Title: Investigating determinants of compliance with wildlife protection laws: Bird persecution in Portugal.

Authors: FAIRBRASS, Alison[a*], NUNO, Ana[a,b], BUNNEFELD, Nils[a,c], MILNER-GULLAND, EJ[a]

[a] Department of Life Sciences, Imperial College London, Silwood Park, Buckhurst Road, Ascot, SL5 7PY, UK

[b] Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter Cornwall Campus, Penryn, Cornwall TR10 9EZ, UK

[c] Biological and Environmental Sciences, School of Natural Sciences, University of Stirling, Stirling, FK9 4LA, UK

[d] Department of Zoology, University of Oxford, South Parks Road, Oxford, OX1 3PS, UK

Keywords: Avian, Attitudes, Rule Knowledge, Subjective norms, Theory of Planned Behaviour (TPB), Unmatched Count Technique (UCT)

Article Type: Original Paper

*Corresponding author: Present address: Department of Civil, Environmental and Geomatic Engineering, University College London, Gower Street, London, WC1E 6BT, UK. Email address: Alison.fairbrass.10@ucl.ac.uk. Tel: 020 7679 7831, Fax: 020 7679 3042

Abstract

Conservation interventions are generally underpinned by formal rules. These rules often suffer from high rates of non-compliance which is difficult to investigate due to its clandestine nature. Here we apply socio-psychological approaches to investigate the prevalence and determinants of three illegal bird-threatening behaviours - shooting raptors, trapping passerines for consumption, and poison use - by surveying 146 respondents in Portugal. We apply the Theory of Planned Behaviour to understand behavioural determinants, and an indirect questioning method, the Unmatched Count Technique (UCT), to estimate behaviour prevalence. The UCT estimated a high prevalence of trapping for consumption (47% SE 15) and shooting raptors (14% SE 11); both estimates being higher than from direct questioning. Poisoning had a lower prevalence according to direct questioning (7%), while the UCT generated a negative estimate suggesting that poisoning is a particularly sensitive behaviour. Different demographic groups were associated with different behaviours and determinants; men with greater rule knowledge were more likely to trap birds, while locally-born people were less likely to approve themselves, or to think others approved of, trapping. Those with more positive attitudes to poisoning were more likely to admit to it, and these positive attitudes were found more in older non-hunters. Rule knowledge was better in younger male hunters. These findings suggest that NGOs aiming to reduce poisoning could enlist the support of hunters, while locally-born people may be more receptive than others to working with NGOs to reduce trapping. These groups may be powerful allies in reducing illegal behaviours in their communities.

1. Introduction

Conservation interventions commonly rely on the use of rules and regulations to alter human behaviour (Keane et al. 2008). However rules are often rendered ineffective due to high rates of non-compliance (Rowcliffe et al. 2004). Understanding rule-breaking involves investigating the complex processes by which different factors, such as knowledge of the rules, attitudes and societal norms, combine to impact behaviour (St John et al. 2013). Effective rules are designed based on an understanding of the factors that affect compliance (Schlager 2005).

Despite having some of the strongest legal protection in the world (Stroud 2003), European birds continue to suffer from illegal persecution that threatens their conservation status (Birdlife 2011). The Portuguese Society for the Study of Birds (SPEA) has identified a number of illegal activities that continue to threaten birds in Portugal, including trapping songbirds for consumption, poison use, and shooting of raptors (Birdlife 2011). These activities are illegal under the European Birds Directive (Council Directive 79/209/EEC) and the Berne Convention (19.IX.1979), both of which Portugal is a signatory. Despite investigation of these behaviours in neighbouring Mediterranean countries (Martínez-Abraín et al. 2013; Mateo-Tomás et al. 2012; Murgui 2014) there remains limited information on the prevalence of these activities in Portugal (Birdlife 2011). Without data on prevalence rates and the demographic groups involved it remains difficult to tackle these issues.

Identifying ineffective conservation rules requires understanding associated rates of non-compliance, the true extent of which is difficult to quantify. Participants' fear of reprimand and legal sanction makes investigation susceptible to bias due to low response rates and evasive answers (Gavin et al. 2010). Indirect questioning techniques have been developed to minimize these sources of bias and have been applied to the investigation of conservation problems (Nuno and St John 2014). The Unmatched Count Technique (UCT) (Droitcour et al. 1991) has been shown to work well when investigating sensitive behaviours that threaten wildlife (Nuno et al. 2013). In the western Serengeti, researchers using direct questions to assess prevalence of illegal bushmeat hunting reported participation rates of between 8 (Kaltenborn et al. 2005) and 57 percent (Loibooki et al. 2002) of

62 households, depending on the study. In the same area of the Serengeti, a UCT study reduced rates of
63 evasive answers and suggested that 18% (SE 5) of people hunted bushmeat illegally (Nuno et al.
64 2013).

65 To intervene effectively, it is not only necessary to know the prevalence of behaviours, but also the
66 characteristics of those involved, and what affects their personal choices to comply. Socio-
67 psychological models have been advocated to investigate the complexities of the decision-making
68 process in conservation (Schlüter et al. 2012; St John et al. 2010). The Theory of Planned Behaviour
69 (TPB) (Ajzen 1985), a well-researched theory of human behaviour, posits that an individual's
70 behavioural intention is shaped by three aspects; their attitude towards a behaviour, their perceptions
71 of social expectations (subjective norms), and the measure of control they perceive they have over
72 performing a behaviour (perceived behavioural control; Fig. 1). Meta-analyses of studies using the
73 TPB to investigate multi-domain (Armitage and Connor 2001) and pro-environmental (Bamberg and
74 Moser 2007) behaviours illustrate the importance of these aspects in predicting behavioural intention,
75 while highlighting the need to expand the TPB with additional aspects to increase its explanatory
76 power.

