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Consumption of bushmeat around a major mine, and matched communities, in Madagascar

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ABSTRACT

Mining can have serious biodiversity consequences and many mining operations take steps to mitigate their impacts. Evaluating their success poses a significant challenge because appropriate counterfactuals (what would have happened in the absence of the mine) are often unavailable. We aimed to estimate the effects of education and enforcement measures carried out by a large mine in eastern Madagascar on local consumption of illegal bushmeat. We adopt a quasi-experimental approach and use an interview technique designed to reduce sensitivity biases to compare levels of consumption amongst mine employees and people living within the mine's intervention area with those of statistically matched control groups, and to relate differences to respondents' knowledge of relevant wildlife laws. Consumption was lower, and awareness of the law higher, amongst mine employees and those living in the mine's intervention area. However caution should be applied in interpreting these results as evidence of the effectiveness of anti-bushmeat efforts by the mine due to potential confounding factors: for example abundance of bushmeat species may vary between the study areas, and our method may not have completely removed the sensitivity of questions about illegal consumption. This illustrates the challenges of evaluating conservation impacts. We highlight the low level of understanding of wildlife laws, including among mine employees, and suggest better communication of these laws, as part of an education programme, could be a useful first step towards reducing illegal hunting.

1. Introduction

The commercial extraction of valuable minerals is economically important in many parts of the world. Mining can have a positive impact on human development by generating jobs and raising government tax receipts (ICMM, 2012), although Seagle, 2012 and Filer, 2006 discuss potential negative social impacts. However, mining can also have highly negative environmental impacts both directly, including through pollution (Uryu et al., 2001), habitat destruction, introducing alien species (Gould, 2011), and indirectly, by facilitating access for logging, agricultural expansion or hunting (Wilkie et al., 2008; Raiter et al., 2014). There is therefore a potential conflict between mining development, which may contribute to human wellbeing through economic growth, and biodiversity conservation, where the role of biodiversity in underpinning ecosystem services may also contribute to human wellbeing but be less well valued by markets.

To mitigate the potential negative consequences to biodiversity from mining activities, companies can adopt measures to minimise or prevent such impacts around mining areas. To minimise their negative effects, mines are often required by legislation, or the terms of their loans, to ameliorate their biodiversity impacts, and of course may go beyond national legislative requirements. Mitigation measures tend to follow a hierarchy: (a) avoiding environmental impacts where possible, (b) minimising unavoidable impacts and (c) remediating, offsetting or otherwise compensating for residual, negative effects (McKenney and Kiesecker, 2010). Measures to mitigate the potential impacts of mining on biodiversity may include the designation of conservation areas and implementation of forest management plans, investment in alternative livelihoods, with the objective of taking pressure off remaining habitat, and education about and enforcement of conservation rules.

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Madagascar possesses significant mineral resources (Cardiff and Andriamanalina, 2007) and is also a global hotspot for biodiversity. In recent decades both artisanal and large-scale mining operations have increased across the country (Cartier, 2009). Over the same period, hunting of Madagascar's unique wildlife has come to the fore as a key conservation issue, with pressure on threatened and protected species linked to rising demand for wild meat and the breakdown of traditional taboos (Jenkins et al., 2011). Laws are a crucial aspect of conservation and natural resource management (Keane et al., 2008) and although Madagascar has a clear system of wildlife laws (Rakotoarivelo et al., 2011) which defines what species can be hunted, where and when, evidence suggests that these are often very poorly understood and therefore unlikely to influence behaviour (Keane et al., 2011). The major mines in Madagascar operating in biodiversity-rich areas attract significant international scrutiny and have made explicit commitments to reduce their net impacts on biodiversity (Vincelette et al., 2007; Ambatovy Project, 2009) and reducing illegal hunting is a stated objective of Ambatovy Minerals and QIT Madagascar Minerals (QMM), Madagascar's two largest mines (Ramahavalisoa et al., 2012). Both Ambatovy and QMM use environmental education and enforcement measures as part of their strategies to minimise or offset their biodiversity impacts (e.g. Office Nationale de l'Environnement, 2006), but the effectiveness of such efforts in changing behaviour has not previously been measured.

