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RECEIVED 30 November 2025  
REVISED 28 March 2026  
ACCEPTED 09 April 2026  
PUBLISHED 28 April 2026

CITATION  
Lukubwe MS, Craig AJFK and  
Byaruhanga C (2026) Farmers' knowledge  
of, and attitudes towards oxpeckers in the  
Salambala Conservancy,  
northeastern Namibia.  
*Pastoralism* 16:15978.  
doi: 10.3389/past.2026.15978

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# Farmers' knowledge of, and attitudes towards oxpeckers in the Salambala Conservancy, northeastern Namibia

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Oxpeckers (*Buphagus* spp.) are obligate avian mutualists that feed on ectoparasites of large mammals, including cattle. Despite their ecological significance, few studies have examined local perceptions of oxpeckers in communal pastoral systems where chemical tick control is prevalent. This study assessed livestock farmers' knowledge, attitudes, and experiences with oxpeckers in the Salambala Conservancy, northeastern Namibia, where Red-billed Oxpeckers and Yellow-billed Oxpeckers co-occur with managed cattle herds. Structured interviews were conducted with 200 randomly selected farmers. The respondent perceived oxpecker impact (positive or negative) on cattle farming was evaluated using scores from six impact responses. Data analyses were conducted to determine the association of predictor variables (participant socio-demographics, knowledge, attitude and perceptions) with perceived oxpecker impact using descriptive, random forest and linear modelling, univariate and multivariable statistics. Awareness of oxpeckers was high (99.5%). Tick control was practiced by 78% of farmers, primarily using synthetic pyrethroids and organophosphates (52%), while some farmers applied traditional practices (20.5%), or did not control at all (21.5%). Positive oxpecker perceptions predominated (79.5%), mainly linked to tick removal, although 29% reported negative impacts such as wound aggravation and blood-feeding. The final multivariable analysis revealed that respondents who applied oxpecker control measures had significantly lower impact scores (more negative oxpecker attitude) compared to those who did not ( $p < 0.0001$ ). Conversely, respondents who wished for increasing oxpecker populations had significantly higher impact scores (more positive oxpecker attitude,  $p = 0.029$ ). Suggestions to increase oxpecker populations were through conservation programs and captive breeding (29% respondents) and re-introduction of oxpeckers from other areas (19.5%). These findings highlight the importance of integrating ecological knowledge with socio-economic realities to promote coexistence. Strengthening integrated tick management approaches that reduce chemical control and keep ticks to acceptable numbers can enhance community-based conservation initiatives, which are critical for sustaining oxpecker-livestock interactions.

## KEYWORDS

acaricides, attitudes, cattle, oxpeckers, perceptions

## Introduction

The Red-billed Oxpeckers (*Buphagus erythrorhynchus*) and Yellow-billed Oxpeckers (*Buphagus africanus*) are obligate avian mutualists native to sub-Saharan Africa (Weeks, 2000; Plantan, 2009). They are well-known for their specialized behaviour of perching on large mammals including domestic livestock where they feed primarily on ectoparasites such as ticks, insects, and skin debris (Stutterheim and Brooke, 1981; Weeks, 2000; Plantan, 2009). This feeding interaction is widely interpreted as a form of mutualism, wherein oxpeckers obtain food while potentially offering ectoparasite control benefits to their hosts (Plantan, 2009).

Ticks and tick-borne diseases pose a significant threat to cattle health and production throughout Africa (Diarra et al., 2023; Makwavela et al., 2025; Yessinou et al., 2025). They are associated with reduced body condition, skin damage, weight loss, low milk yield, and increased susceptibility to secondary infections (Haikukutu et al., 2020). In severe cases, a high tick burden can lead to elevated mortality rates (Githaka et al., 2022; Moyo et al., 2023). Conventional tick control practices across the region involve the use of acaricides, which are synthetic chemicals applied through dipping, spraying, or injection (Githaka et al., 2022; van den Heever et al., 2023). Despite their widespread application, these chemicals pose multiple challenges, including escalating costs of production, limited accessibility, and the growing threat of acaricide resistance in tick populations (Walker, 2011).

Moreover, the misuse or overuse of acaricides can inadvertently disrupt non-target species such as oxpeckers (Keesing et al., 2022). Although newer compounds (e.g., amitraz, ivermectin, and cypermethrin) are marketed as being less harmful to birds, sublethal effects and indirect consequences such as reductions in tick availability may impact oxpecker populations. In regions where veterinary support is limited or constrained, the absence of coordinated control programmes further complicates tick management and places additional burdens on farmers with limited resources.

Oxpeckers have often been regarded as a potential natural ally in tick control, offering an ecologically compatible alternative or supplement to chemical interventions (Weeks, 2000; Stutterheim and Brooke, 1981). However, the empirical findings have been mixed. While some studies highlight the reduction in tick load attributable to oxpecker activity, others argue that the impact is limited, particularly when compared to self-grooming or other control methods (Mooring and Mundy, 1996; Weeks, 2000). Furthermore, oxpecker behaviour is not uniformly perceived as beneficial. Under certain conditions, these birds have been observed aggravating wounds, feeding on blood, or prolonging healing times, prompting some farmers to view them as pests rather than partners.

These perceptions are further influenced by cultural beliefs and anecdotal experiences. In some communities, oxpeckers are stigmatized as “vampire birds” or “devils,” believed to harm livestock by opening wounds or transmitting diseases. These views can lead to direct persecution through harassment, exclusion, or even deliberate killing (Adeyanju and Adejumo, 2019). Nevertheless, studies investigating oxpecker feeding behaviour have shown that wound feeding is relatively rare, estimated at around 6% of feeding events compared to the more common consumption of ticks, skin flakes, and mucosal debris

(Plantan, 2009; Adeyanju and Adejumo, 2019). This suggests that misconceptions about oxpecker behaviour may be overstated, and better education could help alleviate conflict.

