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Attitudes and behaviour toward snakes on the part of Igbo people in southeastern Nigeria

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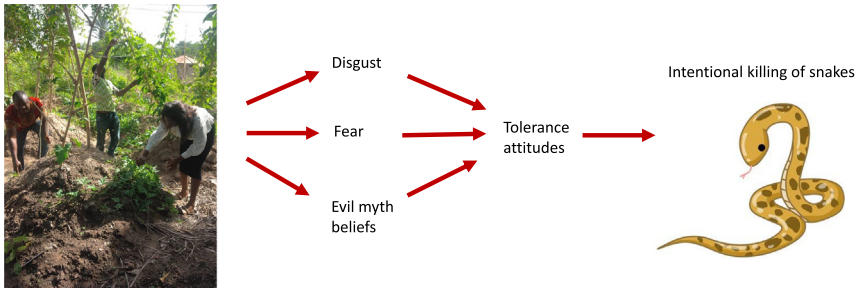
HIGHLIGHTS

- Fear and disgust negatively correlated with high tolerance of snakes.
- Evil myth beliefs were related to low tolerance of snakes.
- High tolerance of snakes correlated with less frequent killing of snakes.
- Snakebite experience was associated with a higher probability of killing snakes..

GRAPHICAL ABSTRACT



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ABSTRACT

Snakes play a crucial role in natural ecosystems, providing ecological services to people by decreasing rodent populations which may cause disease transmission and impair agricultural production. Despite these benefits, snakes are historically a target of persecution and negative attitudes across cultures, and many of them are threatened. Understanding the predictors of snake-human conflicts is essential to improve conservation efforts. We investigated the degree to which emotions, myth beliefs, experience with snakes (via exposure, bites, and knowledge of mortality from a snakebite), and education would predict attitudes toward snakes in a sample of southeastern Nigerian people. We further examined whether attitudes would predict intentional killing of snakes. Ordinal regression analyses revealed that fear, disgust, and belief in the myth that snakes are evil were related to low tolerance of snakes. More frequent encounters with snakes and higher education were associated with higher tolerance of snakes. Furthermore, higher tolerance of snakes was associated with a reduced likelihood of intentionally killing snakes, even when controlling for the influence of the other psychological and experiential variables. Wildlife management education interventions may be important to change attitudes and decrease intentional killing of snakes.

1. Introduction

Throughout evolutionary history, snakes were predators of our mammalian ancestors (Isbell, 2006). As a result, snakes are prototypical stimuli for inducing fear in humans as well as in other non-human primates (Öhman and Mineka, 2001). Both venomous and non-venomous snakes can pose a serious danger to humans. A current estimate of the

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occurrence of venomous snakebites per year is 421,000–1,841,000 cases resulting in 20,000–90,000 deaths worldwide (Kasturiratne et al., 2008). These data are likely underestimated because many developing countries have no detailed information about snakebites, and a number of injured people in local communities do not seek or do not have access to hospital care (Fry, 2018). With respect to the threat posed by non-venomous snakes, data are rather anecdotal, but Headland and Greene (2011) found that 26% of Philippine Agta Negritos males (preliterate hunter–gatherers) had been attacked by pythons.

Selective pressures caused by the potential lethality of snakes contributes to acquiring a fear response toward snakes, and likely influences the perception of snakes in contemporary humans (Öhman and Mineka, 2001, 2003; Prokop et al., 2009; Prokop and Randler, 2017; Prokop et al., 2018). Indeed, snakes are historically the target of persecution and negative attitudes in a number of countries (Ashley et al., 2007; Ceríaco, 2012; Alves et al., 2014; Secco et al., 2014; Pandey et al., 2016). Snakes are considered to be one of the least attractive animals in people of all age groups (Kaltenborn et al., 2006a; Borgi and Cirulli, 2015). They are both feared and disgusted by people (Rádlová et al., 2019). No snake species is listed among the top 20 most charismatic animals, and people are very unlikely to support their conservation (Morris and Morris, 1965; Martín-López et al., 2007; Knight, 2008; Prokop and Fančovičová, 2013; George et al., 2016; Albert et al., 2018).

Human activities such as habitat destruction, intentional killing of snakes, and using snakes in medicine, fashion, and the pet trade, contribute to population decline worldwide (Gibbons et al., 2000; Webb and Shine, 2000; Alves and Pereira Filho, 2007; Alves et al., 2009; Beaupre and Douglas, 2009; Fita et al., 2010; Reading et al., 2010; Robinson et al., 2015). The killing of snakes may have widespread consequences; for example, the decline in snakes results in an increase in rodent populations, which impairs production of agricultural products and supports disease transmission (Meerburg and Kijlstra, 2007; Singleton et al., 2010). Snakes are also important food resources for many top predators, such as eagles and owls (Mendall, 1944; Brooker and Ridpath, 1980; Shehab, 2004). Therefore, understanding the variables associated with negative attitudes and harmful behaviours toward snakes is essential to improve conservation efforts.

