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Using local ecological knowledge to determine status and threats of the Critically Endangered Chinese pangolin (*Manis pentadactyla*) in Hainan, China

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ABSTRACT

The use of robust ecological data to make evidence-based management decisions for highly threatened species is often limited by data availability, and local ecological knowledge (LEK) is increasingly seen as an important source of information for conservation. Pangolins are now the most heavily trafficked mammals in illegal wildlife trade, and Chinese pangolins (*Manis pentadactyla*) are Critically Endangered, with no recent baseline data available to assess status of pangolin populations in China. We conducted community-based interviews across seven protected areas in Hainan, China, to investigate whether LEK can provide novel insights for pangolin conservation. LEK of pangolins remains high in Hainan (90% of respondents recognize pangolins and can provide supporting information), and pangolins are likely to survive in all protected areas that were surveyed, as evidenced by recent sightings dating from 2013 to 2015. However, all populations have declined and are now perceived to be of very low abundance (only 34% of respondents consider pangolins to remain locally present, and these respondents all regard pangolins as rare). Illegal hunting continues across this region, with pangolin body parts used locally and sold to outsiders. Pangolins are likely to soon become extirpated across Hainan unless effective conservation management plans can be initiated. Methods to monitor and assess pangolin status and threats are urgently required across all range states, and we demonstrate that large-scale LEK surveys can strengthen the evidence-base for informing robust conservation action and management plans for these species.

1. Introduction

The importance of using evidence-based conservation to inform effective management decisions is increasingly recognized by conservation researchers and practitioners (Sutherland et al., 2004; Segan et al., 2010). Developing a robust evidence-base for conservation planning using rigorous, objective data is particularly important for ecosystems in eastern and southeast Asia, which are experiencing extreme levels of anthropogenic pressure and contain the world's highest proportion of threatened vertebrate and plant species (Schipper et al., 2008; Sodhi et al., 2010). However, highly threatened species can be challenging to study due to low population density or detectability, and robust data on key parameters (e.g., population status, threats) may be difficult or impossible to collect using standard field techniques. Relevant information about such species may also be available in the form of local ecological knowledge (LEK) held by untrained local people using the same environments (Berkes et al., 2000; Anadón et al., 2009; Newing, 2011). LEK is increasingly seen as an important alternative source of conservation data, especially for "charismatic" large-bodied vertebrates (van der Hoeven et al., 2004; Meijaard et al., 2011; Parry and Perez, 2015; Turvey et al., 2015a). However, smaller-bodied species, including mammals, are more likely to be unreported or misidentified by respondents in interview surveys (Turvey et al., 2014). Assessing the effectiveness of LEK for providing robust baselines for such "non-charismatic" (cf. Entwistle and Stephenson, 2000) species, particularly in Asia, has been the focus of relatively little investigation. Identifying tools to combat the Asian biodiversity crisis is imperative, and such research is an important conservation goal.

The Chinese pangolin (*Manis pentadactyla*) is an insectivorous scaly-bodied small mammal with a wide historical distribution across eastern, southern and southeast Asia, but populations across its range are now severely threatened by hunting and illegal wildlife trade (Corlett, 2007; Challender et al., 2014b). Pangolins are the most heavily trafficked mammals in illegal wildlife trade globally (Challender et al., 2015), with trade driven by demand for meat as a luxury food item, and skins and scales for traditional medicines (Wu and Ma, 2007; Pantel and Chin, 2009; Challender, 2011; Zhou et al., 2014). All pangolin species are globally threatened, and the Chinese pangolin is Critically Endangered (IUCN, 2015). Legislation exists to protect Chinese

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pangolins across their range (CITES, 1975; Jiang, 2014), with pangolins listed under Category II of 'Animals Under State Special Protection' in China (Li et al., 2000; Watters and Wang, 2002). However, legal hunting of pangolins was widespread in China until the 1980s (Li et al., 2000), and illegal hunting and trade of many wild animals in China remains a serious conservation problem (Liu et al., 2011; Liang et al., 2013; Li and Lu, 2014; Pan et al., 2015). Changing such illegal but entrenched behaviours is challenging (Wu et al., 2002b; Zhang et al., 2008; Fellowes et al., 2009; Challender et al., 2014a).

Developing an effective conservation management framework for Chinese pangolins is hindered by a lack of robust recent baseline data on status, distribution and population sizes across most of their range. Although field survey methods can provide ecological information about pangolins, such studies are often small-scale, impractical, or of limited use due to rarity and cryptic status of surviving populations (Wu et al., 2004b). Pangolins are unlikely to be detected through monitoring approaches that are effective for other mammals, and are often not well-covered in general wildlife surveys because of their different ecologies (Duckworth et al., 1999; Shek et al., 2007). Chinese pangolins are predominantly nocturnal ground-dwellers that excavate burrows (Wu et al., 2004c), and burrow counts have been used to estimate abundance and density (Wu et al., 2002a; Thapa et al., 2014), but these estimates are complicated by low and variable rates of burrow reutilization (Wu et al., 2004c).

Despite being small-bodied mammals, pangolins are morphologically distinctive with important economic and cultural value and are unlikely to be misidentified even by untrained respondents, and may therefore constitute useful target species for LEK-based research (Newton et al., 2008; Thapa et al., 2014). Small-scale LEK studies on pangolins, collected from hunters, market traders and forest workers, have previously been used to supplement ecological field surveys (Sodeinde and Adedipe, 1994; Duckworth et al., 1999; Newton et al., 2008). As data on key pangolin conservation parameters remain otherwise difficult to obtain, it is important to further investigate the efficacy of LEK-based surveys for clarifying regional population status, trends and threats in pangolins, and to conduct such studies at larger scales than before to generate robust baselines for regional conservation management.

