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Confronting cultures: northern Madagascar's cultural beliefs and the relationship of owls and humans

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Abstract

Owls are often associated with superstitions and witchcraft in various cultures, leading to conflicts between human communities and these birds. This study, conducted in 2023 across 16 villages in Andapa, a northern district of Madagascar, aimed to investigate the challenges of human-owl coexistence. It specifically explored the cultural beliefs and conflicts driving the motivation to kill owls, particularly during witch-hunting incidents between 2021 and 2022. The findings revealed a prevalent belief among the local population in the close association between witches and owls. Both villagers and witches demonstrated a lack of understanding of environmental laws and regulations, intensifying motivations for owl hunting. The limited awareness of the legal consequences of hunting owls among the local population, combined with a lack of understanding among witches about the law prohibiting the keeping of owls as domestic companions, significantly contributes to this issue. Furthermore, the analysis showed that individuals with strong traditional beliefs or who had encountered dead owls were more likely to engage in owl hunting. Conversely, those more educated, knowledgeable about wildlife protection laws, or aware of the ecological importance of owls were less likely to participate in such practices. This study underscores the urgent need to raise awareness of owls' ecological value, improve understanding of wildlife protection laws, and promote education to reduce owl-hunting behavior in the region.

Keywords Madagascar, Culture, Conflict, Owls, Witchcraft

Background

The relationship between humans and nature has been fundamental to human existence, shaped by ecological processes and natural energy cycles [1]. However, this relationship often leads to conflict, particularly between humans and wildlife. For instance, Talkokulwar [2] reported the tragic deaths of a tigress and her cub in India's Umred-Karhadla-Pavani Wildlife Sanctuary due to poaching and human encroachment. Such incidents draw attention to the ongoing concern of human-wildlife conflict, which Penteriani [3] argues may be influenced more by human behavior than by the actions of animals. Human-wildlife conflict is a significant challenge to conservation efforts, as it often results in environmental degradation, loss of biodiversity, and the depletion of natural resources [4]. As the studies in human geography have proved, successful biodiversity conservation must consider local land-use patterns and the socio-political dynamics of affected communities [5–8].

Like many other countries and communities, Madagascar faces human-wildlife conflicts, with human-owl conflicts being notably frequent in rural areas. Known for its rich biodiversity, Madagascar is a global hotspot for endemic species of both flora and fauna [9]. Among the distinctive wildlife in Madagascar are its endemic owls,

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which comprehend four species: Madagascar Scops Owl (*Otus rutilus*), Torotoroka Scops Owl (*Otus madagascariensis*), Madagascar Red Owl (*Tyto soumagnei*), and Madagascar Owl (*Asio madagascariensis*). In this study, conducted in Madagascar, the situation under examination is not a conflict directly caused by wildlife, specifically owls, affecting humans, but by a small segment of the human population, specifically witches who exploit owls for cultural purposes, viewing them as sacred birds. This exploitation, in turn, leads another part of the population to hunt owls indiscriminately. Understanding the tensions between Malagasy cultural practices and environmental conservation is crucial for the well-being and future of the population.

The human-owl conflict in Madagascar originates from traditional witchcraft practices that are deeply rooted in the country's culture. Witchcraft has deep historical and cultural roots, often associated with spiritual healing, protection, and the quest for power. Many people believe that witches or sorcerers possess supernatural abilities that can influence the lives of others. In Malagasy culture, there are three main types of witches: "Mpamosavy" (typically women over 50), "Mpisikidy," and "Mpanandro" (both usually men over 50). Mpamosavy are infamous for their malevolent powers, often visiting graves or homes at night with amulets and owls and using dark magic to harm others. The people feared them as they aided thieves by providing protective amulets that render criminals invulnerable, which spreads fear, hatred, and grief throughout communities. Despite widespread disapproval of witchcraft's harmful effects, witch-hunting is rare in Madagascar due to fear of homicide legal repercussions.The local population typically expresses their discontent through whispered accusations, defamation, or the expulsion of suspected "Mpamosavy" from villages. However, from late 2021 to early 2022, a severe incident triggered widespread anger. Over 30 boys and girls, aged 13 to 17, reportedly possessed by spirits, began leaving school and wreaking havoc in nearby villages, assaulting people and setting homes on fire. This chaos led to a witch-hunt, resulting in the deaths of at least four witches, over 25 owls, and injuries to 20 people. Owl hunting, a long-standing practice in the region, became a way for villagers to seek revenge on witches without directly confronting or killing them. Since the local population feared legal consequences for killing witches, they targeted owls instead, believing that killing the owls, which are associated with witches and components in the rituals and practices of witchcraft, would weaken or harm the witches indirectly.

