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# PARTICIPATORY EPIDEMIOLOGY TO ASSESS SARCOPTIC MANGE IN SEROW OF TAIWAN

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ABSTRACT: We used participatory epidemiology (PE) in remote areas to understand the observed distribution and prevalence of infestation by sarcoptic mange mites (*Sarcoptes scabiei*) on wild Formosan serow (*Capricornis swinhoei*) in Taiwan. A semistructured interview protocol was used for 37 interviews during June–December 2008. Serow with skin lesions consistent with sarcoptic mange were reported within a latitudinal range of approximately 24°00′N to 22°40′N on the Central Mountain Range of Taiwan. The observed prevalence was 40–80% in seven of the 19 interview districts. Clinical signs were observed mainly on serow at elevations >1,000 m and most commonly winter (December–February). *Sarcoptes scabiei* has been observed in the infestation area for at least 80 yr. No other wildlife species with similar skin lesions were reported except wild boar. Sarcoptic mange mites on Taiwan serow might prefer a low-temperature environment, but other factors such as physiologic differences among serow populations might be involved in the determination of the northern boundary of the enzootic range. The use of PE to collect enzootic information on sarcoptic mange in wild serow was effective and rapid.

*Key words:* *Capricornis swinhoei*, participatory epidemiology, *Sarcoptes scabiei*, Formosan serow.

## INTRODUCTION

Field observations in the past decade have reported alopecia and skin lesions on Formosan serow (*Capricornis swinhoei*) in Taiwan (Wang, 2005; Wu, 2005). Infestation by Sarcoptic mange mites (*Sarcoptes scabiei*) was confirmed and documented from a serow in southern Taiwan in 2007 (Chen and Pei, 2007).

Serious impact by sarcoptic mange mites on wildlife populations has been reported in cantabrian chamois (*Rupicapra pyrenaica parva*), common wombat (*Vombatus ursinus*), and red foxes (*Vulpes vulpes*). There are 104 mammalian species reported with sarcoptic mange (Fernández-Morán et al., 1997; Bornstein et al., 2001). The impact of sarcoptic mange on wildlife populations can be severe, especially when newly introduced (Bornstein et al., 2001; Pence and Ueckermann, 2002). Among *Capricornis* species, the Japanese serow (*Capricornis crispus*) is the only other serow species known to be affected by the parasite and exhibit clinical signs. The first case on Kyushu Island, Japan was found in 1995, and another eight suspected cases were reported in 1995 to 1996 on Kyushu Island (M. Baba, pers. comm.). Two additional cases were discovered in Saitama Prefecture, central Honshu Island, in 1996 and 1997 (Takahashi et al., 2001).

Serow are endemic to Taiwan and widely distributed in the mountainous regions of the island (McCullough, 1974; Lue, 1987), from lowland rainforests to alpine meadow and tundra. Because of human activities at lower elevations, they occur more frequently above 1,000 m (Chiang and Pei, 2008). Since 1989, the Formosan serow has been listed as a "Precious and Rare Species" under Taiwan's Wildlife Conservation Act, and hunting is prohibited. Nevertheless, illegal hunting continues by indigenous people.

Determining the spatial and temporal distribution of sarcoptic mange in serow is valuable to understanding its potential impact on this protected, endemic species.



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Skin lesions caused by sarcoptic mange in serow are specific and characterized by alopecia, lichenification, crusting, fissuring, and skin erosions (Chen and Pei, 2007). Because direct assessment of the mite is not practical, we chose to use participatory epidemiology (PE) in aboriginal tribes to collect disease information, including spatial and temporal distribution, historical occurrence, and possible prevalence of sarcoptic mange in wild serow populations.

An assumption of PE is that local community members have rich and detailed knowledge about the animals they observe and harvest. This survey method is rapid, low cost, and especially useful in remote areas (Jost et al., 2007). Furthermore, through the process of interviews, sample collection and multiple independent respondents, information quality can be controlled and validated.

