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**Human dimensions of pangolin conservation: indigenous and local knowledge, ethnozoological uses, and willingness of rural communities to enhance pangolin conservation in Nepal**

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**Abstract**

Understanding local knowledge about wildlife, local uses, and local people's willingness to support conservation activities, are crucial factors to help in formulating wildlife conservation strategies. We conducted a semi-structured questionnaire survey of 1,017 people from 105 villages located in different ecological regions across all seven Provinces of Nepal. We performed generalized linear mixed modelling to investigate the key drivers influencing respondents' knowledge about pangolins, based on a questionnaire score. We identified provinces, ethnicity, occupation, gender, and age group as strong predictors influencing local ecological knowledge

about pangolins. The respondents from provinces in the western part of Nepal represented significantly lower knowledge scores than the respondents from the eastern and central provinces. Similarly, respondents belonging to non-indigenous groups, students, females, and people aged between 18-30 years had the lowest knowledge scores about pangolins. A range of uses and beliefs about pangolin were reported across Nepal, and 48% of respondents believed in the use of pangolin scales and meat for traditional medicines. The majority of respondents (71.1%) were willing to support pangolin conservation in their local areas. Our study suggests that awareness programs, alternative livelihood, and income-generating trainings for local communities could be helpful to enhance the long-term conservation of pangolins in Nepal. Increased efforts are needed in western Nepal, and across the country with non-indigenous communities, females, young people, and students. Thus, this study offers an important baseline to help design and execute effective community-based conservation actions and management decisions for pangolin conservation.

**Keywords:** Awareness, local communities, pangolins, uses, Nepal

## INTRODUCTION

Human communities living in and around wildlife and their habitats often have a vital role in effective management and successful wildlife conservation (Gandiwa 2012). It has been recognized that the conservation of biodiversity is best conducted with the support, engagement, and active participation of indigenous people and local communities (Cooney and Challender 2020; Hill et al. 2020; Malmer et al. 2020). Knowledge is transferred from one generation to the next and is modified and amended as a result of new experiences and observations (Fernandez-

gimenez 2000). The local ecological knowledge (LEK) of people in a given area, is gained through extensive personal observations, practices, beliefs, and interactions with the local ecosystem and environment which are shared among local resource users (Charnley et al. 2007). LEK is increasingly considered an effective alternative source of conservation data, especially for "charismatic" large-bodied vertebrates (Parry and Peres 2015; Turvey et al. 2015), including in the Convention on Biological Diversity. Nevertheless, smaller-bodied species, including some mammals, are more likely to remain unreported or be misidentified by respondents in interview surveys (Turvey et al. 2014). Recently, however, LEK has been shown to be an important tool to inform conservation management decisions and has been increasingly applied to help understand the distribution and status of highly recognizable species (Nash et al. 2016; Archer et al. 2020; Fopa et al. 2020; Mouafo et al. 2021). Harnessing local ecological knowledge may therefore help to promote sustainable long-term conservation and integrating species and community-based strategies (Kupika et al. 2019).

A wide array of human dimensions, such as local people's perceptions towards wildlife conservation, have become important to consider when attempting to develop long-term species protection through community involvement (Newmark et al. 1993). There is increasing recognition that diverse knowledge systems can work in mutually enriching ways and that Indigenous and Local Knowledge (ILK) can enhance biodiversity conservation (Torrents-Ticó et al. 2021). Similarly, conservation that works in collaboration with local communities, taking into account their willingness to engage with it, ensures local commitment and motivates people to take ownership of wildlife conservation.

One group of species for which community-based approaches have been applied for their conservation are the pangolins (Pholidota: Manidae). Local knowledge is an important source of conservation-relevant baseline information on pangolins because they are a highly elusive group of species for which monitoring in the field is very challenging (Nash et al. 2016), often due to their low population density and detectability (Willcox et al. 2019). Nepal is the home of two species of pangolins, the Chinese pangolin (*Manis pentadactyla*) which is Critically Endangered and the Indian pangolin (*M. crassicaudata*) which is Endangered (IUCN 2020). Both species are globally threatened due to illegal poaching and trade for their meat, scales and skin (Challender et al. 2020). They are listed on CITES Appendix I, which prohibits international and commercial trade of wild pangolins. In Nepal, pangolins are an Endangered species, protected under the National Parks and Wildlife Conservation Act 1973 (DNPWC and DFO 2018). Although legislation exists to protect pangolins in all range countries, illegal pangolin hunting is widespread and increasing in Nepal (Katuwal et al. 2015; Ghimire et al. 2020). Pangolins have also long been used for traditional medicine in Nepal (Katuwal et al. 2015). The Chinese pangolin has mostly been recorded in the mid-hills region while the Indian pangolin is distributed mostly outside protected areas, in the southern and western lowland Terai, and mostly in human-dominated landscapes (Suwal et al. 2020). Given the presence of pangolins outside protected areas, community-based approaches could be vital for pangolin conservation and sustainable management.

Nepal is not only rich in terms of biodiversity, it is also culturally diverse with 126 ethnic groups speaking 125 languages (CBS 2011). About 82% of the total population in Nepal (29.4 million; male = 45% and female = 55%) are living in rural areas (UNFPA 2017). Given that people are not

homogenous, local people will differ in their behaviours, knowledge, and perceptions of wild animals, which may be relevant to directing conservation efforts (Bitanyi et al. 2012). There is a lack of research exploring the perceptions, awareness, and use of pangolins for traditional medicine by local communities (Heigton and Gaubert 2021), and how this may be influenced by socio-demographic characteristics. There has been only one interview-based study to investigate local knowledge of Chinese pangolin which was limited to a single district in Central Nepal (Sharma et al. 2020). Similarly, only one study on the ethnomedical importance of Chinese pangolin has been conducted in eastern Nepal (Katuwal et al. 2015), albeit with a limited number of interviewees. Therefore, we conducted a large-scale interview survey of local people, covering a wide geographical area of Nepal, with specific objectives to: a) understand the local ecological knowledge of pangolins, b) identify the ethnozoological uses and beliefs about pangolins and their body parts, and c) identify the willingness of local people to engage in pangolin conservation and their preferred conservation solutions.

