Special Section Contributed Paper

The role of psychology in determining human–predator conflict across southern Kenya

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Abstract: Conflict between people and carnivores can lead to the widespread killing of predators in retaliation for livestock loss and is a major threat to predator populations. In Kenya, a large, rural, pastoralist population comes into regular conflict with predators, which persist across southern Kenya. We explored the social and psychological backdrop to livestock management practices in this area in a process designed to be easy to use and suitable for use across large areas for the study of conflict and transboundary implementation of wildlife conflict reduction measures, focusing on community involvement and needs. We carried out fully structured interviews of livestock managers with a survey tool that examined how social and psychological factors may influence livestock management behavior. We compared survey responses on 3 sites across the study area, resulting in 723 usable responses. Efficacy of individuals' livestock management varied between and within communities. This variation was partially explained by normative and control beliefs regarding livestock management. Individual livestock managers' self-reported management issues were often an accurate reflection of their practical management difficulties. Psychological norms, control beliefs, and attitudes differed among sites, and these differences partially explained patterns associated with conflict (i.e., variation in livestock management behavior). Thus, we conclude that a one-size-fits-all approach to improving livestock management and reducing human–predator conflict is not suitable.

Keywords: African carnivores, comparative methods, conservation psychology, human–wildlife conflict, livestock management, livestock predation

El Papel de la Psicología en la Determinación del Conflicto Humano – Depredador en el sur de Kenia

Resumen: El conflicto entre las personas y los carnívoros puede derivar en la cacería extendida de los depredadores como consecuencia de la pérdida del ganado, además de ser una amenaza importante para las poblaciones de depredadores. En Kenia, una gran población rural y pastora entra en conflicto regularmente con los depredadores, que son muy comunes en el sur del país. Exploramos el trasfondo social y psicológico de las prácticas de manejo de ganado en esta área en un proceso diseñado para ser fácil de usar y adecuado para grandes áreas para el estudio del conflicto y la implementación transfronteriza de medidas de reducción del conflicto con la fauna. Nos enfocamos particularmente en las necesidades y en la participación de la comunidad. Realizamos entrevistas estructuradas a los manejadores del ganado con una herramienta de censo que examinó cómo los factores psicológicos y sociales pueden influir sobre el comportamiento del manejador del ganado. Comparamos las respuestas del censo en tres sitios del área de estudio, lo que resultó en 723 respuestas útiles. La efectividad del manejo de ganado realizado por los individuos varió entre y dentro de las comunidades. Esta variación estuvo explicada parcialmente por las creencias normativas y de control en relación al manejo del ganado. Los temas de manejo reportados por los mismos manejadores individuales de ganado casi siempre fueron un reflejo acertado de sus complicaciones prácticas en el manejo. Las normas psicológicas, las creencias de control y las actitudes difirieron entre sitios, y estas diferencias explicaron parcialmente los patrones asociados con el conflicto (es decir, la variación en el comportamiento del manejador del ganado). Por lo tanto, concluimos que una estrategia igual-para-todos para mejorar el manejo del ganado y reducir el conflicto humano – depredador no es la adecuada.

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Palabras Clave: carnívoros africanos, conflicto humano – fauna, depredación del ganado, manejo de ganado, métodos comparativos, psicología de la conservación

摘要: 人类与食肉动物之间的冲突会导致人类大范围捕杀食肉动物, 以报复其造成的家畜损失, 这对食肉动物种群构成了重大威胁。在肯尼亚存在一个庞大的农村游牧民族, 时常在整个肯尼亚南部地区与食肉动物发生冲突。通过一种易于使用且适用于在大尺度上研究冲突和实施跨边界冲突减缓措施的方法, 我们探讨了这一地区畜牧业管理实践的社会和心理背景, 其中特别关注了社区参与及社区需求。我们对家畜管理者进行了全面的结构化访谈, 并利用调查工具分析了社会和心理因素如何影响其家畜管理行为。接下来, 我们比较了研究区域三个地点的调查结果, 得到了723 条有效记录。结果显示, 社区之间和社区内部个体家畜管理的有效性均有所不同。对家畜管理的规范信念和控制信念可以部分解释其中的变异。个体家畜管理者自我报告的管理问题往往准确地反映了他们实际的管理困难。不同研究地点的心理规范、控制信念和态度各不相同, 这些差异部分解释了与冲突相关的模式 (即家畜管理行为的差异)。因此, 我们认为用一刀切的方法来改进家畜管理和减少人与食肉动物的冲突是不合适的。**翻译: 胡怡思; 审校: 聂永刚**

关键词: 保护心理学, 家畜管理, 对比法, 人兽冲突, 对家畜的捕食, 非洲食肉动物

Introduction

Human–wildlife conflict is a multidisciplinary problem (Thirgood & Redpath 2008), and successful conflict mitigation draws on fields from education (Espinosa & Jacobson 2012) to economics (Nyhus et al. 2005). The social sciences often inform conservation but can be misused or underutilized (Bennett et al. 2017). Recent focus has been on the need for social psychology to be more widely integrated into conservation science (Selinske et al. 2018). This is especially true for human–wildlife conflict issues, where psychology influences tolerance (Bruskotter et al. 2015; Kansky et al. 2016) and conflict behavior (Beedell & Rehman 2000). Thoughtful applications of psychology to conservation have shown that, for example, behavioral control can predict hunting behavior (St. John et al. 2018), and social motivations are important determinants of conflict behavior (Marchini & Macdonald 2012). Psychology offers powerful insights into various conservation problems, not least human–wildlife conflict, and may provide a useful perspective for understanding and developing tools to address conflict.

