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Ethnozoological uses of wild animals among the Iraqw in Northern Tanzania

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Abstract: Historically, humans have developed knowledge of how to exploit and use wildlife species for food, clothing, traditional healing, and other purposes. This study aimed to determine the scale and scope of the ethnozoological uses of wild animals in the Iraqw community, in northern Tanzania. The study used semi-structured face-to-face questionnaire interviews with 45 key respondents in Endagaw, Mewadan, and Ng'wandakw villages in Mbulu District, to acquire the required data. The results found that 28 wild animal species including mammals (13 species), birds (12), insects (1), fish (1), and reptiles (1) were used by Iraqw for different purposes. Most species (n=23) were used mainly for food, namely helmeted guinea fowl (*Numida meleagris)*, African savanna hare (*Lemus microtis*) and Hildebrandt's francolin (*Francolinus hildebrandti*), while other wild animals were used for medicine, traditional beliefs, and rituals. This study provides information on the historical human-nature relationships and a baseline for developing future conservation efforts in the region to protect wild fauna. We recommend similar studies on other traditions and/or modern usages of wildlife to improve protection worldwide and that actions be taken to heighten community awareness of ethnozoological uses of faunal resources to ensure retention of this knowledge for future generations.

Key words: ethnozoology; ethnomedicine; faunal resources; food; wild animal uses.

Introduction

Ethnozoology is a broad discipline that details the historical, economic, sociological, anthropological, and environmental relationships between people and wild animals (Alves 2012; Alves and Souto 2015; Pongener et al. 2019). Ethnozoology is founded on the strong and close connection that has existed throughout history between humans and wild animals, which influence humans to interact with wild animals and utilize them for food, medicines, and traditional ceremonies (Bello-Román et al. 2023). This has greatly influenced classification, the naming of zoological taxa, and cultural knowledge on the use of wild animals, including zootherapy (dos Santos Soares et al. 2018; Martínez 2013). Zootherapy is the healing of

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human diseases by using therapeutics that are obtained from animals or are ultimately derived from them and play an important role in securing human health (Castillo and Ladio 2019; Costa-Neto 1999; Hajdari et al. 2018). Ethnozoology has been intergenerationally transmitted as Traditional Knowledge (TK) through cultural means such as oral traditions, hands-on experience and interactions with the environment (Alves and Souto 2015; Reyes-García et al. 2009). Archeological discoveries show that humans have consumed a wide variety of insects, fish, mollusks, birds, mammals, reptiles, and amphibians throughout human history (Clark 2019; Medeiros et al. 2018). This knowledge of the interrelationship of wild animals and humans can positively influence conservation using customary rules and taboos, but can negatively impact conservation when humans overconsume wild animals for food or medicines, resulting in wildlife population declivity.

Globally, wildlife resources have played a variety of functions in human lives, ranging from their use in religion, art, music, literature, and other human cultural manifestations (dos Santos Soares et al. 2018; García-Onetti et al. 2021; Jaisankar et al. 2018; Kideghesho 2009). Such use has been found in numerous works of art, indicating evidence of the past and present interrelationship between humans and wild animals for millions of years (Alves 2012; Vandebroek et al. 2020; Vats and Thomas 2015). The decline and extirpation (local extinction) of some wild animal species pose serious threats to the existence and continuation of traditional uses for future generations. The increased demand for wild animals, their products, and parts concurrent with the increasing human population raises conservation challenges and concerns, particularly within protected areas and their neighborhoods (Alves et al. 2021; Alves and Rosa 2013; Bello-Román et al. 2023; Tanalgo 2017). Given the ecological functions of wild animals like mammalian species, its overexploitation might have adverse ecological effects on other species. Species like Green Sea turtles (*Chelonia mydas* (Linnaeus, 1758)) have also been reported to be used as food by humans. As a result, this species has been red-listed as a critically endangered species by the International Union for Conservation of Nature (IUCN-SSC, 2022; Nogueira and Alves 2016).

Ethnozoological studies have recently gained attention in many places of the world. Among the most common cited animal species from different places there are more than 498 species of fauna documented for food and to treat various ailments in Brazil (Alves and Souto 2011). Use of animal organs to treat human diseases is reported in Karbi, northeast India (Medeiros and Alves, 2020). Green Sea turtles (*Chelonia mydas*) are used for food (IUCN-SSC 2022; Nogueira and Alves 2016). In Botswana, pangolin scale and carapace scutes are used for the treatment of various ailments, while a tortoise carapace (shell) as a container to carry their supplies by traditional healers (Setlalekgomo 2013, 2014). In Ghana, spotting a Pangolin is associated with cultural beliefs (Boakye et al. 2015). In Congo (DRC), the Kinda baboon (*Papio kindae* Lönnberg, 1919) is used for food (bushmeat), and the treatment of diseases, while the skin/hide is used for clothing against bad weather (Carpaneto and Germi 1989; Kazaba 2019). In Benin, the hippopotamus (*Hippopotamus amphibius* Linnaeus, 1758) is used for traditional medicine and religious ceremonies, while bones are considered vital for protection against evil spirits, food, and witchcraft (Dossou et al. 2018).