Conversely, the name of the owl in the Malagasy language reinforces the negative perception of this bird. In Malagasy, owls are called 'vorondolo,' a term derived from 'vorona,' meaning 'bird,' and 'Lolo,' meaning 'spirit' or 'spirit of death,' collectively signifying 'bird of spirits.' This terminology elicits controversy between environmentalists and the local population. Environmentalists propose that the term is a mispronunciation of the English word 'owl,' combining 'vorona' with 'owl,' resulting in 'voron(d)_owl,' with the added 'd' introduced according to the grammatical rules of the Malagasy language. This reinterpretation aims to alter the Malagasy perspective on the life of owls. However, the local population interprets it literally within the context of their cultural beliefs. Owls, associated with the night and darkness, are perceived as spirit birds (vorondolo). Their physical features, such as long ears resembling horns, frightening facial expressions, and clawed feet, contribute to their portrayal as birds of the devil in local culture. Wizards, magicians, and witches employ owls as intermediaries for their amulets (ody) and spirits, exploiting their association with darkness to sanctify malevolent amulets. Many witches in Madagascar keep at least one owl in their homes or agricultural fields, believing it increases the effectiveness of their amulets. This practice suggests that the presence of owls and other wildlife is crucial for success in sorcery, emphasizing the ongoing role of owls in preserving the potency of their amulets over time [10].

This research aligns with broader anthropological studies on indigenous knowledge systems, aiming to understand how local beliefs shape human-wildlife interactions. Malagasy beliefs, similar to those in other regions such as Bali where animals hold spiritual significance, highlight the importance of understanding cultural dynamics when developing conservation strategies [11]. This study aims to clarify the research framework by: a) investigating the cultural significance of owls in Malagasy folklore, traditions, and belief systems; b) examining the interactions and conflicts between humans and owls in Madagascar, including superstitions and hunting practices; and c) developing strategies to promote sustainable coexistence between humans and owls [12].

Materials and methods

Materials

Description of the study area

Our study was conducted in 16 villages within the Andapa district in northern Madagascar (Fig. 1). Andapa, part of the Sava Region, borders the districts of Ambilobe and Sambava to the north, Antalaha to the east, Maroantsetra to the south, and Befandriana Nord and Bealanana to the west (Fig. 2). Marojejy National Park, located in the eastern part of Andapa, serves as a habitat for various wildlife species, including four owl species endemic to Madagascar. The owl breeding

