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Perceived entertainment and recreational value motivate illegal hunting in Southwest China

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A B S T R A C T

Globally, the overexploitation of wildlife presents one of the greatest challenges for biodiversity conservation and sustainable rural livelihoods. Research on the human dimensions of hunting is critical for identifying potential levers for behavioral change interventions. This is especially true in China where hunting threatens to extirpate avian species such as the green peafowl (*Pavo muticus*) and great hornbill (*Buceros bicornis*). Nevertheless, regulations restricting gun ownership and hunting have made interviews on this topic highly sensitive. Direct questions about conservation non-compliance are often affected by response bias such as refusals to answer or self-protective denials.

We used the randomized response technique (RRT) to estimate the prevalence and drivers of illegal hunting targeting four focal bird taxa (barbets, bulbuls, partridges, and pheasants). Furthermore, we used statistical models that have recently been introduced to the conservation science literature to perform multivariate analyses for RRT data. We measured economic, demographic, and attitudinal covariates that could be associated with hunting. We found high awareness of laws banning hunting in Southwest China, but we also observed that 29.2% of the adult male population may have hunted birds in the past year.

Contrary to previous findings highlighting subsistence and finance as major factors driving hunting, the most important predictors of hunting activity in this landscape were related to attitudes regarding the enjoyment of hunting. Extra-economic motivations, such as the entertainment value of hunting, may be underappreciated drivers of hunting behavior. Behavioral change interventions such as pride campaigns may be a promising approach to regulate bird hunting in Xishuangbanna in collaboration with local communities.

1. Introduction

Excessive hunting pressure is one of the greatest threats to both vertebrates and the structure and functioning of natural ecosystems, particularly in tropical forests (Maxwell et al., 2016; Ripple et al., 2015). Previous research has documented wide-ranging, deleterious ecological impacts of defaunation. Examples include reduced carbon sequestration from the loss of large frugivores (Peres et al., 2016), altered nutrient cycling regimes (Doughty et al., 2016), and trophic release of meso- and micro-herbivores and granivores (Young et al., 2016).

Moreover, depleted vertebrate populations may drive declines in human welfare, contributing to the maintenance of poverty traps and malnourishment (Duffy et al., 2016; Golden et al., 2011). Yet in many regions, our understanding of the motivations of hunters lags behind documentation of the ecological consequences of defaunation, in large part due to the sensitivity of asking questions around potentially illegal activities (Chang et al., 2018; Nuno and St John, 2015).

Across Southeast Asia, hunting is a common problem facing natural-area managers despite economic growth, the expansion of protected areas, and human-wildlife conflict compensation programs (Corlett, 2007; Rao et al., 2010; Sodhi et al., 2004; Velho et al., 2012). China is a case in point. Increasing investments in protected area enforcement have not deterred poaching (Corlett, 2007; Kamp et al., 2015). Illegal, unreported, and unregulated hunting is a particularly prominent problem in Southwest China where the economic and socio-cultural factors influencing hunting activity are poorly understood (Chang et al., 2017; Kai et al., 2014; Yang et al., 2015; Zhang et al., 2008). Nevertheless, a recent study suggests that local community perceptions of enforcement were positively correlated with the abundance of exploited taxa (Chen et al., 2018).

As increased attention has been devoted to enforcing wildlife protection measures, understanding the drivers of non-compliant hunting has become increasingly important (Blank and Gavin, 2009; Gavin

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et al., 2010; St John et al., 2014). Yet asking about conservation non-compliance can be difficult, and interview data often incur two forms of bias: non-response and social desirability. Non-response bias describes situations where individuals who perform a criminalized or sanctioned activity (e.g. illegal logging, blast fishing, gun hunting) decline to participate. Social desirability bias refers to the tendency for respondents to alter their answers toward a more socially acceptable direction (e.g. interviewees in political science studies altering their answers about discriminatory views). Indirect questioning techniques can reduce non-response and social desirability bias, offering improved estimation of conservation compliance (Lensvelt-Mulders et al., 2005; Nuno and St John, 2015). Of the different indirect questioning techniques, the Randomized Response Technique (RRT) has become increasingly prominent in the conservation science literature (e.g. Blank and Gavin, 2009; Gavin et al., 2010; Randriamamonjy et al., 2015; Razafimanahaka et al., 2012; Santangeli et al., 2016).