In Tanzania, studies on ethnozoological uses of wild animals have been carried out among Kurya, Chagga, Datoga, Pare, Maasai, Meru, Sukuma, Hadzabe, and Ikoma (Kideghesho 2008, 2009; Magige and Røskaft 2017). Spotting of Temminck's pangolin (*Smutsia temminckii* (Smuts, 1832)) was used by the Sangu of southwestern Tanzania to foretell heavy rainfall (Walsh 2020). A study by Vats and Thomas (2015) documented multiple uses of wild animals and their products as treatment of various diseases. African savanna hare (*Lepus victoriae* Thomas, 1893), African crested porcupine (*Hystrix cristata* Linnaeus, 1758), and rock

hyrax (*Procavia capensis* (Pallas, 1766)) are used for the treatment of various diseases (Magige 2015). African elephant (*Loxodonta africana* (Blumenbach, 1797)) is used by Kurya, Maasai, and Ikoma of the Serengeti for treatment. Besides that, elephant is used as a totemic animal among the Ikoma, hence protected due to their crucial role in the community, and less vulnerable to being hunted, killed, and consumed (Kideghesho 2009; Magige and Røskaft 2017; Ntalwila et al. 2019).

Despite increasing efforts to document this knowledge, the available information is still scant. The Iraqw, one of the agro-pastoral peoples of northern Tanzania, represents a community with a wealth of ethnozoological knowledge, which is, however, undocumented. The main objective of this study is to determine the scale and scope of the ethnozoological use of wild animals in Tanzania with a particular focus on the Iraqw, a Cushitic-speaking agro-pastoral ethnic group in north-central Tanzania. To date, no comprehensive ethnography has been written on them, although various aspects of their culture have been studied by anthropologists. This study addresses questions such as: What species are being used, for what purpose, and at what scale? Which species are not used, and why not? Have the trends in the ethnozoological use of wild animals changed over time? If so, how, and what are the drivers? By looking at trends in the ethnozoological use of wild animals over time and the drivers of change, this study forms a basis for the preservation of the knowledge and sustainable use of the species to preempt their extinction. Therefore, creating an efficient conservation program should be put into action due to the rising demand and business related to wild fauna (Alves and Rosa 2013).

Materials and methods

Description of the study area

The United Republic of Tanzania, with a population of more than 60 million, consists of 31 administrative regions (National Bureau of Statistics 2018). There are more than 120 different ethnic groups in Tanzania with their own distinct ways of life. The current study was carried out in the Mbulu district of the Manyara region in the northern part of the country bordering the Arusha, Dodoma, Singida and Tanga regions; specifically in three villages located in the Haydom ward of Mbulu District with populations as follows: Endagaw (1,978), Mewadan (1,638), and Ng'wandakw (1,500) (National Bureau of Statistics 2022) (Figure 1).

The study area, located at 04°11′30″S, 35°01′33″E, has a population of 5,116 and an average household size of 6.0 (National Bureau of Statistics 2018). The elevation is 1110 to 2250 m, and the climate is semi-arid to subhumid, with annual precipitation of 400-1200 mm, relative humidity of 55 to 75%, and mean annual temperatures of 17°C to 24°C (Raphael 2018). The study area is home to the Iraqw (Mbulu), Hadzabe (Tindiga) and Barabaig (Shetto and Owenya 2007). The main group is the Iraqw agro-pastoralists engaged in subsistence agriculture, husbandry, and occasional hunting and foraging of small mammals and birds for food and other traditional uses. The three villages in the study area were selected due to their proximity to Haydom Mountain (Mbulu Highland), which comprises a diversity of natural vegetation that favors a diversity of bird species, small mammals, and reptiles.

Data collection

Data were collected June 2-18, 2021. Face-to-face interviews were conducted using a semi-structured questionnaire to document the ethnozoological uses of wild animals from 15 key respondents in each village (n=45). We used purposeful sampling to select the majority

of potential respondents as in Etikan et al. (2016). This selection was done with the help of the chairperson of each village, using the village register, to select potential respondents whose opinions could be considered as 'expert,' based, on age (>30) and their role as traditional healers or elders with ethnozoological knowledge of different uses of faunal resources (wild animal species and their derivatives or parts). In case of unavailability of the respondent, we were referred by the respondent to the next respondent. We were able to obtain 30 respondents from the village registers, and the remaining 15 respondents were obtained by referral. All the taxonomic names of wild animals were as per Avibase - the World Bird Database, BioLib and CITES species databases.