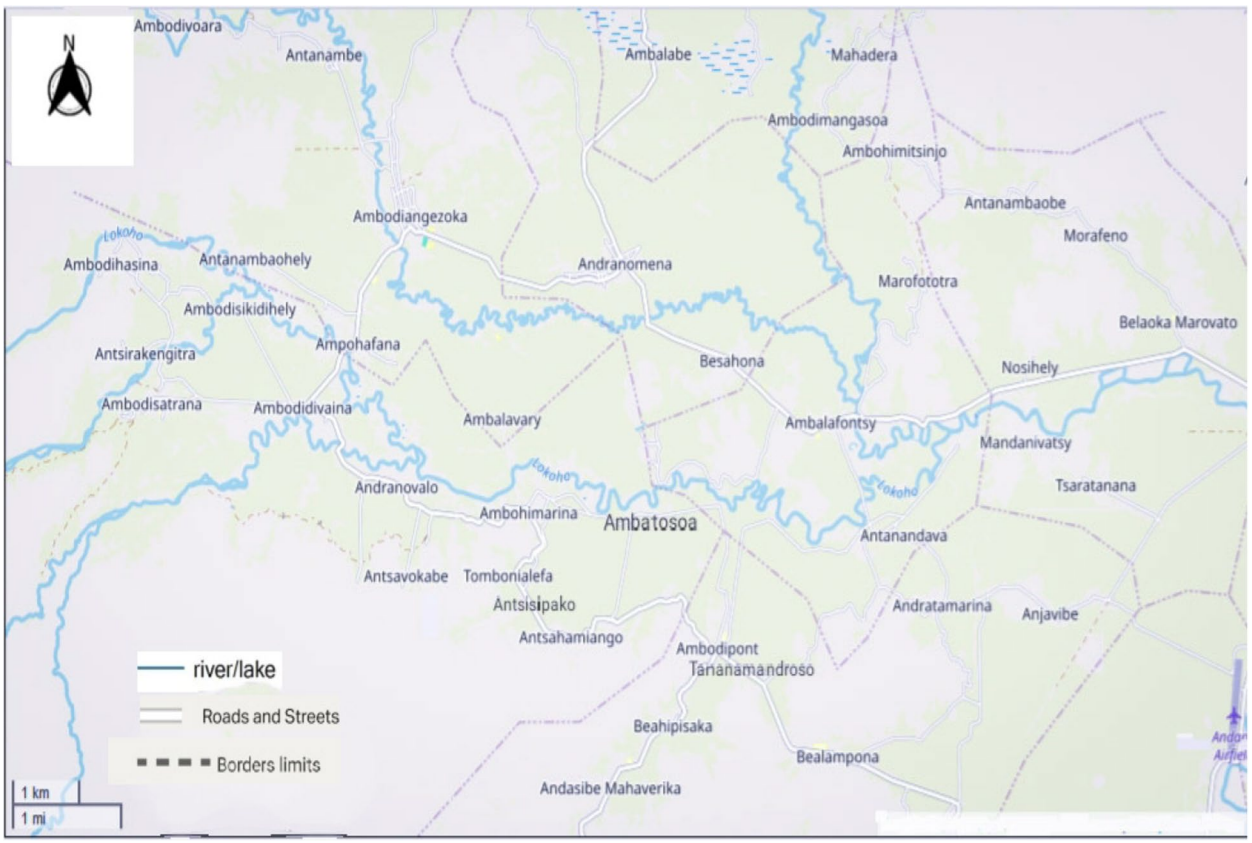

Fig. 1 Villages and river systems in northern Madagascar

season starts in August, with egg-laying in September, and the nesting period lasts through November, which spring in Madagascar.

In this region, owls are widely associated with witches, often seen as their companions or symbols, particularly the "Mpamosavy". These cultural beliefs have fueled owl hunting, as many villagers fear that the presence of owls signals witchcraft practices, widely believed to harm the community. Owls are known for assisting witches in their sorcery and acting as spiritual intermediaries or protectors. Witch-hunting operations in 2021 and 2022 occurred in this region, sparked by reports of spirit possessions and community disturbances, which led to the killing of both witches and owls. We chose the Andapa district for this study due to the strong presence of traditional beliefs and practices and the frequent association of sorcery with the breeding, raising, and keeping of owls in households. Owl breeding is viewed as a time of heightened mystical power, with the birth of new owls as a key moment to engage in powerful witchcraft rituals. The use of owl offspring in sorcery symbolizes a connection to life cycles and supernatural forces. As a Malagasy saying goes, "lohataona masiaka mpamosavy," meaning "in the spring season, witches work intensely."

Data collection

A combination of probability sampling and non-probability sampling techniques was employed to gather comprehensive data. Data collection involved questionnaires, interviews, observation checklists, and Focus Group Discussions [13] (see list of topic areas in Table 1). The villages involved in this study maintain an agrarian lifestyle and lack electricity, internet access, and entertainment options. The primary form of recreation for the local population revolves around evening conversations on verandas, serving not only as a pastime but also as a medium for information sharing and knowledge transmission. Leveraging this cultural setting, we initiated discussions with various age groups, engaging them on the research theme to capture a comprehensive perspective.

We organized the focus groups according to local customs, based on sex and age: men aged 18–25, men aged 26–50, men over 50, women aged 18–30, women aged 31–50, and women over 50. The distinction in age categories for men and women reflects local customs and cultural norms, which define roles and expectations for different life stages. Men aged 18–25 are typically unmarried, while women in the 18–30 age group are in the reproductive period and are often new to household

