Evaluating deterrents of illegal behaviour in conservation: carnivore killing in rural Taiwan

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Abstract

Rules restricting resource use are ubiquitous to conservation. Recent increases in poaching of iconic species such as African elephant and rhino have triggered high-profile interest in enforcement. Previous studies have used economic models to explore how the probability and severity of sanctions influence poacher-behaviour. Yet despite evidence that compliance can be substantial when the threat of state-imposed sanctions is low and profits high, few have explored other factors deterring rule-breaking. We use the randomised response technique (RRT) and direct questions to estimate the proportion of rural residents in north-western Taiwan illegally killing wildlife. We then model how potential sources of deterrence: perceived probabilities of detection and punishment, social norms and self-imposed guilt, relate to non-compliant behaviour (reported via RRT). The perceived likelihood of being punished and two types of social norms (injunctive and descriptive) predict behaviour and deter rule-breaking. Harnessing social norms that encourage compliance offers potential for reducing the persecution of threatened species.

Keywords: compliance; enforcement; guilt; randomized response technique; social norms

1. Introduction

Effective conservation depends on understanding human behaviours, particularly those that threaten biodiversity such as illegal logging (Laurance 2008), fishing (Hilborn 2007) and hunting (Milner-Gulland and Bennett 2003). Positive incentives, such as the provision of resources to those behaving in a pro-conservation manner, is one way of encouraging behaviour change (Milner-Gulland and Rowcliffe 2007). However, conservation and natural resource management are widely dependent upon negative incentives, principally the making and enforcing of rules that restrict access and use of resources (St. John et al. 2013).As a result, successful management demands an understanding of factors deterring rule-breaking so that compliance can be encouraged.

Recent increases in wildlife crime including the poaching of iconic, commercially valuable species such as African elephant (Burn et al. 2011) and white rhino (Biggs et al. 2013; Smith et al. 2013) have triggered increased interest in enforcement (Goldenberg 2013; The White House 2013)which typically involves the use of patrols to detect infractions (Keane et al. 2008) and the application of state-imposed legal sanctions to punish violators. By increasing the severity of sanctions, criminal justice policies aim to increase deterrence (Kennedy 1997). Rational choice theories of crime assume that individuals weigh up potential costs (probability of being detected and likelihood and severity of penalties), rewards and preferences when deciding how to act (Becker 1968; Garoupa 1997). The rational actor therefore should comply when fairly certain of capture and punishment. The physical distribution or 'ecology' of crimes suggests that offenders do make rational choices: by committing crimes against poorly protected targets (e.g. houses, public property or people) in familiar locations, offenders reduce risk, effort, and inconvenience (Clarke and Cornish 1985). However, the assumption that offenders act as rational utility maximizers who respond to the threat of sanctions in a predictable fashion has been challenged (Akers and Sellers 2009; Paternoster 1987). Evidence suggests that, constrained by availability of time, ability and information, human behaviour is only boundedly rational (Simon 1955): rather than assessing the pros and cons of alternative courses of action, people employ 'shortcuts' or rules-of-thumb (also referred to as heuristics) when processing information and opt for satisfactory rather than optimal solutions (Clarke and Cornish 1985; Cornish and Clarke 1986; Milner-Gulland 2012). Further, social-psychological factors also influence people's behaviour. With respect to pro-environmental behaviours, attitude, social norms, behavioural control and moral norms influence the decisions that people make (Bamberg and Möser 2007; Mastrangelo et al. 2013; Williams et al. 2012), whilst people's feelings (Van Gelder 2012), perceptions of informal social control (Felson 1986), self-control (Pratt and Cullen 2000) and an ability to manage fears, moral scruples and guilt influence criminal decision making (Cornish and Clarke 1986).

There is evidence that investment in conservation law enforcement is effective. For example, anti-poaching patrols were a determining factor in the recovery of African buffalo and elephant in Serengeti National Park, Tanzania (Hilborn et al. 2006) and increased effectiveness of anti-poaching patrols reduced poaching of wildlife in Ghana's protected areas (Jachmann 2008). Enforcement however is costly and studies investigating illegal

behaviour have reported mixed results concerning the influence that probabilities of capture and punishment have on actors (Kroneberg et al. 2010). For example, compliance in some fisheries was found to be high despite low probabilities of detection and illegal profits in excess of fines (Sutinen and Kuperan 1999), the threat of detection failed to deter drink-driving (Berger and Snortum 1986) and the expectations of capture and punishment were unrelated to people's intention to commit tax fraud or shop-lift (Kroneberg et al. 2010). In addition, industry characteristics more strongly deterred corporate crime compared to formal sanction risk (Simpson and Koper 1992). This raises questions about what other factors encourage compliance and whether they can be harnessed to supplement or even reduce reliance on conventional and costly enforcement.

Economic models of law enforcement in conservation and natural resource management have incorporated probabilities of detection and punishment based upon information including enforcement data and legal proceedings (Milner-Gulland and Leader-Williams 1992; Sumaila et al. 2006). However, would-be-violators do not know the actual probability of being caught or punished, rather their behaviour is influenced by their perceived threat of enforcement action (Grasmick and Bryjak 1980; Grasmick and Green 1980). Studies investigating the links between perceived sanction risk and severity generally find that criminality is lower amongst those perceiving higher risks of detection and severity of punishment (Nagin 1998). There is evidence in conservation that rule-breakers adjust their perceptions of the risks of sanctions. For example, following an initial market inspection, trade in the North Sulewesi endemic babirusa (babyrousa celebensis) halted for one year. However, by the third inspection trade only stopped for one month as traders refined their perceptions of the threat of capture from high to the true level of virtually zero (Milner-Gulland and Clayton 2002). However, none have investigated how an individual's compliance behaviour relates to their reports of the perceived probabilities of detection and punishment.