In RRT questionnaires, respondents use a randomizing device (such as rolling dice or flipping a coin) and observe the outcome privately (Warner, 1965). Central to RRT is that the outcome of the randomizing device is private to the respondent and their answer may be true or false depending on the device. As such, the observed response (typically "yes" or "no") obscures the interviewee's true state, which prevents the open admission of guilt (in the case when the respondent answers "yes") (Lensvelt-Mulders et al., 2005; St John et al., 2014). Typically, RRT covers binary (or dichotomous) questions (but see Conteh et al., 2015, for an alternative implementation).

We used RRT to evaluate illegal bird hunting in Southwest China, a biodiversity hotspot where overexploitation is a primary threat to several charismatic avian species, such as the green peafowl (*Pavo muticus*, IUCN Endangered), the oriental pied hornbill (*Anthracoceros albirostris*, Least Concern), great hornbill (*Buceros bicornis*, Near-Threatened (NT)), and Austen's brown hornbill (*Ptilolaemus austeni*, NT) (Han et al., 2009; Kai et al., 2014); the remaining galliform and large frugivore species in our study area have greatly reduced abundances (Chang et al., 2017; Chang and Drohan, 2018; Zhang et al., 2017).

Chang et al. (2017) performed mixed-methods interviews with a non-representative snowball sample of hunters to elucidate the motivations for hunting in Southwest China. For the surveyed population of trusted hunter informants, recreation emerged as a major reason for hunting. However, at a broader, landscape scale, the prevalence and drivers of hunting, particularly hunting targeting birds, remained unclear. In this manuscript, we estimated the prevalence of illegal hunting targeting four focal bird species: red-whiskered bulbul (*Pycnonotus jocosus*, LC), blue-throated barbet (*Psilopogon asiaticus*, LC), bar-backed partridge (*Arborophila brunneopectus*, LC), and silver pheasant (*Lophura nycthemera*, LC).

In this manuscript, we used interview data to answer the following questions:

1. Were the interview data affected by response bias?
2. How prevalent was hunting for these four focal bird species?
3. What characteristics distinguished hunters from non-hunters?
4. What factors tended to increase the numbers of species hunted by an individual?

2. Methods

2.1. Study location and legal context

Our study was performed in Xishuangbanna Dai Autonomous Prefecture (henceforth "Xishuangbanna"). Within Xishuangbanna, the national nature reserve (Xishuangbanna National Nature Reserve) contains several large protected lowland and montane tropical rainforest tracts (Xu et al., 2014; Yi et al., 2014). The indigenous people of Xishuangbanna have traditionally practiced hunting (Xu, 2006), and the impacts of hunting have interacted synergistically with population growth and deforestation, leading to the local extirpation of mammal and bird species (Chang et al., 2017; Kai et al., 2014). Currently, the primary rural livelihood in the study region is rubber (*Hevea brasiliensis*) smallholder farms (Hammond et al., 2015; Yi et al., 2014).

As currently implemented, under the 1988 Wildlife Protection Law and the 1994 Hunting Rifle and Ammunition Control Act, it is prohibited to own guns or hunt nationally listed species (Li, 2007). Moreover, most forest-dependent vertebrates today occur solely in protected areas (Zhang et al., 2017), and human access to protected areas is generally prohibited under the 1994 Regulations on Nature Reserves Act (Article 18) (Harris, 2007; Kram et al., 2012). The Department of Forest Police of the State Forestry Administration is responsible for enforcing penalties for poaching protected species, illegal entry into protected areas, and violations of any other relevant wildlife laws. Generally, village committees (comprising roles such as the village chief, secretary, women's affairs representative, etc.) also have regulatory duties to discourage poaching, gun ownership, and illegal entry into protected areas, though in practice, this varies quite a bit from village to village.