Although environmental psychology is well established, emerging as a subdiscipline in the 1950s, the concept of conservation psychology is recent. The term appeared in the late 1990s and is defined as the study of "relationships between humans and the rest of nature, [focusing] on how to encourage conservation" (Saunders 2003). Psychological components are often central to frameworks for understanding human–wildlife conflict (Kansky & Knight 2014; Kansky et al. 2016), but there is increasing focus on using explicitly psychological theories to understand conservation problems. The most widely applied of these psychological models is Ajzen's (1991) theory of planned behavior, which argues that social norms, individual agency, and attitudes determine an individual's behavior (Ajzen 1991) (Fig. 1). The theory of planned behavior has been used to understand numerous human–wildlife conflict problems, from light pollution around turtle nesting beaches (McDonald et al. 2014) to farmers' wildlife management practices (Beedell & Rehman 1999). Wider application of the theory of planned behavior is likely to prove useful in understanding and developing approaches to reduce conflict.

Many instances of human–wildlife conflict occur in agricultural and pastoral systems. These issues are notably severe in sub-Saharan Africa, where agricultural systems are being extended alongside relatively intact megafauna assemblages (Sillero-Zubiri & Switzer 2001). For livestock producers, predators can be major sources of livestock loss (Ogada et al. 2003; Kuiper et al. 2015). The costs of livestock predation are high for smallholders (Holmern et al. 2007), and even where actual costs are small, perceived loss can cause high levels of conflict between livestock owners and predators (Koziarski et al. 2016). Various approaches to conflict reduction have been attempted: bomas or kraals (overnight livestock pens), which can be supplemented with vegetation (Lichtenfeld et al. 2015), chain link mesh (Sutton et al. 2017), and flashing LED lights (Lesilau et al. 2018). Livestock-guarding dogs (Marker et al. 2005) and general improvement in husbandry practice (Hazzah et al. 2014) also reduce losses. But none of these approaches are completely effective, nor have they been rigorously tested across different sites (van Eeden et al. 2018). Even where evidence-based strategies have been implemented, problems remain. In particular, enabling or motivating livestock owners to act on these recommendations is a consistent barrier to reducing conflict (Loveridge et al. 2010).

If poor management practices exacerbate human–wildlife conflict, understanding the psychology of livestock management may be key to encouraging improved husbandry. We used a theory of planned behavior model to explore the factors influencing livestock management performance. At its core, the theory of planned behavior separates 3 distinct psychological components: normative beliefs—perceptions regarding the social appropriateness of behaviors (Ajzen & Fishbein 1972); control beliefs—beliefs regarding an individual's agency over behavior or outcomes (Ajzen & Driver 1991); and

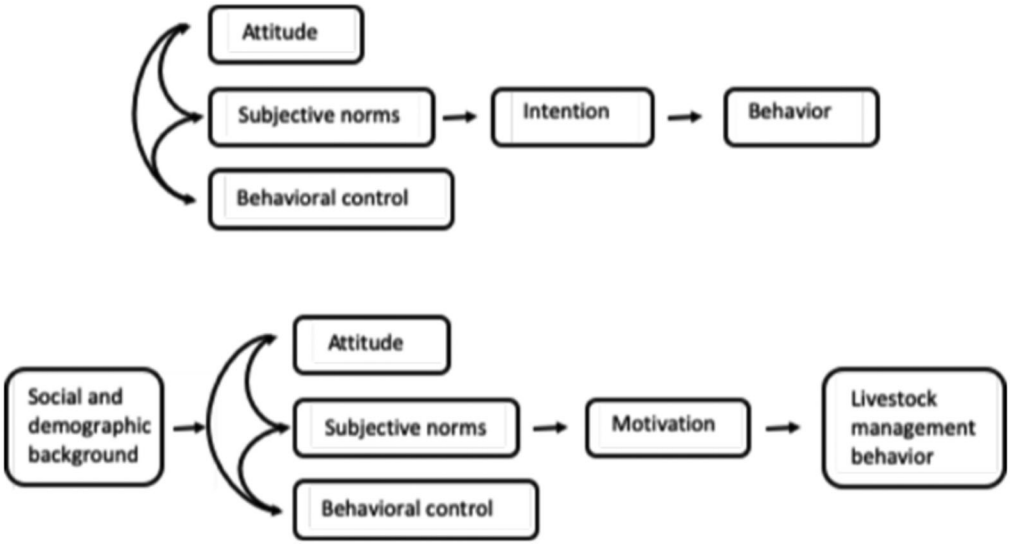

Figure 1. (a) Simplified depiction of the theory of planned behavior and (b) the study model, which considered the social and demographic background of participants in the design of the survey and had a survey module on motivation to examine behavioral intention.

attitudes—an individual's judgements about an object (Katz & Stotland 1959). Separating these components has proven useful for behavior-change interventions, notably in health behavior (Conner & Sparks 2005), so we employed the same approach. In addition to the core theory of planned behavior modules, we used another psychological module to explore motivation, following on from the work of Pinder (1984) in industrial psychology. If a "psychological landscape" can be defined as "the suite of attitudes, beliefs, and intentions an individual possesses in relation to a particular object, problem, or behavior," we expect these landscapes to have a strong influence on an individual's conflict-related behavior (Daigle et al. 2002; St. John et al. 2018). We asked how different components of individuals' psychological landscapes correlate with their livestock management performance and how these factors vary locally with a view to developing focused conservation interventions.