The present research investigates several variables that may predict attitudes toward snakes, and furthermore tests whether attitudes predict intentional killing of snakes. Although attitudes are characterized as being comprised of three different components (cognitive, affective, and behavioral; Eagly and Chaiken, 1993), our focus is on the cognitive component, such as appraisals about the value of snakes to society. We also examine how discrete emotions, such as fear and disgust, may be precursors to adopting negative attitudes, especially considering that affective reactions to stimuli can be drivers of attitudes (Eagly and Chaiken, 1993). Previous research has shown that negative attitudes and behaviours are associated with lower education level and beliefs of untrue myths (Alves et al., 2012, 2014; Moura et al., 2010; Ferreira et al., 2013; Pinheiro et al., 2016). Cultural myth beliefs have been shown to influence community attitudes toward animals (Herzog and Burghardt, 1988), and misconceptions about snakes frequently emerge in rural folklore, which may relate to cognitive attitudes. It is also possible that myth beliefs overlap considerably with negative emotions (e.g., people who fear snakes most may also tend to believe in myths about snakes).

Although fear of snakes is innate in humans, it may be exacerbated by experience, knowledge, and social learning (Bandura, 1986; Delgado et al., 2006; Rachman, 1977; Schönfelder and Bogner, 2017). For example, frequent encounters with snakes, direct experience with snakebites, and knowledge of mortality from snakebites may increase negative attitudes and destructive behaviours toward snakes. Traditional societies living in rural Africa are excellent candidates to examine how experience with snakes relates to attitudes and behaviour, as these populations are most vulnerable to snakebites (Harrison et al., 2009; Kasturiratne et al., 2008; Sharma et al., 2013). Moreover, rural communities experience more intensive human-wildlife conflict than people living in cities, which leads to more aggressive behaviour toward snakes (Ceríaco, 2012; Dehghani et al., 2012; Dickman, 2010). Indeed, the closer humans live to an area with potentially dangerous animals, the more negative attitudes they have toward them (Karlsson and Sjöström, 2007; Stronen et al., 2007; Caruso and Pérez, 2013). The notion that personal experiences underly attitude formation (Eagly and Chaiken, 1993) may have downstream consequences such as increased incidents of intentional killing. There are several ways in which someone living in rural Africa might encounter snakes, such as seeing them in their home or garden, having suffered an injury from a snakebite, or having a family member or friend suffer a fatality from a snakebite. These different types of exposure to snakes may relate differently to attitudes and behaviour.

The primary aim of this study is to investigate how emotions (fear and disgust), myth beliefs, experience with snakes (encounters with snakes, experience with snakebites, and knowledge of fatality from a snakebite), and education level relate to attitude formation and intentional killing of snakes. Previous research has demonstrated that females express more negative attitudes toward snakes than males (Prokop et al., 2009; Alves et al., 2014; Ceríaco, 2012; Pinheiro et al., 2016; Liordos et al., 2018) and suffer from a greater incidence of snake phobia than males (Fredrikson et al., 1996; Polák et al., 2016), so we also consider sex in our investigation. We utilize a sample of inhabitants of an indigenous community living in southeastern Nigeria. The incidence of snakebites in Nigeria has been reported as 497 per 100,000 people per year, with a 12% mortality rate (Habib et al., 2001). There is an urgent need to investigate this topic in order to better understand human perceptions of snakes and implement these findings into conservation policy and management approaches. Unlike the majority of research on snakes conducted in Western countries, where real contact with snakes is minimal, we investigated attitudes and behaviour toward snakes in a community where snakes possess a serious threat. Data from such communities are necessary to better understand human-snake interactions. We make the following hypotheses:

1. Fear, disgust, myth beliefs, encounters with snakes, experience with snakebites, knowledge of mortality from a snakebite, and lower education will be associated with negative attitudes toward snakes.
2. Negative attitudes toward snakes will be associated with a greater likelihood of intentional killing of snakes.
3. Women will have more negative attitudes and a greater inclination to kill snakes, compared to men.