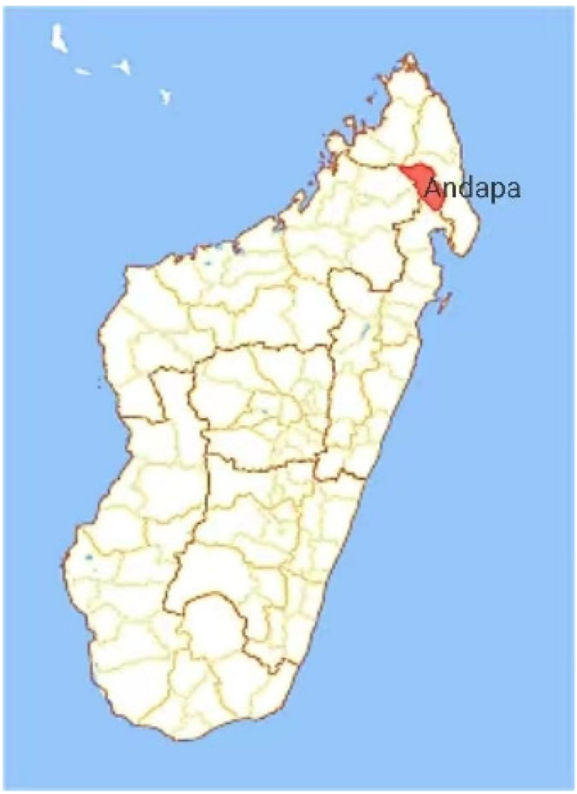

Fig. 2 The Andapa study area in northern Madagascar

responsibilities. These groups tend to share similar conversation topics related to early adulthood, family formation, and household life. The women aged 30–50 tend to have more experience with household life, and their discussions reflect these shared experiences. Men aged 26–50, often already having families, are more mature and tend to focus on topics related to family life and responsibilities. These age distinctions are rooted in local customs, which recognize different individual roles and life stages based on gender. We have recorded 600 participants in focus group discussions across the 16 villages. The day following each evening discussion, we conducted individual interviews, interviewing 30 people in each community to verify the accuracy of the information gathered during the focus group discussions and asking them to complete a questionnaire totaling 480 interviewees. Finally, we conducted interviews with 15 witches to gather more detailed information about the role of owls in their ritual practices.

To respect local customs during evening conversations, we only attended the discussions involving men under 50. For men over 50 and women of all ages, we employed facilitators from the same demographic groups to lead the discussions and used mobile phones to record them. Men and women under 50 were more open and forthcoming during the conversations. However, the age group over 50 posed challenges, especially when individuals accused of witchcraft were present. Fearing potential consequences, participants refrained from expressing their views openly, limiting the discovery of information regarding these individuals. To address this issue, we strategically redirected the conversation topics to focus on the situation in other villages, ensuring the safety and comfort of participants. The close connections and mutual familiarity among the populations of these villages facilitated a seamless transition between discussion topics.

Methods of data analysis

Qualitative analysis

The qualitative method is a key research approach in ecological studies. In this analysis, we adopted a descriptive approach, complemented by a narrative descriptive method following the framework of Creswell [14]. This process captured recurring themes related to the cultural significance of certain species and documented personal accounts from local villagers, highlighting their experiences with ecological changes and wildlife interactions.

Table 1 The list of variables (topics) examined within the 16 village areas in this cultural study

Variables	Notation	Type of variable
Number of people who have killed or will kill owls	Killing	Dependent variable
Number of people who have seen dead owls	Dead	Independent variables
Number of people who fear owls	Fear	
The number of people who believe that owls are witches' companions or birds of witches and darkness	Witch	
Number of people who know the importance of owls in their lives	Importance	
Number of people aware of owl protection laws	Law	
The number of people in High school who graduated	H.G	
Number of people who believe in the power of traditional religion	Tradition	
The number of people who know environmental protection value	Environment	

We thematically organized the qualitative data and presented them through narrative reports. We analyzed these narratives to understand how traditional beliefs influence conservation behavior and conflicts with wildlife. The contextual information gathered through qualitative analysis provided a valuable understanding of the challenges experienced by both owls and humans. It also identified opportunities to promote positive change and harmonious coexistence between them. Luetkemeier [15] similarly used a qualitative method to explore human-wildlife conflicts in Namibia. This study applied the same strategy to investigate the conflict between humans and owls in the Andapa region of Madagascar.

Quantitative analysis

Multiple regression analysis

We presented the quantitative data as frequencies and percentages within tables, supplemented by regression analysis. Multiple Linear Regression was employed in this study to analyze the relationship between the dependent variable (owl killing) and several independent variables [16]. This approach enabled the examination of various factors influencing the conflict between humans and owls in the study area. This method is considered standard practice in ecological studies. For example,Xu [17] applied Multiple Linear Regression to analyze the relationship between vegetation habitats and bird communities in urban mountain parks in China. Similarly, Zhang [18] used the method to study the effects of environmental factors on bird communities across different levels of urbanization.

In this study, the dependent variable was the number of people who have killed or are likely to kill owls. The independent variables included the number of people who had seen dead owls, those who fear owls, believe owls are associated with witches, recognize the importance of owls, are aware of the laws protecting owls, have completed high school, believe in traditional religion, and understand the environmental value of owls (Table 1). Each variable in the model was analyzed to assess its influence on owl-killing behavior.

Results

Descriptive statistical analysis result

The interview data from 16 villages provide valuable information on the causes of owl hunting, as detailed in the statistical summary (Table 2) and the percentage breakdown (Table 3). The Killing variable, with a mean of 27.94 (std. dev. = 1.18), indicates that 93% of respondents have either killed or are likely to kill owls, with men (52%) slightly more likely to engage in this practice than women (48%). This finding suggests that owl hunting is widespread, particularly among men. Additionally, 91.7% of respondents reported seeing dead owls multiple times, emphasizing the commonality of owl deaths. The Fearing variable, with a mean of 5.63 (std. dev. = 1.71), reveals that only 19% of respondents expressed fear of owls. Of these, 97% were women, particularly those aged 18–30, indicating that fear of owls is notably higher among younger women, although overall fear levels are low across the study population.