77 The TPB has been applied to the investigation of compliance with rules regarding digital downloading
78 (Wang and McClung 2011), drug use (Armitage et al. 1999), and recently to compliance with
79 wildlife-protection laws (Shrestha et al. 2012). Normative compliance is influenced by what people
80 regard as just and moral. The TPB reveals psychological aspects relevant to normative compliance in
81 the form of personal attitudes and perceived social norms. The different aspects of the TPB
82 framework vary in their influence, depending on the behaviour. For example, attitudes have been
83 found to be of importance in relation to the conservation of forest habitat (Primmer and Karppinen
84 2010), natural resource use (Holmes 2003) and illegal poaching (St John et al. 2012), but not
85 compliance with protected area restrictions (Aipanjiguly et al. 2003; Seeland et al. 2002). Subjective
86 norms have been shown to influence conservation behaviours including compliance with fishery
87 regulations (Gezelius 2004; Hatcher et al. 2000) and protected area restrictions (Aipanjiguly et al.
88 2003) and to vary in importance by behaviour and demographic group (Beedell and Rehman 2000;

89 Zubair and Garforth 2006). Identification of the most important behaviour-specific aspect(s) of the
90 TPB can inform the design of behaviour-change interventions (St John et al. 2013).

91 Instrumental compliance is the behaviour occurring in response to external factors, such as formal
92 rules and regulations. Knowledge of conservation rules may influence a person's behaviour and
93 compliance (Keane et al. 2011) but there is limited evidence as to the routes by which it affects
94 behavioural intention (whether directly, or through aspects of the TPB; Fig. 1). We use the TPB to
95 investigate the influence of attitudes, subjective norms, and rule knowledge on the decisions of
96 individuals to comply with wildlife-protection laws. Rather than explicitly testing the theory itself, we
97 chose key aspects of the TPB to frame the investigation of predictors of compliance (knowledge,
98 attitudes and subjective norms), similar to previous work (Steinmetz et al. 2014). We do not
99 investigate perceived behavioural control, because our study aims to explore the TPB aspects most
100 relevant to the public engagement activities of NGOs.

101 As well as understanding the predictors of non-compliance, it is also important to understand the
102 characteristics of rule-breakers. Hunting, including of birds, is an important part of rural culture in
103 Portugal, practiced by 8% of the adult male population (Apollonio et al. 2010), although the number
104 of younger hunters has been decreasing. Laying of poison in this region is associated with the control
105 of pest and predator species on agricultural and hunting land (Hernández and Margalida 2008). We
106 investigate three demographic characteristics: age, gender, and locality of birth, to test whether the
107 individuals associated with the illegal activities investigated are similar to the demographics typical of
108 the Portuguese hunting and agricultural industries i.e. the older, rural male population.

109 We apply the UCT to estimate prevalence rates and the TPB to identify important behaviour-specific
110 aspects of three illegal behaviours that threaten biodiversity in Portugal: the shooting of raptors,
111 trapping of passerines for consumption, and use of poison to control wild animals (Birdlife 2011).
112 Given the lack of data for validation purposes, we followed previous researchers' assumption that any
113 prevalence estimate produced by the UCT higher than one produced by direct questioning is
114 potentially more accurate (Dalton et al. 1994; Rayburn et al. 2003; Tsuchiya et al. 2007). We test the

UCT alongside direct questioning to assess whether it does estimate higher prevalence rates in this study system. To investigate predictors of the three behaviours, we apply the TPB to quantify the role of attitudes, subjective norms, and wildlife rule knowledge on individuals' self-reported behaviours under direct questioning.

2. Materials and Methods

2.1 Study system and population

Portugal supports 308 bird species, including eight globally threatened species including *Neophron percnopterus* (Egyptian Vulture) (Birdlife International 2014). Hunting, including of birds, is an important part of rural Portuguese culture, practiced by 8% of the adult male population (Apollonio et al. 2010). A general hunting licence is required to hunt game birds in Portugal, which is obtained by passing an examination on hunting capabilities and knowledge.

2.2 Data collection

Between 1st and 31st May 2012 interviews were conducted in two villages in the Alentejo, Portugal. Village identities are not reported to preserve respondents' anonymity. The two villages had demographic and livelihood profiles consistent with the region as a whole but were of interest due to the presence of an environmental organisation in one of the villages (Village A). This organisation had not worked on hunting or bird conservation, but was interested in our findings. Village B had a slightly larger population than A, and was the location for meetings of a local hunting association. 146 interviews were conducted in Portuguese, by the first author (AF) or local interpreters. Sampling was conducted opportunistically through household visits. In 48 households, two interviews were conducted with different household members simultaneously in separate rooms. These interviews were treated as independent data points, because decisions about the behaviours concerned are made by individuals not at household level. As a pilot methodological study, issues of non-independence could not be addressed with the sample size available; for this reason the study focus is on areas of future investigative potential rather than drawing general conclusions about the wider population. Research was conducted according to the Imperial College London research ethics policy.

2.3 Interview protocol

Respondents were randomly assigned to a control or treatment group for the UCT using a coin toss. The questionnaire commenced with an explanation of the study purpose, the interviewer's independent student status, and assurances that participants' responses would be anonymous, at which point respondents could decline to proceed. Consenting respondents (146/147) were firstly asked several socio-demographic questions, then administered the UCT, followed by a series of attitudinal questions, a rule knowledge quiz, a series of perceived subjective norms questions, and finally the direct questions.