2. Method

2.1. Study area

Nigeria is classified as a developing country with high levels of poverty, with over 100 million people out of its estimated population of 200 million living in extreme poverty (World Poverty Clock, 2020). The unemployment rate in Nigeria is estimated to be 23.10%, while underemployment is 20.10% (National Bureau of Statistics, 2018). The Nigerian literacy rate is estimated at 62.02%. The statistics on employment, literacy level, and poverty in Nigeria represent the general characteristics of population of the current study. Our study area included communities within Abakaliki capital of Ebonyi State Nigeria, located 64 km (40 miles) southeast of Enugu, the former regional capital of Southeast, Nigeria (Fig. 1). The communities include Ndebor Ophoke, Ohatetwe, Ishieke, Ezza Owhu, Igweledoha, Enyibuchiri, Enyadulugu, Obobo, Nchoko-Okwu, Abarigwe, Mbamiri, Ugwuachara, Orokeonuoha, and Edomoke. Abakaliki is a center of agricultural trade, including products such as yams, cassava, rice, and palm products. As of 2015 the population of Abakaliki was 438,700, which equates to 0.24% of total Nigerian population. With respect to snakes in the study area, pythons

Fig. 1. Map showing study site in the southeastern Nigeria.

(*Pythonidae*) and several colubrid (Colubridae) species (predominantly venomous) are most common (Table 1).

2.2. Participants and procedure

Ethics approval was obtained from the Research and Ethics Committee of the Department of Psychology of the University of Nigeria. The study was conducted between August 2018 and February 2019. We utilized a convenience-sampling method in this study for pragmatic purposes. Participants in the study were 335 inhabitants of a local community (175 males, 153 females, five people did not provide information regarding their sex). The inhabitants are primarily members of the Igbo ethnic group. All participants were literate inhabitants of Abakaliki who can read, understand, and write in English. Abakaliki people are predominantly farmers, but several people engage in small-scale businesses, and a few others engage in public service jobs working in government establishments such as schools, hospitals, and civil services.

Study participants were approached in their homes by the researchers, and those who volunteered to participate were given a questionnaire to complete. Participants were assured of the confidentiality of their responses before the questionnaire was administered. Participation in the study was voluntary. Individuals who agreed to participate in the study and were at least 18 years old were given a copy of the questionnaire to respond to. We did not attempt to recruit a particular member of each household, and data on the number of persons that participated in a household were not collected.

2.3. Research instruments

The questionnaire contained several measures that assessed encounters with snakes, experience with snakebites, knowledge of mortality from snakebites, emotions, myth beliefs, attitudes, and intentional killing of snakes, along with demographic information. Details regarding each measure are provided below.

2.3.1. Encounters with snakes

Snake-human encounters were examined with three items: How many times have you seen a snake near your house in the last month?, How many times have you seen a snake in your garden in the last month?, How many times have you seen a snake elsewhere in the last month? Responses to these items were scaled (1 = 0 times, 2 = 1–2 times, 3 = 3–4 times, 4 = 5–6 times, 5 = 7–8 times and 6 = 9 times and more). We conducted a factor analysis, which demonstrated a one-factor solution explaining 74% of the variance (Eigenvalue = 2.24). Items were averaged to form a composite variable with excellent reliability ($\alpha = 0.83$). See Table 2 for details.

2.3.2. Experience with snakebites

Personal experience with snakebites was examined with the questions: “Have you ever been bitten by a snake?” and “Do you know anyone from your community who has ever been bitten by a snake?” Responses were coded (1 = yes; 0 = no) and summed across items, such that higher numbers indicated more experience with snakebites.

2.3.3. Knowledge of mortality from snakebites

Knowledge of mortality was examined with two items: “Has any member of your family been killed by a snakebite?” and “Has any other person from your community ever been killed by a snakebite?” Responses were coded (1 = yes; 0 = no) and summed across items, such that higher numbers indicated greater knowledge of snakebite mortality.

Table 1
Conservation status and venomosity of the five snake species occurring in the study area.

S/N	Local/dialect	Common name	Family name	Scientific name	Conservation status	Venomosity		Intensity
1	Eke	Python	Pythonidae	*Python sebae*	NONE	√		
2	Oghu	Cobra	Elapidae	*Naja nigricollis*	NONE		√	High
3	Oroke	Caspian Whipsnake	Colubridae	*Coluber caspius*	NONE	√		
4	Ikputu	Viper	Viperidae	*Echis ocellatus*	NONE		√	High
5	Ota/Agwo-igu	Western green mamba	Elapidae	*Dendroaspis viridis*	NONE		√	High

Table 2
Results of factor analyses for myth beliefs, attitudes, and exposure measures.

