with more negative attitudes toward wildlife and its management (Hart & O'Connell-Rodwell, 2000). Rural areas near forests showed more negative attitudes compared to urban areas, where residents typically encountered only urban wildlife species (Lunney & Burgin, 2004). Lack of exposure to wildlife led to negative attitudes due to the "extinction of experience" and

"alienation from nature" (Vogel, 1988; Soga & Gaston, 2016).

In summary, frequent interactions with wildlife in rural areas, particularly in Borneo, often led to negative attitudes toward wildlife and its management. These attitudes were influenced by direct impacts of human-wildlife conflicts, property damage, and the lack of economic benefits from wildlife, making locals less inclined to support conservation efforts.

4.3.2. Influential factors on the acceptance of wildlife management methods

The survey found that both urban and rural locals in Malaysia preferred non-lethal methods, such as capture and relocation, for managing wildlife conflicts. This preference aligned with findings from other studies where non-lethal methods were considered more humane (Reiter et al., 1999; Massei et al., 2010). However, a common misconception was that capture and relocation involved sending wildlife to zoos rather than releasing them back into the wild, highlighting a need for better communication about these practices (Asimopoulos, 2016).

Education emerged as a critical factor influencing attitudes toward wildlife management, with higher education levels correlating with more positive views (He et al., 2011). Educating locals about wildlife and management methods could help bridge the gap between local perceptions and expert practices (Woodroffe et al., 2005). The study also highlighted strong support for habitat management and removing attractants, with locals recognizing that food availability in human areas could increase wildlife encounters (Van Eeden & Newsome, 2017).

Gender differences were also noted, with males tended to have

more negative attitudes, possibly due to greater involvement in activities like hunting and fishing (Bennett et al., 2000). Females, however, are generally more tolerant and supportive of wildlife management, likely due to concerns about dangerous wildlife species and less frequent engagement in outdoor activities (Kaltenborn et al., 2006).

Non-lethal methods were widely accepted due to their perceived humaneness, while hunting received limited support, especially among females and the older generation. Younger males showed more support for hunting, reflecting the complex nature of attitudes toward wildlife (Tobias et al., 2021).

The study highlighted the importance of residential areas and wildlife experience in shaping local attitudes toward wildlife management in Malaysia. The strong preference for non-lethal methods over lethal options underscored a disconnect between local views and wildlife management practices. Understanding these attitudes was crucial for improving communication and gaining broader support for conservation initiatives, ultimately leading to more effective wildlife management strategies.

4.4.Technical-based research: Geo Wild System

4.4.1. Insights from initial deployment of the Geo Wild System

From January to June 2024, the initial deployment of the Geo Wild System (GWS) provided crucial insights into its effectiveness in wildlife management in Malaysia. The system, bolstered by citizen science, successfully identified key conflict hotspots, particularly in Daerah Hulu Langat and Daerah Shah Alam, where frequent encounters with long-tailed macaques (*Macaca fascicularis*) were recorded. The GWS proved robust in

swiftly collecting and analyzing data to guide targeted interventions. It demonstrated its adaptability by managing conflicts involving various species, such as the Asian palm civet (*Paradoxurus hermaphroditus*) and wild boar (*Sus scrofa*). These early results underscore the GWS's potential to reduce ecological disturbances and socio-economic impacts of wildlife conflicts.

4.4.2. Wildlife conflict patterns analysis and species-specific management strategies

The detailed analysis of GWS data revealed spatial and temporal patterns of wildlife conflicts, with Kernel Density Estimation (KDE) heatmaps highlighting conflict hotspots, particularly in urban and suburban areas like Hulu Langat and Shah Alam, where long-tailed macaques (*Macaca fascicularis*) were most active. These persistent hotspots suggest that factors like food availability and habitat encroachment drive these conflicts. The GWS also enabled species-specific analysis, providing wildlife officers with insights into the behavior of species such as wild boars (*Sus scrofa*) and Asian palm civets (*Paradoxurus hermaphroditus*), leading to more effective, targeted management strategies. For example, the strategic placement of traps based on this data has proven to be a more effective use of resources, ensuring that interventions are concentrated in areas where they are most needed

4.4.3. Comparative impact: GWS vs. SMART system in wildlife conservation

The GWS has advanced wildlife conservation in Malaysia by shifting from reactive to proactive management strategies. Unlike SMART, which focuses on protected area management,

GWS includes real-time public reporting and community engagement, making it particularly effective for urban wildlife conflicts. By involving local communities, GWS enhances data accuracy and provides real-time insights for timely interventions. Its use of GPS tracking and GIS tools has been key in managing hotspots, especially involving long-tailed macaques, reducing conflict frequency and severity. This integration of community data with advanced spatial tools complements SMART by addressing broader human-wildlife interactions, promoting coexistence.