Any factor that reduces the expected utility of a crime may encourage compliance and empirical evidence suggests that sources of social control may play a greater role in shaping compliance compared to the certainty and severity of punishment (Paternoster 1987). In addition to regulations enforced by formal institutions, social norms (obligatory, shared or forbidden behaviours) mediate the way in which people in societies behave (Ostrom 2000). Peers may reward individuals for following social norms by conferring status or material resources towards them, or punish transgressions through ostracism or the withholding of favours or goods (Posner 1997). Social norms have been found to deter a range of antisocial behaviours including drink-driving (Berger and Snortum 1986), illegal gambling (Grasmick and Green 1980) and environmental theft (Cialdini 2003). Further, enforcement within some fisheries appears to stem largely from social influences (Gezelius 2002; Sutinen and Gauvin 1989). For example, Norwegian fishers comply for fear of being labelled dishonourable by gossiping peers (Gezelius 2002). Evidence from social psychology suggests that two types of social norm influence behaviour: injunctive norms (what people typically approve of) and descriptive norms (what people typically do) (Cialdini et al. 1991). To date, the role of these two types of social norm in encouraging compliance with conservation rules has not been explored in a quantitative manner.

The behaviour of individuals is also regulated by internal feelings such as guilt, shame and self-esteem. Anticipated or actual guilt may be felt by an individual when they consider performing, or actually execute a behaviour that defies their morals, values or social norms (Vining and Ebreo 2002). The immediate response may be felt in the form or physiological discomfort, however, long-term impacts may include anxiety or depression impeding personal performance (Grasmick and Bursik 1990). Whilst acts that trigger guilt may differ between cultures (Scollon et al. 2004), feelings of guilt have been shown to influence a range of behaviours including willingness to help others (Freedman et al. 1967), participate in extra-curricular activities (Boster et al. 1999) and engage in pro-environmental behaviours (Ahn et al. 2013). With respect to compliance, guilt has been found to have a stronger influence on behaviour compared to the threat of capture in the case of tax fraud and drunk-driving (Grasmick and Bursik 1990; Wenzel 2004). Whilst fishers have reported feeling 'morally uncomfortable' when breaking the law (Gezelius 2002; Sutinen and Kuperan 1999), the utility of self-imposed guilt as a deterrent has not been investigated within a conservation and natural resource management context.

Understanding the potential value of such factors as deterrents requires that they be linked to reports of people's compliance behaviour. Innovative developments in the analysis of randomised response data (van den Hout et al. 2007) recently applied in conservation (St. John et al. 2012) support such an approach. The randomised response technique (RRT) (Warner 1965) has improved estimates of rule-breaking in conservation producing higher estimates of non-compliance compared to direct questions (Razafimanahaka et al. 2012; Solomon et al. 2007; St. John et al. 2010a). By using a randomising device such as dice, RRT provides respondents with levels of protection greater than a simple guarantee of anonymity. For example, provided with a beaker and a die, respondents may be instructed to: answer a sensitive question truthfully choosing 'yes' or 'no' if the die lands on one through to four (probability = 0.66); select 'yes' if the die lands on five (probability = 0.167); or select 'no' if the die lands on six (probability = 0.167) (St. John et al. 2010a). The result of the die is never revealed to the interviewer so a truthful response can never be distinguished from a prescribed one. By adapting the logistic regression model to account for answers forced by the randomising device (van den Hout et al. 2007), characteristics of respondents (e.g. attitudes) can be linked to behaviours of interest such as killing of protected carnivores (St. John et al. 2012).

In this study we use both RRT and direct questions (DQ) to estimate the proportion of rural residents in north-western Taiwan killing four species as well as asking someone else to hunt a legally protected endangered species on their behalf. We then use an adapted form of logistic regression (St. John et al. 2012; van den Hout et al. 2007) to investigate the potential deterrent effects of the perceived probabilities of detection and punishment, injunctive and descriptive norms, and self-imposed guilt on wildlife persecution reported via RRT (Figure 1). By linking reports of rule-breaking behaviour to potential sources of deterrence, this study makes a novel contribution to the study of conservation enforcement, a neglected area of research (Keane et al. 2012; Robinson et al. 2010).