	Factor loading		
	1	2	3
Myth belief items			
Factor 1: Bad luck myth beliefs			
When you see a snake in your house, it is sent by your enemy to harm you.	**0.84**	0.07	
Snakes bring bad luck to people.	**0.73**	0.35	
It is a sign of bad omen if you frequently come across snakes in your compound.	**0.76**	0.19	
Factor 2: Evil myth beliefs			
Snakes are evil.	0.19	**0.75**	
Snakes are used by witches in their trade.	0.09	**0.88**	
Snakes are used by witchdoctors to cast spells on people.	0.44	**0.61**	
Attitude items			
Factor 1: Tolerance attitudes			
The government should aim at the increasing current snake populations.	**0.64**	-0.03	0.30
I would like to see snakes in the wild.	**0.58**	0.38	0.02
I would like to coexist with snakes.	**0.76**	0.15	-0.04
Snakes are attractive animals.	**0.74**	0.24	-0.03
I would feel safe around snakes in the wild.	**0.72**	0.07	-0.24
Factor 2: Conservation attitudes			
Snakes must exist because they are valuable to nature.	0.13	**0.87**	0.04
Snakes must exist because they are valuable to people.	0.16	**0.84**	0.06
Factor 3: Not used			
Any snake should be killed upon encounter. (r)	0.27	0.07	**-0.66**
Endangered snake populations should be protected by people.	0.24	0.20	**0.80**
Exposure to snakes items			
Factor 1: Exposure to snakes			
How many times have you seen a snake near your house in the last month?	**0.86**		
How many times have you seen a snake in your garden in the last month?	**0.91**		
How many times have you seen a snake elsewhere in the last month?	**0.82**		

2.3.4. Emotions

Fear of snakes was investigated with a single item (How much do you fear snakes?) following Kaltenborn et al. (2006b). The responses were rated on a 5-point scale anchored from 1 (absolutely not) to 5 (extremely). Disgust of snakes was investigated with a single item (To what degree do you find snakes disgusting?) following Kaltenborn et al. (2006b). The responses were rated on a 5-point scale anchored from 1 (not at all disgusting) to 5 (extremely disgusting).

2.3.5. Myths beliefs about snakes

Myths about snakes are specific for each region (Prokop et al., 2009). We therefore developed a questionnaire consisting of six items reflecting existing myths about snakes in the Igbo community (e.g., "Snakes bring bad luck to people", see Table 2 for more details). Participants indicated their agreement with each item on a scale from 1 (strongly disagree) to 5 (strongly agree). We conducted a factor analysis to determine whether myth beliefs constituted a single or multiple factor structures. We extracted factors based on an Eigenvalue >1 criterion and applied a Varimax rotation. Two factors emerged accounting for 49% and 17% of the total variance (Eigenvalues = 2.91, 1.01). Factor 1 was comprised of three items reflecting the belief that snakes are bad luck. These items demonstrated good reliability and were averaged to form a composite variable we refer to as *bad luck myth beliefs* (α = 0.74). Factor 2 was comprised of three items reflecting the belief that snakes are associated with evil and witchcraft. These items showed adequate reliability and were averaged to form a composite variable now referred to as *evil myth beliefs* (α = 0.69).

2.3.6. Attitudes toward snakes

Attitudes toward snakes were assessed with Liordos et al. (2018) measure. Participants indicated their agreement with 9 items on a scale from 1 (totally disagree) to 5 (absolutely agree). A factor analysis with Varimax rotation revealed a three-factor structure accounting for 35%, 15%, and 12% of the total variance (Eigenvalues = 3.11, 1.35, 1.07). Factor 1 was comprised of five items reflecting attitudes about tolerance toward snakes. These items showed good reliability and were averaged to form a composite variable hereby referred to as *tolerance attitudes* (α = 0.74). Factor 2 was comprised of two items reflecting attitudes about conservation of snakes. These items showed good reliability and were averaged to form a composite variable we now refer to as *conservation attitudes* (α = 0.72). Factor 3 was comprised of two items that had very poor reliability and were therefore excluded from further analyses (α = 0.29).

2.3.7. Behaviour toward snakes

To understand people's behaviour toward snakes found in or near their homes, we asked respondents to first indicate whether they had encountered a snake in or near their homes. If participants replied "yes" to this question, they were asked to choose one of the following six options; 1 = I killed many of them, 2 = I chased it away, 3 = It escaped on its own, 4 = I ran away because I was afraid, 5 = I did nothing to it, and 6 = I contacted the responsible officer. We then created a dichotomous variable reflecting killing snakes (1 = yes, 0 = no).

2.3.8. Perceived benefits of snakes

We assessed perceived benefits of snakes for exploratory purposes. Participants were asked the question: "list the benefits which people receive from snakes in your community." Responses were open-ended.