To administer the UCT, respondents were shown four cards, one initial non-sensitive training card, and one card for each of the three behaviours investigated. For each card, respondents were asked to state a number in response to the question, "How many of these activities have you conducted in the past 12 months?". Each control card depicted four non-sensitive behaviours. Each treatment card contained the addition of one of the illegal behaviours under investigation. Cards were shown to all respondents in the same order. All non-sensitive items related to legal behaviours typical of the local population and were chosen based on the authors' knowledge of the study system. Items were grouped based on similarity of activity. For example, catching wild birds was grouped with other activities related to harvesting resources, such as picking olives. Laying of poison was grouped with other activities related to the use of chemical substances such as the use of insect repellent.

Next, respondents were asked about their attitudes toward the three investigated behaviours by stating on a seven-point Likert scale (1="completely disagree" through 7="completely agree") their feelings towards the statements, "[Conducting specific sensitive behaviour] *would be useful*", and, "[Conducting specific sensitive behaviour] *would be enjoyable*".

Next, respondents were shown a randomised series of cards depicting 13 Portuguese animal species accompanied by their locally-common names and asked to state whether killing of the species was '*always legal*', '*always illegal*', or '*legal only at certain times of the year*'.

Respondents were then asked about their perceived subjective norms by stating in a seven-point Likert scale their feelings towards the statements "*The majority of people in this village* [conduct specific sensitive behaviour]", "*The majority of people important to me think that I should/I should not* [conduct specific sensitive behaviour]", and "*The approval of my family and friends is important to me*.".

Finally, respondents were asked the direct question, "Have you undertaken [sensitive behaviour] in the past 12 months?", and asked to respond with either "Yes", "No", "I don't know", or "I don't want to answer". The order of asking about the three behaviours was randomised. A sample questionnaire, full list of UCT behaviours, and full list of the species tested and protection status are provided in the Electronic Supplementary Material.

2.4 Statistical Analysis

2.4.1 Prevalence estimates

UCT prevalence estimates were calculated as the mean difference between the sample means of the UCT treatment (74) and control (72) group counts (i.e. number of self-reported activities). As respondents were randomly assigned to the two groups, the difference in means represents the estimated proportion of the treatment group engaging in the sensitive behaviour. Welch's t-test was employed to calculate the standard error of the estimates as the variance of the error term was likely to be different between the two groups. Direct question prevalence estimates were calculated as the proportion of respondents who answered "Yes" to the direct questions regarding participation in each behaviour investigated.

2.4.2 Multivariate analysis

One drawback of the UCT is that large sample sizes are required to conduct multivariate analysis using UCT counts. Unfortunately the sample size of this study was not sufficient to reliably conduct multivariate analysis with the UCT data. Instead, multivariate analysis was used to identify predictors of two illegal behaviours based on the direct question data. TPB variables were used as predictor

191 variables, as well the demographic variables which were judged to be of importance. Due to the small
192 number of respondents answering affirmatively to the direct question regarding shooting of raptors
193 this behaviour was omitted from multivariate analysis. Those answering positively to direct questions
194 are a biased sub-sample of those who have actually undertaken the behaviour (hence the need for
195 indirect questioning for accurate prevalence estimation). Therefore, the results of this analysis are an
196 indication of who is prepared to admit to the behaviour rather than of who is actually undertaking it.

197 Data were visually assessed for normality. The two variables related to attitude were combined to
198 generate a composite score, and similarly for the two variables related subjective norms. Composite
199 scores were not checked for internal consistency as they were a product of just two variables each.
200 These two composite scores, along with the answer to whether others' approval mattered to the
201 respondent, were binomially transformed, due to their positive skew. To estimate the correlates of
202 behaviour, generalised linear models (GLMs) were fitted with a binomial error structure and a logit
203 link function, with respondents' direct question answers as binomial dependent variables. Where TPB
204 variables were included in the top models, their predictors were investigated using GLMs fitted with
205 binomial error structure and a logit link function, with composite attitude, social norm, and approval
206 scores as binomial dependent variables. Residuals of all models were checked with QQ-plots and
207 found to be Normal.

208 Knowledge scores were computed as the total of correctly answered questions regarding the legal
209 protection of 13 Portuguese animal species, and arc-sine transformed for normality. GLMs fitted with
210 a Gaussian error structure were employed to model knowledge scores against demographic and TPB
211 variables. Respondents' ability to correctly classify species' protection status (game, protected,
212 unregulated) was compared using Wilcoxon paired-tests for proportional data.

213 In all multivariate analyses, the relative importance of predictor variables was computed as the sum of
214 the Akaike weights (based on the Akaike information criterion, AIC) for the variables included in the
215 averaged models (Burnham and Anderson 2002). GLMs were fitted in R v.2.15.1 (R Development
216 Core Team 2011). Parameter estimates were averaged across models with $\Delta AIC < 4$, and the

corrected AIC was used to select and rank the most parsimonious models using the MuMIn package v.1.7.7 (Bartoń 2012). Details of predictor variables and models considered are given in the Electronic Supplementary Material.

3. Results

3.1 Sample characteristics

More men (60%) were interviewed than women (40%). The treatment group contained significantly more men (Treatment: 70% Control: 49%, χ^2 (1)=6.24, p=0.013) and non-significantly more hunters (T: 32% C: 18%, χ^2 (1)=3.26, p=0.071) than the control group. The groups did not differ by age (χ^2 (7)=8.16, p=0.32), village (χ^2 (1)=0.055, p=0.81), knowledge (two-sample t-test (144)=-0.15, p= 0.56), or locality of birth (χ^2 (1)=0.99, p=0.32).