Before the interview, the main purpose of the study was explained to the village executive officer and the chairman, and permission was granted to conduct interviews. Before beginning the interview, each respondent was asked for their consent as in Vedeld et al. (2012). The interview was conducted with the help of local translators. The transcribed information included socio demographic variables (tribe, age, sex, education level, occupation, and duration of residency in years). We asked questions such as: "What animal species are being used and at what scale?" "Which species are not used, and why not?" "What are the species being used for?" and "Have the trends in the ethnozoological use of wild animals changed over time, and if so, how, and what are the drivers?" The 13 guide questions were prepared in English and translated into Swahili (Kiswahili) during the interview.

The data collection procedures for the respondent interviews were in accordance with the ethical standards of the Research Committee of the College of African Wildlife Management as per the World Medical Association Declaration of Helsinki (WMA 2013). All interviewees gave their informed consent prior to being included in the survey. At the beginning of the interviews, respondents were informed that they could seek clarification at any time during the

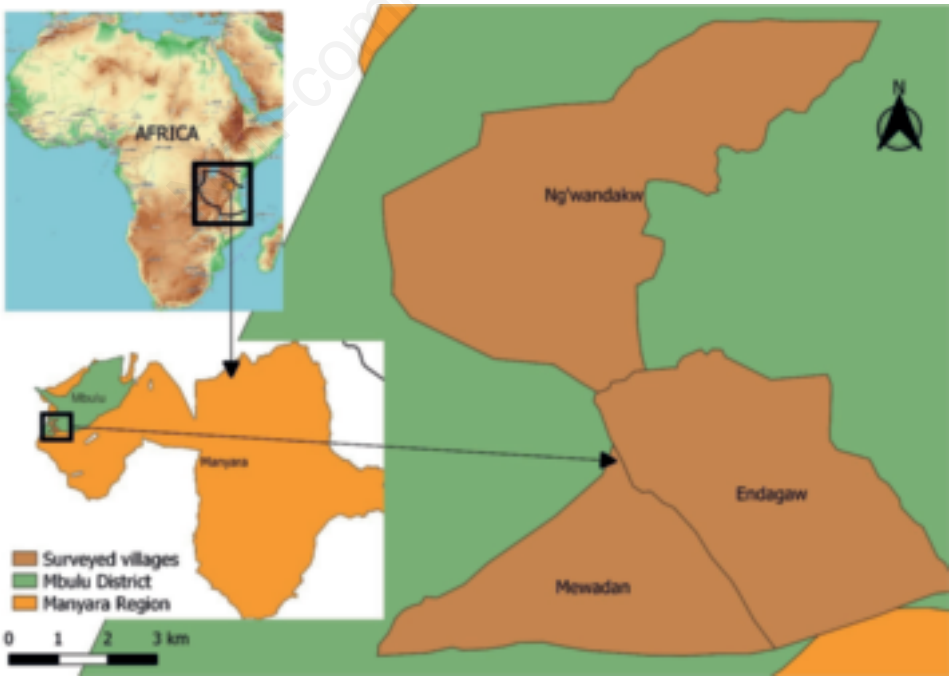

Figure 1. Map showing the study area with the three study villages.

interview. We anonymized the respondents by not asking for their names and assigned a number to each questionnaire. Our study did not involve human health issues.

Data analysis

We first coded the content of qualitative data by sorting the variable and themes for all the responses as per Sandelowski (2000). We collected qualitative data to allow more room for traditional healers (respondents) to provide detailed information. Data from the responses to the 13 open ended questions were entered as text in a spreadsheet (Microsoft Excel 16.0, 2018), sorted into coded themes and issues, and frequency of use was calculated for the coded themes.

Relationships between the demographics of the respondents and their knowledge of ethnozoology were identified with frequency tests of the responses for the following dependent variables: age in years (30-40, 41-50, 51-60, and >60), sex (male/female), residency duration (RD) in years (16-20, 21-26, and >30), education level (none formal classroom attendance, primary, secondary, and college/university), and economic activities (crop farming, livestock keeping, and agropastoralism). The trend of ethnozoology knowledge in the village (declining, stable, or increasing) was used as an independent variable.

All analyses were performed using R Statistical Software (v4.1.2; R Core Team 2021). Quantitative data were processed via the ethnobotanyR package (v0.1.8, Whitney 2019) to calculate common quantitative ethnozoology indices that included the Frequency of Citation (FC), Use Value (UV), Frequency Index (FI), and Fidelity Level (FL) (Tardio and Pardo-de-Santayana 2008; Whitney 2019) which used informant (respondent) consensus to determine the cultural value of different plant species.