In Taiwan, the majority of indigenous tribes live in remote mountainous areas and have a long tradition of hunting wildlife for cultural and subsistence reasons. Species commonly hunted are wild boar (*Sus scrofa taivanus*), Reeves' muntjac (*Muntiacus reevesi micrurus*), sambar (*Rusa unicolor swinhoei*), and serow. Forest rangers, many of whom are also tribal members, work for the Forestry Bureau and National Parks of Taiwan. They have many opportunities to observe serow during the course of their work, and they can also provide PE data.

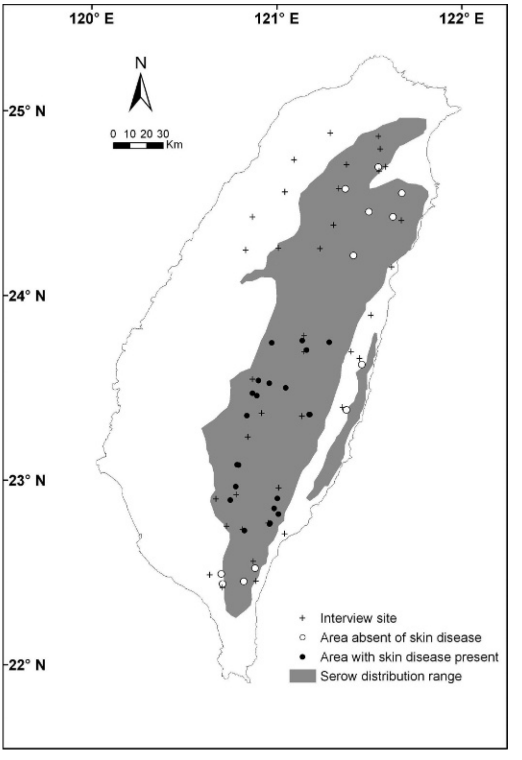


FIGURE 1. Locations of the 2008 participatory epidemiology interviews and interview results identifying the area absent of skin disease and the area where skin disease was observed in the Formosan serow (*Capricornis swinhoei*) on Taiwan. Distribution range of Formosan serow on the Central Mountain Range (large shaded area on left) and Coastal Mountain Range (small shaded area on right) were adopted from Chiang and Pei (2008).

## MATERIALS AND METHODS

Interviews were arranged in indigenous communities and at ranger stations within the known distribution range of serow. Hunters and elders in indigenous communities were contacted by the tribal chief and hunting or religious leaders. Rangers for interview were selected by the directors of each forest district office and national park.

We conducted 37 interviews (25 communities belonging to 20 tribal districts and 12 ranger stations) during June–December 2008 (Fig. 1). Interviews were conducted in groups of two to four interviewees simultaneously. Other tribal members often participated and provided additional information during community interviews. Interviews with tribal members fluent only in their mother languages were facilitated by translators.

A semistructured interview was used to avoid the potential of leading responses and limiting information, which can occur with formally structured interviews (Ferguson and Messier, 1997). The initial question was "Have you ever seen any sick animal in the wild?" No further prompting or guidance was provided, thereby allowing the interviewees to describe their most memorable incidents. If the responses included "skin disease" or "skin lesion" of serow, interviewees were asked to describe the clinical signs and characteristics of lesions that helped to confirm sarcoptic mange.

Local and color topographic maps (scale 1:50,000) showing trails, rivers, mountains, and villages were used to facilitate identification of hunting grounds or mountain trails where serow with skin diseases or lesions were observed or

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hunted. Additional information obtained included elevation range, history of observations, prevalence in the enzootic areas, seasonal occurrence, and other species involved. Prevalence of mange in a tribal district was determined by all participants in an interview through group discussion (Jost et al., 2007). If more than one community interview was conducted within a tribal district, the average was used to represent the prevalence of infestation in that district.

If the interviewee did not mention skin diseases or lesions in their first response, pictures of serow with sarcoptic mange were shown to confirm their observations. The spatial distribution of disease occurrence was identified as the area that serow skin disease was observed by interviewees; the area where serow skin disease had not been seen was categorized as the area of disease absence.

## RESULTS

Fifty-four elders and hunters were interviewed; 28 from seven districts stated they had observed skin diseases or lesions on serow. Thirty-eight forest rangers were interviewed, 19 of whom, from five ranger stations, also observed skin diseases or lesions on serow. The seven tribal districts and five ranger stations overlapped spatially. This area has an approximate latitudinal range between 24°00′N and 22°40′N in the Central Mountain Range of Taiwan (Fig. 1). Twenty-five elevation ranges were provided by interviewees in the enzootic region. Skin diseases or lesions of serow were most commonly (76%) seen between 1,000 m and 2,000 m, and the two lowest records were around 700 and 800 m (Fig. 2).