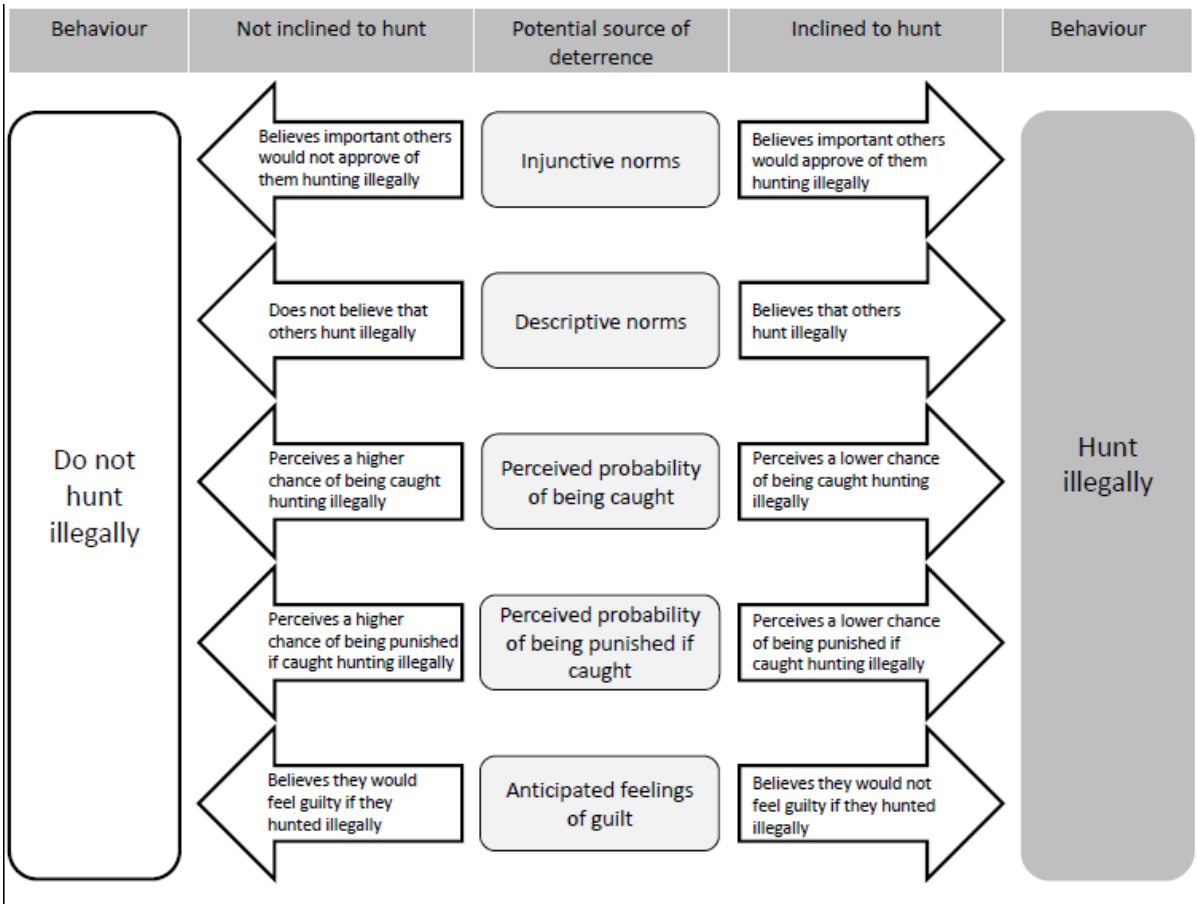

Figure 1 Conceptual framework of factors influencing an individual's decision to hunt a legally protected species. All things held equal, the more strongly a person believes killing a protected species is disapproved of, that others do not kill protected species, that the probability of being caught and punished is high, and that they would feel guilty for engaging in such a behaviour, the more deterred they are from hunting illegally.

2. Methods

2.1 Case study: wildlife persecution in rural north western Taiwan

Data from ecological surveys confirm the existence of leopard cat (Prionailurus bengalensis chinensis) and masked palm civet (Paguma larvata taivana) within Miaoli County, Taiwan (Pei 2008). Before 1970 the leopard cat population was greatly reduced through habitat loss and commercial harvesting for their skin, resulting in a call for their legal protection (Ian 1979; McCullough 1974). Now listed as endangered under Taiwan's Wildlife Conservation Act (WCA) (Council of Agriculture 1989), Miaoli County is probably the only area where a viable population of this species is still found (Pei 2008). Whilst more common, the masked palm civet, long popular in game meat markets (Wang 1986) is also protected under the WCA due to intensive trapping pressure in rural areas. Article 21 of the WCA only permits the authorised killing of protected species under limited circumstances including risk to human life, damage to crops or stock and for indigenous people's traditional ceremonies or rituals. Any unauthorised person caught killing protected wildlife may be fined between NT$200 000 and NT$1 000 000 (between approx. US$6 600 and US$33 000) and face up to

five years in prison. Despite these considerable sanctions, anecdotes from Miaoli County suggest that leopard cat and masked palm civet are still trapped for the commercial gain of professional hunters, and, with respect to leopard cat, because they are perceived by poultry farmers as pest. Other species including rodents and ferret badger (Melogale moschata) are not protected under the WCA but are included in this study so that both illegal and legal behaviours could be investigated. All species are found across the study site (Pei 2008).

2.2 Data collection

We drafted the questionnaire (available from F.A.V.St.John) in English, it was then translated to Chinese and back-translated to English to verify the translation. We then piloted it on colleagues, clarifying wording where required, before a formal pilot with residents within the study site. The questionnaire were administered through face-to-face interviews at the homes of residents between August and October 2012 by CHM. Hakka, Taiwanese or Mandarin (all dialects spoken by CHM) were used to deliver the questions; as there are no written characters for Hakka and Taiwanese, Chinese characters were used throughout. The sampling strategy used to identify respondents involved multiple steps. First, we identified three townships in Miaoli County with the highest leopard cat densities using data from camera trap surveys (Pei 2008). Second, after excluding urban areas we listed all rural villages per township; the RAND function in Microsoft Excel was then used to select a simple random sample (Newing 2011) of four villages per township. Lastly, using either the phone book (two townships) or electoral role (one township) as a sampling frame, we systematically sampled (Newing 2011) 20 households per village by selecting every nth household on the list (the first house to be surveyed was selected using the RANDBETWEEN function in Microsoft Excel) i.e. we sampled 242 households across the 12 villages; approximately 4% of the total households. Within households, elder members were recruited as respondents as locally they were believed to have more experiences with the study species. Names of villages are not revealed to protect respondents.