In addition to direct interactions, oxpecker populations are influenced by environmental pressures (Kalle et al., 2017; Keesing et al., 2022). Habitat fragmentation, veld burning, drought, and land conversion for agriculture can degrade or eliminate key nesting and roosting sites, thereby threatening the long-term viability of the population (Robertson and Jarvis, 2000). Shifts in rainfall and temperature regimes due to climate change may further influence tick abundance and distribution, thereby affecting oxpecker foraging success (Estrada-Peña et al., 2014; Keesing et al., 2022; Moyo et al., 2023).

In Namibia, the Yellow-billed Oxpecker is currently considered endangered in parts of the country, whereas the Red-billed Oxpecker is listed as rare and peripheral (Simmons et al., 2015; Ward and Robertson, 2017). Conservation efforts have included proposals for reintroduction, habitat protection, and greater oversight of chemical use in livestock management (Stutterheim and Brooke, 1981). There is growing recognition that sustainable coexistence between oxpeckers and farming communities requires context-specific strategies that balance ecological functions with local livelihoods (Berkes, 2007).

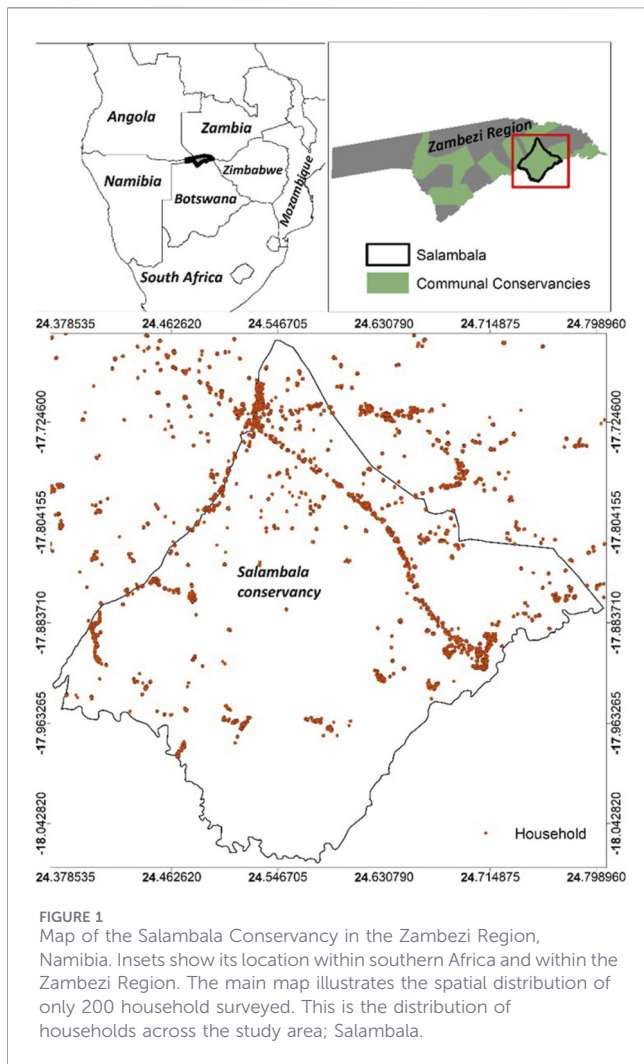
Understanding community knowledge, attitudes, and perceptions (KAP) of local residents, especially livestock farmers, is critical for informing conservation strategies and promoting coexistence in human-modified landscapes. KAP studies can provide insights into the social acceptability of conservation interventions, prevalence of ecologically harmful practices (e.g., poisoning or shooting oxpeckers), and community willingness to participate in restoration or stewardship efforts (Waylen et al., 2009; Bennett et al., 2018). Moreover, local knowledge of species presence, behaviour, and seasonality may contribute valuable information to conservation biology and landscape-scale monitoring.

This study assessed the knowledge, attitudes, and perceptions of livestock farmers regarding oxpeckers in the Salambala Conservancy in northeastern Namibia. Specifically, it examined (i) the socio-demographic profiles of respondents, (ii) tick control practices and chemical usage, (iii) species awareness and reported experiences with oxpeckers, and (iv) attitudes toward their conservation and population trends.

## Materials and methods

### Study area

This study was conducted in the Salambala Conservancy in northeastern Namibia. Officially registered in 1998, Salambala is one of Namibia's pioneer communal conservancies and has since gained recognition for its role in community-based natural resource management (NACSO, 2023). The conservancy spans approximately 9,300 ha and supports a population of around 9,193 residents distributed across 18 villages and over 290 cattle posts (Figure 1). The terrain is predominantly flat, with an elevation ranging from 928 to 983 m above sea level, and the vegetation consists of a woodland–grassland mosaic, dominated by mopane and Kalahari woodlands in the north and open grasslands in the



south (Mendelsohn et al., 1997). The area experiences a semi-arid climate, with annual rainfall averaging 650–700 mm, falling mainly between October and April, and temperatures ranging from 21 °C to over 35 °C depending on the season (Krug, 2017). The agricultural system is characterised by small-scale, subsistence farming, where communal grazing is practiced year-round. Cattle are the dominant livestock, and common breeds include Sanga, Brahman-Sanga, and Simbra crosses. Livestock are typically kraaled at night and graze freely during the day with minimal supplementation. Tick infestations are common due to the extensive grazing system, and tick-borne diseases such as anaplasmosis, babesiosis, and heartwater remain persistent challenges in the region (Haikukutu et al., 2020; Githaka et al., 2022). Chemical control using acaricides is the primary strategy employed by farmers, although accessibility remains a challenge, with most products only available in the regional capital, Katima Mulilo. This logistical constraint, along with high product costs, has led some farmers to use unconventional or informal substitutes. Salambala was selected as the study site due to its ecological complexity, high livestock–wildlife interface, and documented presence of oxpeckers, making it a suitable setting for investigating tick control practices, oxpecker-host dynamics,

and conservation attitudes in a real-world communal farming context.