Table 2 Descriptive statistic result

Variable |	Obs	Mean	Std. dev.	Min	Max
+					
Killing |	16	27.9375	1.181454	26	30
Dead |	16	27.5	1.591645	25	30
Fearing |	16	5.625	1.707825	3	9
Witches|	16	27.875	1.821172	25	30
Law |	16	1.6875	1.014479	0	3
+					
Hg |	16	1.125	0.8062258	0	2
Tradition |	16	28.4375	1.209339	27	30
Environment |	16	1.25	0.9309493	0	3
Importance |	16	1.0625	0.9979145	0	3

The Witches variable, with a mean of 27.88 (std. dev. = 1.82), shows that 93% of respondents associate owls with witchcraft, demonstrating how deeply ingrained cultural beliefs shape local perceptions of owls. However, this belief is less prevalent among older individuals and those with higher education, suggesting that age and education play significant roles in shaping these beliefs. The Law variable, with a mean of 1.69 (std. dev. = 1.01), indicates that only 5% of respondents understand the legal protections for owls, pointing to a lack of legal awareness, especially among women and younger individuals. Similarly, the Environment variable, with a mean of 1.25 (std. dev. = 0.93), shows that only 4% of respondents recognize the importance of environmental conservation, reflecting a general lack of environmental awareness in the region. The Importance variable, with a very low mean of 1.06 (std. dev. = 0.998), reveals that just 3% of respondents understand the ecological significance of owls, emphasizing widespread ignorance about their environmental and economic role. Lastly, the Tradition variable, with a mean of 28.44 (std. dev. = 1.21), indicates that 94.8% of respondents adhere to traditional beliefs or esoteric traditions, particularly those related to astrology, cleromancy, spiritual beliefs, occult mysticism, and wizardry. However, they strongly dislike witchcraft practices. The local population generally associates witchcraft with malevolence and harm while revered wizardry as a

Table 3 Descriptive statistic result with percentage

VARIABLE	sex	AGE			Total answer		TOTAL Interview
		18–25(%)	26–50(%)	50 + (%)	particular(%)	All (%)	
Killing	M	100	97	94	97	93	240
	F	90	91	86	89		240
See	M	99	97	100	99	91	240
	F	76	87	90	84		240
Fearing	M	2	1	0	03	19	240
	F	55	38	16	36		240
Witches	M	97	100	87	95	93	240
	F	99	90	84	91		240
Law	M	3	7	15	8	5	240
	F	1	2	6	3		240
Hg	M	2	5	6	4	3	240
	F	1	4	4	3		240
Tradition	M	87	95	97	93	94	240
	F	94	96	99	96		240
Environment	M	2	6	5	4	4	240
	F	2	5	4	4		240
Importance	M	0	2	9	4	3	240
	F	1	2	6	3		240

symbol of wisdom and knowledge. This cultural distinction reflects a belief system where witchcraft is fearful for its destructive potential, and wizardry is admirable for its scholarly and protective qualities. Adherence to such esoteric traditions strengthens negative attitudes toward owls, as wizards often accuse individuals of practicing witchcraft bringing misfortune to others. Villages with stronger adherence to these traditions are more likely to engage in owl hunting. However, it is necessary to note that cultural beliefs can also mitigate negative perceptions of owls, as the witches regarded them as wise, extraordinary creatures and faithful companions of those who practice witchcraft. This duality may explain why the data indicate that women and older individuals, who are tied closely to traditional beliefs, tend to have slightly less negative attitudes toward owls than men and younger people.

The evident antagonistic relationship between the population and owls

The multiple regression analysis output in Table 4 reveals a highly significant model, as evidenced by the Model F-statistic of 25.33 and a Prob > F value of 0.0002, well below the standard threshold of 0.05. Additionally, the substantial R-squared value of 0.9666 indicates that the model accounts for nearly 97% of the variability in the dependent variable "killing." The Root Mean Square Error (RMSE) of 0.31603 further attests to the model's accuracy in predicting owl killings. When exploring the individual predictor variables, the "Witch" variable appears obviously, showcasing a coefficient of 0.2046 and a p-value of 0.036. This finding highlights a predominant belief deep-seated within the population regarding the perceived association between owls and witches. Interestingly, raising owls at home or in fields is commonly interpreted as indicative of witchcraft. This cultural belief has influenced not only perceptions of owls but also behavioral practices within the community, potentially impacting owl populations. During the witch-hunting operations of 2021 and 2022, 28 owls died, indicating a fragile relationship between humans and owls that likely predates these events, with an estimated average of 8 owls killed annually. On the other hand, the variable "Law" presents a statistically significant coefficient of −0.6881 alongside a p-value of 0.027. This finding suggests a noticeable deficiency in environmental law knowledge among the population. The lack of awareness of the law may stem from the failure of local government and judicial institutions to enforce punishment for those involved in owl hunting, possibly due to fear of provoking a revolt. Similarly, during witch-hunting operations, the Andapa district security forces struggled to control the population's anger. To manage the unrest, they received additional support from 300 security personnel from Sambava (the capital of the SAVA region) to suppress the revolt, as these