To verify respondents' familiarity with species included in the questionnaire we showed respondents photos of study species (rodents, ferret badger, masked palm civet and leopard cat) and non-study species (domestic cat and pangolin). Those familiar with each of the study species completed the questionnaire which included sections on rule-breaking (RRT and DQ), demographics and three potential sources of deterrence. Using the Morakot '88' flood of 2009 as a historic reference, RRT and DQ questions referred to the last three years (e.g. for DQ: *'*Since the 88 Flood which was 3 years ago, did you kill any leopar*d cats?'*). This time period was chosen as it was considered long enough to have allowed the behaviours under investigation to have occurred whilst not being too long ago for people to remember.

2.3 Estimating the proportion of people killing wildlife

We used the 'forced response' randomised response technique (Warner 1965) to question respondents about their involvement in the killing of wildlife and whether they had requested another to hunt a leopard cat on their behalf. Respondents were given a set of instruction and question cards, including one example question, a pair of dice and a non-transparent beaker.

RRT was first explained to respondents using the example question: '*Since 88 Flood" which* was three years ago, did you ever ride a motorbike wit*hout a helmet?'* Roles of interviewer and respondent were reversed when required and the interviewer did not proceed with RRT questions until it was clear that the respondent understood the method. Before each RRT question, respondents shook the dice in the beaker and added the value of the dice together. If the sum of the two dice came to five through to ten (probability = 3/4), respondents were asked to answer the sensitive question honestly by saying 'yes' or 'no' out load to the interviewer. If the dice summed two, three or four (probability 1/6) respondents were instructed to give a fixed answer 'yes'. Finally, if the dice summed 11 or 12 (probability 1/12), respondents were instructed to give the fixed answer 'no'. Respondents never revealed their dice roll to the interviewer therefore the interviewer could not tell if a respondent was saying 'yes' because they have performed the sensitive behaviour, or because they were providing a prescribed response. However, by knowing the probability of respondents instructed to answer honestly, and the probability of respondents instructed to provide the prescribed response of 'yes', the prevalence of the sensitive characteristic could be estimated. To maximise respondents' compliance with RRT instructions we used the analogy of playing a game encouraging respondents to follow RRT instructions just as they would follow the rules of a game. Literacy and numeracy are high in Taiwan so are not believed to limit respondents' understanding or use of RRT.

In order to test the utility of RRT, we asked respondents the same wildlife killing questions directly at the end of the questionnaire. The wording of DQ and RRT questions was identical. Respondents answered DQs by placing a tick in either a 'yes' or 'no' box.

2.4 Perceived probabilities of detection and punishment as deterrents

Economic models of enforcement focus on the probabilities of rule-breaking being detected and punished, with non-compliance occurring when the benefits outweigh the costs (Becker 1968). To investigate how the perceived probability of being caught relates to behaviour (measured via RRT) we asked respondents to indicate how frequently they believed the authorities would catch them if they killed each of the four species. Respondents also reported their perceived likelihood of receiving a penalty for killing each animal if they were caught (eight statements in total). Answers were given using a five-point Likert scale (from 'never' through to 'always') coded so that lower scores corresponded to lower deterrence.

2.5 Social norms as deterrents

To understand the relationship between social pressures and behaviour reported via RRT we investigated two different types of social norms: injunctive norms, which measure what friends, family or peers typically approve or disapprove of; and descriptive norms which capture respondents' perceptions of how other people typically behave (Cialdini 2003). To measure injunctive norms we asked respondents to indicate on a five point Likert scale (from 'highly disapprove' through to 'highly approve') the degree to which they thought their family and friends would approve or disapprove of them for killing each of the four species (four statements in total). We measured descriptive norms by asking respondents to state whether or not they thought people that they know, had killed each of the species in the last

three years. Response options were 'yes' and 'no'. The coding of answers for injunctive and descriptive norms means that lower scores suggest weaker social deterrence for wildlife persecution.

2.6 Self-imposed guilt as a deterrent

To investigate the relationship between anticipated guilt and behaviour reported via RRT, we asked respondents to indicate, using a five point Likert scale (from 'strongly agree' through to 'strongly disagree') how much they agreed or disagree with the statement *'I would feel guilty if I killed x'.* This statement was repeated for each of the four species. Higher scores were indicative of stronger feelings of guilt, which is suggestive of stronger self-imposed deterrence for killing wildlife.

2.8 Data analysis

We analysed data using R version 2.15.0 (R Development Core Team 2012). The proportion of respondents admitting via RRT to killing each species was estimated using the following equation (Hox and Lensvelt-Mulders 2004):

$$\pi = \frac{\lambda - \theta}{s}$$

where π is the estimated proportion of the sample admitting to the behaviour, λ is the proportion of all answers that are 'yes', θ is the probability of the answer being a prescribed 'yes', and s is the probability of being asked to answer the question truthfully. Ninety-five per cent confidence intervals for RRT and DQ data were estimated from 10,000 bootstrap samples (St. John et al. 2012). A significant difference between RRT and DQ estimates was concluded when the 95% confidence intervals for the mean difference did not include zero (St. John et al. 2010a).

Before modelling, we used Cronbach's alpha coefficient (Cortina 1993) to check each set of four species-specific statements measuring the probability of being caught, probability of receiving a penalty, injunctive norm and self-imposed guilt for internal consistency. Categories within predictor variables measuring probabilities of detection and punishment were collapsed from five to two representing 'never caught' and 'sometimes caught'. Categories measuring injunctive norms and anticipated guilt were collapsed from five to three corresponding to low, neutral and high levels of social approval and guilt.