## METHODS

### Study Area

Our study was focused outside of protected areas and based on interviews with local people. Our survey was conducted in villages/rural areas in 21 districts covering all seven federal provinces of Nepal. According to the federal system of Nepal established by the current constitution of Nepal (GoN 2015), the country has been divided into 7 provinces, 77 districts (Supplementary Table 1), and 753 local units. Province 1 (P1) is the easternmost region varying between an altitude of 70m and 8,848m above sea level (asl), whereas Province 2 (P2) is located on the flat plains of the Terai.

Province 3 (P3) is situated in the central region with the capital city, Kathmandu, and has the largest population, followed by P2 and P1. Similarly, Province 4 (P4), Province 5 (P5), Province 6 (P6), and Province 7 (P7) have the lowest population and are located in the western region of the country which varies from lowland Terai to Mid-Hills and the high Himalayas. Topographically, the study area covers the Terai and Mid-Hills (Figure 1). Terai regions cover 17% of Nepal's land area, lie at an elevation between 60m and 305m asl, and mainly support tropical and subtropical grasslands and evergreen forests with Sal trees. Hilly regions begin with the Mahabharata range varying in altitude from 1,000 m to 2,700 m asl and covers 68% of the total area of Nepal. It has a subtropical climate at low altitudes and a temperate climate at high altitudes.

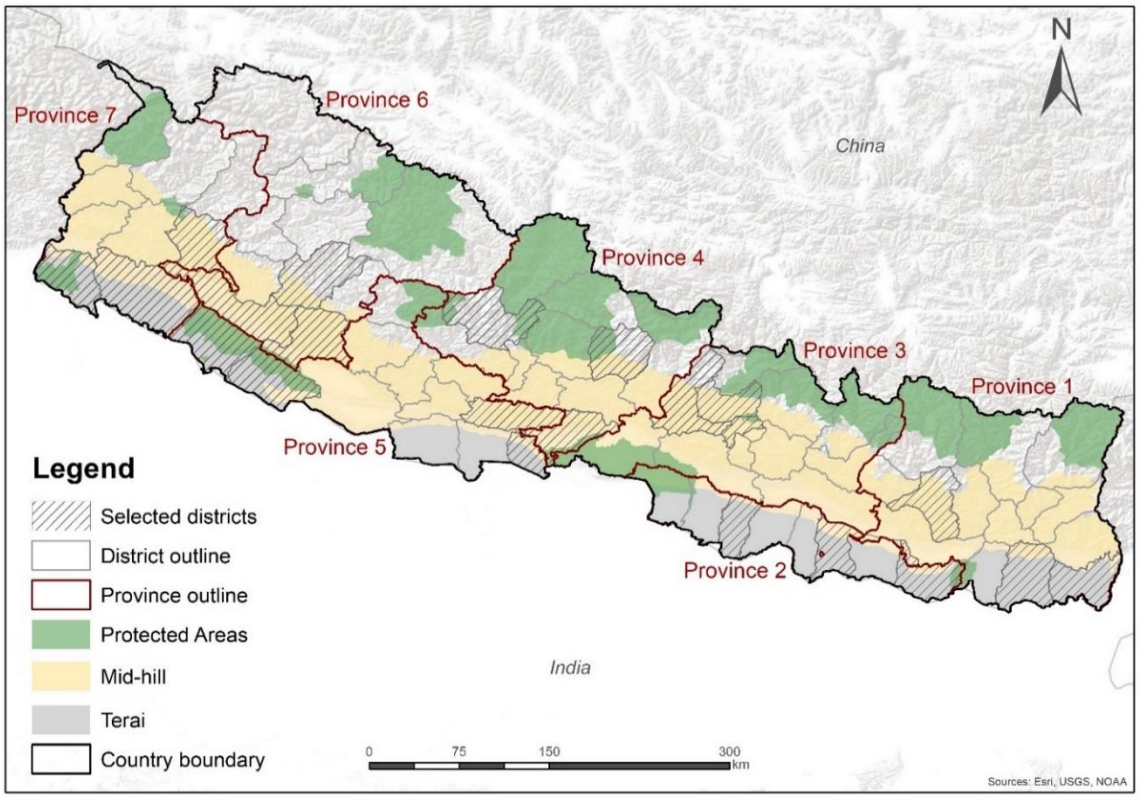



Figure 1. Districts that were surveyed within each Province in Nepal, showing the Terai, and Mid-hill areas, as well as the protected areas.

**Data Collection**

Data were collected from 21 districts; three districts from each province. A total of 105 villages, five per district, were selected to cover a wide geographical area. The villages nearer to pangolin habitat were targeted for the survey to understand local people's knowledge, ethnozoological practices, and willingness of local people to engage in pangolin conservation. A minimum of 10 respondents per village were sampled to ensure a wider and more representative sample of respondents from each district. We interviewed one respondent per household above the age of 18 and considered the equal representation of respondents based on their sex, age, education levels, and occupations (Supplementary Figure 1). We interviewed 1,017 people from rural communities across all seven provinces (P1-135 people in eastern Nepal, P2-153 and P3-142 in central Nepal, and P4-136, P5-180, P6-129, and P7-142 in western Nepal) aged between 18 to 80 years old.