Southern Kenya has high levels of human–predator conflict, which varies across the region (Hazzah et al. 2009; Schuette 2012). Communities, generally traditional Maasai pastoralists, are highly dependent on livestock, making the area suitable to study patterns and variation in livestock management psychology. We wished to explore how these psychological landscapes related to human–predator conflict across southern Kenya. Higher standards of perceived norms (i.e., expectations of the behavior of friends and neighbors) were expected to be associated with better individual management performance. Various nongovernmental organizations (NGOs) are highly involved with the communities we surveyed, so we expected control beliefs—individual agency over management standards—to have relatively little effect on the outcomes because most individuals are thought to have access to the resources required to perform livestock care. We also expected livestock managers' motivations to positively correlate with performance.

We created a survey with the following objectives: determine the structure of normative beliefs, control beliefs, attitudes, and motivation in livestock-owning communities in southern Kenya; study the relationship between psychological landscapes and livestock management, specifically whether more positive psychology or components thereof promote better management; and explore whether livestock management behavior explains differences in livestock predation.

Methods

Study Areas

Research was conducted across 3 sites in southern Kenya (Fig. 2) from March to November 2018. Sites are part of a contiguous transboundary arid rangeland system that extends across southern Kenya and northern Tanzania, where wildlife is free to move across much of the landscape. The region has resident populations of lions (*Panthera leo*), leopard (*Panthera pardus*), spotted hyena (*Crocuta crocuta*), and cheetah (*Acinonyx jubatus*) (Bohm & Höner 2015; Durant et al. 2015; Bauer et al. 2016; Stein et al. 2016).

The South Rift, in Kajiado county (36.21°E, 1.58°S), consists of 2 Maasai group ranches (GR): Shompole and Olkiramatian. Land is communally owned; ~200 km^2 are community-managed conservation area (Western 2017). Livestock management is traditional and for subsistence. Shoats (mixed herds of sheep and goats) and cattle are present at moderate to high densities (Schuette 2012).

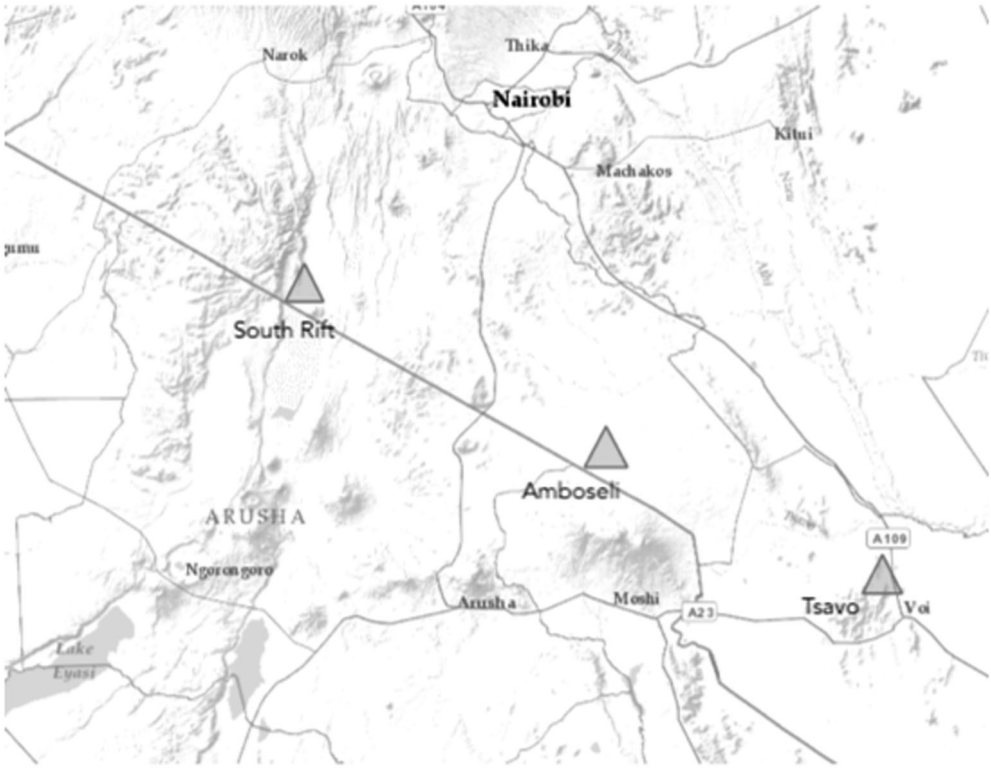

Figure 2. Approximate locations (triangles) of study sites in southern Kenya.