## Sample size determination

The interviewed number of cattle keepers ( $n$ ) was calculated using the formula by Thrusfield (2007):

$$n = \frac{(z^2 p(1-p))}{d^2}, \quad (1)$$

where,  $n$  is the required sample size,  $Z$  is the standard normal deviate corresponding to a 95% confidence level ( $Z = 1.96$ ),  $p$  is the expected proportion of cattle farmers with experience of oxpeckers, and  $d$  is the desired absolute precision (0.05). A previous study found a total experience of 10.9% ( $p = 0.109$ ) among cattle farmers in Nigeria (Abakpa et al., 2023). The initial sample size ( $n = 149$ ) was adjusted for a finite population ( $N = 9193$ ) using the correction formula:

$$n_{adj} = N \times n/N + n \quad (2)$$

resulting in an adjusted sample size of 146. To account for potential non-response, the sample size was inflated by 37% (non-response rate based on preliminary field expectations and similar rural surveys), yielding a final target sample size of approximately 200 respondents.

## Sampling procedure and interview design

A stratified random sampling approach was used to ensure representation across the Salambala Conservancy. A complete list of the villages within the conservancy was obtained from local administrative records, and villages were treated as primary sampling units. A total of 15 villages out of 30 villages in Salambala Conservancy (50%) were randomly selected, with the village number decided on by the available survey resources.

Within each village, households owing cattle were identified with the assistance of community leaders and extension officers. From these lists, households were assigned unique identification numbers and selected using a random number generator in Microsoft Excel. Only one respondent per household was interviewed, and eligibility required that the individual be actively involved in cattle management and aged 18 years or older. In cases where a selected household was unavailable or declined participation, it was replaced by the next randomly generated household from the same village list. The 200 targeted households were distributed across the villages in proportion to the village household populations. The number of households selected per village ranged from 10 to 20.

Data were collected through structured face-to-face interviews using a pre-tested questionnaire. The questionnaire was developed based on a review of relevant literature and previous socio-ecological studies on human-wildlife interactions, and was validated by co-authors who have experience in community and oxpecker behaviours. A total of 10 pilot interviews (five in English and five in Subia) were conducted prior to the main survey to refine question clarity and translation accuracy. All interviews were conducted by a single trained interviewer to ensure consistency, and each interview lasted approximately 20–25 min. Interviews were conducted in either English or Subia, the predominant local language in the

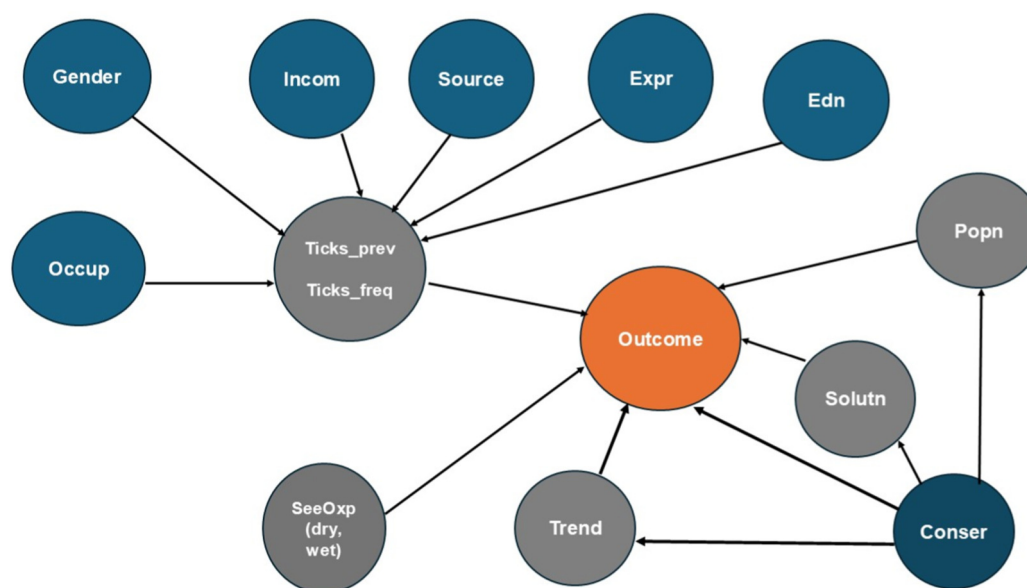


FIGURE 2

A pathway analysis to investigate the influence of community practices, knowledge, attitudes and demographics on the perceived impact of oxpeckers. The light maroon circle represents the outcome (impact score of oxpeckers), grey circles are variables with direct hypothetical effect on the outcome, and blue circles are the respondent socio-demographic characteristics. Gender = gender; Conser = conservancy membership; Occup = occupation; Incom = household income range; Source = source of income; Expr = farming experience in years; Edn = highest education attained; TickPrev = do you apply methods to prevent or reduce ticks; Tickfreq = how often do you apply chemicals to control ticks; SeeOxp (dry, wet) = how often did you see oxpeckers on your farm last wet season, last dry season; Trend = what has been the trend over the years on the population of oxpeckers in your area; Solutn = do you have any solutions you apply to reduce the problem of oxpeckers; Popn = would you want the population of oxpeckers to increase. The outcome was the total oxpecker impact score from the following variables: positive experiences with oxpeckers (yes, no); negative experiences with oxpeckers (yes, no); number of positive and negative experiences; extent of problem of oxpeckers; extent of monetary damage experienced due to oxpeckers.

area. This approach minimised literacy-related bias, ensured consistency in data collection, and allowed real-time clarification of responses. The methodology follows established approaches in community-based conservation research in rural Africa (Roe et al., 2009; Waylen et al., 2010).