2.3.9. Education level

We asked participants to indicate their highest level of education. Responses were coded as follows. 1 = none, 2 = primary, 3 = secondary, 4 = college, 5 = university.

2.3.10. Demographic variables

We also assessed several demographic variables to provide more detailed information about our sample. These included participant age, sex, relationship status, and number of children.

2.4. Data analysis

All statistical analyses were performed with SPSS version 20. We computed medians for ordinal variables, and we conducted

frequency distributions for categorical variables. Attitude data were not normally distributed, and normality could not be achieved even when various types of data transformation were applied. Thus, ordinal regression analyses were conducted to examine predictors of attitudes (ordinal outcome variable), following recommendations by Jamieson (2004). We conducted a series of ordinal regression analyses to examine which variables predicted attitudes toward snakes. We regressed conservation attitude scores and tolerance attitude scores onto the following variables simultaneously: Fear, disgust, evil myth beliefs, bad luck myth beliefs, snake encounters, experience with snakebites, knowledge of fatal snakebites, education, and sex. This analytic strategy allowed us to assess the unique association between each predictor variable and attitude scores, while controlling for the influence of all the other variables in the model. Binary logistic regression analyses were conducted to examine predictors of intentional killing of snakes because the outcome variable had a binomial distribution (yes or no). Nagelkerke R^2 was used to examine the explained variance of the regression results.

3. Results

3.1. Sample characteristics

The mean age of the participants was 37.8 years ($SD = 9.87$), ranging from 19 to 68. The educational level of the participants was as follows: no formal education ($n = 4$, 1.2%), primary education ($n = 33$, 10%), secondary education ($n = 101$, 30.1%), college education ($n = 57$, 17%), university education ($n = 138$, 41.2%), and two participants (0.5%) did not provide information about their education level. Most respondents were married ($n = 323$, 88.7%), but some were single ($n = 26$, 7.8%), or divorced ($n = 9$, 2.7%), and three participants (0.8%) did not provide information about their relationship status. The mean number of reported children was 2.61 ($SD = 1.62$, range = 0–5).

3.2. Descriptive statistics

Participants generally reported a moderate amount of fear and disgust of snakes. Evil myth beliefs and bad luck myth beliefs were also near the midpoint of the scale. Attitudes toward snakes were generally negative. Correlations between variables can be found in Table 3.

Thirty-one participants (9.3%) had reported being bitten by a snake, and 147 participants (43.9%) reported knowing someone that was bitten by a snake. Thirteen people (3.9%) had a family member killed via snakebite, whereas 41 people (12.2%) knew someone else in their community that suffered a fatal snakebite injury. Two hundred four people (60.9%) reported encountering a snake in their home. The most common response to encountering a snake was intentional killing ($n = 106$; 52%), followed by the snake escaping on its own ($n = 43$; 12.8%), chasing the snake away ($n = 21$; 10.3%), running away from fear ($n = 19$, 9.3%), doing nothing ($n = 12$; 5.9%), and contacting the authorities ($n = 3$; 1.5%).

3.3. Predictors of attitudes toward snakes

3.3.1. Conservation attitudes

Our set of predictor variables accounted for 6.3% of the variance in conservation attitudes, which was statistically different from zero, χ^2 (10) = 20.73, $p = 0.03$. Inspection of the estimates revealed that none of the individual predictors in the model were associated with conservation attitudes (all $p > 0.11$) except for sex (Table 4). Males expressed more positive conservation attitudes toward snakes than females.

3.3.2. Tolerance attitudes

Altogether, our predictors accounted for 26% of the variance in tolerance attitudes, which was significantly different from zero, χ^2 (10) = 96.19, $p < 0.001$. Inspection of the individual estimates revealed that higher levels of fear were negatively associated with tolerance, and higher levels of disgust were also associated with lower tolerance of snakes. Stronger endorsement of evil myth beliefs was negatively related to tolerance, but endorsement of bad luck myth beliefs was unrelated to tolerance of snakes. More frequent exposure to snakes was related to higher tolerance, but experience with snakebites and knowledge of snakebite fatalities did not emerge as predictors of tolerance. Finally, education level was significantly related to tolerance of snakes, such that more education predicted higher tolerance (see Table 4 for a summary). Differences between males and females were not statistically significant.

3.4. Predictors of intentional killing of snakes

First we tested the degree to which attitude components predicted intentional killing of snakes. Conservation attitudes were not significantly related to intentional killing of snakes ($b = -0.14$, $p = 0.26$). However, high tolerance attitudes were significantly related to a reduced likelihood of intentionally killing snakes ($b = -0.48$, $p = 0.006$), Nagelkerke $R^2 = 0.083$.