Table 4 Factors influencing owl killing behavior in northern Madagascar

Source	SS	df	MS	Number of obs = 16
+				F(8, 7) = 25.33
Model	20.2383876	8	2.5297984	Prob > F = 0.0002
Residual	699112368	7	09987319	R-squared = 0.9666
+				Adj R-squared = 0.9284
Total	20.9375	15	1.39583333	Root MSE = 0.31603
Killing	Coefficient Std. err	t	P>|t|	[95% conf. interval]
Dead	0052339	1007758	-0.05	-.2435308 .233063
Fearing	084327	0606279	-1.39	-.2276893 .0590353
Witches	2046124	0790973	2.59	.017577 .3916478
Law	6880889	2456916	-2.80	-1.269057 -.1071205
Hg	1003798	2841665	0.35	-.5715672 .7723268
Tradition	0969927	1876513	0.52	-.5407176 .3467321
Enviro~t	2352861	1426877	-1.65	-.572689 .1021168
Import~e	2621066	3256984	-0.80	-1.032261 .5080478
_cons	27.23125	4.952788	5.50	15.51977 38.94273

forces were responsible for protecting the lives of the accused witches.

After completing the regression analysis, we conducted a Variance Inflation Factor (VIF) analysis to identify multicollinearity within the model. The results indicate that all VIF values are below the critical threshold of five, with the variable 'tradition' exhibiting the highest VIF score of 4.09 and the variable 'fearing' presenting the lowest score of 1.16. The average VIF value across all predictor variables is 3.02, suggesting the absence of severe multicollinearity among the variables in the model.

After performing a multiple regression analysis, we also conducted the Shapiro–Wilk W test to assess the normality of the residuals (Table 5). The Shapiro–Wilk test is employed to evaluate whether data follows a normal distribution. The test result shows that the value of the test statistic for normality, $W = 0.97056$, is close to 1, indicating that the data closely approximates a normal distribution. The p-value of the test ($Prob > z = 0.68084$) is higher than 0.05, suggesting insufficient evidence to reject the null hypothesis. Since the p-value exceeds the 0.05 significance threshold, we fail to reject the null hypothesis, confirming that the residuals follow a normal distribution, thereby validating this assumption.

Table 5 The Shapiro-Wilk test result

Variable	Obs	W	V	z	Prob>z
residuals	24	0.97056	0.794	-0.470	0.68084

Discussion

Owl-hunting in Madagascar is not for food purposes, as owl meat is considered "fady" (taboo or prohibited to eat) in Malagasy culture. About 95% of people interviewed claimed that consuming owl meat is "fady" (prohibited, taboo) for them. However, they engage in owl hunting with three main objectives: to eliminate witches' power, catch witches, and harm witches indirectly. The belief is that decreasing the owl population weakens the efficiency of witches' amulets. Witches consider owls their friends and family, and when the owls passed away, the witches lamented their loss and laid them to rest with the same care as a beloved family member. According to the exploration of Emma Wilby [19], witches regarded the animals as familiar spirits and spiritual companions. To identify witches in society, the population may publicly display killed owls and observe individuals who show interest or sympathy for them (Fig. 3). Thus, expressing positive sentiments about owls in Madagascar may lead to social problems. On the other hand, the local population also firmly believes that the fragments of dead owls can be employed to kill the witches indirectly; people perceive that witches will be cursed if they consume fragments of deceased owls. As a result, villagers hunt owls and place small pieces of owl meat in the village wells, believing the witches will fall ill or die after drinking the water.

Additionally, the incidence of witchcraft in the Andapa district obstructs economic, educational, and social development in the region. Bizarre supernatural events or accidents occur as a result of sabotage by witches against those who are making progress in their lives [20], such as the mysterious deaths nearly every four days during three months in Andongozabe