To preserve the confidentiality of our respondents, we do not report our specific study areas within the Xishuangbanna National Nature Reserve. Our surveys focused on bird hunting because in our pilot study, it was infeasible to ask questions about mammal hunting; mammal hunting implicitly reveals gun hunting, whereas bird hunting can be performed with a range of weapons, such as nets, slingshots, and the use of decoys. Gun ownership is an extremely sensitive topic for rural villagers in our study area.

2.2. Survey design

We used a social psychology framework, the Theory of Planned Behavior (Ajzen, 1991), to understand what factors differentiated hunters from non-hunters. Under the Theory of Planned Behavior, an individual's propensity to perform an act is informed by attitudes (personal beliefs and feelings about the action), subjective norms (communal beliefs regarding the action), and perceived ability (Williams et al., 2012).

The lead author wrote the survey in Mandarin Chinese with assistance from two co-authors on grammatical and vernacular edits. The survey was piloted with 20 hunter informants outside of the final sample. From February–March 2015, 200 adult male villagers (ages 18–65) were surveyed across 20 villages surrounding two protected areas in Xishuangbanna. Each village was located within 5 km of a protected area, and site selection was conducted a priori from published geospatial data (Xu et al., 2014). We stratified the sample by altitude and the dominant ethnic group in each village.

The survey enumerators were two local fourth-year undergraduate students who were fluent in the local dialect. The enumerators and lead author approached the village committee for permission before conducting the survey. The enumerators walked the main paths in the village and selected every 3rd, 4th, or 5th household to interview. Generally, the male head of household was interviewed. If a respondent refused to participate (2% of households), the enumerators went to the house next door. Each questionnaire required 25–40 min to complete.

The survey was performed using the Qualtrics Offline application for tablets. Permission was granted for the study by the Princeton University Institutional Review Board (# 6682) and Xishuangbanna Tropical Botanical Garden (# 2015.2). The questionnaire instrument can be found in Appendix A. The survey asked respondents a variety of questions about their socio-economic status and their views on hunting.

2.2.1. Socioeconomic and psychological covariates

The questionnaire included demographic questions as well as statements about attitudes (also termed psychographic questions) at the scale of individual beliefs to community-level views. Respondents reported their age, ethnicity, material wealth, household per-capita

income, rubber plantation area, and crop area for all other commodities (e.g. bananas, pineapples, sugarcane, corn). One of the clearest indicators of wealth in Xishuangbanna is the ownership of a car (Hammond et al., 2015); as such, wealth was given a score of 0 if the respondent did not possess a pig, cow, refrigerator, or car; 1 for possession of a pig, cow, or refrigerator; 2 for two or more of the previously mentioned items; and 3 for car ownership. We provide more information on why these wealth indicators were chosen in Appendix A.

The interview also touched on leisure pursuits: the number of outdoor activities (scored from 0 to 3: fishing, mushroom gathering, and/or wild vegetable harvesting), and entertainment activities (scored from 0 to 4: karaoke, basketball, tuoluo, and gambling). We also asked about past hunting, which received an ordinal score from 0 to 6, based on whether or not respondents had hunted several focal species.

We asked questions about attitudes regarding hunting across four categories: social norms, personal attitudes, perceived behavioral control, and risk assessment (Ajzen, 1991). Social norms denoted questions regarding village-level normative views on hunting, such as "My friends and family think that capturing birds is bad for wild bird populations." Personal attitudes encompassed the respondent's own view on the ethical and ecological impact of hunting birds. Under the perceived behavioral control subsection, the questions asked about the respondent's access to tools for hunting as well as their own assessment of their skill. Finally, personal attitudes examined the respondent's views on different reasons for hunting. There were five questions in each category, and each question was scored on a 5-point Likert scale. To avoid potential issues arising from some of the attitudinal questions touching on sensitive topics, we used reverse wording, placing questions in a historical context, and local euphemisms for hunting (e.g. "going up the mountain", "playing in the mountain" are both expressions that connote hunting, especially with firearms, in this region; Chang et al., 2017).