The Amboseli area, in Kajiado county, includes Amboseli National Park and 6 GRs, across which >75% of the population derive their livelihood from livestock (Manoa & Mwaura 2016). Work was conducted on 2 Maasai GRs: Mbirikani (1229 km^2, 37.59°E, 2.51°S) and Rombo (~520 km^2, 37.7°E, 2.9°S). Livestock husbandry is largely traditional (Maclennan et al. 2009), and a fund exists on Mbirikani to provide recompense for livestock predation. Although there are some differences between GRs, social, cultural, and conflict backgrounds are similar, so the Amboseli area was considered a single study region (Amboseli Ecosystem Stakeholders and Kenyan Wildlife Service [Kenyan Wildlife Service] 2008).

The Tsavo ecosystem, in Taita Taveta County, covers 2 large national parks and the Kasigau Carbon Credit REDD+ project. Surveys were conducted in the Voi region (38.7°E, 3.4°S), which is surrounded to the north, west, and south by national parks. Both communally owned and private ranches are present in the area, and 14 of 28 smaller ranches are involved in the REDD+ project.

Survey Participants and Collection Protocol

Survey protocol was approved by the University of Oxford Social Sciences and Humanities Interdivisional Research Ethics Committee (reference number R53944/RE001). Key regions and core communities (those most typical of each region) were identified through discussion with NGOs and local people. We concentrated on the core communities in each region and chose not to include responses from more widely dispersed—and less typical—community members. Once key regions were identified, research assistants were each allocated a study area. Choice of participants within these regions was opportunistic, through door-to-door surveying or interactions at communal locations (e.g., markets). Study participants were livestock owners or managers over the age of 16. Only individuals who were responsible for either herding or managing livestock were surveyed. Questions were translated into Maa and Kiswahili via a group discussion process, with translate–retranslate methodology where there was poor consensus over the translation. Each survey was administered as a face-to-face interview by local research assistants. Responses were recorded using the Qualtrics offline survey application (Qualtrics 2015), a survey platform designed to be used as an app. Pilot surveys were timed, and a minimum realistic duration measured. Because most questions followed an identical format, participants were able to respond rapidly, and the minimum survey time was set at 20 min. Surveys that took less than this minimum were excluded from analysis. Overall, 207, 286, and 230 usable surveys were collected from the South Rift, Amboseli, and Tsavo, respectively.

Survey Design

In psychology, underlying explanatory variables—psychological constructs—are not directly observable, so on surveys multiple questions on the same theme are proxies for these underlying constructs. Our survey (Supporting Information) consisted of ~175 questions, although the exact number varied because question inclusion was contingent on previous answers. The survey was split into 6 modules: social and demographic properties (19 questions on age, education, positions of leadership, etc.); livestock management practices (31 questions on herding, kraaling, veterinary care, etc.); normative beliefs (31 questions on perceptions regarding the social appropriateness of behaviors); control beliefs (16 questions on beliefs regarding an individual's agency over behavior or outcomes); attitudes (31 questions on an individual's judgements about an object, including emotional and cognitive components); and motivation (18 questions on willingness of managers to carry out livestock-related activities).

Most responses were on a 5-point Likert scale: strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree, although some questions had different 5-point scales (e.g., extremely likely to extremely unlikely). Because Likert scales operate in a nonlinear, ordered manner, analysis requires ordinal approaches.

Data Analyses

We wished to explore the psychological landscape of livestock managers and to understand the relationship between psychology and livestock management standards. All analysis was carried out using the free statistical software R version 3.5.1 (R Core Team 2018). To explore the psychological landscape required metrics that captured different components of individuals' latent beliefs. As these properties cannot be measured directly, we used exploratory factor analysis, a form of principal components analysis (R packages: psych [Revelle 2018] and lavaan [Rosseel 2012]) to identify clusters in the survey responses for each of the 6 modules; each cluster was treated as a proxy for an underlying psychological factor (an approach common in psychology studies [e.g., Andriotis & Vaughan 2003]). Only the subsets of survey questions that gave clustered responses were used for further analysis. Using the theoretical background employed in survey design, we developed 2–3 psychological factors for each module (Table 1). Confirmatory factor analysis was carried out on each of these factors ($n = 12$) to test how the measured variables represented underlying psychological constructs (Floyd & Widaman 1995). To test the fit of all factors to each of the 6 modules, we used the comparative fit index (CFI), standardized root mean square residuals (SRMSR), and root mean square error of approximation (RMSEA) (Hooper et al. 2008). To test the internal validity of each individual factor, Cronbach's alpha was used (Table 1). Because we were not aiming to measure one specific property, but rather form a broad psychological overview of particular topics, we used a low alpha threshold of 0.5. Two factors failed to reach this threshold and were omitted from further analysis. Having established the structure of factors within each module and the validity of individual factors, we created variables from these constructs for use in analysis. Each factor contained 2–8 survey questions. For a psychological factor to be used as an explanatory variable in the model, it was necessary to compile responses into one metric for each factor. Because all questions were scored on the same 5-point scale, the responses were summed to create a single equally weighted numeric value for each factor. These numeric measures were then converted into a 2- (poor and good) or 3-level ordered qualitative score (poor, medium, and good), depending on the variation in the metric (Table 1).