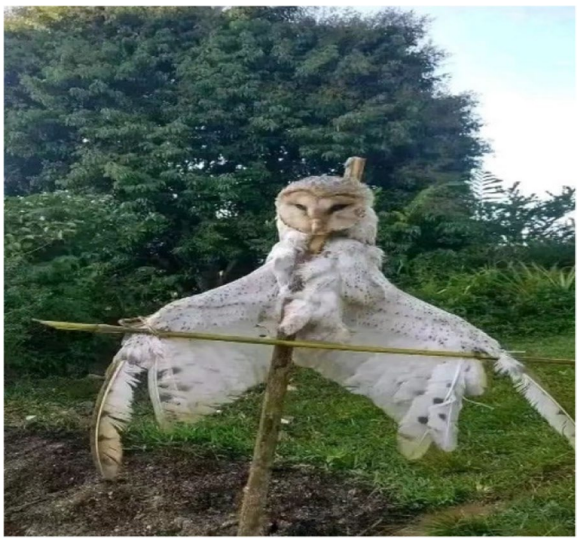

Fig. 3 A Tyto owl killed in Antsahamiangona, northern Madagascar in 2021

village in 2022 and the possession of devil over 30 young people in Antsahamiangona (2021), which illustrates the societal impact of witchcraft. These incidents led to witch-hunting operations, forming the focus of this paper. While the accusation of witches about these tragedies seems superstitious and incredible, it is essential to acknowledge the mystical and magical facets inherent in every culture. In Madagascar, this mystical dimension is called 'ody,' encompassing witchcraft, shamanism, and voodoo. Magic holds a prominent place, with healers known as 'Ombiasy' (traditional Malagasy healers) possessing knowledge of medicinal plants, divination, and the creation of magical charms called 'Sampy' (sacred objects believed to wield protective or mystical powers) [21]. The owls play a crucial role in upgrading the efficacy of these charms, accenting their significance in the sacred and cultural fabric of Madagascar.

Furthermore, the complexity of cultural identity is dominant among witches as they navigate the intersections of tradition, belief systems, and modern society. Even though the population strongly disapproves of the dangerous behavior of the witches towards them, the witches affirm their inability to control their 'ody' (talisman or amulet, witchcraft). They claim that sometimes the 'ody' compels them to harm someone, as they become possessed by other spirits and are unaware of their actions until it ends. Despite acknowledging the danger, the witches mention their hesitation in discarding the amulet, considering it a heritage of their ancestors. They stress that the ancestral spirits do not permit the abandonment of those costumes. The decision to forsake this practice would bring suffering to their lives and families. The responsibility for the amulet is passed on to another family member if they die, perpetuating the cycle. The primary threat to the population posed by witches is the sabotage of economic prosperity. Witches specifically inflict harm upon individuals possessing prosperity and a promising future, creating a vital obstacle to success in life. Therefore, these villages find it challenging to achieve economic and social development.

This study identifies issues related to legal norms and the lack of environmental education in the region. Since 2005, Madagascar has had a wildlife protection law, primarily governed by Law No. 2005–018, which regulates the international trade in endangered species of wild fauna and flora [22]. This law aligns Madagascar national legislation with the provisions of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), to which Madagascar is a signatory. However, public awareness of this law remains low. In Madagascar, particularly in rural areas, there is widespread ignorance of ecological laws, especially those related to owl hunting. While environmental protection laws mainly focus on deforestation and lemur hunting, authorities pay less attention to regulations concerning other wildlife. Individuals may prioritize compliance with environmental or penal laws based on their perception of the potential consequences [23, 24]. The threat posed by witches complicates legal matters, as killing a witch could result in a 10-year jail sentence, while killing owls may lead to a maximum of two years in jail, but they do not know that the law prohibits killing. The government focuses primarily on ensuring population security, often taking precedence over environmental law enforcement. Most of all, the sorcery acts are not officially recognized by the legal system of Madagascar, allowing witches to continue their practices without fear of legal repercussions. The lack of awareness regarding the law may also lead witches to capture owls and keep them as mascots at home, despite the Madagascar ecological legislation prohibiting such practice. It induces the necessity of biodiversity conservation law and education reform to enhance the protection of local biodiversity [25]. Legal awareness and education are essential strategies for reducing human-wildlife conflicts globally. In Madagascar, as in similar regions with significant human-wildlife conflicts, improving community knowledge about environmental laws can reduce wildlife persecution [26]. Furthermore, aligning conservation strategies with local cultural beliefs advocated in environmental anthropology can foster greater community involvement and acceptance of conservation efforts [27, 28]. As Penteriani [29] argue, conservation strategies must be culturally adaptive

to succeed in areas where traditional beliefs dominate local perspectives on wildlife.