3.2 Prevalence estimates

UCT prevalence estimates suggest that trapping birds for consumption was conducted by approximately 47% (15 SE) and shooting of raptors by approximately 14% (11 SE) of respondents during the 12 months prior to interview, 31% and 12% higher than direct question estimates respectively (Fig. 2). In the case of poison use, the UCT failed to produce a valid prevalence estimate, estimating a negative prevalence rate for the behaviour (Fig. 2).

3.3 Correlates of trapping and poison use behaviours

Due to the small sample size of this study, the direct question results were used to investigate determinants of the illegal behaviours rather than the results of the UCT, which limits inference to the characteristics of people prepared to admit to the behaviour in question. Individuals admitting to trapping birds for consumption in answer to a direct question tended to be male hunters who scored highly on the knowledge quiz (Table. 1). Those admitting to trapping were more likely to come from village B. Three variables from the TPB, relating to social norms, social approval and individual attitudes, were also positively but weakly related to admitting to trapping (Table 1). The admission of using poison to control populations of wild animals was strongly predicted by an individual's attitude

242 towards the behaviour, with individuals with a positive attitude being more likely to admit to
243 engaging in it (Table. 1).

244 **3.4 Correlates of underlying constructs affecting trapping and poison use**

245 We investigated the correlates of TPB aspects that were included in the minimum model set for
246 trapping birds (attitudes, approval and social norms). The main correlate of all three aspects was
247 respondents' location of birth (Table. 2). Locally born respondents held a more negative attitude
248 towards trapping and perceived it to be less socially acceptable, while also attributing less importance
249 to the approval of others. Older hunters perceived trapping to be less socially-acceptable, while male
250 respondents attributed greater importance to the approval of others. We investigated the correlates of
251 attitudes surrounding poison use, as attitude was an important predictor in the minimum model set.
252 Individuals who held a positive attitude towards poison use tended not to hold a hunting licence, to be
253 older, and scored highly on the knowledge quiz (Table. 2).

254 **3.5 Knowledge of wildlife laws**

255 Respondents correctly classified on average 86% of protected and unregulated species and 65% of
256 game species. Game species were correctly classified significantly less often than protected
257 (W=968.5, p=<0.001, paired-test) and unregulated species (W=1163.5, p=<0.001, paired-test).
258 Knowledge of wildlife laws was a relatively important correlate of admitting to trapping birds for
259 consumption and was strongly associated with age, gender, and possession of a hunting licence
260 (Table. 3). Younger male respondents scored highest in the quiz, while respondents in possession of a
261 hunting permit scored higher than those without (W=1063, p=<0.001). Respondents from village B
262 performed better than respondents from village A, and locally born respondents performed better than
263 those born outside the local area.

264 **4. Discussion**

265 Here we use two socio-psychological approaches, the UCT and the TPB, to investigate illegal
266 wildlife-threatening behaviours. The UCT revealed that trapping birds for consumption remains

widely practiced in our sample, and that a smaller number of people continue to shoot raptor species. Our analysis indicated that the characteristics of self-confessed rule-breakers were behaviour-specific. A positive attitude towards poisoning was found to be the most important correlate of admitting to poison use whereas men from one of the villages and those with a good knowledge of game laws were more likely to admit to trapping birds for consumption. We also showed that the demographic groups who approved of these behaviours differed. Those who felt trapping was socially acceptable and held a positive attitude towards this behaviour tended to be from outside the area, while those admitting to poisoning were less likely to be registered hunters.

There currently exists only limited and anecdotal information on the prevalence of shooting, trapping and poisoning of birds in Portugal (Birdlife 2011). Our results reveal that Portuguese bird populations continue to be threatened by these illegal activities, and that the demographics of offenders differ between the activities. Ongoing initiatives include a broad national assessment of illegal bird persecution behaviours in Portugal which has focused on law enforcement records, advertisements in online platforms, reports on injured, sick and dead animals, and direct observation reports by the public (Leitão et al. 2014). Our results highlight the need for further investigation into this topic using techniques from social science to understand the attitudes and characteristics of offenders. There is also a need for greater conservation attention on these behaviours in Portugal, and in the other Mediterranean countries where these behaviours remain widespread.

The characteristics of respondents admitting to catching birds for consumption were congruent with a formal association to hunting. This finding suggests that a targeted conservation intervention to tackle this behaviour in the region should focus resources on changing behaviours of the hunting community. Respondents admitting to using poison to control populations of wild animals were strongly predicted by expressing a positive attitude towards this behaviour and tended not to be hunters. Examples of conservation behaviour-change interventions elsewhere suggest that members of local hunting organisations are likely to influence attitudes and subjective norms of the local community more than external environmental organisations (Heberlein 2012). This, together with the

293 importance of holding a hunting licence as a correlate in our models for knowledge and attitudes,
294 suggests that Portuguese hunters are potential partners for organisations wishing to tackle poison use
295 in this region. A partnership between hunting associations and *Programa Antídoto*, a national
296 platform incorporating a range of organisations dedicated to tackling this issue, could focus on
297 influencing the attitudes of non-hunters towards the use of poison in Portugal. Successful partnership
298 on this issue may then make it easier to work with hunters to reduce their trapping of songbirds for
299 consumption.