To create a model exploring psychology in relation to livestock management performance, we needed a response variable for performance. A composite measure of self-assessed performance was created by combining Likert scale responses to questions concerning good livestock management behavior, including measures of boma use, herding practices, veterinary care, livestock loss in the 12 months prior to surveying, and other indicators of good management. This metric produced an approximately normal distribution, showing that the composite reflected variation in livestock management performance (Fig. 1 & Supporting Information). This metric was converted into categorical response with 3 levels (poor, medium, and good), with approximately the same number of samples in each category. A second management performance metric, which excluded terms for livestock losses, was created to evaluate the effect of management practice on losses. We wanted to include a term for affluence in the model. Because the study communities are largely outside monetary economies, we again needed a composite measure. This composite included numerous variables to measure relative affluence in rural communities (e.g., regularity of meat eating and number of wives [Supporting Information]).

Overall, we had 12 separate psychological factors (Table 1), site, and affluence variables. Because it was possible for these factors to have interdependence, correlation tests were run for all variables using R package arm (Fig. 2 & Supporting Information). Two pairs of factors were highly correlated (>0.68), so the factor in each pair with the lowest Cronbach's alpha was dropped from further analysis. This left 8 psychological factors (Table 1), site, and affluence as variables. To understand the influence of each of the 10 variables on livestock management performance, we carried out an ordinal (for nonlinear Likert responses) logistic regression analysis. Akaike's information criterion (AIC) was used to distinguish the best-fitting

Table 1. Psychological-factor structures used in all models[a] of livestock management performance and details on overarching psychological modules, specific factors, and factor properties.

Module	*Factor*[b]	*Definition*	*Example quotation*	*No. of questions; response levels*	*Comparative fit results*	*CA*[c]	*Reference*
Normative beliefs	Perception norms*	Expectations regarding perception (i.e., How do people perceive the behavior of others, and think others perceive their behavior?)	"My friends think it is important to herd their livestock during the day."	8; good, poor	CFI = 0.97 SRMSR < 0.01 RMSEA < 0.05	0.88	Ajzen and Fishbein 1972
	Behavioral norms*	Expectations of actual behavior (e.g., How often does a respondent think a behavior occurs?)	"How many successful Kenyans do herd their livestock during the day?"	3; good, poor		0.61	
Control beliefs	Management performance*	How easy or difficult would the respondent find improving management behavior?	"To improve my boma would be very easy."	3; good, mid, poor	CFI = 0.69 SRMSR = 0.095	0.65	Ajzen and Driver 1991
	Management agency*	Extent to which respondents control management decisions and can perform those actions	"If I wanted to, I could improve my boma."	6; good, mid, poor	RMSEA = 0.105	0.53	
	Management difficulties*	Assessment of how difficult or easy the respondent finds carrying out a management behavior	"To kraal my livestock every night is difficult."	3; good, mid, poor		0.60	
Attitudes	Positive affect*	Positive attitudinal response toward management activities	"Livestock management makes me feel calm."	3; good, mid, poor	CFI = 0.76	0.79	Katz and Stotland 1959
	Negative affect*	Negative attitudinal response to livestock management activities	"Livestock management makes me feel angry."	3; good, mid, poor	SRMSR = 0.081	0.72	
	Self-assessment	Perception of individual's own livestock management skill	"I am good at managing my livestock."	2; good, poor	RMSEA = 0.087	0.62	
	Cognitive beliefs*	Beliefs about good livestock management techniques	"Employing an adult or trained herder is more effective . . . than using a child herder."	4; good, poor		0.67	
Motivation	Positive management properties	Positive aspects or perceptions of livestock management work	"Livestock management gives me a lot of independence and freedom."	6; good, mid, poor	CFI = 0.96	0.77	Vroom 1964
	Social importance	Perceived social importance of carrying out livestock management	"Livestock management allows me to provide everything my family needs."	2; good, poor	SRMSR = 0.038	X	
	Outcome agency	Extent to which respondent feels control over outcomes of livestock management	"How I manage my livestock has a large effect on the number that are predated."	2; good, mid, poor	RMSEA = 0.056	X	

[a]*Models show importance of different psychological factors in determining livestock management performance.*
[b]*Factors with an asterisk passed all tests and were retained for the model. Other factors were excluded.*
[c]*Cronbach's Alpha. Entries marked 'X' had low alpha scores, and were removed from subsequent analysis.*
Abbreviations: CFI, comparative fit index; SRMSR, standardized root mean square residuals; RMSEA, root mean square error of approximation.

combinations of explanatory variables. Interaction terms were not included because we had no prior reason to expect interactions between the variables. All combinations of the explanatory variables were tested. Models with $\Delta_i \leq 2$ were considered to have substantial support (Burnham & Anderson 2004). Conditional model averaging of this subset of models using R package MuMIn was used to create the top overall livestock management model, and one for each of the 3 sites. Plots were created using R package effects. To test whether livestock management influenced differences in predation outcomes, we used a t test and a generalized linear model with a Poisson distribution to compare count data of livestock losses and our management composite.

Results

Descriptive

Across the region, the median household had 6–10 cows and 21–50 shoats. Self-reports of livestock management behavior indicated that most participants regularly—but not always—implemented good practices (e.g., bringing animals into a boma overnight or herding during the day). Most households (94.9%) had access to a boma. Herders were commonly used, with unpaid adults, paid adults, and children primarily used by 45.0%, 34.9%, and 20.2% of households, respectively. Labor, including herders, was hired by 42.0% of households, and 50.0% of households provided supplementary feed for animals. Veterinary care was uncommon and 52.6% of households used no veterinary services. Combining all sources of mortality in the previous year, livestock deaths were a mean of 5.67 (SD 16.9) cows and 15.6 (46.4) shoats; this was unusually high because of a severe drought.