A set of semi-structured questionnaires were prepared in Nepali. Forty-two local interviewers including both bachelor (n=7) and master's degree (n=9) natural science students along with forest staff (n=5) and local resident assistants (n=21) were hired to conduct interviews to make respondents more comfortable and facilitate communication in their mother tongue. Furthermore, respondents could easily contact us through the interviewers from their location in their own language. Each interview lasted approximately 30-40 minutes. Upon being approached, all respondents were given a full account of the purpose of the study and informed that participation was entirely voluntary. For those who accepted to participate, we acquired verbal consent from all respondents before conducting the questionnaire survey, and respondents remained anonymous.

The relevant bodies of the Government of Nepal (the Department of National Parks and Wildlife Conservation and the Department of Forests and Soil Conservation) approved this study.

A standardized questionnaire survey with open- and closed-ended questions was conducted (Newing et al. 2011) to gather information regarding: a) Respondents background and demographic profile: gender, age, education, occupation, family size, and their ethnicity; b) local ecological knowledge about pangolins including their behavior, diet, habitat, indirect signs such as burrows, pug marks and fecal pellets and reproduction, c) ethnozoological uses and beliefs about pangolins, and d) willingness to conserve pangolins with long-term solutions. Color-printed photographs of the two pangolin species (Chinese and Indian pangolins) were displayed to ask respondents about the species that they have seen, heard about, and/or found in their areas. Moreover, participants were classified into Indigenous and Non-indigenous groups based on their cast, mother tongue, tradition, and culture (Supplementary Table 2). Similarly, the ethnozoological beliefs and uses were divided into different categories based on types of beliefs and uses (Supplementary Table 3). Knowledge level was classified into three groups based on the total number of questions answered correctly based on the responses collected during the interviews: High (>6 questions answered correctly), Medium (3-5 questions answered correctly), and Low (<2 questions answered correctly; Supplementary Table 4). It is important to note that research participants decline to provide knowledge to interviewers for innumerable reasons; therefore, our score should be seen as more indicative of what was shared than what knowledge participants held.

**Data Analysis**

Questionnaire data were translated into English for data analysis. Excluding 33 unclear and incomplete answer sheets out of 1,050 interviews, we acquired a total of 1,017 completed questionnaires, which were included in the data analysis. We used R version 3.4. (R Development Core Team 2020) for statistical analysis. We used numerical codes for answers where possible such as for yes/no responses, categories of age groups, and family sizes, or used the narrative responses as qualitative data (Kusi et al. 2020). We used knowledge level scores as response variables and province, topography, gender, age group, education level, occupation, family size, and ethnic group as predictor variables in order to understand the influence of these demographic and biogeographical factors on local knowledge about pangolins.

We treated "village" identity as a random factor to account for spatial clustering. Since the data included continuous, ordinal, and nominal variables, different methods were adopted for the different combinations of variable types. We ran Fisher's exact test for nominal variables, Kruskal-Wallis tests on combinations of numeric to nominal and ordinal to nominal variables. Combinations of nominal variables were examined using Cramer's V, with a cut-off criterion of 0.5 (Ellis et al. 2010). These tests were used in combination with variance inflation factors (VIFs) to explore collinearity among predictors using the *rms* package (Harrell Jr 2021). VIFs above the value 10 indicate a serious collinearity problem (Lin 2008). Where evidence for high collinearity was present, we excluded the variables that were substantially collinear (Miles 2014). Descriptive statistical tests were used to compute cross-tabulations and $\chi 2$ tests to determine association and significance between two dependent variables. There were no problematic levels of collinearity

between the variables in our study. We fitted a cumulative link mixed-effects model with the *clmm* function in the *ordinal* package (Christensen 2011) to construct models predicting ordinal responses from a series of generalized linear mixed models (GLMMs).

We used the R package *effects* (Fox et al. 2020) to visualize the effect sizes for predictors of knowledge scores fitted with the global model. We used an Information Theoretic approach for model selection (Grueber et al. 2011) and applied the Akaike's Information Criterion (AICc) for ranking the models (Beier et al. 2001). The model with the lowest AICc was considered the best supported model given the data, and the remaining models were ranked from best to worst, with increasing AICc values (Anderson et al. 2000; Burnham et al. 2011). The differences among the models are represented by ΔAICc - the gain in AICc over the model with the lowest value of AICc. Top models with $\Delta AICc < 2$ are considered to be better supported than other available candidate models. The model weights were calculated using R package *MuMIn* (Barton and Barton 2020) to evaluate relative model weights in the set of candidate models (Bolker et al. 2009). We examined parameter estimates of variables in the global models in order to assess the marginal significance of their effect on overall knowledge scores. We accounted for model uncertainty by using model averaging based on model weights (Beier et al. 2001) and averaged the parameter estimates in all the models to a cumulative weight of 0.95. We compared the willingness of respondents to support different types of pangolin conservation, and the proportion of respondents willing to support different preferred conservation solutions, graphically.

## RESULTS

### Respondent Characteristics

Among respondents, 55.3% were male and 33.0% were aged 31-45 years. Nearly an equal percentage of respondents had primary (30%) and secondary education levels (29%). Half of the respondents were farmers (52.1%), while 57.6% were living in a joint family of between 5-8 members, and 53.2% belonged to an indigenous community. The number of respondents was the highest from Province 5 (17.7%), the western region of the country (Supplementary Table 5).