Finally, the lack of understanding about the small yet valuable role owls play in economic development, environmental protection, and public health management is one of the key factors contributing to owl hunting in the region. In promoting owl protection in Madagascar, it is necessary to inform the population about the indirect economic benefits of owls. Owls, being predator birds, play a role in reducing the need for pesticides in agriculture [30]. The agricultural sector of Madagascar confronts adversities posed by insects (grasshoppers) and rodent attacks; this phenomenon leads Madagascar to persistent food insecurity. According to ReportLinker (2023, https://www.reportlinker.com/clp/country/13/726257) the estimation of pesticide consumption in Madagascar will rise from 813 metric tons in 2021 to 990 metric tons by 2026, reflecting a compound annual growth rate of 3.1%. This increase is part of a broader trend, with pesticide use consciously growing at an average rate of 10.5% since 1995. Effective measures for protecting owls are vital, as their abundant presence can naturally control pest populations, reducing the need for pesticides. Such measures alleviate financial burdens on impoverished farmers and promote sustainable agricultural practices. Madagascar, where 85% of the population relies on agriculture for their livelihoods and 80.7% live on less than $2.15 per day (World Bank 2023)., requires such ecological protection measures. In addition, owls, as nocturnal predators, contribute to reforestation and seed dispersal. They influence germination rates and support seedling establishment by providing nutrients through their pellets and excreta [31]. Rodent populations in Madagascar are widely recognized as a substantial public health hazard, notably because they serve as carriers of the endemic plague [32]. The natural predation of rodents by owls can play a critical role in mitigating this public health risk. Recognizing the ecological, economic, and public health benefits of owls can encourage sustainable practices, improve the financial well-being of the population, and support harmonious coexistence between humans and owls.

The limitations of this research span several areas, including geographical scope, sampling methodology, cultural sensitivity, and ecological data. The study focuses on 16 villages within the Andapa district in northern Madagascar, and while this provides valuable insights, the limited geographic scope may not fully represent the diversity of human-owl interactions and cultural beliefs across the entire country. Although we used probability and non-probability sampling techniques, cultural norms influenced participation. Discussions with demographic groups, such as men over 50 and women of all ages, required facilitators, and fear or reluctance to speak openly, particularly in the presence of accused witches, may have affected the completeness and accuracy of the data collected. Additionally, topics such as witchcraft and associated beliefs are inherently sensitive, and participants may have withheld information due to fear, superstition, or social stigma, potentially limiting the depth and accuracy of the findings. Furthermore, while the research primarily addresses socio-cultural and anthropological aspects, it provides limited ecological data on owl populations, habitat dynamics, and their broader environmental significance, restricting a comprehensive understanding of the ecological context of human-owl conflicts. Addressing these limitations in future studies could provide a more holistic understanding of human-owl interactions and their societal and ecological implications in Madagascar.

The interaction between the Malagasy population and owls remains marked by conflict, resulting in tensions across various regions. It is essential to address the prevailing atmosphere of hostility, mistrust, and fear among the population, particularly toward individuals associated with perceived witchcraft, and to encourage peaceful coexistence between humans and owls. This study examined the complex dynamics of human-owl interactions in the Andapa district, offering a detailed analysis of these relationships. By employing a mixed-method approach, the research provides a well-rounded understanding of quantitative and qualitative aspects. The findings reveal that the lack of ecological knowledge, gaps in environmental legislation, and the influence of cultural and traditional beliefs drive owl-hunting behavior. Cultural practices and beliefs play a critical role, with men more likely to engage in owl hunting, women more inclined to fear owls, and older individuals more closely tied to traditional beliefs. The lack of awareness about environmental conservation, legal protections, and the ecological significance of owls sustains these harmful practices. Owls are now classified as a vulnerable species in Madagascar, highlighting the urgent need for targeted education and awareness campaigns to change public attitudes and behaviors. Addressing this issue requires strategic and comprehensive interventions. These include enhancing ecological education, revising environmental laws to strengthen wildlife protection, and promoting reconciliation between owl keepers and local communities. Strong government support is vital to ensure the success of these efforts and achieve peaceful coexistence between humans and owls in Madagascar.

Supplementary Information

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Supplementary Material 1.

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Acronyms
HG (High School graduate); HWCs (Human-wildlife conflicts).

Authors' contributions
ARSENE Manana Oclin: Data curation, investigation, methodology, resources, writing—original draft; Shan Xiao Ya: supervision, writing—review & editing. All authors have read and agreed to the published version of the manuscript.

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Data availability
The datasets supporting the conclusions of this article are included within the article and additional files.

Declarations

Ethics approval and consent to participate
The study received approval from the Research Ethics Committee of Guizhou University of Finance and Economics, China, and was conducted in full compliance with the ethical guidelines and regulations established by the Parc National Montagne d'Andapa. The research adhered to internationally recognized standards for ethical conduct in anthropological and social research, following the principles outlined by the Association of Social Anthropologists (ASA). These guidelines ensured respect for cultural values, voluntary participation, and the confidentiality and anonymity of all participants.
All participants were adequately informed about the purpose of the study, and informed consent was obtained prior to the commencement of the research. The study population consisted of individuals aged 18 years and above; therefore, there was no requirement to obtain consent from guardians, parents, or legal representatives.

Consent for publication
Not applicable.

Competing interests
The authors declare no conflict of interest.

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