In the 12 months prior to the survey, 40.8% of households reported livestock predation and 42.2% of households had livestock predated while in a boma. During this period, mean household livestock depredation was 1 cow (SD 3.7) and 4.1 shoats (9.6); however, only 21.7% and 37.8% of households experienced depredation of shoats and cows, respectively. Thus, mean losses for each affected household were much higher: 4.6 (6.7) cows and 10.8 (13.1) shoats.

Analytical

We explored how psychological factors affected livestock management behavior, including the relative contribution of different factors, and whether these factors were the same across sites. Our preconceived factor structures were an acceptable fit to the latent psychological constructs (normative beliefs: CFI = 0.97, Standardised Root Mean Square of Residuals = 0.0027, and RMSEA = 0.049; control beliefs: CFI = 0.69, SRMSR = 0.095, and RMSEA = 0.105; attitudes: CFI = 0.76, SRMSR = 0.081, and RMSEA = 0.087). Twelve AICc models were within $\Delta_i \leq 2$ and were considered top models (Table 2). Livestock management behavior was affected by site and affluence, with all of the 12 best models containing both terms. Overall, normative and control factors appeared particularly important. Two control factors were generally retained by each model (management difficulty, $n = 12$; management agency, $n = 10$), although management performance was less important ($n = 5$). Most models also had one normative factor (normative behavior, $n = 8$; normative perceptions, $n = 3$). The only attitude factor retained by any top model was positive attitude ($n = 5$). The averaged model (Table 3) contained terms for site, affluence, normative behaviors and perceptions, all control variables, and positive attitude. There was strong evidence for a positive relationship between reported management difficulty levels and livestock management performance. Management performance was also positively associated with normative behaviors, and negatively associated with management agency, but these were only weakly supported (Supporting Information). There was very strong evidence for effects of affluence (Fig. 3) and site. To explore this further, we broke the analysis down by study site.

There were 10, 6, and 8 models within AIC $\Delta_i \leq 2$ for Tsavo, South Rift, and Amboseli, respectively, with no overlap in models between sites (Supporting Information). The averaged models contained different terms ordered by importance: affluence, normative perceptions, normative behavior, management performance, positive attitude, and management agency for Tsavo; affluence, normative behavior, management agency and difficulties, positive attitude, management performance, and normative perceptions for South Rift; and affluence, positive attitude, normative behavior, management agency, and normative perceptions for Amboseli.

For Tsavo, 1 or both normative terms appeared in 80% of the top models, falling to 66% and 50% for South Rift and Amboseli, respectively. Control beliefs terms were present in 100% of models in South Rift, in 80% of models in Tsavo, and in 38% of models in Amboseli. Management performance occurred in 80% of models in Tsavo, compared with only 38% for agency and none for difficulties. By contrast, management agency and difficulties were present in all South Rift models. Positive attitude was a term in all top models for Tsavo, but seldom retained on other sites.

The index of livestock management behavior was normally distributed across all sites. This index varied significantly with predation outcomes; livestock owners who experienced any predation of cows, shoats, or donkeys in the previous 12 months had a lower management behavior score than those who experienced no predation (t test, $p = 0.0019$). Our generalized linear regression revealed a small but significant relationship between

Table 2. Top-ranking models (ΔAIC $\leq$ 2) of the influence of different combinations of psychological factors on livestock management performance across 3 study sites in southern Kenya.

Rank	*Model*	*ΔAIC^**	*Likelihood*	*Weight*
1	Site + affluence + behavioral norms + management performance + management agency + management difficulties + positive attitude	0	1	0.079
2	Site + affluence + behavioral norms + management agency + management difficulties + positive attitude	0.0910	0.951	0.075
3	Site + affluence + behavioral norms + management agency + management difficulties	0.163	0.922	0.072
4	Site + affluence + behavioral norms + management agency + management difficulties	0.363	0.834	0.065
5	Site + affluence + management performance + management agency + management difficulties	0.916	0.633	0.050
6	Site + affluence + management agency + management difficulties	1.007	0.604	0.047
7	Site + affluence + behavioral norms management difficulties	1.579	0.454	0.036
8	Site + affluence + management performance + management agency + management difficulties + positive attitude	1.663	0.435	0.034
9	Site + affluence + perception norms + behavioral norms + management performance + management agency + management difficulties + positive attitude	1.732	0.421	0.033
10	Site + affluence + perception norms + behavioral norms + management agency + management difficulties + positive attitude	1.785	0.410	0.032
11	Site + affluence + management difficulties	1.854	0.396	0.031
12	Site + affluence + perception norms + behavioral norms + management agency + management difficulties	1.871	0.392	0.031

**Difference between the Akaike information criterion values for 2 models.*

Table 3. Averaged Akaike information criterion (AIC) for the top model, showing the role of site, affluence, and psychological factors in determining overall livestock management performance on sites across southern Kenya.