### Local Ecological Knowledge

The majority of respondents (64.1%, n= 652) were able to recognize pangolins and provided some supporting information on species presence when we showed them photographs of pangolins. The respondents mostly knew the species by the common Nepali name 'Salak' (38.9%, n= 396) and 'Sal machha' (12.3%, n= 125). The respondents from the Tharu indigenous community in Saptari district referred to pangolins by the local names 'Pakhe machha' (1.0%, n=10) and 'Kahot machha' (2.4%, n= 24). Approximately fifty percentage of respondents claimed to have seen a pangolin, among which 37.4% had seen one alive, whereas 9.8% had seen one dead and 4.2% had seen both live and dead pangolins. 33.3% of respondents explained that they had encountered pangolins mostly in forests, 4.1% of respondents mentioned they encountered the species in agricultural land, 8.4% mentioned encountering them near human settlements, 0.9% in shrubland/grassland, while 3.2% mentioned seeing rescued pangolins captive in forest offices and 0.9% reported seeing one in and around water bodies. Most of the respondents reported they had not seen indirect signs of pangolin (62.5%) and did not know about the food habit (59.6%) and behavior (55.3%) of

pangolin. The majority of respondents (64.8%) stated they knew about the habitat of pangolins, however most stated they did not know about the reproduction age of pangolins (94.7%), their litter size (89.8%), or the reproduction months/seasons (95.6%) of pangolins.

Based on our scoring system, the majority of respondents (63.0%) from Province 1 (eastern Nepal) had a higher knowledge score, while those from Province 6 (71.0%) had lower knowledge scores among the provinces. Similarly, the respondents from the mid-hill region (46.0%) had lower pangolin knowledge scores in comparison to those from the lowland Terai. Among the districts, the respondents from Khotang district had the highest pangolin knowledge scores (78.0%), followed by those from Morang (71.0%), both in eastern Nepal, while Achham and Salyan districts had the lowest pangolin knowledge scores, both in western Nepal (100%) (Supplementary Figure 2).

The top models ($\Delta$AICc< 2) predicting the knowledge score about pangolins contained province, ethnicity, occupation, gender, and age group as the predictor variables (Supplementary Table 6). Province was consistently included in the higher-ranked models predicting the knowledge score. Model-averaged parameter estimates provided evidence that provinces were highly statistically significant with respondents from Province 6 representing significantly lower knowledge scores (Estimate= -4.47, p= <0.001) followed by Province 5 (Estimate= -3.46, p= <0.001), and Province 7 (Estimate= -2.89, p= <0.001) (Table 1), all in western Nepal. Similarly, the model-averaged parameter estimates predicted that the respondents belonging to the age group above 60 years represented significantly higher knowledge scores (Estimate= 0.88, p<0.001) followed by those

holding the government service jobs (Estimate= 0.85, p= 0.008) (Table 1 and Figure 2; Supplementary Figure 3).

Table 1. GLMM of ordinal knowledge score about pangolins in Nepal.

**Model-averaged coefficients: (conditional average)**

| **Predictors** | **Estimate** | **Std. Error** | **z value** | **Pr(>\|z\|)** | **Sig.** |
|---|---|---|---|---|---|
| Age group: 31-45 | 0.62 | 0.23 | 2.71 | 0.0067 | ** |
| Age group: 46-60 | 0.37 | 0.24 | 1.53 | 0.1250 | |
| Age group: Above 60 | 0.88 | 0.27 | 3.28 | 0.0010 | ** |
| Ethnicity: Non-Indigenous | -0.48 | 0.16 | 3.02 | 0.0026 | ** |
| Gender: Male | 0.34 | 0.14 | 2.48 | 0.0131 | * |
| Occupation: Farmer | 0.30 | 0.27 | 1.10 | 0.2697 | |
| Occupation: Government service | 0.85 | 0.32 | 2.64 | 0.0083 | ** |
| Occupation: Self- employed | 0.00 | 0.31 | 0.01 | 0.9946 | |
| Occupation: Student | 0.01 | 0.36 | 0.03 | 0.9774 | |
| Province: P2 (central Nepal) | -2.01 | 0.57 | 3.54 | 0.0004 | *** |
| Province: P3 (central Nepal) | -2.20 | 0.53 | 4.12 | 0.0000 | *** |
| Province: P4 (western Nepal) | -2.78 | 0.53 | 5.21 | 0.0000 | *** |
| Province: P5 (western Nepal) | -3.46 | 0.54 | 6.46 | < 2e-16 | *** |
| Province: P6 (western Nepal) | -4.47 | 0.63 | 7.12 | < 2e-16 | *** |
| Province: P7 (western Nepal) | -2.89 | 0.55 | 5.21 | 0.0000 | *** |
| Topography: Terai | 0.36 | 0.38 | 0.94 | 0.3477 | |

| | | | | |
|---|---|---|---|---|
| Education: Primary | 0.00 | 0.20 | 0.00 | 0.9975 |
| Education: Secondary | -0.19 | 0.23 | 0.84 | 0.4016 |
| Education: Tertiary | 0.25 | 0.28 | 0.90 | 0.3685 |
| Family size: 5-8 members | 0.11 | 0.17 | 0.61 | 0.5409 |
| Family size: 9-12 members | 0.14 | 0.25 | 0.55 | 0.5842 |
| Family size: >12 members | 0.29 | 0.40 | 0.73 | 0.4634 |