300 Our results suggest that the UCT was effective in reducing the response bias associated with
301 investigation of two illegal activities, but not for poison use. It is unclear why this might be in the
302 absence of more detailed study. The confidence interval of the UCT overlaps both zero and the
303 estimate of the direct question, suggesting that people were answering the sensitive card in a strategic
304 manner to avoid revealing their behaviours. One explanation may be that poison use is a highly
305 sensitive behaviour because of its indiscriminate nature; there were anecdotal claims that domestic
306 pets had been killed by poisoning in the villages and that this was a source of conflict between people.
307 The direct question regarding poison use noticeably elicited the most evasive answers, with one
308 respondent refusing to respond and two respondents appearing to give false negative answers. It has
309 been argued that conservationists should take advantage of social taboos by using them in partnership
310 with formal rules, involving cooperation between conservationists and local communities (Colding
311 and Folke 2001). This supports our argument for a partnership between the Portuguese hunting and
312 conservation communities to tackle poison use, with hunters strengthening the social taboo of the use
313 of poison and acting as advocates for conservation.

314 Alternatively, it may also be that the non-sensitive behaviours on this card were not well aligned with
315 the sensitive behaviour, revealing it too clearly as being an outlier. This experience highlights the
316 limitations even of indirect questioning methods when the behaviour concerned is seen as particularly
317 shameful, when prevalences are relatively low and sample sizes small.

Unfortunately we did not have the sample size to be able to use the UCT results in the TPB model. A larger sample size would have allowed this work to be extended to use the UCT estimates in multivariate analyses including socio-psychological constructs, thereby producing an integrated approach to investigating illegal behaviours. We propose that such an integrated approach could facilitate the investigation of illegal and socially-unacceptable behaviours that threaten biodiversity, and could be used to supplement SPEA's ongoing investigation into illegal activities in Portugal. Our results suggest that the illegal trapping of birds for consumption, use of poison to control populations of wild animals, and shooting of raptor species continue to be practiced in Portugal. Future conservation efforts aimed at combating these activities require a greater understanding of the characteristics of the demographic groups undertaking each activity, and of the attitudes and perceived subjective norms which they hold. Conservation interventions designed to alter human behaviours must take these differences into account and should tailor behaviour-changing interventions to specific activities and target groups.

5. Acknowledgements

We thank the Centro de Convergência, research assistants and respondents for supporting the study. AF was supported by Imperial College London. AN was supported by the Portuguese Foundation for Science and Technology (FCT; doctoral grant SFRH/BD/43186/2008). NB acknowledges the financial support of the European Commission under the HUNT project of the Seventh Framework Programme for Research and Technological Development. This paper is a contribution to Imperial College's Grand Challenges in Ecosystems and the Environment initiative. This study complies with the current laws of the countries in which it was performed. The authors declare that they have no conflict of interest.

6. Electronic Supplementary Material

The Electronic Supplementary Material contains Portuguese and English versions of the study questionnaire, UCT protocol and example set of UCT cards, list of the species included in the

343 knowledge quiz and their protection status, and a summary of the predictor variables used in the
344 multivariate analysis and details of all models considered.

345 **7. References**

346 Aipanjiguly S, Jacobson SK, Flamm R (2003) Conserving manatees: knowledge, attitudes, and
347 intentions of boaters in Tampa Bay, Florida. Conserv Biol 17:1098-1105 doi:10.1046/j.1523-
348 1739.2003.01452.x

349 Ajzen I (1985) From intentions to actions: A theory of planned behaviour. In: Kuhl J, Beckman J
350 (eds) Action-control: From Cognition to Behaviour. Springer, Heidelberg, Germany, pp 11-39

351 Apollonio M, Andersen R, Putman R (2010) European ungulates and their management in the 21st
352 century. Cambridge University Press, Cambridge

353 Armitage CJ, Conner M, Loach J, Willetts D (1999) Different perceptions of control: Applying an
354 extended theory of planned behavior to legal and illegal drug use. Basic and Applied Social
355 Psychology 21:301-316 doi:10.1207/S15324834BASP2104_4

356 Armitage CJ, Connor M (2001) Efficacy of the Theory of Planned Behaviour: A meta-analytic
357 review. Brit J Soc Psychol 40:471–499 doi:10.1348/014466601164939

358 Bamberg S, Moser G (2007) Twenty years after Hines, Hungerford, and Tomera: A new meta-
359 analysis of psycho-social determinants of pro-environmental behaviour. Journal of Environmental
360 Psychology 27:14-25 doi:10.1016/j.jenvp.2006.12.002

361 Bartoń K (2012). Package 'MuMIn'. Multi-model inference (1.12.1). http://cran.r-
362 project.org/web/packages/MuMIn/index.html. Accessed 9/01/2015

363 Beedell J, Rehman T (2000) Using social-psychology models to understand farmers' conservation
364 behaviour. Journal of Rural Studies 16:117–127 doi:10.1016/S0743-0167(99)00043-1

365 Birdlife (2011) Review of the Illegal Killing and Trapping of Birds in Europe. Paper presented at the
366 European Conference on Illegal Killing of Birds, Larnaca, Cyprus, 6-8 July

Birdlife International (2014) Country profile: Portugal. http://www.birdlife.org/datazone/country/portugal. Accessed 19/05/2014

Burnham KP, Anderson DR (2002) Model selection and multimodel inference : a practical information-theoretic approach. 2nd ed. edn. Springer, New York

Colding J, Folke C (2001) Social taboos: "Invisible" systems of local resource management and biological conservation. Ecol Appl 11:584-600 doi:10.2307/3060911

Council Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds.

Council of Europe Convention 19.IX.1979 of 19 September 1979 on the Conservation of European Wildlife and Natural Habitats.