Following St. John et al. (2012), we used generalised linear mixed models (GLMMs) with a binary response and binomial error to investigate relationships between behaviour reported via RRT and each predictor variable. GLMMs were fitted by penalised-quasi-likelihood using the glmmPQL function from the MASS package. Because of the forced 'yes' responses contained within randomised response data, simple logistic regression is not appropriate therefore models were fitted using a customised link function able to incorporate the known probabilities of the prescribed RRT responses (St. John et al. 2012; van den Hout et al. 2007) (supplementary material). To account for the grouping structure of the data whereby each

respondent answered multiple questions on each species, we included respondent ID as a random effect. Species, probability of detection, likelihood of punishment, injunctive and descriptive norms and anticipated guilt were all independently considered as potential fixed effects in GLMMs. We generated predictive scenarios illustrative of respondents reporting polar opposites of opinions from fitted GLMMs.

3. Results

Two hundred and forty two residents completed the questionnaire. Most respondents were male (64.5%, n = 242) which reflects the underlying population (Miaoli County Government Household Registration Service 2014) and the mean age was 62 years (s.e. = 0.84, n = 242). Because our sampling strategy targeted elder members of households, the sample does not perfectly represent the underlying population in terms of age (people above and below 55 years of age were over and under sampled respectively) (Miaoli County Government Household Registration Service 2014). The primary occupation of most interviewees was agriculture, forestry or fish-farming (60.7%, n = 147), whilst some worked in industry, commerce, or the service sector (19.8%, n = 48), were unemployed (16.9% n = 41), or engaged in other occupations (2.5%, n = 6). Nearly all respondents were farming some type of crop (91.3%, n = 221), and 47.9% (n = 116) were keeping poultry. Over eighty percent of respondents (80.2%, n = 194) were aware that there was no penalty for killing rodents whilst 43% (n = 104) knew there was no penalty for killing ferret badgers. Less than one-quarter (24.0%, n = 58) of the sample reported being aware that there is a penalty for killing leopard cats; fewer (13.6%, n = 33) reported being aware that penalties exist for killing masked palm civet. Few respondents (4%, n = 10) reported thinking that leopard cats were a pest; these ten respondents stocked fewer head of poultry (43.2, s.e. = 17.5) compared to the sample mean (274.9, s.e. = 180.9, n = 116).

Cronbach's alpha was high for each set of four species-specific statements measuring the probability of detection (0.75, n = 242), receiving a punishment (0.74, n = 242), injunctive norms (0.77, n = 242), and anticipated guilt (0.79, n = 242) indicating high interval consistency.

3.1 estimating the proportion of people killing wildlife

The proportion of respondents estimated by RRT and DQ to have killed each of the four species, or asked a hunter to kill a leopard cat in the last three years is shown in Figure 2. RRT produced higher estimates than DQ for each of the five behaviours (significantly higher for masked palm civet and asking a hunter to kill a leopard cat). Over 40% (42.7%) (mean difference between RRT and DQ estimates 3.05%) and 12.4% (mean difference between RRT and DQ 4.63%) of respondents admitted to killing legally unprotected rodents and ferret badgers respectively in the three years preceding the study. More than 10% (10.2%) of respondents admitted to killing the protected masked palm civet (mean difference between RRT and DQ 9.82%). A greater proportion of respondents admitted to asking a hunter to kill leopard cat (9.7%) compared to admitting to killing this species themselves (6.0%) (mean difference between RRT and DQ 9.32% and 5.91% respectively). Elder members of households were selected as respondents because locally they are reported to have more

experiences with the study species. However, this may have introduced bias to our results. Estimates of reported levels of killing should therefore be considered conservative.

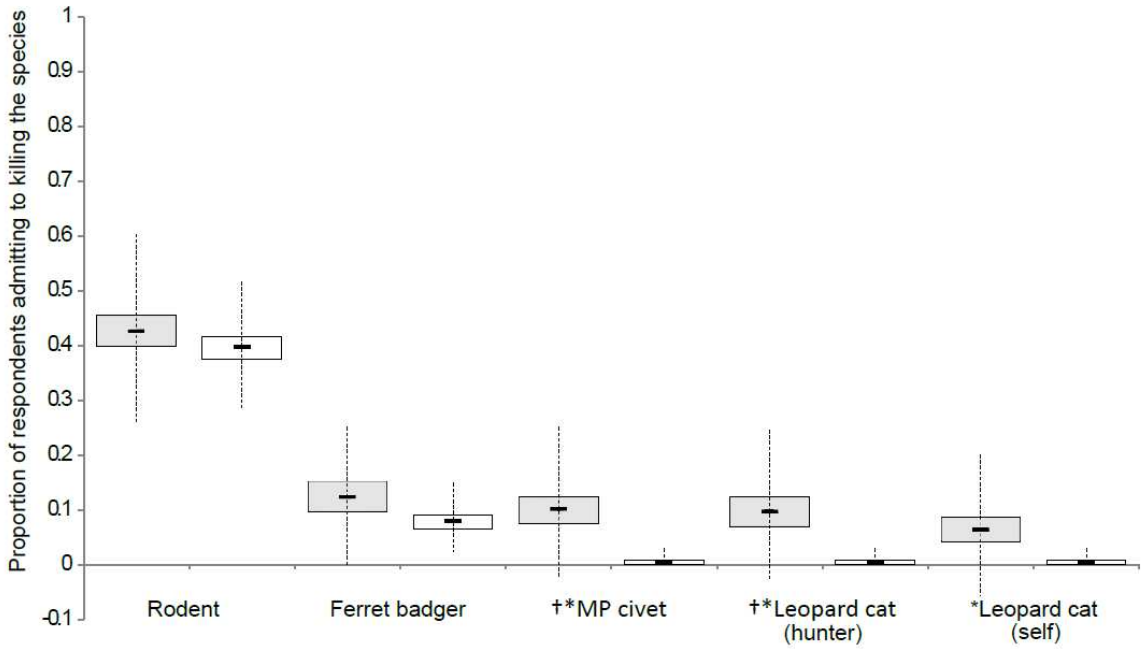

Figure 2 The proportion of respondents admitting to killing each of the species, or asking a hunter to kill leopard cats on their behalf in the three years preceding the study estimated using the randomised response technique (grey bars) and direct questions (white bars). Bold lines represent the median, the lower and upper edges of the boxes represent the first and third quartiles, and whiskers denote the maximum and minimum values. . Asterisks indicate species protected under the Wildlife Conservation Act of 1989. †denotes RRT estimates are significantly different compared to DQ.