Significance codes: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

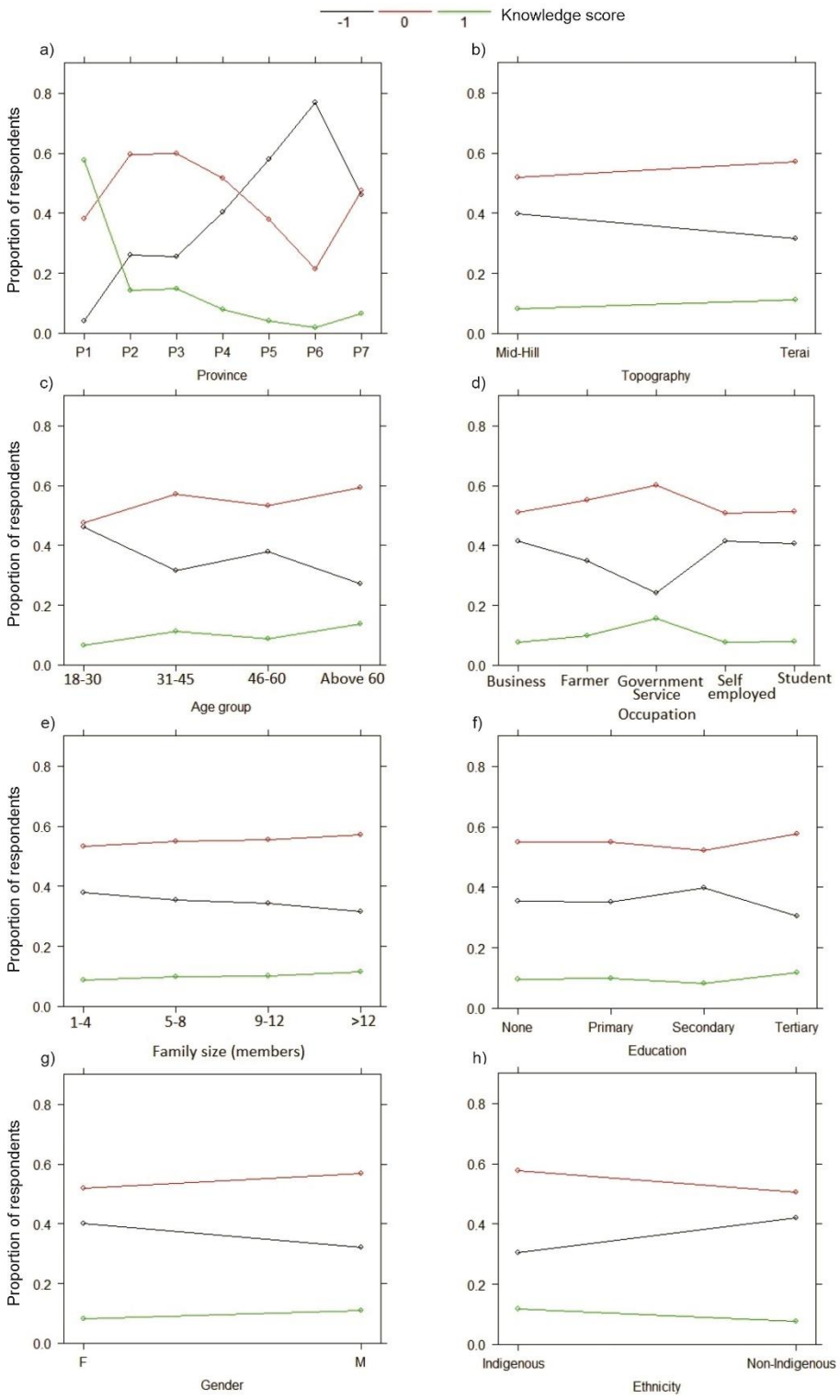



Figure 2: Effect plots illustrating the influence of predictors on knowledge score (-1 = low knowledge score; 0 score= medium knowledge score; +1= high knowledge score).

**Ethnozoological Uses and Beliefs**

Respondents from 15 out of 21 surveyed districts of pangolin range areas had used or heard about the medicinal use of pangolins and their body parts, especially meat and scales. A total of 233 respondents reported information about different uses and beliefs regarding the pangolin and the uses of its body parts (Figure 3; Supplementary Table 3). Nearly fifty percentage (48.0%) of respondents believed that the use of pangolin was for traditional medicine as well as the spiritual creatures that provide guidance and protection (spiritual beliefs) (19.0%) (Figure 3). The meat and powdered scales were used as healing medicine for various kinds of diseases such as back cramps, breathing problems, wound relief, paralysis, pneumonia, tuberculosis in Dhanusa, Rautahat, and Dhading in central Nepal, and Banke and Bardiya districts in western Nepal. The local people in the Myagdi district, western Nepal used scale powder to cure stomach pain and gastritis, and those in Banke, the same region of Nepal, believed it cured malnutrition and piles. We did not find locals wearing rings and bangles made of pangolins scales, however, we found an adult male in Rautahat district, central Nepal, wearing an Indian pangolin scale on his neck with the belief that it will chase away evil and black magic (Figure 4a). Locals from Jhapa (eastern Nepal), Dhanusa (western Nepal) and Myagdi (western Nepal) said that they had consumed pangolin meat before. We had recorded an old photo of a pangolin tied with a rope and children playing with the pangolin in Saptari district in the lowland Terai region.

Traditional healers, or shaman (*Dhami/Jhakiri*), used pangolin scales to make the bottom of their coats to fight against bad powers, remove ghosts and negative energies from the human body, and protect them against different harmful powers. Oil made from pangolins was used to worship gods

and goddesses in different national festivals such as Dashain and Maghesangarti in the Saptari district, in the lowland Terai region. Respondents from Morang, Khotang, and Saptari districts shared that they dipped the rings of pangolin scales in food and alcoholic drinks to test for poison.

