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Beliefs, perceived risks and acceptability of lethal management of wild pigs

Jerry J. Vaske[A,C], *Craig A. Miller*[B], *Hailey E. McLean*[A] and *Lauren M. Jaebker*[A]

[A]Colorado State University, Human Dimensions of Natural Resources, Fort Collins, CO 80523, USA.
[B]University of Illinois, Illinois Natural History Survey, Champaign, IL 61820, USA.
[C]Corresponding author. Email: jerryv@colostate.edu

Abstract

Context. Wild pigs (*Sus scrofa*) are a non-native, invasive species that can cause significant damage to agricultural crops, and native flora and fauna. In the United States, damage and control costs have been estimated at 1.5 billion USD. A combination of early sexual maturity, high fecundity, opportunistic eating and well established populations forces managers to control wild pig densities and resulting damages.

Aims. The present study aimed to examine the relationships among farmers' positive and negative beliefs about wild pigs, their perceived risks associated with wild pigs and their acceptability of lethal management actions for controlling agricultural damage.

Methods. Data were obtained from a mail survey of Illinois farmers ($n = 3035$, response rate = 58%). Variables consisted of six belief statements (three negative, e.g. wild pigs are a source of disease, and three positive, e.g. 'I enjoy seeing wild pigs around my property'), five perceived risk statements (e.g. wild pigs cause property damage) and four statements regarding the acceptability of lethal management actions for controlling the impact of wild pigs (e.g. shooting wild pigs from a helicopter).

Key results. The relationships between the negative and positive beliefs and the acceptability of lethal management were partially mediated by perceptions of risk (Hypothesis 1). Perceived risks associated with wild pigs were related to negative (Hypothesis 2) and positive (Hypothesis 3) beliefs about wild pigs, as well as acceptability of lethal management actions (Hypothesis 4) to control the impact of wild pigs. In addition, negative beliefs (Hypothesis 5) and positive beliefs (Hypothesis 6) were related to support for lethal control.

Conclusions. These relationships occurred despite the relatively low prevalence of wild pigs in Illinois and suggest that lethal actions are acceptable even though perceived risks are low.

Implications. Findings suggested that perceived risks associated with wild pigs were not substantially related to the attributes of the farm (e.g. farm ownership, crops grown, total acres farmed) or demographic characteristics (i.e. sex, age). Managers should focus on influencing the psychological indicators (e.g. negative and positive beliefs, perceived risks) to increase the acceptability of lethal management actions for mitigating the impacts of wild pigs.

Keywords: invasive species, population management, social dimensions.

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Introduction

Wild pigs (*Sus scrofa*), also known as wild boars or feral hogs (Keiter *et al.* 2016), are a non-native, invasive species that can cause significant damage to agricultural crops, as well as native flora and fauna. In the United States, these damages and control costs have been estimated at 1.5 billion USD annually (Pimental 2007; Bevins *et al.* 2014). Wild pigs also pose a risk to humans and livestock safety through the transmission of pathogens (Brown *et al.* 2019). First introduced into the USA by Spanish explorers in the 16th century, wild pigs are now established in at least 35 US states, with an estimated population of six million (US Department of Agriculture (USDA) 2019). High intelligence, generalist diet and the ability to adapt to regional variations have contributed to the expansion and establishment of wild pig populations (Bevins *et al.* 2014). Early maturation before the age of one and high fecundity rates in sows result in up to two litters per year, with as many as six piglets per litter (Higginbotham 2013). This combination of early sexual maturity, opportunistic eating and well established populations forces managers to control wild pig densities and the resulting damages.

Effective management of wild pigs by state and federal agencies, however, requires public support for controlling these animals. Conceptually founded on the cognitive hierarchy, the present study examined: (1) the public's positive and negative

beliefs about wild pigs; (2) the perceived risks associated with the species; and (3) the acceptability of lethal management actions.