Little recent pangolin field research has been conducted in China, the country most responsible for driving pangolin population declines across Asia and Africa (Challender et al., 2015), although local hunting pressure probably remains high (Wu et al., 2004a; Corlett, 2007; Zhang et al., 2008; IUCN, 2015). Targeted pangolin research has not been conducted at all on Hainan Island, China's southernmost province. Hainan is considered likely to retain remnant pangolin populations, recognized as a distinct endemic subspecies (*Manis pentadactyla pusilla*) by some authors (Allen, 1906; Zhang, 1997; IUCN, 2015). Most of Hainan's tropical and subtropical forests have been cleared for agriculture, timber and plantations, with nearly all remaining old-growth forest restricted to medium-high elevations within protected areas, and Hainan's biodiversity is under threat (Chan et al., 2005; Lau et al., 2010; Liang et al., 2013; Turvey et al., 2015b). Pangolins have been exploited heavily for food and medicine on Hainan since at least the early twentieth century (Allen, 1938; Liu, 1938; Xu et al., 1983). In a series of rapid biodiversity assessments in 1998–2001, local reports indicated probable pangolin presence in Bawangling, Diaoluoshan, Jianfengling, Jianling, Jiaxi, Nanweiling, Shangxi, Tongtieling, Wuzhishan and Yinggeling reserves on Hainan (Kadoorie Farm and Botanic Garden, 2001–2003). However, these reports only represent anecdotal presence/absence records, none of which date from within the past decade, and in most cases a status of "insecure" was ascribed to pangolins, meaning that populations were then considered highly threatened and likely to decline rapidly. Reports from other areas of Hainan are unavailable. It is therefore effectively impossible to infer current pangolin status on Hainan in the absence of new baseline data.

We conducted a large-scale community-based LEK survey in 2015 to assess the status of native mammals across seven protected areas on Hainan. In this study, we use this LEK dataset to provide the first detailed assessment of current regional status of Chinese pangolins across Hainan and between different protected areas on the island, to determine past and present pangolin abundance and threats and to understand local beliefs and attitudes about pangolins, all of which are essential for effective conservation management (Jim and Xu, 2002; Redford et al., 2011; Kelbessa, 2015; Weber et al., 2015). We also use these data to determine the extent to which LEK is able to provide novel insights into key pangolin conservation parameters, and we consider the potential strengths and limitations of an LEK-based survey approach for informing pangolin conservation (Olsson and Folke, 2001; Schulman, 2007; Haen et al., 2014).

2. Material and methods

2.1. Survey methods

Community-based surveys were conducted in Bawangling, Diaoluoshan, Jianfengling, Wuzhishan and Yinggeling National Nature Reserves and in Jiaxi and Limushan Provincial Nature Reserves, which together contain much of Hainan's remaining good-quality protected forest (Fig. 1, Table A1). People are not allowed to live inside the reserves, but numerous villages are situated close to the boundaries of each reserve, with local people utilizing animal and plant resources collected inside protected areas (Kadoorie Farm and Botanic Garden, 2001–2003; Chan et al., 2005; Turvey et al., 2015b). We obtained a full list of villages surrounding each reserve from each reserve management office, and randomly selected ten administrative villages per reserve in which to conduct interviews (Fig. 1); this random sampling strategy aimed to ensure that our data would be representative of wider patterns of local knowledge, awareness and attitudes for communities around each reserve. A target number of ≥10 interviews were conducted per village; this number complies with predicted response saturation levels (White et al., 2005; Guest, 2006), meaning that the total number of interviews per village should be sufficient to capture existing potential variation in responses for each question. As a detailed plan of households in each village was not available, our primary strategy for identifying respondents involved randomly selecting people to interview by walking through each village; each village was relatively small, and so this approach usually resulted in the entire village being traversed (cf. Pan et al., 2015). Local village heads sometimes also introduced us to respondents known to have good LEK through targeted "snowball sampling" (Newing, 2011). Children and teenagers below the age of 18 were not interviewed, and only one respondent was interviewed per household to ensure independence of responses; respondents of both genders and any reported occupation were interviewed.

A standard questionnaire was used for all interviews, which took up to 1 h to complete, and which comprised a series of contrast, structured and open-ended questions (Supplementary Material Text-Files A1–A2). We obtained verbal consent before starting interviews, and all responses were anonymous. Prior to being asked questions, respondents were informed that they could stop interviews at any time. Interviews were mainly conducted in Mandarin or Hainanese, and recorded in Chinese, by pairs of volunteers recruited from universities or NGOs in Hainan; most local people could understand and communicate in these languages, although other local ethnic minority languages (Li, Miao/Hmong) were also relatively widely spoken in target communities. Pilot studies were conducted in villages around Bawangling in August 2014 and January 2015, following which the questionnaire was modified to enable more effective data collection. Interviews were conducted in Bawangling, Jiaxi and Yinggeling in January 2015, and in Diaoluoshan, Limushan, Jianfengling and Wuzhishan in April 2015; the four-person team of interviewers changed between these periods except for one team member, who led the second survey period to ensure consistency in interview methods. Local reserve staff were also present during