Respondents from different locations had varying beliefs about pangolins. Sighting a pangolin in the wild is considered as a sign of good luck in some areas of eastern (Khotang), central (Nuwakot, Nawalpur, Myagdi, Lamjung), and western (Kailali) Nepal. Some respondents stated that they believed that if they hung pangolin scales in the main door/gate or outside of windows, it would chase away demons or any dangers. Similarly, when they kept or hung the scales on baby seaters (Kokro) (Figure 4b), some respondents believed it would protect the child from bad evil, black magic, and negative energies. Some respondents also held the belief that if they put scales and money together in a money box it would bring good luck and help to increase their financial status. Some indigenous respondents from the Ruatahat district, lowland Terai, also believed that when they put the gem-shaped pangolin scales in the river, it reversed the flow of the river upstream.

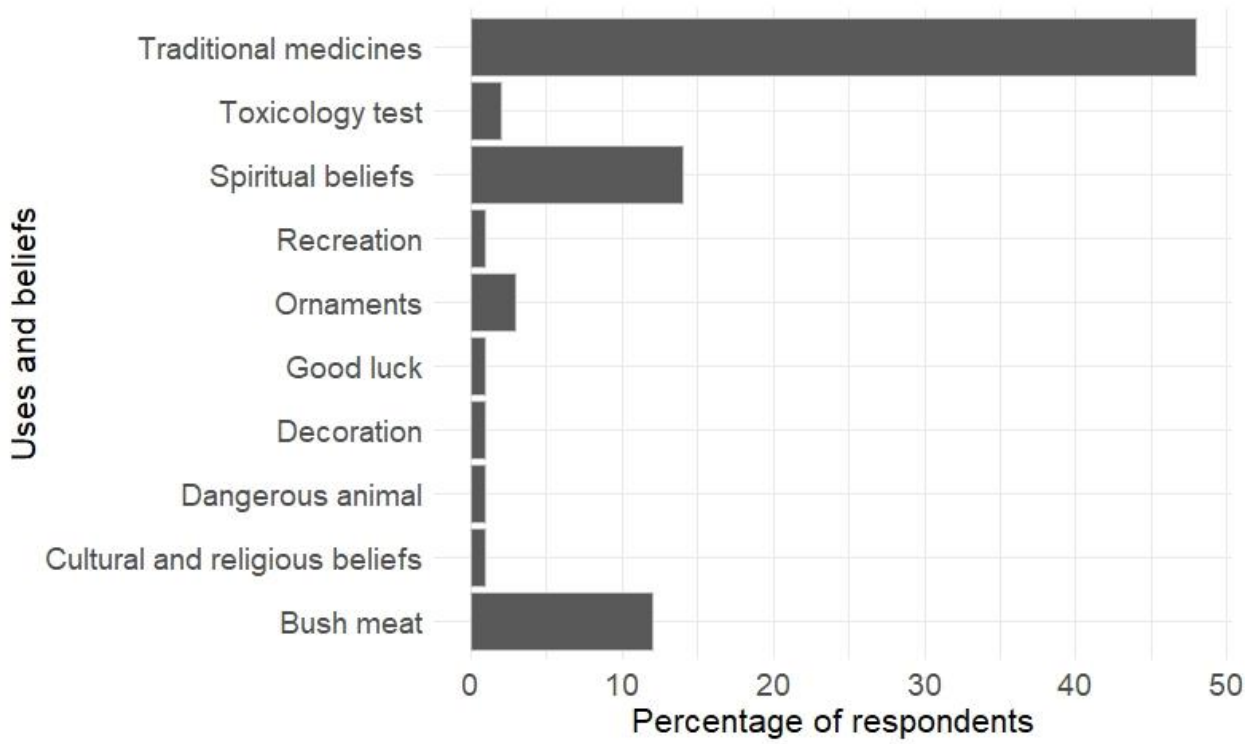



Figure 3. Uses and beliefs about pangolins and their body parts in Nepal. See Supplementary Table 3 for definitions.




Figure 4: The scale of an Indian pangolin used as necklace (a), and another scale hung on a baby seater (b).

**Respondents' Willingness to Support Pangolin Conservation Actions**

The majority of respondents (71.1%) were found to be willing to engage in or support the conservation of pangolins in their respective areas. Almost all respondents (90.0%) from Province 5, western Nepal, and from the lowland Terai (82.0%) agreed they would support pangolin conservation. The willingness to support pangolin conservation was significantly influenced by gender, age group, occupation, and family size (Supplementary Table 7). Male respondents (74.0%), those aged between 46-60 (76.0%), government services holders and businessmen (both 79.0%), and those with big family sizes of >12 family members (89.0%) were more willing to conserve pangolins in their areas (Figure 5). The majority of respondents (79.0%), who were willing to support pangolin conservation, considered awareness programs as their preferred activity. Similarly, 78% of respondents supported habitat management; however, 71% of the respondents did not support donation programs though they expressed their willingness to support pangolin conservation (Supplementary Figure 4). When we asked the respondents whether they were willing to support pangolin conservation and which solution they would prefer as the best solution for long-term pangolin conservation, 78% of willing respondents supported provision of educational opportunities as their preferred solution for the long-term conservation of pangolins. Similarly, 87% of those who showed willingness, preferred alternative livelihood programs for local people. Though willing to support pangolin conservation, 74% of respondents did not prefer employment opportunities as a preferred solution. Furthermore, 80% of respondents who expressed willingness to support conservation, preferred income-generating as the preferred solution to support the long-term conservation of the species (Supplementary Figure 5).