## Variable measurement and scoring

The questionnaire captured four main domains: (i) socio-demographic characteristics, (ii) tick control practices and chemical usage, (iii) knowledge and observations of oxpeckers, and (iv) perceptions and attitudes toward oxpeckers. To assess perceived oxpecker impacts in the community, responses from six variable questions were scored. The impact variables were: (1) presence of positive experiences (yes/no), (2) presence of negative experiences (yes/no), (3) frequency of observed interactions, (4) perceived severity of oxpecker-related problems, (5) reported economic losses, and (6) overall perception of oxpecker impact. Each variable was assigned a numerical score based on predefined criteria (Tables 3, 4), with higher scores indicating more positive perceived oxpecker impact and lower scores indicating more negative perceived impact. An aggregate oxpecker impact score was then calculated for each respondent by summing standardised item scores. This generated an outcome continuous variable to allow comparison across participants.

## Data analyses

Data from the questionnaire interviews were processed in Microsoft Excel spreadsheets before descriptive, random forest and linear modeling, univariate and multivariable analyses in R statistical software 4.4.3 (R Core Team, 2024) at 5% significance level and with a two-tailed approach. The R packages “ggplot2” (Wickham, 2016), “MASS” (Venables and Ripley, 2002), “rcompanion” (Mangiafico, 2026), “rpart.plot” (Milborrow, 2024), lmtest (Zeileis and Hothorn, 2002), “randomForest” (Liaw and Wiener, 2002) and “rpart” (Therneau et al., 2025) were utilised. Descriptive analysis was conducted to determine the percentage and 95% confidence levels of responses with regard to socio-demographics, tick control practices, knowledge, attitudes and perceived or experienced impact of oxpeckers amongst the cattle farmers. An association pathway for the perceived or experienced impact of oxpeckers relative to predictor variables was hypothesised (Figure 2) and this was the basis for selection of 14 explanatory variables for analysis. A combination of random forest (RF) and linear modelling approaches (Breiman, 2001) was used to evaluate the association between the 14 socio-demographic variables, tick control practices and knowledge about oxpeckers with the outcome variable (overall perceived or experienced positive impact of oxpeckers). The non-parametric method, random forest, partitions the data into clusters in order to maximise the variance between groups while minimising the variance

TABLE 1 Socio-demographic characteristics of respondents (n = 200).

Variable	Category	Number of respondents	% Of respondents
Gender	Female	15	7.5
	Male	185	92.5
Conservancy member	No	10	5.0
	Yes	190	95.0
Occupation	Unemployed	128	64.0
	Self-employed	51	25.5
	Employed	21	10.5
Household income range	500–1,500	102	51.0
	1,500–3,500	69	34.5
	3500–Over 5,000	29	14.5
Source of income	Children support	31	15.5
	Government grants	80	40.0
	Retirement benefits	12	6.0
	Salaries and wages	77	38.5
Farming experience (years)	5–15	65	32.5
	16–30	54	27.0
	>30	81	40.5
Highest education	No formal education	37	18.5
	Certificate course	4	2.0
	Primary	77	38.5
	Secondary	60	30.0
	University	17	8.5
	Vocational technical	5	2.5

within a group. The basis for the method is on the classification and regression trees (CART), and this combines predictions from random subsets in the data to produce various decision trees. The random forest method is of significance when working with data that is less balanced and, in the need, to explore multiple interactions in datasets characterised by many variables. In this way, the impact of each explanatory variable is measured against the outcome variable, while measuring the relative proximity of multiple data points. The magnitude of change in response variable due to the explanatory variables is also measured. The final random forest plot revealed three explanatory variables that provided superior split to others in the dataset, in relation to the overall oxpecker impact score. The three variables were: whether respondents applied any solutions to reduce oxpecker impact (yes, no), whether the respondent wanted the population of oxpeckers to increase (yes, no), and how often the respondent saw oxpeckers on his or her farm in the past wet season (weekly, bi-weekly, monthly, every 3 months). Univariate Generalised Linear Models (GLM) with Poisson distribution were conducted to establish association of oxpecker impact scores with socio-demographic, tick control

practice, and oxpecker knowledge variables. Multicollinearity between explanatory variables was assessed using the Cramer's V test, with a threshold value of less than 0.6 for non-collinearity. Statistically significant variables (likelihood p-value <0.05) from univariate analysis were examined further in a multivariable GLM model, which controlled for confounders, in order to establish association with the outcome variable.

## Results

### Socio-demographic characteristics of respondents

The majority of respondents were male and actively engaged in conservancy structures (Table 1). Employment levels were generally low, with most respondents relying on formal or non-salaried income sources. Household incomes were modest, and livelihoods were supported through a combination of government grants, wages, and family support. Farming experience was typically extensive, with

TABLE 2 Tick control practices among livestock farmers.