2.2.2. Randomized Response Technique questions on illegal bird hunting in Southwest China

We used the forced response design to implement RRT questions. Specifically, respondents rolled a die, ensuring that no one else could see its outcome. If it landed on 1, they were instructed to say "yes", "no" for 6, and answer honestly if it showed 2 through 5. Two training questions pertaining to non-sensitive and prevalent behaviors ("Do you play cards?" and "Do you drink?") were used to ensure that respondents understood how to comply with the question design. The forced response questions were always asked after the training question, provided that the respondent understood the training questions, and were always presented before the direct question block. Within each block, the four focal bird species were randomly presented.

To evaluate the prevalence of hunting, we selected four focal bird species—silver pheasant (*Lophura nycthemera*), bar-backed partridge (*Arborophila brunneopectus*), great barbet (*Psilopogon virens*), and red-whiskered bulbul (*Pycnonotus jocosus*)—based on hunter informant recommendations about birds that were commonly hunted or highly desired by hunters (Appendix A 1.3).

We used a salient event that occurred approximately one year before the survey began: the 2014 Dai Water Splashing Festival (also known as Songkran in continental Southeast Asia). For each species, the enumerator asked, "Since the 2014 Dai Water Splashing festival, have you hunted this bird?" Each question was implemented using the forced response design for RRT and direct questioning for a total of eight questions about bird hunting (four species and two methods of questioning). As such, there were two "blocks" of four questions with a total of eight questions (ten including the two training questions).

For the forced response RRT design, researchers cannot take observed "yes" and "no" responses at face value as any given answer could have actually been the outcome of the dice roll (i.e. a "no" forced by a roll of 6). However, we can assume that a dice roll would produce equal probabilities of observing 1–6 (namely $p = \frac{1}{6}$), and we can use these probabilities to estimate the true prevalence of hunting. Below, we describe how we performed analyses to correct for the response randomization process.

2.3. Statistical analysis

We evaluated (1) the prevalence of bird hunting in Xishuangbanna, (2) what factors separated hunters from non-hunters, and (3) what factors were associated with hunting more species. For aim 1, we evaluated the prevalence of hunting for each of the four bird species using the Item Response Theory (IRT) model for RRT data. We also examined whether the data were affected by response bias.

For aims 2 and 3, we generated several candidate models to predict who hunts or not (Table A.1). Broadly, the hypotheses could be grouped as (1) solely economic covariates, (2) economic covariates and recreational activities, (3) economic and attitudinal covariates, and (4) solely recreational activities and attitudes. All models within $\Delta AIC_c \leq 4$ of the most-supported model were averaged (Burnham and Anderson, 2002). We used several estimators for RRT data that are available in the package `zapstRR` (Chang et al., 2018), specifically: the IRT logistic regression model for aim 2, and the sum score model for aim 3. For more details on these estimators, please refer to Chang et al. (2018). Appendix B contains replication code. Before performing the regression models, we reduced the dimensionality of the predictor variables using clustering and performed data pre-processing as described below.

2.3.1. Data imputation

Due to the complexity and length of the survey (75 questions), 80% of respondents neglected or declined to answer at least one question, rendering some form of imputation necessary for regression analyses. Typically, one to two answers would be missing for the 20 attitudinal questions. We chose to impute these missing values using the hot-deck procedure wherein each missing value is replaced by an observed value from a matching respondent (Andridge and Little, 2011). Respondents were matched based on their age group ($18-25$, $25-35$, $35-45$, ≥ 55) and ethnicity. No variable had $> 10\%$ missing values and most had only 1–2 missing values, well within the boundaries that are suitable for hot-deck imputation (Andridge and Little, 2011; Little and Rubin, 2014).