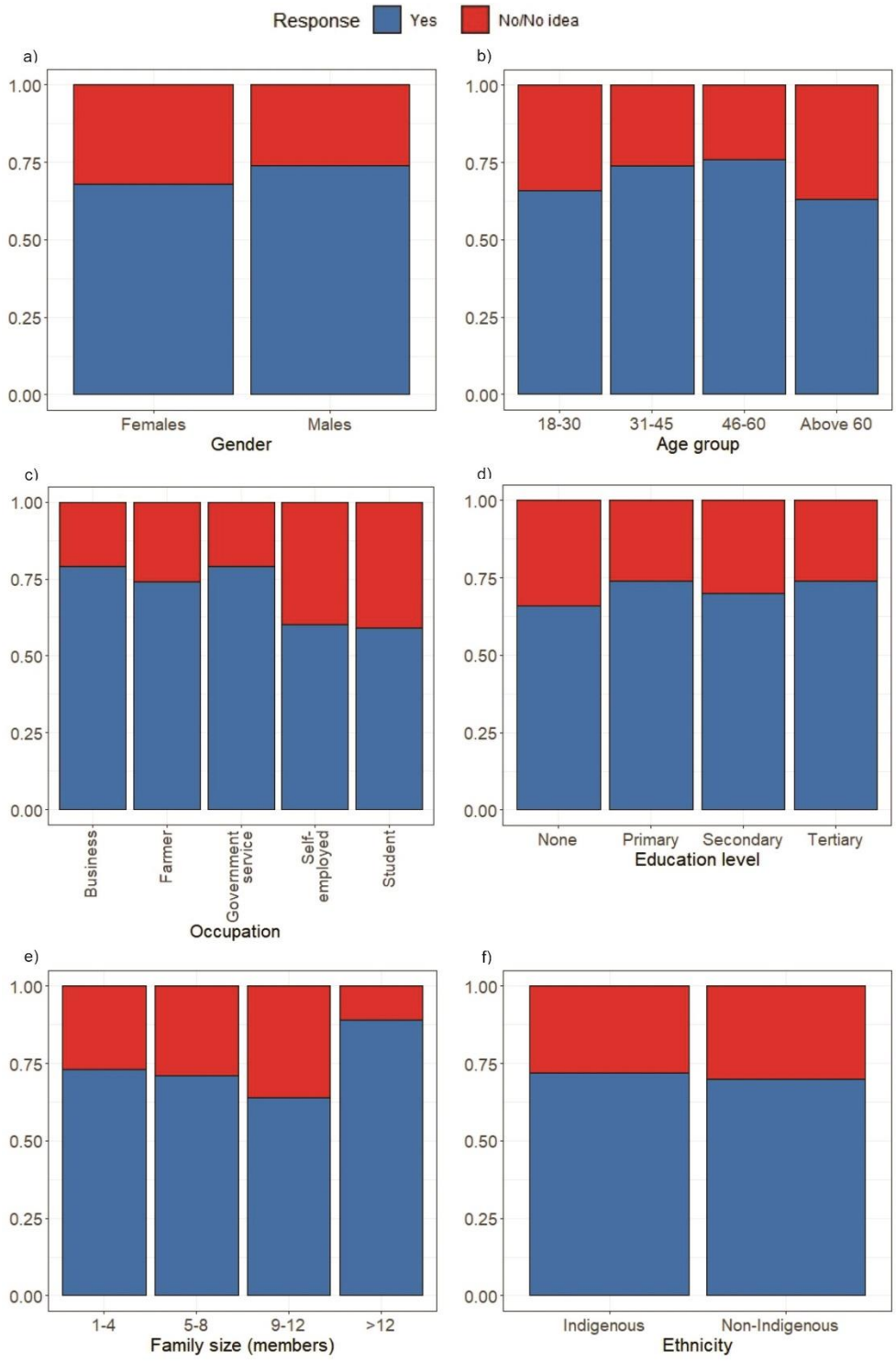



Figure 5. The willingness of respondents to support the conservation of pangolins, separated by gender (a), age group (b), occupation (c), education level (d), family size (e), and ethnicity (f).

## DISCUSSION

We present a large-scale community-based social survey about the conservation of the world's most trafficked wild mammal species, pangolins, which are mostly recorded outside of protected areas in the rural regions of Nepal (Suwal et al. 2020). Our study provides potentially important insights to understand diverse biogeographical, demographic, and socio-economic factors influencing the local ecological knowledge about pangolins and the willingness of locals to support the conservation of the species.

The study findings showed that more than half of the total respondents could recognize pangolins, however more than half of the respondents were not aware of the ecological, reproductive, and behavioral aspects of the species. Similarly, though there has been an increase in pangolin-related publications in recent years, there are still large knowledge gaps in the literature regarding different aspects of the species globally (Heighton and Gaubert 2021), including limited research on pangolin ecology in Nepal (Suwal et al. 2020). Our study suggests that detailed ecological studies (including research on wild behavior and reproduction) combined with conservation outreach programs based on these scientific studies could be beneficial in filling these knowledge gaps and increasing awareness about the species.

This study reported that respondents' pangolin knowledge scores significantly varied among different demographic variables. Male respondents were found to have higher pangolin knowledge scores which could be attributed to the fact that the majority of males in rural areas are exposed to wider activities through education and job opportunities than females who are often limited to

household chores (Yamamoto et al. 2019). The older generations (> 60 years old) have higher pangolin knowledge scores compared to those of younger respondents (< 30 years old). This may be because the older generations were more exposed to forest habitats and wildlife during their daily activities than the younger generations (Yang et al. 2015). Two to three decades ago, livelihoods in Nepal were highly dependent on natural resources, and people traveled to forests daily for fodder and firewood, increasing the likelihood of interacting with wild animals. Therefore, such experiences could have contributed to higher pangolin knowledge scores among older people. However, contrary to our study, people aged 25-35 years old were found to be most aware about pangolins in a study in Cameroon where pangolins are more common (Fopa et al. 2020). Depending on their responsibilities and duties, government officials may have attended different conservation events organized by various levels of government and non-government agencies. This may explain why government officials had higher pangolin knowledge scores compared to those with other occupations, and students. Low pangolin knowledge scores among students could be due to the lack of information about pangolins in school curriculums, and the lack of related awareness programs on the species in schools. Integrating local knowledge into pangolin conservation may be possible if knowledge holders are directly engaged with as active participants in research and conservation education programs, possibly focusing on younger people and students.