Conceptual foundation

Cognitions are mental processes that individuals use for understanding situations (Vaske and Manfredo 2012). The cognitive hierarchy arranges cognitions from general to specific (Vaske and Donnelly 1999). A central concept in the hierarchy is specificity or correspondence among the measured variables (Whittaker *et al.* 2006). When correspondence between variables is similar, correlations between variables are predicted to be larger (Manfredo 2008). Positive and negative beliefs about wild pigs, for example, should predict perceived risks towards the species, which in turn should predict acceptability of specific management actions (e.g. lethal control). Although correlation does not prove causality, the relative strength of relationships can facilitate testing for mediation. Fig. 1 diagrams the predicted relationships among these cognitions.

Beliefs

Beliefs are what we think to be true, not necessarily objective facts (Vaske *et al.* 2009). Beliefs can refer to either a general or a specific object. For example, if 'wild pigs' is the object, the belief reflects a general object because no other specifics are provided (e.g. where they are located). If 'wild pigs eating row crops in Illinois during 2020' is the object, the belief reflects a more specific situation. Beliefs can also be positive or negative. For example, a positive belief might suggest that 'wild pigs are an important part of the environment,' whereas a negative belief might be 'wild pigs destroy native wildlife.'

Perceived risks

Risk perception is the extent to which an individual identifies a risk from a particular source (Siegrist and Cvetkovich 2000; Sjöberg 2000; Miller and Shelby 2009; Needham *et al.* 2017). Although wild pigs can pose a risk to agriculture, they can also be a risk to humans, livestock and wildlife via disease transmission. Perceived risks are integral to many wildlife problems and some wildlife managers now consider risk perceptions in their management programs (Gore *et al.* 2009). Risk perceptions have been shown to influence people's support for wildlife management (Knuth *et al.* 1992; Riley and Decker 2000; Miller and Shelby 2009; Needham *et al.* 2017; Vaske *et al.* 2018; Doney *et al.* 2019). For example, acceptability of lethal wildlife management strategies can increase as perceived risk increases (Gramza *et al.* 2016), particularly in situations where a disease risk is prevalent (Koval and Mertig 2004).

Management actions

Mitigating impacts of wild pigs has been attempted via aerial shooting, baiting and shooting, hunting with dogs and trapping (VerCauteren *et al.* 2019). Wildlife agencies addressing impacts caused by wild pigs may benefit from research on managing other wildlife species. For example, lethal control can be a cost-effective solution for some species, but a highly controversial management approach for other species (Sanborn and Schmidt 1995; Koichi *et al.* 2013; Sponarski *et al.* 2015; Doney *et al.* 2019). Public opinion regarding what is 'acceptable' can also vary greatly among stakeholders (e.g. farmers vs urbanites) (Fraser 2006; Miller 2009; Koichi *et al.* 2013). For example, farmers may have strong negative beliefs about wild pigs because their crops and animals can be directly impacted by wild pigs. Urbanites, on the other hand, may hold neutral or even positive opinions because there are no direct negative consequences for them. A study in Australia (van Eeden *et al.* 2019) suggested that farmers tend to be more supportive of lethal control for wild pigs than are other type of stakeholder groups (e.g. wildlife conservationist and animal rights activists).

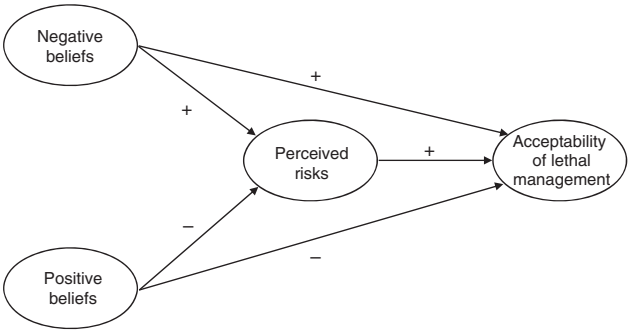

Fig. 1. Hypothesised partial mediation model showing the relationships among beliefs, perceived risks and the acceptability of lethal management.