The UV was calculated using the spreadsheet and the total respondents as follows: UV (use value of a species) =ΣU/n, whereby: *U* represents the number of uses mentioned by the respondents for each wild animal and *n* the total number of respondents.

Fidelity Level (FL)

The FL of the various uses of a species is the percentage ratio between the number of respondents who independently cite the use of a species for the same purposes (Ns * 100) and the frequency of citations (FCs), i.e., the total number of respondents who mentioned the animal for any use (Whitney 2019). FL also identifies the maximum number of species used, ranging from 50 to 100, and is calculated by dividing the number of respondents who claim the use of a wild animal for a specific purpose (NP) by the number of people using that species (N) in any way: FL= Np/N X 100%. The minimum criteria are that the species must be cited more than twenty times for one use and that the species has more than one use.

Frequency Index (FI)

To compare the relative importance of each animal species reported, we calculated the FI according to Chinsembu et al. (2014). In this case, the frequency index is high when many respondents cited a particular animal and low when there are few reports about that animal species.

$$FI = FC/ N X 100$$

Where:
FI = Frequency index

FC = Number of respondents who cited the use of a particular animal species
N = Total number of respondents interviewed in the study area

We used Generalized Linear Models (GLMs) to determine the most important drivers of trends in ethnozoology knowledge of the respondents. This was done by examining the importance of elements that instigate, catalyze, or motivate actions or events (driving factors). The response variable was the trend of ethnozoological knowledge, and the explanatory variables were age, village, sex, education, Duration of Residency (RD) and economic activities. The significance level was established at $p<0.05$.

Results

Demographic characteristics of the respondents

Most respondents (44.4% n=45) were between 41-50 years, followed by above 60 (33.3%), 30-40 (11.1%), and 51-60 (11.1%). Most respondents were male (77.8%). All respondents of the three villages were engaged in agriculture and related economic activities: agropastoralism (71.1%), crop farming (17.8%), and livestock keeping (11.1%). Most of the respondents had a primary level education (62.3%, n=45), followed by those who had no formal classroom education (20.0%), secondary education (13.3%) and college/university education (4.4%). Most of the respondents had RD of more than 30 years (53.3%) followed by those with RD of 16-20 years (31.1%) and 26-30 years (15.6%). Most of the respondents with secondary/college level of education (75.0%) did not prefer using wild animals while most of respondents with primary education (60.7%) and all respondents (100%) who had not been to formal classroom education depended much on wild animals ($\chi^2=48.41$, df=9, $p<0.001$). Most of the farmers (75%) and agro-pastoralist (78.2%) depended much more on wild animals than the livestock keepers (20.0%; $\chi^2=17.71$, df=6, $p=0.007$).

Wild animal species used by Iraqw

The respondents reported the usage of 28 wild animal species for different purposes (Table 1). Most species (23) were used for food, with the most utilized species being the helmeted guinea fowl (*Numida meleagris)*, which had the highest percentage of FC, followed by African savanna hare, Hildebrandt's francolin (*Francolinus hildebrandti*) and aardvark (*Orycteropus afer*) (Figure 2A,B). Aardvark is used for food and medicine; however, it is considered a misfortune when this species is seen in the daytime, which prompts people to pray to preempt the potential menace. Other species associated with traditional beliefs were owls, which were regarded as misfortune if sighted close to home. Pangolin (*Phataginus* and *Smutsia* spp.) and four-toed hedgehog (*Atelerix albiventris*) represent a blessing when encountered around the homesteads. The bones of the bushpig (*Potamochoerus larvatus*) are placed in the house to protect against evil spirits. Table 1 shows the species used for different purposes in the study area. The 28 species of wild animals cited by the respondents were grouped into five taxonomic classes: mammals (13 species), birds (12), insects (1), fish (1), and reptile (1).

The respondents reported that they do not utilize species such as pied crow (*Corvus albus*) (26.7%, n=45), African goshawk (*Accipiter tachiro*) (24.4%), black kite (*Milvus migrans*) (20.0%), spotted hyena (*Crocuta crocuta*) (13.3%), snakes (Serpentes spp.) (6.8%), lion (*Panthera leo*) (4.4%), and all other scavengers or omnivores (4.4%).

Table 1. Different categories of uses (✓) of wild animal species.