3.3 Deterrence

The perceived probability of detection by the authorities for killing wildlife was not modelled as most of our respondents perceived no chance of capture for any of the species. The likelihood of admitting to killing wildlife was negatively related to the perceived probability of being punished if caught ($t = -1.324$, d.f. = 722, $p = 0.186$), however, this result was not significant.

The likelihood of admitting to killing any of the four species was negatively and significantly related to both injunctive ($t = -2.294$, d.f. = 722, $p = 0.022$) and descriptive norms ($t = -5.709$, d.f. = 722, $p = <0.001$). Scenarios simulated from each of our fitted GLMMs predict that respondents reporting the injunctive norm that their family or friends would disapprove of them killing leopard cat were 9% less likely to have killed this species compared to those reporting that their friends and family would approve of such behaviour (Figure 3a). Respondents reporting the descriptive norm that they knew someone who had killed leopard cat in the last three years were 18.3% more likely to have admitted to killing this species

when asked via RRT, compared to someone reporting that they did not know anybody that had killed leopard cat (Figure 3b).

Self-imposed deterrence, measured as the level of guilt respondents associated with the killing of each species, was not related to behaviour reported via RRT ($t = 0.078$, d.f. = 722, $p = 0.938$).

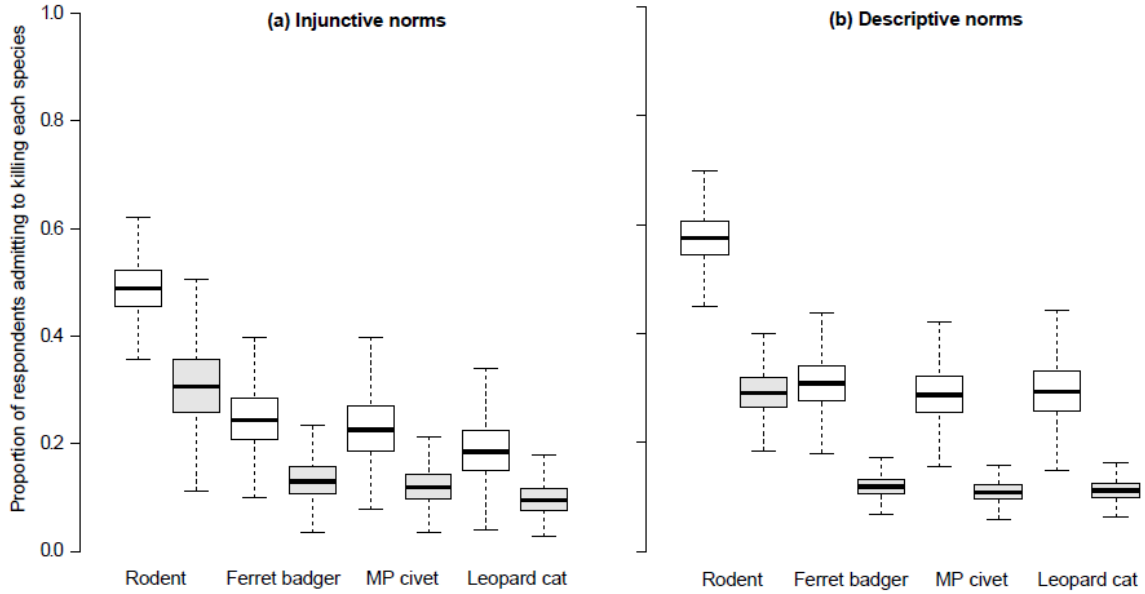

Figure 3 Simulations from fitted generalised linear mixed models illustrating the relationships between human persecution of wildlife and (a) injunctive norms – perceived social approval and (b) descriptive norms – perceived typical behaviour of others. In Scenario 1 (white bars) the norm is set to its minimum value indicative of a weaker norm. In scenario 2 (grey bars) the norm is set to its maximum value indicative of a stronger social norm. Bold lines represent the median, the lower and upper edges of the boxes represent the first and third quartiles, and whiskers denote the maximum and minimum values.

4. Discussion

Investigating illegal resource use presents methodological challenges (Gavin et al. 2010) with data subject to unquantifiable biases, consequently much of our understanding of the determinants of compliance stem from modelling studies (Keane et al. 2008). For example bio-economic and agent-based models underpinned by rational actor assumptions have been used to explore the influence of sanctions on poacher behaviour (Keane et al. 2012; Milner-Gulland and Leader-Williams 1992). However, rule-breakers do not simply compare marginal benefits with marginal costs, but respond to sociological norms internalised throughout their lifetime (Garoupa 1997). Recent developments in the application and analysis of specialised questioning techniques (techniques that add stochastic noise to respondents' answers preventing individually incriminating information from being revealed whilst allowing population-level estimates to be calculated) including RRT (St. John et al.