Model term	*Estimate*	*SE*	*z*	*p*
Site				
South Rift	−0.7509	0.2252	3.330	0.000869
Tsavo	1.9800	0.2595	7.620	$<2 \times 10^{-16}$
Affluence	0.7333	0.1148	6.377	$<2 \times 10^{-16}$
Perception norms	−0.1331	0.2463	0.539	0.589605
Behavioral norms	0.2961	0.1679	1.760	0.078393
Management performance	0.2512	0.1765	1.420	0.155467
Management agency	-0.2785	0.1440	1.931	0.053442
Management difficulties	0.3357	0.1279	2.620	0.008803
Positive attitude	−0.1869	0.1314	1.419	0.155811

livestock management behavior and livestock predation ($p = 0.036$) (Supporting Information).

Discussion

Overall Findings

We found that various psychological constructs can partially explain differences in predation outcomes for livestock managers in southern Kenya. Normative belief factors consistently appeared in averaged models, with the behavioral norms factor approaching significance in the overall averaged model (Table 3). The behavioral norms term contained questions on the livestock management behavior of various groups (e.g., How many people in nearby communities manage their livestock well?). We expected livestock managers to assume that their own management performance was average (i.e., poor managers assumed everyone else was performing poorly, etc.). However, we found that as the normative behavior score increased (i.e., as respondents reported higher perceived standards in other groups), it became less likely that the respondent themselves performed good livestock management (Supporting Information). This suggests respondents had an accurate sense of their own relative performance. Good livestock managers reported relatively poorer performance in other groups and vice versa. Although normative perceptions did not explain a large amount of variance, in the low- and mid-standard management classes there was a tentative positive correlation between performance and perceptions (Fig. 3 & Supporting Information), so those people who thought their friends, elders, and family valued good livestock management more deeply appeared to perform better. This needs further research, but if confirmed, community campaigns that highlight the local importance and value set by good livestock management may prove effective. We found that the lowest performers in a community are

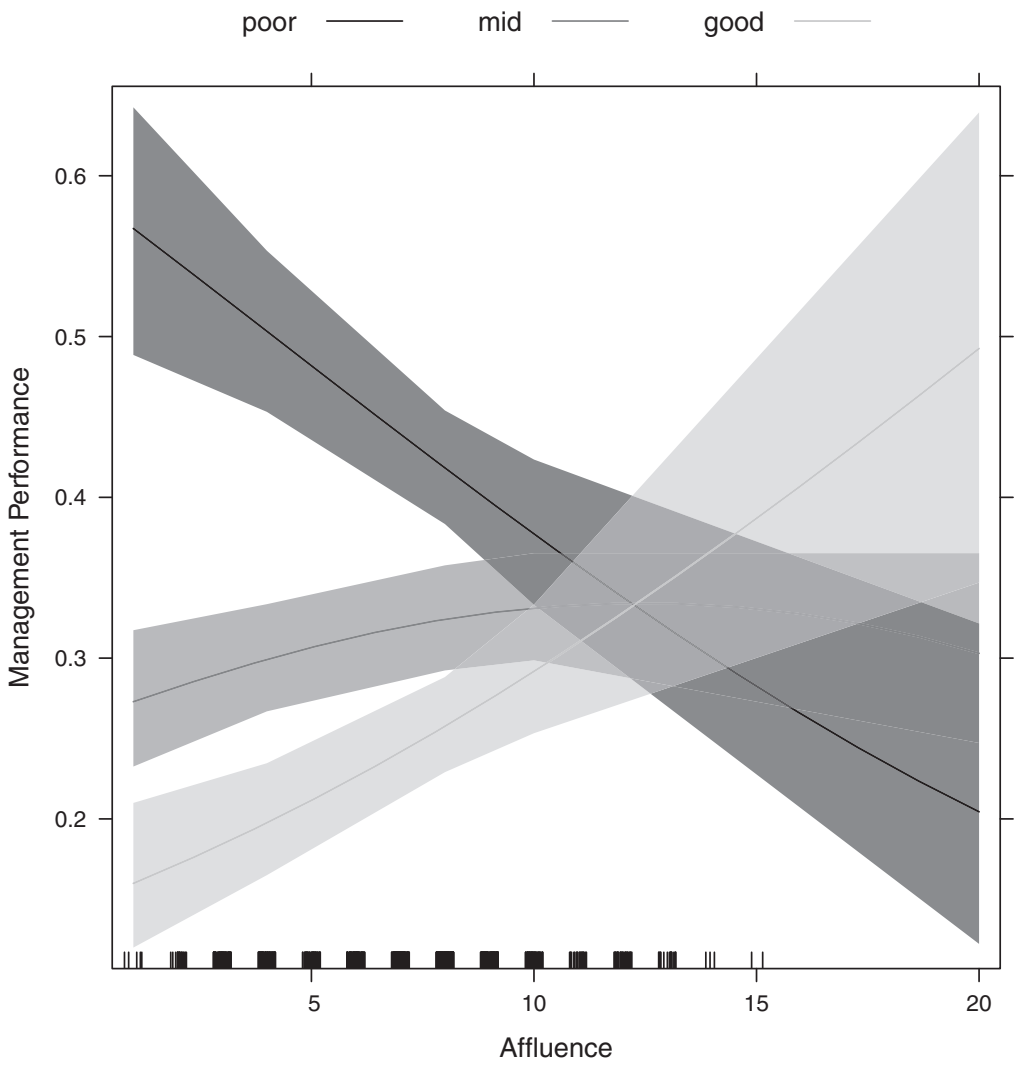

Figure 3. Results of ordinal logistic regression model of effect of affluence on livestock management performance (good, mid, and poor) (y-axis, probability of performance level; x-axis, composite affluence score).

aware of their own position and may be susceptible to the influence of their peers, so psychology-based public opinion campaigns could prove a workable intervention.