Variable levels	Number of farmers for response option	%	95% CI
<b>Do you apply any methods to prevent or reduce ticks?</b>			
No	44	22.0	16.5–28.4
Yes	156	78.0	71.6–83.5
<b>If you apply chemicals to control ticks, what type of chemicals?</b>			
None	43	21.5	16.1–27.8
Amidine	6	3.0	1.1–6.4
Do not know the name	7	3.5	1.4–7.1
House cleaning product	3	1.5	0.3–4.3
Hydrocarbon-based substances	3	1.5	0.3–4.3
Organochlorine	8	4.0	1.7–7.7
Organophosphate	45	22.5	16.9–28.9
Petroleum or mineral products	26	13.0	8.7–18.5
Synthetic pyrethroid	59	29.5	23.3–36.3
<b>How often do you apply the chemicals to control ticks</b>			
Never	43	21.5	16.1–27.8
Every 3 months	29	14.5	9.9–20.2
Monthly	67	33.5	26.9–40.5
Every 6 months and more	28	14.0	9.5–19.6
Weekly	33	16.5	11.6–22.4
<b>What season of the year do you control ticks?</b>			
Both dry and wet seasons	31	15.7	10.8–21.3
Dry season	23	11.7	7.4–16.8
None	43	21.8	16.0–27.8
Wet season	100	50.8	42.9–57.1

many respondents engaged in livestock production for several decades. Educational attainment was generally low, with most respondents having primary or no formal education, and only a small proportion attaining higher education (Table 1).

### Tick control practices among livestock farmers

Tick control was widely practiced among farmers (78%; Table 2), with chemical methods being the dominant approach. Synthetic pyrethroids and organophosphates were the most commonly reported acaricides, although a range of other substances including unconventional products were also used. Application frequency varied across respondents, with some applying treatments regularly while others reported no use of tick control measures. Tick control practices were more commonly associated with the wet season (Table 2).

### Knowledge and observations of oxpeckers

Awareness of oxpeckers was nearly universal among respondents (Table 3). However, the ability to distinguish between species was limited, with most respondents recognising only one type. Oxpecker sightings were frequent, particularly during the wet season, indicating regular interaction between livestock and the birds (Table 3).

### Perceptions and reported experiences

Most respondents reported positive experiences with oxpeckers, primarily related to their role in removing ticks from livestock (Table 3). A smaller proportion of respondents reported negative interactions, mainly associated with wound aggravation, blood-feeding, and livestock discomfort (Table 3).

TABLE 3 Knowledge and experience of oxpeckers amongst respondents.

Variable and level	Score	Respondents (total = 200)		
		Number answering	%	95% CI
<b>Do you know a bird called oxpecker?</b>				
No	0	1	0.5	0.01–2.8
Yes	1	199	99.5	97.2–100
<b>How many types of oxpeckers do you know?</b>				
Do not know	0	2	1.0	0.1–3.6
None	0	1	0.5	0.01–2.8
One (Red-billed Oxpecker or Yellow-billed Oxpecker)	1	159	79.5	73.2–84.9
Two (Red-billed Oxpecker and Yellow-billed Oxpecker)	2	38	19.0	13.8–25.1
<b>How often did you see oxpeckers on your farm last wet season?</b>				
Once in 3 months	1	26	13.0	8.7–18.5
Monthly	2	66	33.0	26.5–40.0
Once weekly	3	70	35.0	28.4–42.0
Twice weekly	4	38	19.0	13.8–25.1
<b>How often did you see oxpeckers on your farm last wet season?</b>				
Once in 3 months	1	23	11.5	7.4–16.8
Monthly	2	69	34.5	27.9–41.5
One weekly	3	53	26.5	20.5–33.2
Twice weekly	4	55	27.5	21.4–34.2
<b>Have you had any particularly positive experiences with oxpeckers?</b>				
No	0	41	20.5	15.1–26.8
Yes	1	159	79.5	73.2–84.9
<b>Nature of positive experiences with oxpeckers</b>				
None	0	41	20.5	15.1–26.8
Reduce tick numbers on cattle	1	156	78.0	71.6–83.5
Reduce other ectoparasites on livestock	1	8	4.0	1.7–7.7
Reduce infection on wounds and skin damage	1	1	0.5	0.01–2.8
Assist cattle herders to locate lost cattle	1	2	1.0	0.1–3.6
Tourist attraction and foreign exchange	1	1	0.5	0.01–2.8
<b>Have you had any negative experiences with oxpeckers?</b>				
No	1	142	71.0	64.2–77.2
Yes	0	58	29.0	22.8–35.8
<b>Nature of negative experiences with oxpeckers</b>				
None	1	142	71.0	64.2–77.2
Bite and cause wound on livestock or open old wounds from tick bites	0	27	13.5	9.1–19.0
Cause discomfort or distress to livestock	0	4	2.0	0.5–5.0
Cause loss of hair and condition in livestock	0	2	1.0	0.1–3.6

(Continued)

TABLE 3 Continued

Variable and level	Score	Respondents (total = 200)		
		Number answering	%	95% CI
Suck animal blood	0	5	2.5	0.8–5.7
Transmit foot and mouth disease from buffalo to cattle	0	4	2.0	0.5–5.0
Excrete in cattle's eyes	0	1	0.5	0.01–2.8

## Attitudes and conservation efforts?

Most respondents did not consider oxpeckers to be problematic, and financial losses attributed to them were uncommon (Table 4). Perceptions of population trends were mixed, with respondents reporting both increases and declines. Reported causes of decline included reduced tick availability, chemical use, and loss of host species or nesting habitat (Table 4). Despite some negative experiences, the majority of respondents supported efforts to increase oxpecker populations and suggested conservation-related interventions (Table 4).