2012) and the unmatched count technique (Nuno et al. 2013), facilitate linking reports of rule-breaking behaviour to a range of characteristics, including potential sources of compliance, thus contributing to a greater understanding of factors driving behaviour.

Validation studies where the actual status of individuals is known (e.g. police or medical records) provide evidence that RRT stimulates more honest answers to sensitive questions compared to conventional survey techniques (Lensvelt-Mulders et al. 2005). This suggests that whilst anonymity may increase response rates and reduce social-desirability bias (Ong and Weiss 2000), other mechanisms that offer respondents added protection further increase the validity of sensitive data. Studies comparing survey methods (including one study in Taiwan (Chi et al. 1972)) have reported that RRT returned higher estimates than DQ when the questions were sensitive; these higher estimates have been interpreted as evidence of more honest reporting (Chi et al. 1972; Lensvelt-Mulders et al. 2005; Solomon et al. 2007). There is growing evidence that RRT produces more accurate reports of involvement in illegal natural resource extraction compared to conventional direct questions: Twelve per cent of the population surveyed near Andasibe-Mantadia protected area, Madagascar reported eating sifaka (Propithecus diadema) when asked using RRT, compared to 3% using DQ (Razafimanahaka et al. 2012); RRT estimates of the proportion of people illegally extracting six types of natural resources from Kibale National Park, Uganda exceeded DQ estimates across all resource types (Solomon et al. 2007); and compared to DQ, RRT estimated that a significantly higher proportion of fishers fished without permits in North Wales, UK (St. John et al. 2010a). However, even when using questioning techniques designed specifically for asking sensitive questions it is impossible to rule out untruthful reporting (Landsheer et al. 1999). To maximise compliance with RRT instructions we used a symmetrical RRT design (meaning that prescribed responses were set as both yes (dice sum two, three or four), and no (dice sum 11 or 12), rather than as either yes or no) which has been shown to increase the extent to which people follow RRT instructions (Ostapczuk and Musch 2011). Further, the analogy of 'playing a game' was used when describing RRT to respondents (Chi et al. 1972). One principle disadvantage of RRT is that, because noise is added to the data by forced responses, the method demands a large sample size in order to achieve estimates with an acceptable margin of error; further, the random noise complicates analyses of associations (e.g. between behaviour and norms) (Lensvelt-Mulders et al. 2005; Moshagen et al. 2013).

Our estimates that within the last three years nearly 10% of residents asked someone to hunt leopard cat, whilst 6% admitted to killing them in person require serious consideration, particularly given the recent confirmed extinction of the clouded leopard (Neofelis nebulosa) in Taiwan, a loss partially attributed to human encroachment and hunting (Chiang 2007; Taipei Times 2013). Whilst there may be some overlap in the two estimates (i.e. some people admitting to killing the species themselves may be the hunters reported by other respondents) the number of killings every year may be detrimental to the population which numbers no more than several hundred individuals (Pei 2008). Leopard cats are nocturnal lowland forest edge species with home ranges of ca. 5-6 km^2 as such it is inevitable that their home ranges will overlap with rural residences and agriculture lands (Pei 2008). Conflicts between humans and carnivores often stem from threats to human lives or livelihoods (Treves and Karanth

2003). This small carnivore (weighing 3-5kg; Francis 2008) poses neither threat within human-managed landscapes in Taiwan, with faecal analysis confirming that livestock do not constitute a major part of leopard cat diet. Nearly 60% of their diet constituted mammalian species (mainly rodents), the remainder being passerine birds, reptiles and invertebrates. Evidence of gallinaceous birds was found in just two out of 74 faecal samples (Chuang 2012). Contrary to anecdotal evidence, poultry farmers (those owning thousands of poultry) did not report thinking that the leopard cat was a pest. The ten respondents perceiving leopard cat to be a pest owned less poultry (quantities below the mean), so any loss to predators represent a greater proportion of their property. Ten per cent of respondents also admitted to killing masked palm civets, the other protected species included in this study. Just three respondents reported perceiving this small omnivorous mammals, which feed mainly on fruits, other plant parts and occasionally invertebrates (Hwang 2008; Wang and Fuller 2003), as a pest. Further, masked palm civets have never been reported to injure or kill livestock such as chickens in Taiwan.

A number of studies have used rational choice models to explore how economic incentives of illegal resource extraction should influence people's behaviour (Keane et al. 2012; Milner-Gulland and Leader-Williams 1992; Sumaila et al. 2006), but none have investigated relationships between peoples' perceived threat of sanctions and their actual non-compliant behaviour. Deterrence is created by the threats of detection and punishment being communicated to individuals who then mediate these threats before they influence behaviour; perceived deterrence may therefore be a more informative way of understanding how enforcement influences behaviour (Grasmick and Green 1980). Across all species few respondents in our study perceived any threat of capture, precluding this variable from modelling. However, evidence that violators adjust their rule-breaking behaviour in response to patrol frequency (Milner-Gulland and Clayton 2002) suggests that this factor warrants further attention. Incorporating the perceived probability of receiving a penalty into our GLMM allowed us to investigate how the probability of being punished relates to rule-breaking behaviour. Results suggest that respondents perceiving lower chances of being punished once caught, were marginally more likely to have admitted (via RRT) to killing wildlife in the three years preceding the study. Research on perceived deterrence indicates that the influence of penalties on behaviour strengthens as the perceived probability of capture increases. For example across eight illegal acts Grasmick and Bryjak (1980) reported a strengthening relationship between behaviour and severity of penalties as the perceived certainty of capture increased. The zero chance of capture perceived by most of our respondents prevented us from exploring any interaction effects between perceived probabilities of detection and punishment.