Common name	Scientific name	Uses			Use Value
		Food	Medicinal	Belief	
Mammals					
Impala	*Aepyceros melampus* (Lichtenstein, 1812)	✓			0.51
Four-toed hedgehog	*Atelerix albiventris* (Wagner, 1841)			✓	0.58
Plain zebra	*Equus quagga* Boddaert, 1785	✓	✓		0.13
Porcupine	*Hystrix cristata* Linnaeus, 1758		✓	✓	0.47
African savanna hare	*Lepus microtis* Heuglin, 1865	✓	✓		0.56
African elephant	*Loxodanta africana* (Blumenbach, 1797)		✓		0.07
Kirk's dik-dik	*Madoqua kirkii* (Günther, 1880)	✓		✓	0.67
Klipspringer	*Oreotragus oreotragus* (Zimmermann, 1783)	✓			0.35
Aardvark	*Orycteropus afer* (Pallas, 1766)	✓	✓	✓	0.20
Olive baboon	*Papio anubis* (Lesson, 1827)		✓		0.04
Bush pig	*Potamochoerus larvatus* (F. Cuvier, 1822)	✓		✓	0.24
Rock hyrax	*Procavia capensis* (Pallas, 1766)	✓			0.31
Pangolin	*Smutsia temminckii* (Smuts, 1832)			✓	0.31
Birds					
Egyptian goose	*Alopochen aegyptiacus* (Linnaeus, 1766)	✓			0.17
Superb starling	*Lamprotornis superbus* Rüppell, 1845	✓			0.13
Yellow-necked spur fowl	*Pternistis leucoscepus* (Gray, 1867)	✓			0.58
Ring necked dove	*Streptopelia capicola* (Sundevall, 1857)	✓	✓		0.56
African mourning dove	*Streptopelia decipiens* (Hartlaub & Finsch, 1870)	✓	✓		0.56
Owl	*Strigiformes* spp.			✓	0.36
Ostrich	*Struthio camelus* Linnaeus, 1758	✓	✓		0.13
Speckled pigeon	*Columba guinea* Linnaeus, 1758	✓	✓		0.47
Red-necked spurfowl	*Francolinus afer* (P.L.S. Müller, 1776)	✓			0.58
Hildebrandt's francolin	*Francolinus hildebrandti* Cabanis, 1878	✓			0.60
Helmeted guineafowl	*Numida meleagris* (Linnaeus, 1758)	✓	✓		0.73
House sparrow	*Passer domesticus* (Linnaeus, 1758)	✓			0.22
Insects					
Honey bee	*Apis mellifera scutellata* Lepeletier, 1836	✓	✓		0.24
Reptiles					
Black-necked spitting cobra	*Naja nigricollis* Reinhardt, 1843		✓		0.36
Fish					
Catfish	*Clarias gariepinus* (Burchell, 1822)	✓			0.22

Use Value (UV)

UV indicates the animals that are used more frequently compared to others (*Table S1*). In this study, helmeted guinea fowl (*Numida meleagris)* had the highest UV (0.7), followed by Hildebrandt's francolin (*Francolinus hildebrandti*), ring-necked dove (*Streptopelia capicola*), African mourning dove (*Streptopelia decipiens*), and speckled pigeon (*Columba guinea*) (Table S1).

The respondents cited the use of these wild animals and their derivatives or body parts for the treatment of human diseases such as burns, all types of body infections (eye, respiratory, gastrointestinal), pain, and earache, and as snake antivenom (Table S1). Other uses were food and traditional beliefs such as rituals. In some cases, the entire faunal resource, including meat, organs, offal, bones, spines, or quills; as well as products such as fur, skin, fat or oil, dung, and honey, were used for medicinal and/or food. Most of the wildlife species (21), mainly mammals and birds, were used for food, while others had medicinal (14) or ritualistic value or were associated with traditional rituals and beliefs (7).

Fidelity Level (FL)

The species with the highest FL were Kirk's dik-dik, Hildebrandt's francolin, red neck spur fowl, hedgehog, African mourning doves, and Impala, each with a 100% fidelity level. The fidelity levels for guinea fowl, bushpig, and African savanna hare were 77%, 69%, and 66%, respectively. Aardvark had the lowest fidelity level of 39%.

Frequency Index (FI)

The species with high frequency index (FI), which implied a higher level of utilization compared to other species, were helmeted guinea fowl, followed by hares, Kirk's dik-dik, aardvark, and Hildebrandt's francolin (Figure 2A,B). The black-necked spitting cobra with an FI of 36% was the only reptile cited as utilized. African honey bees and catfish had an FI of 24% and 24%, respectively.