Researchers commonly define acceptability as a 'judgment or decision regarding the appropriateness of a particular management action or policy' (Bruskotter *et al.* 2009: p. 121). Failure to effectively include the public in decision making regarding wildlife has led to unsuccessful management outcomes (Riley *et al.* 2002; Manfredo 2008; Bennett *et al.* 2017) and reduced public support for a range of initiatives (Stern *et al.* 2017; Doney *et al.* 2019). Understanding public acceptance of lethal management approaches requires knowledge of people's beliefs (Decker *et al.* 2006; Bruskotter *et al.* 2009; Loyd and Miller 2010) and their perceived risks associated with a given species (Harper *et al.* 2016).

Hypotheses

The literature suggests that developing an appropriate management strategy for wild pigs requires an understanding of the relationships among (1) the public's positive and negative beliefs about wild pigs, (2) the perceived risks associated with the species and (3) the acceptability of lethal management actions. The following hypotheses were examined:

H_1: Perceived risks will mediate the relationship between negative/positive beliefs and the acceptability of lethal management;
H_2: Perceived risks of wild pigs will be positively related to negative beliefs about wild pigs;
H_3: Perceived risks of wild pigs will be negatively related to positive beliefs about wild pigs;
H_4: Perceived risks of wild pigs will be positively related to acceptance of lethal management;
H_5: Negative beliefs about wild pigs will be positively related to acceptance of lethal management; and
H_6: Positive beliefs about wild pigs will be negatively related to acceptance of lethal management.

Methods

Questionnaires were mailed to 5320 randomly selected Illinois farmers who owned ≥1 acre (0.4 ha) of land in counties where wild pigs were observed (Harper *et al.* 2014). Wild pigs have established small populations in a few Illinois counties, but are uncommon in most of the state. The questionnaires were mailed July through September of 2013. Participants were mailed a survey packet containing a cover letter explaining the study, a questionnaire and a first-class stamped return envelope. A reminder/thank you postcard was sent 2 weeks later to non-respondents. The mailings were repeated on 2-week intervals for a total of two survey packets and two postcard mailings. There were 45 undeliverable surveys from the initial mailing ($n = 5320$). Completed questionnaires were received from 3061 farmers (response rate = 58%), of which 3035 were usable. A non-response bias was not conducted given the response rate (Babbie 2016).

Variables

Variables consisted of six belief statements, five perceived risk statements and four statements regarding the acceptability of management actions for wild pigs. Of the belief statements, three were positive – 'Wild pigs are an important part of the environment', 'I enjoy seeing wild pigs around my property' and 'People should learn to live with wild pigs near their homes or farms', and three were negative – 'Wild pigs are a source of disease', 'Wild pigs destroy native wildlife' and 'Wild pigs should be eliminated wherever possible'. Both the positive and negative belief statements were coded on a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Respondents were also asked to evaluate the perceived risks of wild pigs to 'Native wildlife populations', 'Ground-nesting birds', 'Tree regeneration', 'Wildlife habitat' and 'Causing damage to my property'. These specific perceived-risk variables were coded on a scale ranging from 1 (no risk) to 4 (severe risk).

Acceptability of management actions was based on four statements that asked participants their level of acceptance of 'Aerial control by helicopter', 'Trap and remove', 'Targeted sharpshooting on the ground over bait sites' and 'Capture and removal of wild pigs using dogs'. Each of these items were coded on a 5-point scale ranging from 1 (completely unacceptable) to 5 (completely acceptable).

Analysis strategy

The internal consistency of each multi-item latent concept was assessed using Cronbach's α (Vaske 2019). Confirmatory Factor Analysis (CFA) was also used to empirically validate the observed variables associated with each latent construct (Kline 2015)[1]. LISREL version 10.2 (Scientific Software, Int., Skokie, IL, USA) was used for the CFA using the covariance matrix. Goodness of Fit indices included chi-square ($\Delta\chi^2$, χ^2/d.f.), Comparative Fit Index (CFI; an acceptable CFI value is >0.95), Normed Fit Index (NFI; an acceptable NFI value is >0.90) and Root Mean Square Error of Approximation (RMSEA; an acceptable RMSEA value is between 0.05 and 0.08) (Hu and Bentler 1995).