Next, we repeated this analysis but we included all of the other predictor variables (fear, disgust, evil myth beliefs, bad luck myth beliefs, snake encounters, experience with snakebites, knowledge of snakebite fatalities, education, and sex) to determine whether the relationship between tolerance attitudes and intentional killing of snakes would remain significant when controlling for the influence of these other variables. Tolerance of snakes indeed still predicted intentional killing of snakes ($b = -0.67$, $p = 0.004$) while controlling for the covariates.

Table 3
Descriptive statistics and correlations between variables.

	Descriptives		Correlations									
	Median	95% CI	2	3	4	5	6	7	8	9	10	11
1. Fear	4	3.15–3.50	0.47**	0.26**	0.05	−0.39**	−0.05	0.12*	−0.05	−0.33**	0.03	0.01
2. Disgust	4	3.43–3.76		0.22**	0.03	−0.24**	0.02	0.10	−0.08	−0.34**	0.00	0.10
3. Evil myth beliefs	3.7	3.56–3.8			0.52**	−0.20**	0.05	0.12*	−0.06	−0.24**	−0.12*	0.11
4. Bad luck myth beliefs	3	2.97–3.22				−0.06	−0.03	0.13*	−0.07	−0.07	−0.08	0.13
5. Encounters with snakes	5	5.56–6.28					0.11	−0.01	−0.06	0.28**	−0.10	−0.01
6. Experience with snakebites	0	0.47–0.61						0.28**	−0.01	0.05	−0.18**	0.26**
7. Mortality knowledge	0	0.1–0.18							0.02	−0.12*	−0.09	0.06
8. Conservation attitudes	2	2.27–2.55								0.38**	0.09	−0.16*
9. Tolerance attitudes	1.8	1.81–2									0.18**	−0.24**
10. Education	4	3.75–3.99										−0.07
11. Intentional killings	0.52	0.45–0.58										

* $p < 0.05$.
** $p < 0.01$.

Table 4
Results of ordinal regressions on attitudes toward snakes and binary logistic regression.

	Estimate	SE	Wald χ^2	df	P	−95% CI	+95% CI
Conservation attitudes							
Fear	−0.067	0.073	0.840	1	0.360	−0.210	0.076
Disgust	−0.093	0.072	1.629	1	0.202	−0.235	0.050
Evil myth belief	−0.062	0.110	0.312	1	0.576	−0.278	0.155
Bad luck myth belief	−0.105	0.100	1.088	1	0.297	−0.301	0.092
Encounters with snakes	−0.052	0.033	2.476	1	0.116	−0.116	0.013
Experience with snakebites	−0.017	0.164	0.011	1	0.917	−0.339	0.305
Mortality knowledge	0.425	0.305	1.935	1	0.164	−0.174	1.023
Education	0.143	0.093	2.384	1	0.123	−0.039	0.324
Sex (females)	−0.462	0.204	5.119	1	0.024	−0.862	−0.062
Tolerance attitudes							
Fear	−0.142	0.073	3.762	1	0.052	−0.286	0.001
Disgust	−0.304	0.074	17.084	1	<0.001	−0.448	−0.160
Evil myth belief	−0.269	0.112	5.798	1	0.016	−0.487	−0.050
Bad luck myth belief	−0.014	0.101	0.020	1	0.889	−0.213	0.184
Encounters with snakes	0.088	0.033	7.293	1	0.007	0.024	0.152
Experience with snakebites	0.182	0.164	1.221	1	0.269	−0.141	0.504
Mortality knowledge	−0.364	0.316	1.328	1	0.249	−0.984	0.255
Education	0.341	0.095	12.974	1	<0.001	0.155	0.527
Sex (females)	−0.266	0.205	1.688	1	0.194	−0.668	0.135
Intentional killing of snakes							

	Estimate	SE	Wald χ^2	df	P	Exp(B)	−95% CI for Exp(B)	+95% CI for Exp(B)
Fear	−0.38	0.124	0.097	1	0.756	0.962	0.755	1.226
Disgust	0.032	0.117	0.076	1	0.783	1.033	0.822	1.298
Evil myth belief	−0.015	0.192	0.006	1	0.938	0.985	0.676	1.435
Bad luck myth belief	0.272	0.165	2.714	1	0.099	1.313	0.950	1.816
Encounters with snakes	0.021	0.050	0.181	1	0.671	1.021	0.926	1.127
Experience with snakebites	0.792	0.257	9.467	1	0.002	2.208	1.333	3.656
Mortality knowledge	−0.279	0.473	0.349	1	0.555	0.756	0.299	1.911
Education	0.026	0.155	0.028	1	0.868	1.026	0.757	1.392
Sex (females)	−1.372	0.368	13.91	1	0.001	0.254	0.123	0.522
Conservation attitudes	−0.226	0.149	2.308	1	0.129	0.797	0.595	1.068
Tolerance attitudes	−0.669	0.234	8.191	1	0.004	0.512	0.324	0.810