## Random forest analysis

The random forest model explained 72.0% of the variation in oxpecker impact scores. The most influential variables were the application of control measures against oxpeckers, willingness to support population increases, and frequency of oxpecker observations during the wet season (Figure 3). The classification and regression tree indicated that higher impact scores were associated with respondents who supported increasing oxpecker populations and did not apply control measures, whereas lower scores were associated with respondents who applied such interventions (Figure 3).

## Univariate and multivariable association of predictor factors with oxpecker impact

Univariate Poisson regression analyses showed that all three variables from the random forest plot (whether the respondent applied any interventions to reduce the oxpecker population, their attitude towards increase or decrease in the oxpecker population, and how often they saw oxpeckers in the wet season) were significantly associated with perceived oxpecker impact (Table 5). Out of the 200 cattle farmers interviewed, only 23.0% reported applying solutions to reduce oxpecker presence. Additionally, 63.5% of respondents supported an increase in oxpecker populations. Oxpecker sightings were most frequently reported on a weekly basis (35.0%), with significant variation across observation frequencies. The three variables were subsequently included in the multivariate model, which showed that respondents who applied control measures had significantly lower impact scores (more negative perception) compared to those who did not. Conversely, respondents who supported increasing oxpecker populations had significantly higher impact scores (more positive perceived impact). The frequency of oxpecker sightings during the wet season was not significantly associated with impact scores after adjusting for other variables (Table 6).

## Discussion

Human-wildlife relationships in conservation systems are not determined solely by ecological interactions, but also mediated by socio-economic challenges, access to resources, and underlying conservation attitudes (Waylen et al., 2010; St. John et al., 2011; Bennett, 2016). This study investigated livestock farmer's knowledge, attitudes and perceptions of oxpeckers in the Salambala Conservancy, northeastern Namibia.

One of the aspects assessed was tick control, which represents a critical interface linking animal health and biodiversity conservation. There was widespread reliance on chemical acaricides, which reflects the importance of tick control for livelihood security; however, it also raises concerns about unintended ecological consequences such as residuals in the food chain and non-target impacts on beneficial species including birds and insects. Chemical use in pastoral systems may therefore disrupt ecological interactions such as those between oxpeckers and their hosts (Wardhaugh, 2005; Bishop et al., 2023). There was also use of informal or non-veterinary chemicals, which suggests some gaps in access to appropriate animal health inputs and reflects broader systemic challenges in rural livestock systems across Africa (Machila et al., 2007; Letty et al., 2016; Nyika, 2020). In such contexts, farmers often rely on locally available alternatives when formal veterinary services are limited or inaccessible. This underscores the importance of improving access to veterinary approved acaricides and strengthening extension services to support safe and effective tick control practices.

Although awareness of oxpeckers was widespread, detailed ecological knowledge particularly species-level identification was limited. This pattern reflects a broader disconnect observed in community-based conservation, where species familiarity does not necessarily equate to ecological understanding. Bridging this gap is important, as knowledge alone does not guarantee conservation-supportive behaviour; rather, it is the interpretation of species' roles within livelihood systems that shapes attitudes and decision-making.

The interactions between oxpeckers and livestock were perceived as both beneficial and detrimental, reinforcing the view that this relationship exists along a mutualism-parasitism continuum. While oxpeckers contribute to ectoparasite removal, their occasional blood-feeding behaviour and association with wound aggravation complicate their ecological role. Such dependent interactions have been widely documented and suggest that the balance between costs and benefits may vary depending on environmental conditions and host status (Weeks, 2000; Mbizah et al., 2019). The findings reinforce the concept of conditional mutualism, where the balance between benefits and

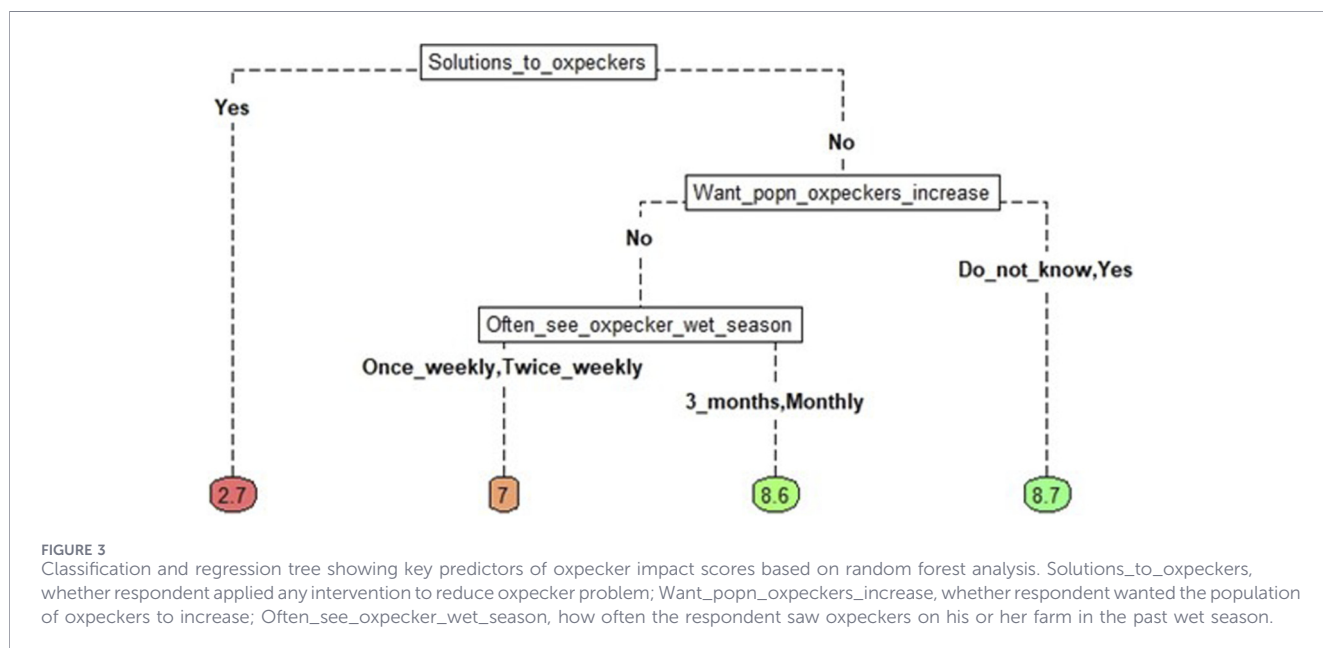
TABLE 4 Perceptions, management responses, and conservation attitudes toward oxpeckers.