2.3.2. Dimensionality reduction: attitudinal statements

We then clustered the 20 attitudinal statements to generate a tractable set of predictors. For the four original attitudinal dimensions, we calculated Cronbach's alpha for all possible combinations of questions in each psychographic dimension (3–5 questions), and alpha was uniformly low (< 0.6), indicating that the designed dimensions of behavior were not clearly divided across the questions. As such, we used hierarchical clustering (`iclust` in package `psych`), as it is an especially robust method for psychological questions (Revelle, 2012; Revelle, 2014).

Clustering produced three distinct attitudinal dimensions: pleasure, risk, and skill. Within the dimension of pleasure, statements encompassed personal and group level perceptions that hunting is an enjoyable activity and that wild birds are tastier than domestic fowl. Pleasure also included two elements of skill: self-confidence in accurate marksmanship and knowledge on the behavioral habits of birds. The risk dimension represented respondents' estimated likelihood of being caught and punished by their village forestry ranger or by the state forestry police. Skill encompassed beliefs regarding one's ability to obtain weapons (bullets and snares) and perceived talent at setting snares. Six statements did not map to any of the clusters and were excluded.

All continuous variables (age, crop area, income, fun, risk, and skill) were centered and scaled. The ordinal variables (entertainment, wealth, outdoors activity, and past hunting) were scaled to $[0,1]$ by dividing

each level by the maximum value (Gelman and Hill, 2007).

3. Results

3.1. Survey demographics and overall attitudes

The surveyed population was 41.5% Dai, 24% Hani, 20% Yao, and the remaining 14.5% were Han Chinese, Jinuo, Bulang, Yi, or Lahu. Respondents ranged in age from 18 to 70 years, with a median of 34 and a mean of 37.6. Households ranged from 1 to 12 individuals, with a median of 5 and a mean of 5.2. The median annual per-capita income in 2015 was 1224 USD (range: [130, 21,216]).

Every surveyed respondent was a rubber (*Hevea brasiliensis*) smallholder farmer. The median rubber holding was 4.4 ha (mean: 6.3, range:[0.9, 40]). Apart from rubber, respondents had anywhere from 0 to 27 ha of other farmland (median: 0.9, mean: 1.4 ha).

29.5% of the respondents agreed that the men of their village enjoy hunting birds. More than half of the interviewees preferred the taste of wild birds to domestic fowl (56.5%). Villagers typically perceived their village committees to be more lax at enforcement than the Forestry Police, the administrative bureau tasked with enforcing the laws protecting the Xishuangbanna National Nature Reserve; while 17 and 4.5% of the respondents did not think that their village committees would punish villagers for using snares or guns, those rates were only 5.5 and 2.5%, respectively, for the Forestry Police. Despite the fact that very few bird species are formally protected from hunting (Classes 1 and 2 of the Chinese Wildlife Protection Law), 53% of the respondents believed that hunting any bird was illegal.

3.2. Compliance with the RRT questionnaire

We evaluated whether there was significant evasive response bias by comparing a covariate-free Item Response Theory (IRT) model with and without an evasive response parameter. We found that around 17.9% of the responses may have exhibited one-sided lying (failing to say "yes" honestly or when forced by the die roll). As the likelihood ratio test of the non-compliant versus the null model was significant ($\chi_1^2 = 3.8, p = 0.05$), we included a noncompliance parameter for both prevalence estimation (Fig. 1) and a logistic regression model differentiating who hunts or not. Nevertheless, a majority (69.6%) of the respondents stated that the forced response question design was "easy to answer" and "protected their privacy".

3.3. Rates of hunting for individual birds and across multiple species

A substantial proportion of adult men were still actively hunting bulbuls between 2015 and 2016 (Fig. 1). Although the prevalence of hunting for the other bird species was not as high (< 10% in all cases), the upper bounds suggested thatas many as 15–20% of the adult men may have hunted these species. We observed slightly higher estimates from the RRT data than the direct question responses, though the confidence intervals overlapped.

Using the sum score model, we identified the proportion of adult men who had hunted a sum of zero to all four of the focal species. We found that 7.2% of the respondents had hunted two species, 4.7% hunted three species, but that no one had hunted all four birds in the past year.