Structural Equation Modelling (SEM) was used to examine the mediation model. The model hypothesised that perceived risks mediate the relationship between negative and/or positive beliefs and the acceptability of lethal management. Mediation occurs under the following conditions: (1) the independent variables must be significantly related to the mediator, and the independent variables must significantly affect the dependent variable (direct effects model); and (2) the paths between the independent variables and the mediator, and between the mediator and the dependent variable, must be significant in both the full and partial mediation models. Full mediation occurs when the change in chi-square statistics indicates that the full mediation model fits better than the direct effects model, and the partial mediation model fits no better than the full mediation model. Partial mediation occurs when the change in chi-square statistics show that the partial mediation model fits the data better than either the direct effects or full mediation models (Hayduk 1987).

To demonstrate the mediation role of perceived risks, three separate structural equation models were analysed. In the first, the full mediation model, the independent variables (negative and positive beliefs) were predicted to influence only the dependent variable (acceptability of lethal management) indirectly through the effect on the mediator (perceived risks). In the second model (partial mediation), the independent variables were permitted to influence the dependent variables directly and indirectly through the effect on the mediator. The third model (direct effects) examined the effect of the independent variables on both the dependent variable and the potential mediator, but the potential mediator was constrained to not affect the dependent variable.

Results

Illinois farmers held negative beliefs about wild pigs with means ranging from 5.68 (wild pigs are a source of disease) to 6.09 (wild pigs should be eliminated wherever possible) (Table 1). The reliability for this three-item scale was 0.84. Conversely, they did not hold positive beliefs. The means for these items ranged from 1.37 ('People should learn to live with wild pigs near their homes or farms') to 1.58 ('I enjoy seeing wild pigs around my property'); the Cronbach's α was 0.68. The standardised factor loadings for the negative beliefs ranged from 0.77 to 0.89, and loadings for the positive beliefs ranged from 0.59 to 0.75.

The perceived-risk variables were coded on a 4-point scale, with a value of 4 reflecting severe risk. The means for the five items in this scale ranged from 3.45 (native wildlife populations) to 3.66 (ground-nesting birds). The reliability coefficient was 0.88 and the standardised factor loadings ranged from 0.63 to 0.83. Respondents indicated that all four of the lethal control

[1]Podsakoff *et al.* (2003) have proposed the Harman single factor test as an approach for examining common method bias. The test is based on a Principal Components Exploratory Factor Analysis (EFA) of all original items, without rotation and with the number of factors fixed to one. If the single factor EFA explains <50% of the variance, method bias is not considered a problem. Applied to the 15 items in the present study, the single factor explained 33% of the variance. This approach, when coupled with the Confirmatory Factor Analysis (CFA) and Cronbach reliability analyses presented here (e.g. factor loadings, fit indices, reliability coefficients), suggests that common method bias was generally absent.

Table 1. Negative and positive beliefs, perceived risks, and lethal control

Concept/variable[A]	M	s.d.	Standardised factor loading	Cronbach's α
Negative beliefs[A]				0.84
Wild pigs are a source of disease	5.68	1.63	0.89	
Wild pigs destroy native wildlife	5.91	1.71	0.79	
Wild pigs should be eliminated wherever possible	6.09	1.64	0.77	
Positive beliefs[A]				0.68
Wild pigs are an important part of the environment	1.55	1.31	0.59	
I enjoy seeing wild pigs around my property	1.58	1.25	0.75	
People should learn to live with wild pigs near their homes or farms	1.37	1.06	0.61	
Perceived risks[B]				0.88
Native wildlife populations	3.45	0.75	0.83	
Ground-nesting birds	3.66	0.63	0.78	
Tree regeneration	3.56	0.70	0.82	
Wildlife habitat	3.49	0.74	0.81	
Causing damage to my property	3.65	0.72	0.63	
Lethal control[C]				0.83
Aerial control by helicopter	3.67	1.44	0.71	
Trap and remove	4.22	1,31	0.70	
Targeted sharpshooting on the ground over bait sites	4.27	1.29	0.73	
Capture and removal of wild pigs using dogs	3.95	1.45	0.81	

[A]Variables coded 7-point scales ranging from 1 (strongly disagree) to 7 (strongly agree).
[B]Variables coded on 4-point scales ranging from 1 (no risk) to 4 (severe risk).
[C]Variables coded on 5-point scales ranging from 1 (completely unacceptable) to 5 (completely acceptable).