4.4.5. User feedback and pathways for system improvements

User feedback has been crucial in evaluating and improving the GWS. The system received high satisfaction ratings, especially for its functionality and ease of data upload, reflecting its user-centric design. However, users, including citizens, wildlife officers, and researchers, suggested that the user interface could be more intuitive, and better training resources would improve the experience, especially for those less familiar with such applications. Engagement from licensed hunters remains low, indicating a need for targeted outreach to integrate GWS into their activities. Additionally, automating the administrative verification process could enhance data accuracy and efficiency as the system scales.

4.4.6. Addressing limitations and future directions for the Geo Wild System

While the GWS shows great promise, several limitations need addressing to fully realize its potential. The initial deployment

phase data may not capture the full scope of human-wildlife conflicts across Malaysia, as it is currently limited to Peninsular Malaysia. Extending coverage to regions like Borneo (Sabah and Sarawak), with its distinct geodetic frameworks and ecological landscapes, is crucial for comprehensive wildlife management. The system's reliance on user-reported data, though valuable, introduces risks of inaccuracies and biases. Future updates should incorporate advanced data validation and predictive analytics to enhance accuracy and shift from reactive to proactive wildlife management, allowing authorities to anticipate and prevent conflicts more effectively.

5. CONCLUSION AND RECOMMENDATIONS

This study examined integrating Hungarian wildlife management strategies, such as the NGMD system, into Malaysian conservation efforts, highlighting key differences between the countries. Malaysia's approach, emphasizing state ownership, no-hunting policies, and ecotourism, contrasts with Hungary's strategies, which combines state ownership with hunting and hunter contributions. Adapting the NGMD system for Malaysia necessitates substantial customization to account for cultural and ecological differences, including integrating traditional knowledge and aligning with local values.

The research also highlighted escalating human-wildlife conflicts, notably with the Asian palm civet (*Paradoxurus hermaphroditus*), emphasizing the need for humane conflict resolution. Tools such as the Wildlife Attitude Index (WAI) and Wildlife Management Method Attitude Index (WMMAI) are crucial for understanding local attitudes, while the Geo Wild System (GWS) offers advanced monitoring capabilities.

Effective strategies include adapting conservation efforts to focus on ecotourism and community-based programs, using non-lethal methods for conflict resolution, and enhancing the GWS with advanced GIS tools and mobile apps for better community engagement. Culling should be a last resort. International collaboration is essential to refine these strategies and develop culturally sensitive conservation practices. By adopting these measures, Malaysia can build a more effective and sustainable wildlife management framework, addressing immediate challenges and ensuring long-term resilience.

6. NEW SCIENTIFIC RESULTS

- The comparative analysis revealed that Hungary's wildlife management, with state ownership and a kind of active community involvement through hunting, contributed 0.05% to GDP within its agriculture sector (1.12%) and supported 0.029% of local employment, helping to maintain stable large mammal populations. In contrast, Malaysia's ecotourism-focused strategy contributed 6.7% to GDP, higher than Hungary's tourism sector, but involved less community financial participation and minimal hunting-related employment, correlating with a decline in large mammal species. Malaysia's higher GDP from ecotourism reflects its rich natural resources, but Hungary's model of direct local engagement in wildlife management offers valuable insights into sustainable conservation, suggesting that Malaysia's approach could benefit from enhanced local involvement in broader conservation efforts.
- The field-based research revealed significant human-Asian palm civet conflicts, particularly among male farmers aged 35 to 55, who reported notable agricultural and poultry losses due to the APC's feeding habits. About 59% reported cultivated fruit damage, with durian being the most frequently consumed during its peak season, and 19% noted poultry attacks, mainly on younger birds during twilight hours. Despite these challenges, 62.3% of locals maintained a positive attitude toward Asian palm civets (*Paradoxurus hermaphroditus*), with attitudes influenced by variables like occupation, gender, and direct damage experiences. Conservation attitudes were notably more negative among those who have suffered

property damage. Most locals favored non-lethal conflict mitigation, with 45.28% opting not to intervene. Additionally, 71.1% of locals reported an increase in the Asian palm civet population, which contradicts global trends of decline, suggesting either a localized surge or an underestimation of the species' adaptability.