3.4. Predictors of hunting activity

We performed multi-model inference on a set of hypotheses regarding which socio-cultural dimensions may have influenced who did or did not hunt the four focal birds (Table A.1). We used the item response theory RRT model to jointly regress over all four bird species simultaneously.

One model (10) was clearly the most parsimonious and contained attitudes regarding the entertainment value of hunting (Likert scale scores for belief statements to the effect that hunting was enjoyable at a personal and community-level), perceived risk, self-assessed skill, past hunting experience, wealth, and rubber planted area (Table A.1). However, the only variable with a clear directional effect was skill. Specifically, individuals who perceived themselves to be more skilled were more likely to be hunters (Fig. 2). There was some evidence that a stronger perception that hunting was enjoyable tended to increase the probability of being a hunter; similarly, there was some evidence that greater perceived risk of hunting tended to depress the probability of being a hunter. All of the other coefficients had confidence intervals spanning negative to positive values, which did not indicate a clear directional effect on hunting.

3.5. Predictors of the number of species hunted

We performed ordinal regression using the sum score regression estimator (Chang et al., 2018; Cruyff et al., 2008) with the same set of hypotheses as the previous section. Similar to the IRT model, the most supported model was model 10; however, there was also strong support for models 1, 4, 2, and 3 (Table A.2).

After full model-averaging (Burnham and Anderson, 2002), the only variable with a clear directional impact was the perception that hunting is enjoyable. A stronger perception that hunting is fun tended to increase the number of species exploited (Fig. 3). Otherwise, because the confidence intervals for each of the coefficients crossed 0, the impact of these predictors on the cumulative sum scores of hunted birds was

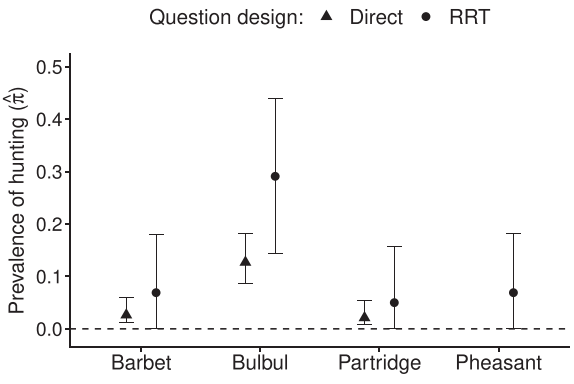

Fig. 1. Estimates of hunting prevalence ($\hat{\pi}$) for each bird species using either direct questioning or indirect RRT questions with the forced response design. The RRT estimates were generated using the item response theory model with evasive bias correction.

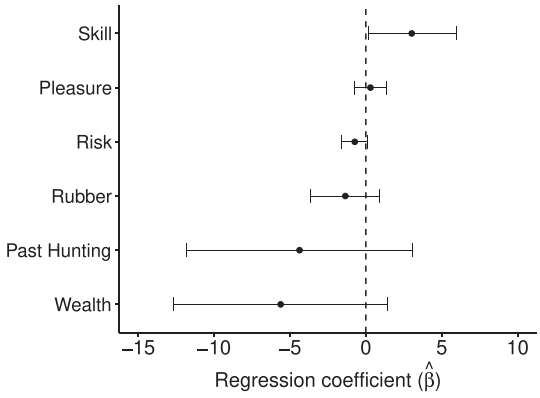

Fig. 2. Estimated regression coefficients ($\hat{\beta}$) for the most parsimonious model identifying hunters. The 95% confidence interval is shown. When the full interval for $\hat{\beta}$ does not cross 0, that indicates that a clear directional (positive or negative) response for hunting.