Variable and level	Score	Respondents (total = 200)		
		Number answering	%	95% CI
<b>What is the extent of problem of oxpeckers?</b>				
Not a problem	3	144	72.0	65.2–78.1
Small problem	2	16	8.0	4.6–12.7
Big problem	1	31	15.5	10.8–21.3
Crisis	0	9	4.5	2.1–8.4
<b>Do you have any solutions that you apply to reduce the problem of oxpeckers?</b>				
No	1	154	77.0	70.5–82.6
Yes	0	46	23.0	17.4–29.5
<b>What solutions do you apply to reduce the oxpecker problem?</b>				
None	1	154	77.0	70.5–82.6
Apply oxpecker repelling chemicals to wounds	0	7	3.5	1.4–7.1
Capture/trap the oxpeckers and kill them or relocate them to protected areas	0	8	4.0	1.7–7.7
Kill them by feeding them on poisoned ticks, poisoning with chemicals or shoot with a gun	0	9	4.5	2.1–8.4
Install scaring devices at kraals	0	15	7.5	4.3–12.1
Introducing oxpecker eating birds	0	2	1.0	0.1–3.6
Control ticks on the animals	0	4	2.0	0.5–5.0
<b>What is the extent of monetary damage you experience due to oxpeckers?</b>				
No damage	2	154	77.0	70.5–82.6
Small	1	14	7.0	3.9–11.5
Large	0	32	16.0	11.2–21.8
<b>What has been the trend over the years in the population of oxpeckers in your area?</b>				
Do not know	0	38	19.0	13.8–25.1
No change	1	17	8.5	5.0–13.3
Decreasing	0	72	36.0	29.4–43.1
Increasing	2	73	36.5	29.8–43.6
<b>What is the cause of decrease in the population of oxpeckers</b>				
N/A		128	64.0	25.6–38.9
Relocation of people		2	1.0	0.1–3.6
Habitat loss and unsuitable environment (due to fire, chemicals, drought, deforestation) for nesting and roosting		3	1.5	0.3–4.3
Due to decreasing wildlife species, the preferred tick hosts		11	5.5	2.8–9.6
Do not know		3	1.5	0.3–4.3
Death (natural, diseases from ticks, tick control chemicals on cattle)		12	6.0	3.1–10.2
Fewer ticks		31	15.5	10.8–21.3
Birds are hunted and killed by people		1	0.5	0.01–2.8
<b>Would you want the population of oxpeckers to increase?</b>				
Do not know	0	9	4.5	2.1–8.4

(Continued)

TABLE 4 Continued

Variable and level	Score	Respondents (total = 200)		
		Number answering	%	95% CI
No	0	64	32.0	25.6–38.9
Yes	1	127	63.5	56.4–70.2
<b>What are your suggestions on increasing oxpecker populations</b>				
Conservation programs and captive breeding		58	29.0	22.8–35.8
Re-introduce oxpeckers from other areas		39	19.5	14.2–25.7
Control causes of death (wildfire, use injectable tick control chemicals)		11	5.5	2.8–9.6
Reduce use of chemicals or eradicate the dipping system which reduce ticks and kills oxpeckers		2	1.0	0.1–3.6
None		67	33.5	27.0–40.5
Increase tick source (protect host wildlife species and increase cattle)		10	5.0	2.4–9.0



costs in context-dependent and mediated by both ecological and socio-economic factors. Seasonal pattern in oxpecker activity further supports this variability, with higher interactions likely corresponding to periods of increased tick abundance (Stutterheim and Brooke, 1981).

Importantly, tolerance toward oxpeckers appears to be shaped more strongly by attitudes and behavioural intentions than by direct ecological exposure. This finding is consistent with human-wildlife coexistence literature, which emphasises that perceptions are influenced less by encounter rates and more by values, beliefs, and lived experiences (Waylen et al., 2010; St. John et al., 2011). In the present study, majority of the farmers held positive conservation attitudes, i.e., did not apply control measures against oxpeckers and wished for the increase in the bird populations. This cohort of farmers more likely interpreted

oxpecker presence as beneficial. However, when negative interactions are experienced, as was reported by minority of the farmers, the experienced conflict prompts communities to adopt control measures that reinforce negative perceptions. The generally favourable outlook toward oxpeckers presents a significant opportunity for strengthening community-based conservation initiatives. However, realising this potential requires addressing both ecological and socio-economic constraints. Community-based conservation approaches have demonstrated success when local participation, benefits, and governance structures are effectively integrated (Fabricius and Collins, 2007; Nelson and Agrawal, 2008; Roe et al., 2009). In this context, targeted interventions could include promoting best practices in livestock management, enhancing awareness of the ecological services provided by oxpeckers, and encouraging the sustainable use of

TABLE 5 Univariate analysis of factors associated with oxpecker impact scores. Conservancy.