Dalton DR, Wimbush JC, Daily CM (1994) Using the unmatched count technique (UCT) to estimate base rates for sensitive behavior. Pers Psychol 47:817-828 doi:10.1111/j.1744-6570.1994.tb01578.x

Droitcour J, Caspar RA, Hubbard ML, Parsley TL, Visscher W, Ezzati TM (1991) The item count technique as a method of indirect questioning - a review of its development and a case-study application. In: Biemer PP, Groves RM, Lyberg LE, Mathiowetz NA, Sudman S (eds) Measurement Errors in Surveys. John Wiley & Sons, Inc., New Jersey, USA, pp 185-210

Gavin MC, Solomon JN, Blank SG (2010) Measuring and monitoring illegal use of natural resources. Conserv Biol 24:89-100 doi:10.1111/j.1523-1739.2009.01387.x

Gezelius SS (2004) Food, money, and morals: Compliance among natural resource harvesters. Hum Ecol 32:615-634 doi:10.1007/s10745-004-6099-5

Hatcher A, Jaffry S, Thebaud O, Bennett E (2000) Normative and social influences affecting compliance with fishery regulations. Land Econ 76:448-461 doi:10.2307/3147040

Heberlein TA (2012) Navigating environmental attitudes. Oxford University Press, Oxford

Hernández M, Margalida A (2008) Pesticide abuse in Europe: effects on the Cinereous vulture (*Aegypius monachus*) population in Spain. Ecotoxicology 17:264-272 doi:10.1007/s10646-008-0193-1

392 Holmes CM (2003) The influence of protected area outreach on conservation attitudes and resource
393 use patterns: a case study from western Tanzania. Oryx 37:305-315 doi:10.1017/S0030605303000565

394 Kaltenborn BP, Nyahongo JW, Tingstad KM (2005) The nature of hunting around the western
395 corridor of Serengeti National Park, Tanzania. Eur J Wildlife Res 51:213-222 doi:10.1007/s10344-
396 005-0109-9

397 Keane A, Jones JPG, Edwards-Jones G, Milner-Gulland EJ (2008) The sleeping policeman:
398 understanding issues of enforcement and compliance in conservation. Anim Conserv 11:75-82
399 doi:10.1111/j.1469-1795.2008.00170.x

400 Keane A, Ramarolahy AA, Jones JPG, Milner-Gulland EJ (2011) Evidence for the effects of
401 environmental engagement and education on knowledge of wildlife laws in Madagascar. Conserv Lett
402 4:55-63 doi:10.1111/j.1755-263X.2010.00144.x

403 Leitão D, Costa J, Lopes P (2014) Captura ilegal de aves: avaliação preliminar.
404 http://www.spea.pt/fotos/editor2/sagres2014capilegalaves.pdf. Accessed 3rd October 2014

405 Loibooki M, Hofer H, Campbell K, East ML (2002) Bushmeat hunting by communities adjacent to
406 the Serengeti National Park, Tanzania: the importance of livestock ownership and alternative sources
407 of protein and income. Environ Conserv 29:391-398 doi:10.1017/S0376892902000279

408 Martínez-Abraín A, Crespo J, Berdugo M, Gutiérrez L, Lafuente A, Mañas A, de Miguel JM (2013)
409 Causes of human impact to protected vertebrate wildlife parallel long-term socio-economical changes
410 in Spain. Anim Conserv 16:286-294 doi:10.1111/j.1469-1795.2012.00599.x

411 Mateo-Tomás P, Olea PP, Sánchez-Barbudo IS, Mateo R (2012) Alleviating human–wildlife
412 conflicts: identifying the causes and mapping the risk of illegal poisoning of wild fauna. J Appl Ecol
413 49:376-385 doi:10.1111/j.1365-2664.2012.02119.x

414 Murgui E (2014) When governments support poaching: a review of the illegal trapping of thrushes
415 *Turdus* spp. in the *parany* of Comunidad Valenciana, Spain. Bird Conservation International 24:127-
416 137. doi:10.1017/S095927091300052X

417 Nuno A, St John FAV (2014) How to ask sensitive questions in conservation: A review of specialized
418 questioning techniques. Biol Conserv. doi:10.1016/j.biocon.2014.09.047

419 Nuno ANA, Bunnefeld N, Naiman LC, Milner-Gulland EJ (2013) A novel approach to assessing the
420 prevalence and drivers of illegal bushmeat hunting in the Serengeti. Conserv Biol 27:1355-1365
421 doi:10.1111/cobi.12124

422 Primmer E, Karppinen H (2010) Professional judgment in non-industrial private forestry: Forester
423 attitudes and social norms influencing biodiversity conservation. Forest Policy and Economics
424 12:136-146 doi:10.1016/j.forpol.2009.09.007

425 R Development Core Team (2011). R: A language and environment for statistical computing.
426 (2.15.1). http://www.R-project.org. Accessed 18/11/2014

427 Rayburn NR, Earleywine M, Davison GC (2003) Base rates of hate crime victimization among
428 college students. J Interpers Violence 18:1209-1221 doi:10.1177/0886260503255559

429 Rowcliffe JM, de Merode E, Cowlishaw G (2004) Do wildlife laws work? Species protection and the
430 application of a prey choice model to poaching decisions. P Roy Soc Lond B Bio 271:2631-2636
431 doi:10.1098/rspb.2004.2915

432 Schlager E (2005) Getting the relationships right in water property rights. In: Bruns BR, Ringler C,
433 Meinzen-Dick RS (eds) Water Rights Reform: Lessons for Institutional Design. International Food
434 Policy Research Institute, Washinton DC, USA, pp 27-54