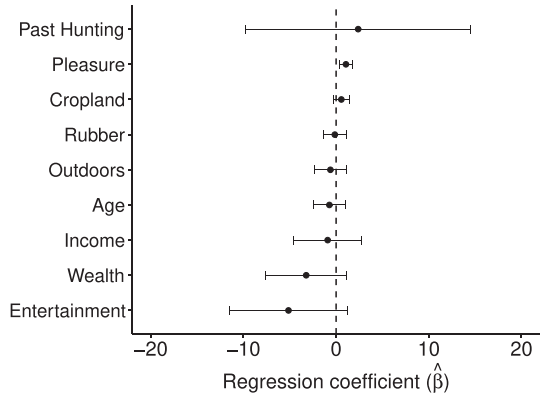

Fig. 3. Model-averaged regression coefficients ($\hat{\beta}$) for the number of species hunted (also called a sum score). The central dashed line corresponds to regression coefficient estimates at zero, which would indicate no discernible relationship between that covariate and the response variable of number of species hunted.

unclear.

4. Discussion

Even though RRT confers anonymity by design, our data were significantly affected by response bias. Applying corrections for response bias, we found that hunting bulbuls was common, and our data indicated that relatively few men hunted barbets, partridges, and pheasants. The substantial prevalence of bulbul hunting indicates that gun hunting continues in this landscape, as bulbuls are often hunted with guns in our study area (Chang et al., 2017). We also observed that the pleasure of hunting was important in differentiating hunters from non-hunters and in characterizing the number of species harvested.

We note that a major issue constraining the interpretation of our data is that our questions did not necessarily measure intention to hunt. It is possible that respondents interpreted our RRT prompts as confirmation of successful kills. Thus, our data, particularly for barbet, partridge, and pheasant, may underestimate true hunting intent. Canopy-dwelling barbets are regarded as very tricky to successfully shoot, and phasianids are extremely rare in our study area (Corlett, 2007; Han et al., 2009; Kai et al., 2014). Barbets, partridges, and pheasants are all more desired by hunters than bulbuls (Chang et al., 2017); should hunters see one within shooting range, they would likely target it, unless they were banking their shot for an even more desirable species (Chang and Drohan, 2018).

Despite the numeracy and literacy of the surveyed population, we still encountered challenges with RRT. Evasive responses significantly impacted our data and required correction in subsequent analyses. Applications of RRT in the conservation science literature have invoked reduced response bias as a major improvement over traditional survey designs. John et al. (2018) describe several important social and cultural reasons why RRT may instead backfire, lead to self-protective response patterns, and under-perform relative to direct questioning by yielding lower prevalence estimates. In the case of our study, we believe that indirect questioning was the better option for measuring hunting because of current enforcement practices. For one, we observed higher point estimates from the RRT data relative to direct questioning. Currently, the limited enforcement of wildlife protection laws in Xishuangbanna has largely relied on extremely infrequent patrols (largely during the dry season) and anonymous tip-offs (Chang et al., 2017; Chen et al., 2018). Yet villagers stated that this enforcement practice has instead led to dishonest reports, as well as discouraging participation in conservation social science research.

By using new, multivariate models for RRT data, we were able to characterize and control for the effects of evasive responses in the item response theory models for prevalence and logistic regression. Our regression models echo previous research showing that in different areas of Southwest China, there have been transitions from subsistence hunting toward recreational hunting (Chang et al., 2017; Harris, 2007; Kai et al., 2014; Yang et al., 2004). The broader literature on tropical hunting has stressed the primacy of generating income or subsistence protein as motivating factors (Brashares et al., 2011; Golden et al., 2011; Nielsen et al., 2018; Rowcliffe et al., 2005). In the logistic (who hunts or not) and ordinal (sum score) regression models, the most supported models both included measures of wealth and livelihoods, such as rubber landholding area. However, the results also highlighted the importance of attitudes, and in particular, the enjoyment of hunting. The importance of extra-economic motivations for harvesters has been observed in a wide variety of settings, including rural poor subsistence hunters and fishers (Alfaro-Shigueto et al., 2016; El Bizri et al., 2015; MacMillan and Nguyen, 2014; Oleson et al., 2015). These results underscore the importance of future socio-ecological research to better understand the entertainment value of hunting as a driver of behavior.