Experience with snakebites also emerged as a significant predictor of intentional killing ($b = 0.79, p = 0.002$), such that greater snakebite experience was associated with a higher probability of killing snakes. Participant sex was also a significant predictor of intentional killing of snakes ($b = 1.37$, $p < 0.001$), indicating that men were more likely to intentionally kill snakes than women. None of the other covariates in the model were significant, though the set of predictors yielded a Nagelkerke R^2 of 0.283 in total.

3.5. Open-ended responses regarding perceived benefits from snakes

The majority of people ($n = 301$, 90% from the total sample) responded to the open-ended question assessing perceived benefits from snakes. A total of 132 people (39% from the sample) said that snakes provide no benefits. Snakes as a food source was the most common perceived benefit, which was mentioned by 131 people (39% from the total sample). Other common themes included reporting snakes as useful for medicine ($n = 62$; 19%) and various rituals ($n = 48$; 14%).

4. Discussion

Intentionally killing snakes is a serious problem for conservation efforts, and our data indicate that tolerance attitudes were a significant predictor of intentional killing, more so than any other variable assessed. Our results indicate that emotions, such as fear and disgust, are significant predictors of tolerance attitudes, but not conservation attitudes. We predicted that negative attitudes toward snakes will be associated with a greater likelihood of intentional killing of snakes. Indeed, the likelihood of someone intentionally killing snakes could be predicted by tolerance attitudes, but not conservation attitudes. These results highlight the notion that affective processes may be important for attitude formation. Although snake myths did not correlate with intentional killing of snakes as we originally predicted, there was a negative correlation between myths and tolerance attitudes. That is, myths seem to be related to attitudes toward snakes, which may indirectly affect negative behaviour toward them. In addition, the affectively driven tolerance attitudes in our study were the only attitudinal predictors of detrimental behaviour toward snakes. This may have implications for conservation efforts, such that interventions designed to reduce negative emotions or increase tolerance attitudes toward snakes may be good starting points for protecting them from human aggression. Participants in the present study had very negative emotional reactions and attitudes toward snakes in general, so future research examining whether these are malleable and have downstream consequences for behaviour would be worth pursuing. Negative emotions toward snakes may be improved at least by two ways. First, physical contact with snakes improves ther perception by children (Morgan and Gramann, 1989; Ballouard et al., 2012). Of course, this may only be beneficial in situations where contact occurs with the absence of a snakebite. Second, presentation of snakes in mass media should be carefully designed, because it is believed that media can influence human attitudes toward animals (Castillo-Huitrón et al., 2020).

A low level of education is associated with less supportive attitudes toward snakes (Alves et al., 2012, 2014; Moura et al., 2010; Ferreira et al., 2013; Pinheiro et al., 2016). As predicted, education level was positively related to tolerance attitudes. Liordos et al. (2018) found that the education level of Greeks was not associated with their tolerance, although more educated people were more supportive toward snake conservation than those with a lower education.

Males showed more positive snake conservation attitudes than females, which is in accordance with previous reports (Prokop et al., 2009; Alves et al., 2014; Ceríaco, 2012; Pinheiro et al., 2016; Liordos et al., 2018), although men were also more likely to kill snakes.

Liordos et al. (2018) found that females were more conservation oriented than males, so it is possible that males in Southeast Nigeria had more real experiences with snakes and could recognize their role in kiling pests more than females.

Guided by research indicating that longer distance from potentially dangerous animals correlates with their acceptability (Karlsson and Sjöström, 2007; Stronen et al., 2007; Caruso and Pérez, 2013), we predicted that more frequent encounters with snakes would correlate with stronger fear, disgust and/or negative attitudes toward them. Contrary to our hypothesis, we found that more frequent encounters with snakes negatively correlated with fear and disgust, and positively correlated with tolerance attitudes. These results are in line with other research suggesting that more encounters with animals can reduce fear of those animals (e.g., wolves and bears: Prokop et al., 2011, Johansson et al., 2016, 2019), and it is consistent with the notion that more exposure to negative stimuli can generally desensitize people to unpleasant emotions and thoughts about those stimuli (Chambless and Ollendick, 2001).