Table 2. Mediation tests for three structural equation models

*$P < 0.001$. $\Delta\chi^2_{(\text{full vs partial})} = (\chi^2_{(\text{full})} - \chi^2_{(\text{partial})}) = (450.18 - 398.04) = 52.14$, $P < 0.001$. $\Delta\chi^2(\text{direct}_{\text{vs full}}) = (\chi^2_{(\text{direct})} - \chi^2_{(\text{full})}) = (472.41 - 450.18) = 22.23$, $P < 0.01$. $\Delta\chi^2(\text{direct}_{\text{vs partial}}) = (\chi^2_{(\text{direct})} - \chi^2_{(\text{partial})}) = (472.41 - 398.04) = 74.37$, $P < 0.001$. CFI, comparative fit index; NFI, normed fit index; RMSEA, root mean square error of approximation

Mediation model	χ^2*	χ^2/d.f.	CFI	NFI	RMSEA
Full mediation	450.18	5.30	0.98	0.98	0.04
Partial mediation	398.04	4.79	0.98	0.98	0.04
Direct effects	472.41	5.62	0.98	0.98	0.04

management actions were acceptable, with means ≥3.67. The Cronbach's α for this scale was 0.83 and the standardised factor loadings were consistently ≥0.70.

Having demonstrated the reliability of the constructs, the three structural equation models were examined. In the direct effects model, negative and positive beliefs were related to (1) the mediator and perceived risks, in the predicted direction, and (2) the acceptability of lethal management, also in the predicted direction. In both the full mediation and partial mediation models, perceived risks were positively related to lethal management.

To address the mediation role of perceived risks and assess the overall fit of the models (full mediation, partial mediation, direct effects model), the three structural equations were compared using five indicators (χ^2, χ^2/df, $\Delta\chi^2$, CFI, NFI, RMSEA). The likelihood χ^2 in LISREL provides one indicator of how well a model fits the data. A non-significant χ^2 indicates a good fit. Although all three models produced significant chi-squares ($\chi^2 \geq 398.04$, $P < 0.001$, in all cases, Table 2), large sample sizes tend to inflate this statistic. Consequently, Marsh and Hocevar (1985) suggest that the Chi-squares should be evaluated in relation to the model's degrees of freedom; a χ^2/d.f. ratio of 2 : 1 to 5 : 1 indicates an acceptable fit. The partial mediation model was within this range, but the ratios for the full and direct effects model were above 5 : 1 (Table 2). Values for the CFI and the NFI were always 0.98, and the RMSEA, which measures the average discrepancies between the observed and the model generated covariances, were 0.04 for all three equations.

Given that all indices generally suggest that any of the three equations could be used to describe the data, the selection of a given model was based on the change in chi-square statistic. In structural equation analysis, models are nested if they contain the same variables and can be constructed from one another by adding or deleting paths (Hayduk 1987: pp. 163–167). The difference between the χ^2s of two nested models is distributed as a $\chi^2$with degrees of freedom equal to the difference between the degrees of freedom for the two models. This change in χ^2, or $\Delta\chi^2$, is unaffected by sample size and can be used as a test to determine which model fits the data better. The model with the significantly smaller χ^2 value is the better fitting model. Consistent with hypothesis one, the partial mediation model had a significantly better fit than either the full mediation model ($\Delta\chi^2 = 52.14$, $P < 0.001$) or the direct effects model ($\Delta\chi^2 = 74.37$, $P < 0.001$). For this reason, the partial mediation model was used to describe the data.

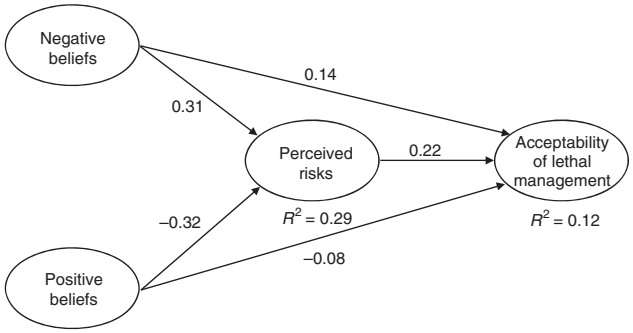

Fig. 2. Structural equation model showing the relationships among beliefs, perceived risks and the acceptability of lethal management. Coefficients are standardised path coefficients. All paths are statistically significant at $P \leq 0.007$.