Respondents' pangolin knowledge scores were also found to be significantly associated with the physiographic division of the study area. The low pangolin densities due to low habitat suitability in western Nepal (Suwal et al. 2020), and/or the concentration of pangolin studies focused in other areas like eastern and central Nepal (Thapa et al. 2014; Katuwal et al. 2015), may have resulted in

lower pangolin knowledge scores from Province 6 respondents. Regular conservation education programs and awareness activities have been conducted in Province 1 in eastern Nepal with the support of different conservation organizations (KTK Belt and ZSL, and WWF Nepal), which may have raised awareness in the east. Larger occurrence of the species in the eastern and central parts of Nepal, due to greater potential habitat for the species (Suwal et al. 2020), could offer comparatively more encounters with pangolins for local people, and thus may explain the greater knowledge of pangolins in the east and center compared to the west. Research extended towards western Nepal could provide better insights into the occurrence and potential habitats of pangolins in those regions. Many protected areas (PAs) in Nepal are located in the lowland Terai, and the revenue from PAs are used for community development and incorporating community participation in wildlife conservation activities (Khatiwada et al. 2020). This has had the effect of raising awareness of people living in and around the Pas about wildlife including pangolin. Greater knowledge about pangolins among indigenous people may be due to socio-cultural and religious factors, close connection with nature, given that indigenous communities possess diverse knowledge on different aspects of nature (Alam et al. 2011).

Pangolin body parts were mostly reported as being used in traditional healing practices and were considered an important source of treatment by local traditional healers as reported in other range countries such as India (Mohapatra et al. 2015; D'Cruze et al. 2018), Sri Lanka (Perera et al. 2017) and Bangladesh (Trageser et al. 2017) in Asia, and Nigeria (Soewu and Adekanola 2011), Benin (Zanvo et al. 2021) and Ghana (Boakye et al. 2015) in West Africa. The scales of pangolins are the most used body part and practitioners use the scales to fight against bad powers and evil spirits, supporting the findings of other studies in Nepal (Katuwal et al. 2015). Although the

ethnomedicinal uses of pangolins have been recorded in almost all range countries of Asia and Africa (CITES 2017; Soewu et al. 2019), our study recorded very unique uses of pangolin scales. Some respondents shared that the ring made of pangolin scales were dipped into food and drinks to test poisons, and gem-shaped scales were used in rituals to worship rivers with a belief that it could cause rivers to flow in the opposite direction. Although rare, pangolin scales were also reportedly kept in boxes with money, believing the scales would help in financial prosperity. The majority of uses of pangolin body parts and associated beliefs were for traditional medicine, which are likely to be associated with socio-economic conditions, ethnicity, and cultural and religious beliefs of the communities (Fokunang et al. 2011; Rumun 2014). Given that traditional medicine is being practiced widely across the country, it could be beneficial to work with traditional healers on guidelines for good practices and raising awareness of the conservation status of currently utilized species.

The majority of respondents, especially those from the lowland provinces, along with central Nepal, were willing to support pangolin conservation efforts in their areas, where pangolin research and conservation activities have previously been conducted. Similarly, those respondents which had comparatively good pangolin knowledge scores such as males, respondents aged >60 years, government services holders, and those living with large family sizes (>12) were more willing to conserve pangolins in their areas (Biddlecom et al. 2005). During this study, many of the respondents indicated that they would be willing to support law enforcement, habitat management, and awareness programs, similar to a study conducted on leopard cats in rural Taiwan (Best and Pei 2018). The solutions reported as the most preferable for long-term conservation of pangolins were wider educational and awareness raising programs, then alternative

livelihoods and employment opportunities including income-generating training for local people. The results of our study suggests that community engagement in wildlife conservation, including pangolin conservation, is likely to be successful (Cooney and Challender 2020). National and local governments, as well as conservation organizations, should develop strategic plans focusing the nature-based practical education, capacity-building training and possibly ecotourism for dual conservation and development to benefit both wildlife and local communities.

## CONCLUSIONS AND IMPLICATIONS FOR CONSERVATION

Understanding local knowledge about pangolins and public support for pangolin conservation by communities residing within the species' habitats across Nepal can catalyze further actions and effective management for conservation. The relatively low pangolin knowledge scores of respondents in different provinces and ecological regions shows the need for awareness-raising programs, and further studies on pangolin ecology, reproduction, and behavior. Pangolin conservation education and awareness-raising campaigns should be conducted among the youth, females, and students in particular. In addition, information regarding pangolins, their ecological values, and conservation, needs to be integrated into the school curriculum for the long-term conservation of the species. The results we present here will also support the newly formed Provincial governments to develop pangolin conservation strategies by incorporating pangolins into their province-based activities. We found that the majority of people we had interviewed were willing to support the conservation of pangolin in their areas. Given these results, we are hopeful for pangolin conservation in Nepal, which could be supported by local communities.

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## DECLARATION OF INTEREST STATEMENT

The authors declare that they have no potential conflicts of interest with respect to research, authorship, and/or publication of this article.

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