435 Schlüter M et al. (2012) New horizons for managing the environment: A review of coupled social-
436 ecological systems modeling. Nat Resour Model 25:219-272 doi:10.1111/j.1939-7445.2011.00108.x

437 Seeland K, Moser K, Scheuthle H, Kaiser FG (2002) Public acceptance of restrictions imposed on
438 recreational activities in the peri-urban Nature Reserve Sihlwald, Switzerland. Urban for Urban Gree
439 1:49-57 doi:10.1078/1618-8667-00006

440 Shrestha SK, Burns RC, Pierskalla CD, Selin S (2012) Predicting deer hunting intentions using the
441 Theory of Planned Behavior: a survey of Oregon big game hunters. Human Dimensions of Wildlife
442 17:129-140 doi:10.1080/10871209.2012.649885

443 St John FAV, Edwards-Jones G, Jones JPG (2010) Conservation and human behaviour: lessons from
444 social psychology. Wildlife Res 37:658-667 doi:10.1071/Wr10032

445 St John FAV, Keane AM, Edwards-Jones G, Jones L, Yarnell RW, Jones JPG (2012) Identifying
446 indicators of illegal behaviour: carnivore killing in human-managed landscapes. P Roy Soc B-Biol Sci
447 279:804-812 doi:10.1098/rspb.2011.1228

448 St John FAV, Keane AM, Milner-Gulland EJ (2013) Effective conservation depends upon
449 understanding human behaviour. In: Macdonald DW, Willis KJ (eds) Key Topics in Conservation
450 Biology 2. John Wiley & Sons, Chichester, UK, pp 344-361

451 Steinmetz R, Srirattanaporn S, Mor-Tip J, Seuaturien N (2014) Can community outreach alleviate
452 poaching pressure and recover wildlife in South-East Asian protected areas? J Appl Ecol 51:1469-
453 1478 doi:10.1111/1365-2664.12239

454 Stroud DA (2003) The status and legislative protection of birds of prey and their habitats in Europe.
455 In: Thompson DBA, Redpath SM, Fielding AH, Marquiss M, Galbraith CA (eds) Birds of prey in a
456 changing environment. TSO, Edinburgh, pp 51-84

457 Tsuchiya T, Hirai Y, Ono S (2007) A study of the properties of the item count technique. Public Opin
458 Quart 71:253-272 doi:10.1093/Poq/Nfm012

459 Wang X, McClung SR (2011) Toward a detailed understanding of illegal digital downloading
460 intentions: An extended theory of planned behavior approach. New Media & Society 13:663-677
461 doi:10.1177/1461444810378225

462 Zubair M, Garforth C (2006) Farm level tree planting in Pakistan: the role of farmers' perceptions and
463 attitudes. Agroforestry Systems 66:217–229 doi:10.1007/s10457-005-8846-z

464 **8. Figures**

Fig. 1 Adapted model of the theory of planned behaviour which includes knowledge of conservation rules as a predictor of behavioural intention, attitudes, and subjective norms. Knowledge may affect several aspects so we consider multiple pathways. Shading indicates the aspect not present in Ajzen's (1985) original model. Dashed lines indicate relationships that were investigated in this study

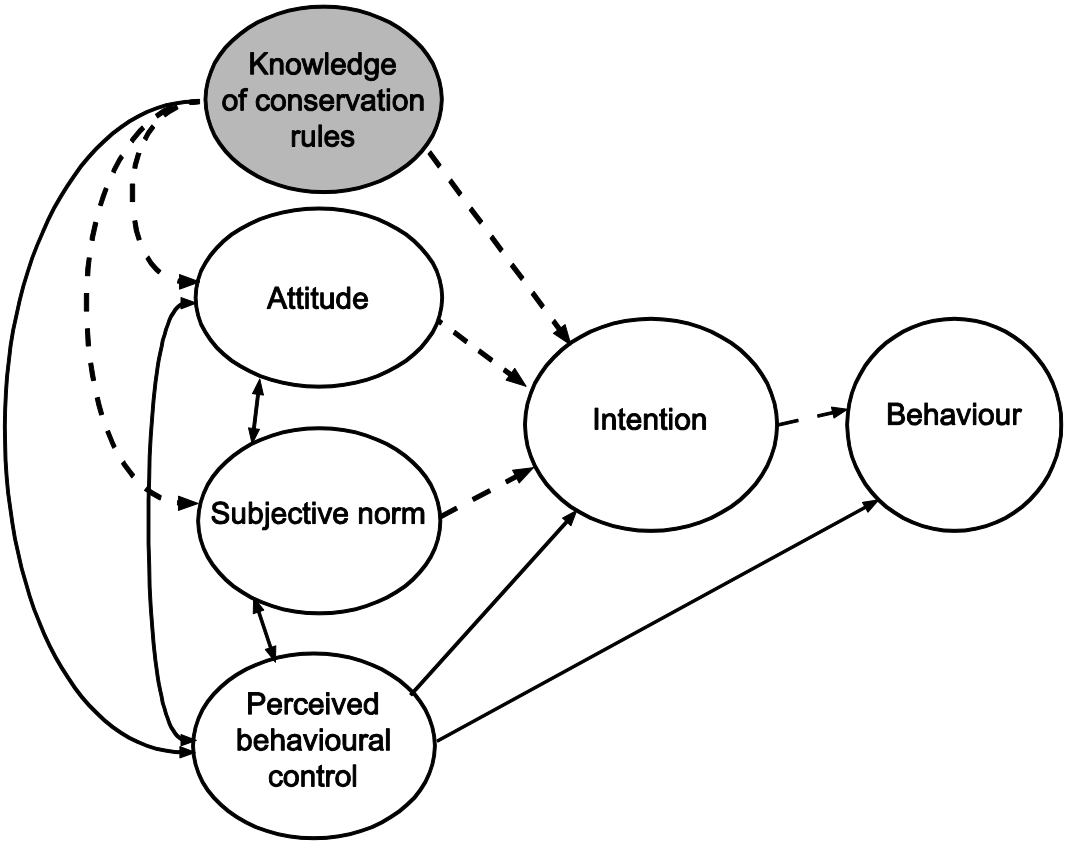
Fig. 2 Prevalence rates (+/- standard error) estimated by the UCT and direct questions for illegal trapping of birds for consumption, shooting of raptors, and use of poison in the villages in the 12 months prior to the study