- The field-based research analyzing local attitudes towards wildlife and their management methods in Malaysia incorporated the development of the Wildlife Attitude Index (WAI) and the Wildlife Management Method Attitude Index (WMMAI) with good internal consistency (Cronbach's Alpha coefficients of 0.71 and 0.72). These indices provide a new structured way to measure local attitudes towards wildlife and management methods, offering a quantifiable measure that can be utilized in future research and policy development. The research revealed that 97.3% of locals support wildlife conservation for future generations, but 63% believe wildlife does not significantly contribute to the local economy. Attitudes toward wildlife as a threat or nuisance varied, influenced by factors such as urban or rural residency, age, and direct encounters with wildlife. Urban residents generally held more positive views, while rural and older individuals, and those with direct wildlife encounters, were more likely to support management interventions such as regulated hunting or relocation. This highlights how demographics and personal experiences shape attitudes toward wildlife management in Malaysia.
- The technical-based research introduced the Geo Wild System (GWS), a new wildlife reporting, monitoring and analyzing

tool in Malaysia, combining open-source software with advanced GIS tools. During its initial deployment (January to June 2024), the system recorded and facilitated the setup of 117 traps, resulting in 88 wildlife captures, including 85 long-tailed macaques (*Macaca fascicularis*), two wild boars (*Sus scrofa*), and one Asian palm civet (*Paradoxurus hermaphroditus*). Utilizing GIS-based Kernel Density Estimation (KDE), the system effectively pinpointed wildlife conflict hotspots, enhancing strategic conservation planning. High user satisfaction reflects its success, and further refinements are anticipated to improve wildlife management in Malaysia.

7. LIST OF PUBLICATIONS

- Publication (Journal Article: Q1 – IF = 3.5) – Peer reviewed

Hasan, S.M., Sainuddin, M., Csányi, S. (2024). The introduction of Geo Wild System (GWS) as a novel wildlife reporting, monitoring, and analyzing system in Malaysia. *Global Ecology and Conservation*. 54, e03183.

- Publication (Journal Article: Q1 – IF = 3.3) – Peer reviewed

Hasan, S.M., Csányi, S. (2023). Human–Asian palm civet conflict in Malaysia. *Sustainability*. 15 (15), 11570

- Publication (Journal Article: Q1 – IF = 2.1) – Peer reviewed

Hasan, S.M., Csányi, S. (2023). Attitude index of local communities toward wildlife and their management methods in Malaysia. *Diversity*, 15(2), 202.

- Publication (Journal Article: Q3 – IF = 1.0) – Peer reviewed

Hasan, S.M., Csányi, S. (2022). The overharvest of porcupine species for bushmeat and traditional medicine in Malaysia. *Review on Agriculture and Rural Development*. 11 (1-2), 161-167.

- Oral Presentation (Conference Abstract)

Hasan, S.M., Csányi, S. (2022). The overharvest of porcupine species for bushmeat and traditional medicine in Malaysia. *19th Wellmann International Scientific Conference*. Hódmezővásárhely, Hungary. 28th April 2022.

- Poster (Conference Abstract)

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- Poster (Conference Abstract)

Hasan, S.M., Csányi, S. (2023) The portrayal of wild boar on social media in Malaysia. *20th Wellmann International Scientific Conference*. Hódmezővásárhely, Hungary. 3rd April 2023.

- Poster (Conference Abstract)

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- Poster (Conference Abstract**)**

Hasan, S.M., Csányi, S. (2021). Dusky leaf monkeys popular on YouTube: rising illegal exotic pet trade on social media in Southeast Asia. *35th Congress of International Union of Game Biologists (IUGB)*. Budapest, Hungary. 21-24 September 2021.

- Poster (Conference Abstract**)**

Hasan, S.M., Csányi, S. (2021). Dusky leaf monkeys popular on YouTube: rising illegal exotic pet trade on social media in Southeast Asia. *18th Wellmann International Scientific Conference*. Hungary. 13th May 2021.

Other publications

- Contributing Author: Journal Article

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