Risk perception is an important deterrent for noncompliance with conservation laws (Chen et al., 2018; Gavin et al., 2010; John et al., 2015; Nuno et al., 2013). In our surveys, the attitudinal statements revealed that the vast majority of villagers felt that hunters could be punished for snaring or gun usage, and were aware of laws protecting wildlife from harvest. Many respondents believed that all birds were protected from harvest, when, in fact, of our focal bird species, only silver pheasant is actually protected. The logistic regression results suggested that higher perceived risk may make an individual less likely to hunt birds. Notably, however, risk perception was not included in the most supported models for the sum score results.

Our results suggest several strategies for improving conservation outreach and hunting management in Xishuangbanna. Although the prevalence of bulbul hunting indicates that gun hunting is common, we found that only 11.9% of the respondents had hunted more than one of the focal birds in the past year. Reaching this subset of hunters may have an outsize impact on the success of biodiversity conservation as these individuals may be more skilled and intensely dedicated to hunting than their peers who have hunted only a single species, which was most likely the still-common bulbul. Nevertheless, as Chang et al. (2018) note, it is possible that sum scores may not be correlated with offtake — unfortunately, the extreme sensitivity of talking about hunting in this region prevented the inclusion of direct questions around offtake or effort, but future research could evaluate whether hunter diet breadth (as revealed by the speciosity of sum scores) is associated with effort or offtake. An anonymized approach could be the "Quantitative RRT" design introduced by Conteh et al. (2015).

Rural villagers in Xishuangbanna have expressed antipathy toward local and regional forestry bureaus (Chen et al., 2013; Xu et al., 2005). Ethnographic studies have identified many problems arising from excluding indigenous communities in Xishuangbanna from conservation management decisions (Sturgeon, 2010; Xu, 2006). Current enforcement tactics have encouraged defiance of the forestry police and have engendered distrust toward local agencies tasked with managing protected areas and wildlife conservation. Involving local communities in devising strategies to meet their aspirations while conserving wildlife has been a cornerstone of effective and ethical management (Duffy et al., 2016; Milner-Gulland and Bennett, 2003; St John et al., 2011).

Of the different motivating factors for hunting that we considered, the pleasure of hunting was one of the most important. This suggests that changing attitudes toward hunting through pride campaigns or redirecting hunting effort toward alternative, regulated forms of nature recreation could be powerful routes for improving conservation practice. Pride campaigns, which aim to make local communities feel a sense of ownership and pride regarding their local natural resources, have successfully reduced poaching pressure in continental Southeast Asia and have led to the recovery of over-hunted ungulates and

carnivores (Saypanya et al., 2013; Steinmetz et al., 2014); recent studies propose methods to assess their effectiveness in changing intents, behaviors, and ecological outcomes (Barca et al., 2016; Karris et al., 2018; Salazar et al., 2018). Alternatively, given the relative prosperity of our study region, conservation practitioners could consider co-developing alternative activities that could raise revenue for conservation and preempt poaching. Chang et al. (2017) observed that hunters in Xishuangbanna view gun shooting as highly entertaining. However, given the politics of gun ownership in China, any firearm-related recreation (e.g. clay pigeon competitions) would face major logistical barriers (Harris, 2007; Li, 2007; Organ et al., 2012).

4.1. Conclusion

Despite legislation restricting hunting of birds and local enforcement of those laws, we found that hunting of birds, especially common songbirds, in Southwest China, remains a widespread practice. Beliefs that hunting is entertaining, perceived skill, and risk were salient predictors of who hunts in Southwest China. The pleasure of hunting was the sole covariate with a clear impact on the number of bird species hunted. These findings reinforce other studies demonstrating that motivations for poaching can be extra-economic and not confined to pecuniary or subsistence reward. As income levels rise in developing countries, hunter motivations may become increasingly oriented toward recreation and other non-material values. If so, conservation interventions will need to focus on changing social norms or finding alternative recreational activities for would-be poachers, as opposed to enhancing livelihoods or providing incentives not to hunt, as such tactics are more appropriate for poaching driven by economic need.

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Competing interests

The authors report no competing interests.

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