9. Tables

Table. 1 Parameter estimates obtained from the averaged generalised linear models for answers to direct question about (a) trapping birds for consumption, and (b) using poison. Variables of importance <40% omitted

Table. 2 Parameter estimates obtained from the averaged generalised linear models for : (a) perceived subjective norms of trapping birds for consumption, (b) attitudes towards trapping birds for consumption, (c) respondent's stated importance of approval, and (d) attitudes towards poison use. Variables of importance <40% omitted

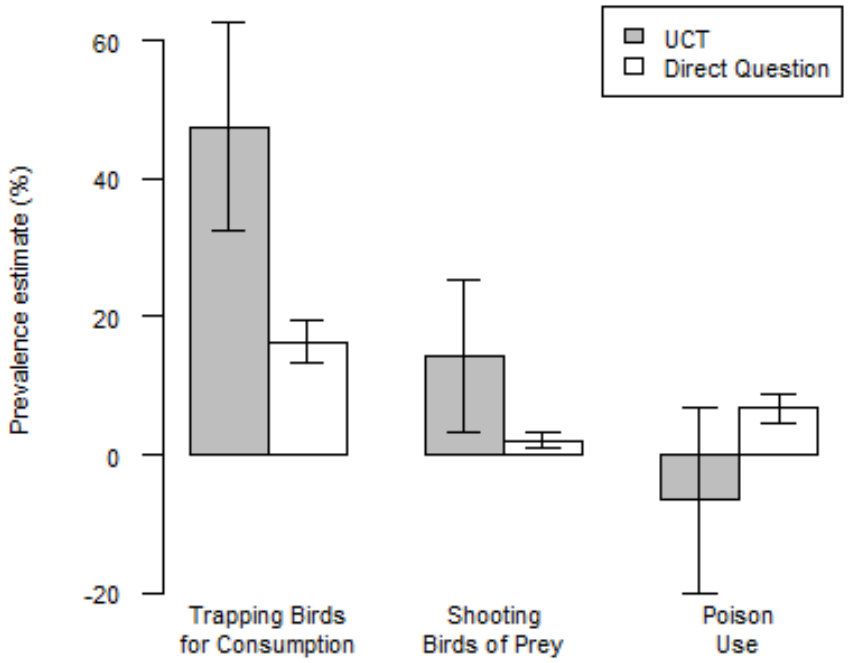
Table. 3 Parameter estimates obtained from the full generalised linear model of knowledge of wildlife laws. Variables of importance <40% omitted



483

484 **Fig. 1**

485



486

487 **Fig. 2**

488

489 **Table. 1**

Parameter	**Estimate**	**S.E.**	**z-value**	**Relative variable importance**
(a) Model of predictors of answers to direct questions about trapping birds for consumption				
Intercept	-7.470	2.051	3.622	1
Gender: Male	2.630	1.108	2.353	1
Knowledge	2.358	1.131	2.069	0.85
Village: B	1.169	0.555	2.088	0.83
Hunting permit: Yes	0.949	0.597	1.578	0.54
Social norm	0.939	0.627	1.486	0.52
Approval	0.797	0.604	1.310	0.47
Attitude	0.822	0.588	1.386	0.46
(b) Model of predictors of answers to direct questions about poison use				
Intercept	-4.623	1.352	3.395	1
Attitude	2.664	0.833	3.170	1

490

491

492 **Table. 2**

Parameter	**Estimate**	**S.E.**	**z-value**	**Relative variable importance**
(a) Model of predictors of perceived subjective norms of trapping birds for consumption				
Intercept	2.728	0.928	2.918	1
Local Born: Yes	-2.104	0.771	2.704	1
Age	-0.015	0.010	1.487	0.52
Hunting permit: Yes	-0.520	0.442	1.168	0.42
(b) Model of predictors of attitudes towards trapping birds for consumption				
Intercept	1.677	0.753	2.211	1
Local Born: Yes	-1.291	0.586	2.182	0.97
(c) Model of predictors of respondents stated importance of approval				
Intercept	0.839	0.624	1.336	1
Local Born: Yes	-1.253	0.484	2.567	1
Gender: Male	0.495	0.379	1.296	0.46
(d) Model of predictors of attitudes towards poison use				
Intercept	-2.538	1.374	1.839	1
Hunting Permit: Yes	-1.748	0.678	2.560	1
Age	0.023	0.012	1.969	0.83
Knowledge	1.387	0.931	1.477	0.52

493

494 **Table. 3**

Parameter	Estimate	S.E.	z-value	Relative variable importance
Intercept	1.083	0.064	16.746	1
Age	-0.002	0.001	2.527	1
Hunting Permit: Yes	0.195	0.052	3.661	1
Gender: Male	0.114	0.043	2.582	1
Village: B	0.069	0.042	1.624	0.57
Local Born: Yes	0.065	0.052	1.240	0.43

495