Of the psychological modules, control factors appeared the most important; management agency and difficulty control terms (Table 3) featured in the global model, although they were less consistent on a local level. The management performance variable (e.g., To hire a herder for my livestock would be easy.) appeared in 80% of the models for Tsavo, whereas both management agency and difficulties appeared in all the South Rift models. Management difficulty (e.g., To herd my livestock is difficult.) was the most important control term across sites, and was highly correlated with management performance (Supporting Information) (i.e., those livestock mangers who performed most poorly reported highest levels of difficulty and vice versa). This term was designed to detect inability to access resources (e.g., adequate fencing materials), so its significance in the model demonstrates that local people for whom there were barriers to good livestock management reported this proportionate to their need. Integration of local knowledge into landscape planning or ecosystem impact assessments is widespread (e.g., Kwiatkowski & Ooi 2003) and increasingly common in conflict mitigation (White & Ward 2011). Our findings confirm that variation in need within communities can be captured by a simple survey, and we suggest that identifying community sectors in need of support may help conservation interventions succeed.

Affluence was a highly significant term in both the overall and site-specific models (Fig. 3), a similar finding to those of other studies (Zimmermann et al. 2005). As affluence increased, so did the probability of better livestock management performance. This was true for all livestock management standards and sites. There were also major significant differences between sites, with no

overlap in the top-ranking models for each site (Supporting Information).

Site-Specific Findings

In Tsavo normative terms for perceptions and behavior were highly important. This was the only site not to include management difficulty in the averaged model. Our metric suggested that farmers in the Tsavo area had the highest management standard. This ran counter to our expectation because although the Maasai have a long history of cattle management, the Tsavo area has the lowest proportion of Maasaipeople and has had a large influx of other ethnic groups over the past 30 years (Muriuki et al. 2011). The more sedentary approach to livestock management taken in Tsavo is fundamentally less risky than traditional Maasai husbandry, which may be reflected in the metric. Similarly, migrants who move to Tsavo to farm and choose to undertake this work may be expected to practice a very high standard of care. That normative terms were locally important could reflect the novelty or diversity of communities, with studies suggesting that conforming to norms can be relatively more important in recently 327 formed or more varied communities (Hogg & Reid 2006; Schultz et al. 2008).

In the South Rift, the averaged model contained normative behavior, followed by management agency and difficulties. These control belief terms were more important here than elsewhere, with all 3 terms appearing. The management agency term measures respondents' sense of control over livestock management (e.g., If I wanted to, I could improve my kraal.), whereas the management difficulties term measures the perceived difficulty of the same aspects of management (e.g., To bring my livestock intro the kraal [. . .] would be difficult.). This was the only site where both agency and difficulties were important. Both factors had a positive relationship with management performance: actors who believed they had more control and fewer difficulties practiced more successful livestock management. Farmers in the South Rift had the most challenges to livestock management including low affluence levels, a serious drought the previous year, and high local density of predators in farming areas (Schuette 2012). Livestock managers here have arguably the most difficult task and the greatest risk of bad outcomes where management is poor. There may be a trade-off between the high productivity of large-scale mobility and more difficult management. Agency and difficulties were relatively less important on other sites, so variation should be tested and, when high, targeted interventions implemented.

Amboseli is a world famous national park and draws international attention (Kibicho 2006). Consequently, there are numerous conservation organizations working in the area. There was relatively little variation in livestock management standards in Amboseli and very little impact of control terms in the models. This may suggest that most livestock managers' basic needs were being fulfilled. The most important psychological model terms were positive attitude and normative behavior, and both had positive relationships with performance. The positive attitude term measured affective states, for example, how much does managing your livestock make you feel content. The importance of positive attitude in the models perhaps shows that once serious threats to management have been removed, the individual preferences of livestock managers—and interest in farming—become a much more important factor in their performance.

Interventions based on a psychological understanding of human behavior have been practiced across a growing range of disciplines, not least conservation (e.g., Kansky et al. 2016; St. John et al. 2018). We found that various psychological constructs explained differences in the outcomes of livestock management in southern Kenya, but that the most important psychological components varied among sites. This result demonstrated that our survey mapped psychological constructs relevant to human–predator conflict and is therefore useful for understanding conflict. Southern Kenya is a large area, and our results reflect differences across the region, which suggests our approach may work across broad spatial scales. The intersite variation we documented shows that assumptions about belief structure should not be made, and practitioners seeking to use psychology to change behavior must carry out local surveys to understand the psychological landscape of their region. We call for wider implementation of both psychology in the study of human–wildlife conflict and comparative approaches similar to our survey. Our results showed such surveys can capture site-specific nuances and may be key to providing fast, evidence-based information with which to tailor conflict-reduction interventions.

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Supporting Information

The survey (Appendix S1), management composite scores (Appendix S2), details on the affluence composite (Appendix S3), a correlation matrix of the variables (Appendix S4), a linear model of livestock loss and management performance (Appendix S5), additional graphs

from specific sites (Appendix S6), livestock management performance relative to normative behaviors and management difficulties (Appendix S7), and top-ranking models of the influence of psychological factors on livestock management performance at individual sites (Appendix S8) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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