Variable levels	No. of cattle farmers interviewed	Percentage	Estimate	95% CI	Std err	Wald p-value	Likelihood ratio p-value
<b>Do you have any solutions that you apply to reduce the oxpecker problem?</b>							
No	154	77.0	Ref.				
Yes	46	23.0	-1.137	-1.325 - 0.958	0.094	<0.0001	<0.0001
<b>Would you want the population of oxpeckers to increase?</b>							
No	64	32.0	Ref.				
Do not know	9	4.5	0.468	0.211-0.712	0.128	0.0003	
Yes	127	63.5	0.431	0.309-0.556	0.063	<0.0001	<0.0001
<b>How often did you see oxpeckers on your farm last wet season?</b>							
After 3 months	26	13.0	Ref.				
Monthly	66	33.0	-0.108	-0.264-0.052	0.081	0.181	
Once a week	70	35.0	-0.318	-0.478 - 0.155	0.082	0.0001	
Twice weekly	38	19.0	-0.199	-0.376 - 0.019	0.091	0.029	0.0004

\*\*Std err, standard error of regression; CI, confidence interval; Ref, reference category.

TABLE 6 Multivariable Poisson regression of factors associated with oxpecker impact scores.

Variable	Estimate	95% CI	Standard error	p-value
<b>Do you have any solutions that you apply to reduce the oxpecker problem?</b>				
No	Ref.			
Yes	-1.061	-1.258--0.872	0.098	<0.0001
<b>Would you want the population of oxpeckers to increase?</b>				
No	Ref.			
Do not know	0.094	-0.169-0.344	0.131	0.472
Yes	0.143	0.015-0.273	0.066	0.029
<b>How often did you see oxpeckers on your farm last wet season?</b>				
After 3 months	Ref.			
Monthly	-0.025	-0.0183-0.135	0.081	0.754
Once a week	-0.101	-0.263-0.064	0.084	0.225
Twice weekly	-0.083	-0.263-0.097	0.092	0.363

tick control methods through reduced reliance on acaricides. Although ticks should be controlled due to their negative effects in animal production, including transmission of infectious pathogens, they also maintain a balance in the ecosystem. In the present study, a high proportion of respondents (78%) stated that ticks are a source of food for the oxpeckers. Therefore, promoting sustainable use of acaricides is important, in a way that manages tick numbers to only economic thresholds while minimising negative environmental impact such as removal of the beneficial aspects for

other animal species. Minimal use of acaricides can be achieved by adopting integrated tick management approaches that include pasture management (e.g., pasture spelling, rotation, vegetation control, stock density), which is a non-chemical (FAO, 2025). This has to take into consideration pasture availability and quality and land ownership. Broadly, the findings highlight the importance of integrating conservation objectives with rural development priorities in communal landscapes. Strategies that align biodiversity conservation with tangible livelihood benefits

are more likely to be adopted and sustained. Oxpeckers, through their role in tick regulation, represent a particularly relevant example of a species whose ecological function directly intersects with livestock health. Given increasing climate variability in southern Africa, future shifts in tick dynamics may further alter oxpecker-livestock interactions, reinforcing the need for adaptive, climate-resilient management strategies. The strategies include improved pasture quality to boost nutrition and animal immunity, thereby making cattle less susceptible to tick effects, and reducing the requirement for chemical use to control ticks. Strategic livestock management has also to incorporate early warning systems to anticipate periods of high tick infestation. All this requires engaging the community and other stakeholders to enhance uptake and ensure compatibility with local socio-economic settings. On the other hand, warmer climates can enhance proliferation of ticks and accelerate their distribution, which is beneficial for oxpecker survival (Konstantinos et al., 2025). Finally, the study underscores the value of incorporating local knowledge systems into conservation planning. Indigenous and experiential knowledge can complement scientific understanding and contribute to more context-specific and socially acceptable management strategies (Berkes et al., 2000; Shackleton et al., 2000). Strengthening this integration will be essential for promoting long-term stewardship and fostering resilient human-wildlife interactions in communal rangelands.

## Conclusion

This study demonstrates valuable interactions between ticks, livestock and oxpeckers in communal rangelands and these are shaped more by socio-economic conditions and conservation attitudes than by direct ecological exposure. While oxpeckers are generally perceived as beneficial for tick removal, their acceptance depends on management practices and farmer experiences. The generally positive attitudes observed provide a strong foundation for developing community-based conservation. However, promoting sustained coexistence will require improved access to veterinary services, safer tick control practices, and targeted ecological education. Integrating local knowledge with conservation strategies will be essential for enhancing both livestock health and oxpecker conservation in communal landscapes.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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## Ethics statement

Ethical approval for this study involving human participants was obtained from the National Commission on Research Science and Technology of Namibia (NCRST, Permit Number: RPIV00642019) and the Namibia Chamber of Environment (NCE, certificate no: RCIV00042018 from 2018 to 2024). All procedures were conducted in accordance with the ethical standards of the institutional and national research committees and in line with the principles of the Declaration of Helsinki. Prior to participation, informed consent was obtained from all respondents. Participation was voluntary, and respondents were assured of anonymity and confidentiality throughout the study.

## Author contributions

ML conceived the study, designed the research, coordinated fieldwork, analysed the data, and led the writing of the manuscript. AC provided supervisory guidance, contributed to study design, assisted with data interpretation, and critically reviewed and revised the manuscript. CB contributed to methodology refinement, assisted with data analysis and interpretation, and provided critical revisions to the manuscript.

## Funding

The author(s) declared that financial support was not received for this work and/or its publication.

## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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