Social norms established by informal institutions have long contributed towards the management of natural resources (Berkes et al. 2000) and continue to exert influence. For example social norms influenced re-enrolment to China's grain-to-green payment for ecosystem services scheme (Chen et al. 2009) and decisions by foresters to conserve habitat (Primmer and Karppinen 2010). In this study we measured two types of social norm in order to explore their potential deterrent effects. Results from our fitted GLMMs indicate that

social approval (injunctive norms) is related to behaviour. Respondents reporting that their family and friends would disapprove of them killing wildlife were less likely to have admitted (via RRT) to killing each species as compared to respondents reporting that their friends and family would approve of such behaviours. Our findings suggest that perceptions of how others behave (descriptive norms) have a stronger influence on behaviour compared to social approval. In our model there was a negative relationship between the descriptive norm reported for each species and RRT response; people reporting that they did not know others who had killed each animal, were less likely to have admitted killing it. The stronger association between behaviour and descriptive, compared to injunctive norms may be an artifice of the 'false consensus' effect (Ross et al. 1977) whereby people bias their reports of others' behaviour in accordance with their own. This phenomenon has previously been suggested as a proxy indicator of involvement in illicit acts (Petróczi et al. 2008; St. John et al. 2012). However, relationships in our data between behaviour and both injunctive and descriptive norms, whereby behaviours typically disapproved of and not thought to be conducted by others are deterred, support the findings of others. For example, messages of social disapproval reduced environmental theft and littering (Cialdini 2003); and estimates of the number of friends' performing illegal behaviours was positively related to respondents' rule-breaking behaviour (Cross et al. 2013; Grasmick and Green 1980; Petróczi et al. 2008).

The anticipation of guilt has been shown to influence decisions to perform pro-environmental behaviours (Ahn et al. 2013) and break the law (Grasmick and Bursik 1990). In Taiwan three types of guilt have been described: Nei jiu associated with failure to fulfil obligations to others; Zui e gan associated with moral transgressions and; Fan zui gan linked to breaking rules or laws that apply to everyone (Bedford 2004). Whilst fan zui gan may be experienced when breaking rules (actual or perceived), if a rule is not accepted or known, guilt may not be associated with transgression (Bamberg and Möser 2007; Bedford 2004). The limited knowledge of wildlife laws observed in our sample may explain why we did not find any association between guilt and respondents' wildlife-killing behaviour (reported using RRT). However, clear relationships between explanatory factors and behaviour may fail to become apparent due to mismatches between information gathered and the behaviour of interest (St. John et al. 2010b), or because questions posed fail to capture the construct of interest (Robinson et al. 1991). Our statements aiming to measure guilt may have lost some of their meaning through delivery or translation although we believe our survey-delivery training and translation-back-translation procedure minimized such errors. Whilst there is considerable evidence that internalised values (e.g. attitude and social norms) influence behaviour (Armitage and Conner 2001), personal values do not always accord with the law. Therefore some people may engage in illegal acts because they do not perceive them to be wrong (Tyler 2006). As such it is possible that guilt is not always associated with rule-breaking behaviour.

Few respondents were aware that law protects leopard cat and masked palm civet and that they could be penalised if caught killing either species. This suggests that knowledge of wildlife laws is insufficient. However, whilst rules are only likely to be effective when they are known by the people whose behaviour they are designed to regulate, currently the extent

to which changes in awareness of rules translate into changes in compliance is unclear (Keane et al. 2011). There is evidence that environmental campaigns that solely provide information can be ineffective at bringing about behaviour change (Kollmuss and Agyeman 2002). Consequently, providing residents of Miaoli County with information on the characteristics and legal status of Taiwan's protected species alone may not reduce illegal hunting. However, social marketing campaigns, which apply commercial marketing concepts to promote behaviour change have had considerable success in reducing undesirable behaviours (e.g. tobacco use) and promoting desirable ones (e.g. using mosquito nets to prevent malaria) (Lee and Kotler 2011). A social marketing campaign promoting the existing social norm that killing protected species is generally disapproved of, may be an effective way of influencing the behaviour of the small minority who currently hunt illegally or seek the services of professional hunters. This information will be fed into the strategy of the Miaoli Leopard Cat Conservation Action Plan run by the Taiwan Forestry Bureau (Pei et al. 2014) which is already undertaking protection activities including establishing the Miaoli Leopard Cat Important Habitat. However, as any behaviour-change intervention takes time, conservation law enforcement will remain important. This study has drawn upon rational choice theories of crime and research in social psychology exploring the influence of social norms and guilt on people's behaviour. Other internal and external factors undoubtedly influence how people behaviour in complex social-ecological systems, however, a single study investigating all potential factors would most probably lose its practicality and meaning (Kollmuss and Agyeman 2002).

Conclusion

Investigating sensitive topics, such as the persecution of protected species, requires the use of specialised questioning techniques that provide respondents with additional assurances of confidentiality. In this study we investigated relationships between past rule-breaking behaviour, reported via RRT, and current perceptions of three potential sources of deterrence: probabilities of detection and punishment, social norms and self-imposed guilt. Our results provide evidence that social pressures influence rule-breaking behaviour even when the perceived threat of state-imposed sanctions is low. We found that two types of social norms deter wildlife persecution: perceptions of what others typically approve or disapprove of; and perceptions of how others typically behave. Whilst conventional enforcement is likely to remain an essential part of any compliance regime, harnessing social norms that encourage compliance offers potential for reducing the persecution of protected species whose survival is threatened. Critically, at a time when conservation law enforcement is receiving increased attention and adopting new technologies (often associated with war zones), care must be taken not to breakdown existing norms that encourage compliance.

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