Fig. 2 shows the partial mediation model. As predicted by hypothesis two, there was a positive relationship between negative beliefs and perceived risks ($\beta = 0.31$, $P < 0.001$). Consistent with hypothesis three, there was a negative relationship between positive beliefs and perceived risks ($\beta = -0.32$, $P < 0.001$). Together, the two sets of beliefs accounted for 29% of the variance in perceived risks. There was a positive relationship between perceived risks and the acceptability of lethal management ($\beta = 0.22$, $P < 0.001$), as predicted by hypothesis four. Finally, consistent with hypotheses five and six, there was a positive relationship between negative beliefs and lethal management ($\beta = 0.14$, $P < 0.001$) and a negative association between positive beliefs and the management action ($\beta = -0.08$, $P = 0.007$). Collectively, the beliefs and perceived risks explained 12% of the variance in the acceptability of lethal management of wild pigs.

Discussion

Illinois farmers were more likely to hold negative beliefs and less likely to hold positive beliefs about wild pigs. They were also likely to consider wild pigs a risk to wildlife, tree regeneration and wildlife habitat, and a cause of personal property damage. Lethal management actions to control these damages were judged as acceptable. The relationships between the negative and positive beliefs and the acceptability of lethal management was partially mediated by perceptions of risk. All six hypotheses were supported by the data.

These relationships occurred despite the relatively low prevalence of wild pigs in Illinois. Lethal or other controversial management actions of wild pigs are likely be acceptable even in areas where perceived threats are low. These findings, however, may be unique to wild pigs and not be generalisable to other species. For example, a study in Victoria, Australia that investigated people's attitudes towards feral horses (*Equus ferus*) found that respondents' normative acceptance of control methods varied under different circumstances (Nimmo *et al.* 2007). Other studies have highlighted the complexity of public support for lethally controlling species such as black bears (*Ursus americanus*) (Agee and Miller 2009), feral cats (*Felis catus*) (Loyd and Miller 2010) and red foxes (*Vulpes vulpes*) (van Eeden *et al.* 2019).

Even in similar situations where wildlife species cause damage to agriculture, use of lethal control has been shown to be controversial. Sijtsma *et al.* (2012) found that acceptance of lethal control for geese and deer on agricultural crops varied depending on the severity of the problem within a local context. Given these examples, 'variations in the animal's symbolic value or image, perceived abundance and impact potential may affect the acceptability of management practices' (Nimmo *et al.* 2007; p. 239).

Conclusion

The present study examined the relationships among psychological indicators of beliefs (positive and negative), perceived risks and acceptability of lethal control. From a managerial perspective, it is reasonable to ask who hold these beliefs and evaluations. Ancillary analyses indicated that females (54%) were slightly more likely to evaluate wild pigs as a severe risk compared with males (50%), and older individuals (65+) were slightly more likely to see wild pigs as a severe risk (54%) compared with those less than 65 years of age (46%). Level of perceived risk from wild pigs, however, was not related to (1) whether the respondent personally owned farmland, (2) the types of crops grown (e.g. row crops, forage, orchards, tree nursery) or (3) total acres farmed. Overall, these additional findings suggest that perceived risks associated with wild pigs were not substantially influenced by property or demographic characteristics, but rather by psychological indicators (e.g. negative and positive beliefs, perceived risks or perceived acceptability of management actions). Because demographic and land ownership characteristics were not statistically important factors further suggests support for lethal control lies with beliefs regarding wild pigs. Managers need to be aware of these psychological factors and provide sufficient information concerning impacts of wild pigs to increase the acceptability of lethal management actions to mitigate damage.

Conflicts of interest

The authors have no conflicts of interest regarding the collection and dissemination of data or findings in the present study.

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