We predicted that experience with snakebites would be associated with negative attitudes toward snakes. A total of 10% of our sample reported at least one snakebite in their lifetime, and greater snakebite experience was associated with a higher probability of killing snakes, supporting our prediction. This is consistent with research indicating that painful experiences contribute to fear of animals (Boyd et al., 2004; Di Nardo et al., 1988; Schönfelder and Bogner, 2017). Thus, it seems that encounters with snakes may only relate to reduced negative emotions and attitudes in the absence of an injury. Future research utilizing a large sample of snakebite victims would be help draw more definitive conclusions. It is not clear, for instance, whether snakebites are consequences of human interactions with snakes during intentional killing (Waldron et al., 2013), or whether people accidentally bitten by a snake developed negative attitudes toward snakes. Nonetheless, nature conservationists may pay specific attention to victims of snakebites who engage in intentional killing (perhaps motivated by a revenge) more than people inexperienced with snakebites.

A notable limitation of this study is our utilization of a convenience-sampling method, which may not be fully representative of the population of the Igbo community. All of our participants were literate, and it may be important to study illiterate peoples' attitudes and behaviour as well (especially when generalizing to developing countries). Doing so would require substantial resources, as face-to-face interviews would be necessary rather than administering questionnaires. However, it would certainly be worthwhile to include a more diverse sample, perhaps by utilizing stratified-sampling procedures in future investigations. Additionally, our measure of attitudes provided a slightly different factor structure than previous research (Liordos et al., 2018). We opted to compute attitude sub-scales of conservation and tolerance from the factor structures that emerged from our data, rather than utilizing the factor structure composed by the creators of this measure. This may inhibit the generalizability of our findings to some degree, and caution should be used when comparing results across studies when subscales are comprised of different items.

It could be questioned whether the difference in lethality or toxicity among snake species could play a role in shaping people's attitudes or whether people would treat venomous and non-venomous snakes in different ways. First of all, we do not know whether people are capable of distinguishing between venomous and non-venomous snakes. There are no simple rules how to do this, as associations between bright colors and venom potency do not exist (Allen et al., 2013). This suggests that laypeople could have low snake discrimination skills. Furthermore, people living in a region with a low abundance of dangerous snakes show similar fear of snakes as people living in countries where snakes represent a health risk (Prokop et al., 2009, Landová et al., 2018, but see Ballouard et al., 2013). Perhaps educating people living in areas with no dangerous snakes would be helpful, because they could be ensured that snakes in their home areas are not dangerous to them.

Our research on perceived benefits from snakes uncovered a hidden side of attitudes toward them. All the reported benefits from snakes were purely *direct* (their use in medicine, rituals, or as a food source, see Alves and Pereira Filho, 2007, Alves et al., 2009), but there was no mention of the *indirect* benefits from snakes (e.g., their role in ecosystems). This suggests that positive attitudes toward snakes could be rather utilitarian, concerned for the practical and material value of snakes (Kellert, 1993). Thus, attitudes toward snakes among southeastern Nigerian people seem to be similar to attitudes toward animals among meat hunters in Western society, in that they believe that animals should be used primarily for the benefit of humans (Kellert, 1985; Gamborg and Jensen, 2016).

5. Conclusion

This study aimed to investigate human-snake interactions in an indigenous community in southeastern Nigeria. We assessed emotions, encounters with snakes, experience with snakebites, knowledge of mortality from a snakebite, attitudes, and behaviours toward snakes, and we tested how these variables related to each other. Emotions seem to be related to the development of tolerance attitudes toward snakes, and low tolerance was associated with more hostile behaviour toward snakes. Exposure to snakes seemed to have a positive influence on attitudes and behaviour, unless this exposure was tied to an injury-related outcome, in which it had the opposite effect. Participation of wildlife management on collaborative learning processes is required to change peoples' attitudes toward controversial wild animals. In particular, people should be aware of the role of snakes in ecosystem functioning as well as their role in ecosystem services. Future research investigating potential interventions aimed at shifting attitudes toward snakes would be welcomed, as this would greatly assist in conservation efforts.

CRediT authorship contribution statement

Ike E. Onyishi: Conceptualization, Methodology, Data curation, Draft preparation. **Sampson K. Nwonyi:** Methodology, Data curation, Draft Preparation. **Pavol Prokop**: Supervision, Conceptualization, Methodology, Visualization, Formal analysis, Draft preparation. *Adam Pazda:* Methodology, Visualization, Formal analysis, Draft preparation, Writing- Reviewing and Editing.

Declaration of competing interest

We confirm that this manuscript has not been published before and is not currently being considered for publication elsewhere. All authors have approved the manuscript and agree with submission to Science of the Total Environment.

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