Driving factors for the decline of Iraqw ethnozoological knowledge

Most respondents (86.7%, n=45) claimed that the knowledge of the uses of wild animals

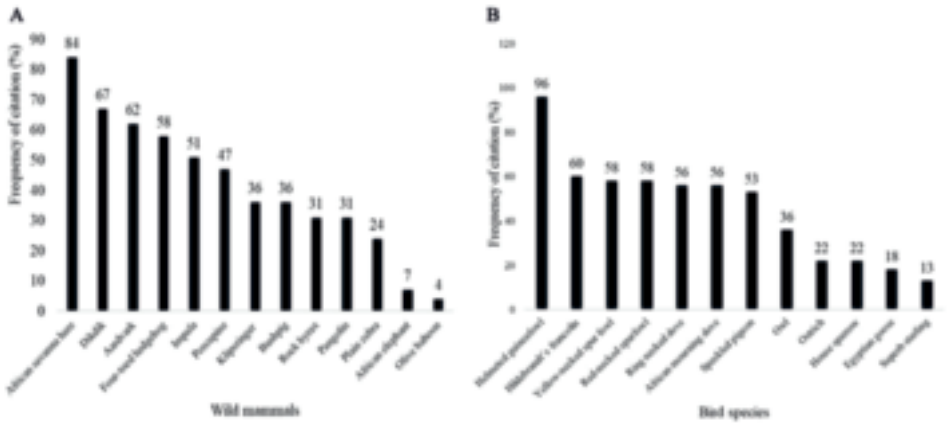

Figure 2. Frequency of citation of A) wild mammals and B) bird species.

is declining; only 8.9% said it is stable, and 4.4% claimed that the knowledge is increasing. Driving factors of the declining trend of ethnozoological knowledge cited or identified by the respondents included: a lack of interest among young people to learn ethnozoology (33.3%, n=45), the decline and extirpation of some species of wildlife (22.2%), economic activities such as agriculture and livestock keeping (15.6%), western Christian religion (8.9%), globalization (social media) (8.9%), the availability and ease of access to modern healthcare facilities (6.7%) availability of alternative domesticated animals for food and/or traditional medicine (4.4%).

We used the ordinal regression model to examine the driving factors for the decline in ethnozoological knowledge among Iraqw. We found that male respondents were more knowledgeable about ethnozoology than female respondents (Table 2). Furthermore, respondents from Endagaw village had more ethnozoological knowledge than people from other villages. Other variables, such as education, occupation, residence duration, and age of the respondents, did not influence their knowledge of ethnozoology. However, respondents perceived that the knowledge of the usage of faunal resources for purposes such as food and traditional medicines, has decreased significantly, compared to the use in the past/previous 15 years (Table 2).

Discussion

Ethnozoological uses of wild animals in the Iraqw people

Our results revealed that the Iraqw use wild animals for food and medicines and associate some with cultural beliefs. Species with high UV, i.e., those species most utilized by all local communities, may be subjected to overexploitation and, consequently, to an increased risk of extirpation. This study revealed that some different species, such as helmeted guinea fowl, African bee, aardvark, and black spiting cobra, are all protected by the local community due to their UV for food, medicine, and rituals/beliefs. For example, the aardvark is hunted for meat and fat, which are used both for food and to treat many types of body infections, while claws and skin are used in traditional belief practices. It should be noted the possibility that during the study, not all wild animals utilized by the local community for medicinal purposes and other cultural uses were mentioned by the respondents. The species cited may include only species that are frequently hunted or influence of cul-

Table 2. Ordinal linear regression model with dependent variable (trend of ethnozoology knowledge (increasing, stable, or decreasing) versus independent variables (village, sex, age, education level, duration of residency, and occupation).

Parameter estimates	Estimate	Std. error	Wald	df	p
[Trend_Knowledge = increasing]	8.8	4.6	3.7	1	0.055
[Trend_Knowledge = declining]	11.4	5.0	5.1	1	**0.024**
Village	-3.9	1.5	7.3	1	**0.007**
Sex	3.9	1.6	6.0	1	**0.014**
Age	1.1	0.8	2.0	1	0.152
Education	1.1	1.1	1.1	1	0.299
RD	0.3	0.6	0.3	1	0.580
Activity	1.2	0.8	2.6	1	0.110

RD, duration of residency.

tural preferences distinctive traits of an animal species, such as the body mass, higher cultural or dietary importance while forgetting the other species that are really or seasonally being caught (Oliveira et al. 2022). This kind of utilization contributes to the decline in the species population. Similar findings were also reported by Kideghesho (2008) and Das (2008), who found local and traditional culture plays a role in conservation among different tribes, such as the use of wild animal names by some clans, which increases respect for the animal and increases chances of protecting the species.