In this study, we aimed to evaluate the impact of the Ambatovy Minerals mine on the consumption of bushmeat in eastern Madagascar. In the absence of a controlled experiment, it is often difficult to draw robust conclusions about causality (Ferraro and Pattanayak, 2006). It is therefore inherently challenging to investigate the impact of a major intervention such as a mine *post hoc*; where the intervention is not placed randomly, adequate before and after comparisons do not exist, and the lack of replication of the intervention makes spatial comparisons problematic. For example, systematic differences (such as in terms of socio-economic variables) between the population exposed to the intervention and those not exposed could confound estimates of the intervention's true effect. Studying the impact of an intervention on potentially sensitive behaviour, such as bushmeat hunting, is particularly challenging as respondents may not be willing to admit to involvement, even if guaranteed anonymity (Solomon et al., 2007; St John et al., 2010; Nuno and St John, in press). We therefore use a combination of specialized techniques to statistically reduce the potential biases caused by underlying systematic differences between our control and intervention samples (non-parametric matching; Abadie and Imbens, 2011) and the reluctance of people to admit to illegal behaviour (the Randomized Response Technique, RRT; St John et al., 2012).

2. Methods

2.1. Study area

The Ambatovy mine, one of the world's largest lateritic nickel mines, started production in 2012 with operations planned to continue over a lifespan of 27 years. The mine itself is situated in an area of rainforest in eastern Madagascar (Fig. 1) adjacent to the new protected area of Ankeniheny-Zahamena Corridor. The mine is connected to a refinery plant at Toamasina on the country's east coast via a 220 km pipeline. The forest around the mine provides an important habitat for many globally threatened species, several of which are hunted for bushmeat (Goodman and Mass, 2010). The mine has committed to having a net positive effect on biodiversity by avoiding impacts where possible, minimising unavoidable impacts, carrying out progressive footprint restoration and implementing a multi-component offset program (Ambatovy Project, 2009). The mine's enforcement activities and environmental education among its staff and local villages form part of the forest management component of this program.

2.2. Data collection

Between February and June 2011 interviews on bushmeat consumption were conducted with three groups: mine employees (hereafter "employees"), people living in villages within the mine's zone of intervention but not employed by it ("intervention group") and people living in similar area outside of the mine's zone of intervention ("non-intervention group"). Both areas provide favourable conditions for agriculture, logging and hunting.

We sampled mine employees from a list provided by the mine administration, interviewing 30% of employees in each department. Villages from within the mine's zone of intervention were selected at random from the Ambatovy project databases. The area selected for comparison from outside the zone of intervention was in the commune directly north of the mine: an area with a similar level of access to forest and socio-economic setting. Villages in this area were selected at random, based on a Madagascar vegetation and habitation map (see Fig. 1). In smaller villages (<30 households), we attempted to carry out interviews with every household; in larger villages we sampled households by following a zig-zag route and conducting interviews at every second or third household (cf. East et al., 2005).

Respondents were asked about their consumption in the preceding 12 months of 8 animal species (whose distributions include the study areas), and their knowledge of the legal status of each species (Table 1; Goodman and Mass, 2010). Seven of the species are protected from hunting under Malagasy law while one is classified as a game species, so we used a specialised interview technique, the Randomised Response Technique (RRT), to reduce potential biases due to question sensitivity. The method had been extensively tested in both eastern and western Madagascar before being applied in this study (Razafimanahaka et al., 2012) and is useful for providing answers to sensitive questions of a yes/no format (i.e. it can give information on whether a species has been consumed, but not easily on the frequency or volume of consumption).

Pictures of the eight selected species, which had previously been tested locally to ensure they were easily recognised, were shown to respondents. The RRT survey followed a 'forced response' model (Lensvelt-Mulders, 2005). Respondents were given a cloth bag with 10 balls (blue, white and black) in it. They were asked to take a ball from the bag (without looking) and not show it to the interviewer. They were asked to truthfully answer the question ('have you eaten this species in the last twelve months?') if they had chosen a blue ball (probability 8/10). Respondents were asked to simply say 'have eaten' if they selected a white ball ($P = 1/10$) and to say 'haven't eaten' if they selected a black ball ($P = 1/10$). Because the interviewer does not know whether a respondent is saying they have eaten a species because they have indeed eaten it, or because they selected a white ball, the interviewer does not have any definite information about the respondent. However, an unbiased estimate of the proportion of the population who have consumed bushmeat can still be obtained. We explained the method and said it was like a game (*kilalao*) and that like a game they should follow the rules. We then worked through two to four non-sensitive example questions (using pictures of fish, bush pig, snake and cow) depending on how quickly they appeared to understand the method and the protection it offered. The probabilities associated with each response are explained in full in Razafimanahaka et al. (2012). It is important to note that for species consumed infrequently, memories about whether consumption has occurred within the last twelve months may not be accurate. The team worked hard to remind respondents of