Birds have higher UV compared to other classes of animals, probably due to their availability in villages and the leniency in enforcing the bird conservation laws. Furthermore, according to Iraqw culture, the consumption of birds of prey such as African goshawk, black kite, pied crow, and all omnivores animal species is taboo due to their funerary practice of natural excarnation (de-fleshing) by exposure to the elements and scavengers. Hence, consuming such species implies the possibility of consuming the departed. As one of the key respondents said:

> "Eating birds of prey is strictly prohibited and a strange thing to do in our community, as we believe that they might have eaten the dead bodies of our grandparents, our parents, and other relatives. Consuming these species is like eating the bodies of our relatives" (R6).

Consistent with a study by Gandile et al. (2017), such cultural beliefs could be useful in promoting biodiversity and species conservation, mitigating overexploitation, and preventing extirpation.

Furthermore, the study revealed that the use of wild animals for medicinal purposes is the preferred method because it was regarded by many people to be the most effective in treating non communicable diseases such as asthma. The observed declining trend in the use of wild animals for food and medications can be explained by the current decline of wild animals and the extirpation of species such as elephant, ostrich, baboon, and zebra. This is also common in other parts of the world. For instance, according to Boakye et al. (2015), Ripple et al. (2016) and Dery et al. (2022), overconsumption of armadillo, pangolin, primates, platypus and echidna, even-toed ungulates, and lagomorphs (rabbits, hares, and pikas) for food and medicine has resulted in placement of some species in the IUCN Red List of Threatened Species (IUCN-SSC, 2022). Our findings and other studies have shown that wild animals may be used for food and medicine, however, Van Vliet et al. (2017) have shown the presence of toxic element including heavy metals nickel and chromiumin in some bushmeat. Apart from that transmission of zoonotic diseases as well as viruses, germs, protozoa, and parasites by coming into contact with bush meat during processing before cooking, hunting, transportation if not well handled through safety practices.

The African elephant is threatened by illegal hunting, but in this study, we only recorded the use of elephant dung. Other uses of elephants that are common in Africa may not have been reported because respondents are reticent due to strict laws and enforcement and fear of exposure. Throughout Africa, elephants are killed primarily for ornamental ivory and not for the consumption of meat or medicine alone. For example, studies in the Samburu pastoral community in Kenya pointed out usage of elephants that included ivory to make earplugs and the finger rings worn by ritual leaders to signify their importance and status within their community (Kahindi 2001; Ocholla et al. 2016). Other documented uses include the wearing of beads made from elephant tusks, the use of elephant dung to build a house, particularly for newlyweds, and dry dung from elephant calves is traditionally used to make the first fire

during the wedding ceremony to symbolize unity. However, some of these practices, such as the use of ivory, are currently inactive due to the enforcement of strict laws enacted by the government banning the possession of ivory (Kahindi 2001; Ocholla et al. 2016).

There were gender differences between men and women in their utilization of wild animals; men were found to be more knowledgeable compared to women. However, this difference could have been influenced by the fact that most of our respondents were male. The greater knowledge among men of the traditional uses of wild animals could be influenced by traditional African cultures, which define specific gender roles as per Mmassy and Røskaft (2014). Men are usually involved in roles such as hunting, field dressing, and butchering, as well as preparing, setting, and monitoring of traps. Women remain home with roles in childrearing and domestic chores, including cooking. They receive and cook the meat, which has already been butchered by men without prior knowledge of the operations involved. This observation is consistent with that of Arluke (2003) who claimed that most men are more knowledgeable about ethnozoological practices.

Respondents with higher levels of education, from secondary school through university degrees, were found to prefer using wild animals less frequently than those with lower levels of education. This could likely be attributed to the fact that those with higher levels of education tend to be more civilized and therefore abandon most of the cultural practices (Hariohay et al. 2019). A high degree of education also raises awareness of the importance of conservation while enhancing one's ability to think creatively and find alternative sources of income other than wild animals (Hariohay et al. 2018). In addition, the high level of education increases the chances of being skeptical on the efficiency of traditional medicine products from wild animals. The lower level of education means limited exposure into the modern ways of live. The higher level of education provides a possibility of having diversified and reliable means of income hence ability to afford costs such as purchasing meat for food and ability to cover modern healthcare expenses.

Respondents engaging only in livestock keeping they are also likely to be less depending on utilization of wild animals. This is because the possession of many domesticated animals could also be used as an alternative means to the use of wild animals or people with domesticated animals find better to use domesticated animals for food and medicine due to legal restrictions on the use of wild animals. Similarly, Ferreira et al. (2016) recommended that encouraging the use of domesticated animals by products medicinal can be used as an alternative means to promote conservation particularly for animal traded in the cities. This will ultimately enable development of policies that promote the use of animal products including fat, skin and horns to ensure the sustainability of wild species.

Driving factors for the decline of ethnozoological knowledge among Iraqw

Our results revealed that modern health facilities, such as hospitals and pharmaceuticals, have replaced the use of animals for medicine and, therefore, hindered the transmission of ethnozoological knowledge from one generation to the next. Other studies have reported similar findings in the Serengeti (Kideghesho 2008; Magige 2015) and in the Chitwan-Annapurna Landscape (CHAL) in central Nepal (Adhikari et al. 2020). Such a development can contribute significantly to the conservation of species due to the minimal dependence of wild animals on zootherapy, particularly when medications involve the killing of animals. As in similar studies by Kideghesho (2008), Magige (2015) and Adhikari et al. (2020), our study found that the demand for wildlife-related medicines is one of the major threats to wildlife species, including charismatic species such as elephants, rhinos, and tigers.

The introduction of western religions, such as Christianity, is attributed to the decline of

transmission of ethnozoological knowledge from one generation to generation due to the abandonment of cultural practices, which were often regarded as devilish. Similarly, Graburn (2021) claimed that the introduction of a new religion may destroy culture, especially as people subscribing to the imported religion eventually tend to forget their culture.

The decline in interest among youth in traditional practices is mainly fueled by the current globalization and the presence of formal classroom education, as most of the time, students spend their time in formal classrooms, unlike in the past, when the traditional lifestyle was more popular among teachers and students. This is in support of the results of Berry (2008) and Pacheco (2020). This is parallel to Slutsky et al. (2021) and Reyes-García et al. (2009), who indicated that children do not have interest in learning and practicing traditional practices such as hunting, compared to their parents and grandparents, thus leading to a lack of inheritability of ethnozoological knowledge. One of the respondents said:

> "When wild animals are caught and brought home, children enjoy eating the meat, but nobody bothers to learn the hunting techniques. This makes it difficult for them to continue using the animals when their parents and grandparents are gone" (R1).

Formal education has also promoted the changes of traditional beliefs, increased their awareness, and exposed them to modern ways of life. This has helped them to learn new ways of life, including traditions and culture. This can be useful to them to be enlightened on the best way to think about alternative and different ways of living, thus abandoning and challenging parts of their culture that are harmful.

Local extirpation of species due to increased human activities was also found to limit the transmission of ethnozoological knowledge to new generations. The increased human activities result in the destruction of habitats, hence reducing the number of species that could be used for zootherapy, and this could probably be the reason for the shift into alternative sources of treatment such as pharmaceuticals, which are more accessible (Breed et al. 2009; Dirzo and Raven 2003).

Conclusions

This study documented that traditional knowledge on the use of faunal resources is well established among elders of the Iraqw, and a total of 28 species of wild animals were used for different purposes, mainly for food, medicine, and cultural beliefs. The perception of the respondents was that the knowledge of ethnozoology is declining with time due to the minimal interactions between the youth and nature. This declining trend was perceived by respondents to be caused by the emergence of the modern institutions (schools, religions, and health facilities) and local extinctions of wildlife species. The decline and extirpation of wildlife populations are common in many parts of Africa, where human population and urbanization trends are increasing, which consequently causes overexploitation of species, habitat fragmentation and loss, pollution, introduction of exotic species, and climate change.

Therefore, we recommend first, similar studies on other traditions and/or modern usages of wildlife to improve their protection worldwide. Second, ensuring and raising community awareness on ethnozoological uses of wild animals for a particular purpose over a long period of time and passed onto future generations to reduce its decline more specifically among the Iraqw community. Not all traditional uses of wildlife products are harmful to animals, especially when they do not involve killing an animal, e.g., collecting animal dung and furs. There-

fore, these uses can be permitted to provide incentives for local communities to support conservation efforts. To provide a basis for the conservation and sustainable use of wild animals in different parts of Africa and worldwide.

Authors' contributions

KMH, GJC, AKM, JRK conceptualized and designed the study; GJC collected and analyzed the data; KMH, AKM, RDL, JN re-analyzed the data and wrote the article, with support from JRK. Three anonymous reviewers greatly helped improve this manuscript.

Conflict of interest

The authors declare no potential conflict of interest.

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Ethics approval and consent to participate

The data collection procedures for the respondent interviews were in accordance with the ethical standards of the Research Committee of the College of African Wildlife Management as per the World Medical Association Declaration of Helsinki (WMA 2013). All interviewees gave their informed consent prior to being included in the survey. At the beginning of the interviews, respondents were informed that they could seek clarification at any time during the interview. We anonymized the respondents by not asking for their names and assigned a number to each questionnaire. Our study did not involve human health issues.

Availability of data and materials

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Online supplementary material:

Table S1. Ethnozoological uses and conservation status of wildlife used in the Mbulu district of Tanzania.