Affected serow were observed in all seven tribal districts during winter (December–February). One district had observations in autumn (September–November) and one in spring (March–April). Average observed prevalence of skin lesions in serow in the enzootic range was 57% (range 40–80%, SD=15, $n$=7).

Tribal elders and hunters in five districts indicated this phenomenon had been seen for more than 80 yr in their hunting grounds. In general, elders and hunters had much more personal experience in handling wildlife than forest rangers. Interviewees from three districts reported similar skin diseases or lesions on wild boar but observed rarely. Sarcoptic mange on wild boar in Taiwan has not been confirmed by appropriate sample collection and laboratory diagnosis. There are no other sympatric ruminates (i.e., muntjac and sambar), or carnivores with similar reported skin lesions.

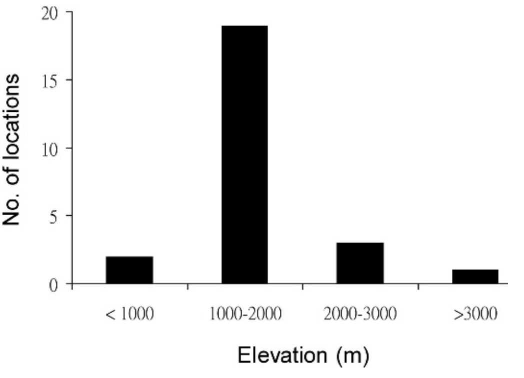


FIGURE 2. Frequency distribution of elevations for 25 locations in Taiwan, where Formosan serow (*Capricornis swinhoei*) with skin disease were observed by interviewees.

## DISCUSSION

Although PE is developed and used originally for rapid assessments of domestic animal health threats (e.g., Mariner and Roeder, 2003; Jost et al., 2007; Azhar et al. 2010), we demonstrated its usefulness in collecting disease information for a wildlife species. The disease characteristics (lesions) described by the participants could be validated through the process of triangulation by comparing with modern veterinary knowledge of sarcoptic mange and sample collection (Jost et al., 2007).

Nevertheless, biases are expected. The prevalence reported in our study might be an underestimate due to the existence of asymptomatic (in early or recovery stage) cases. Conversely, because areas of alopecia reflect the hunters' spotlights and affected serow usually prefer open areas and move less, serow with skin lesions might be more

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easily detected than uninfected individuals, resulting in overestimation. A similar behavior change was observed in common wombats (Hartley and English, 2005). Thus, direct estimation of prevalence and the mortality would be valuable.

According to our interviews, the occurrence of sarcoptic mange infestation on serow was observed in a defined area of the Central Mountain Range. Using the north and south latitudinal boundaries and the knowledge that the majority occurred above 1,000 m, we created a projected distribution map for sarcoptic mange infestation on Taiwan serow (Fig. 3). Skin diseases or lesions on serow outside of this region were rarely or never reported.

It is not clear what factors contribute most to the observed spatial and seasonal patterns we discovered. Poor health status, increased population density, and host susceptibility increase the severity and prevalence of infestation (Arlian, 1989; Fernández-Morán et al., 1997; Skerratt, 2001). Although the low population density at elevations <1,000 m (Chiang and Pei, 2008) might significantly reduce prevalence and frequency of observation, climatic factors such as temperature and humidity may also play a role. All life stages of *S. scabiei* var. *canis* live longer off the host at lower temperatures (10–15 C) and higher humidity (>75%), especially adult females and nymphs (Arlian et al., 1989). Winter was the season sarcoptic mange was most frequently reported in this study and in other hosts (Fernández-Morán et al., 1997; Perez et al., 1997; Skerratt, 2001). Although the optimum climatic conditions for *S. scabiei* on serow are not known, the projected range for the mite in this study has an annual mean minimum temperature <12 C (Fig. 3). If climatic factors are important, it may explain the absence of observed sarcoptic mange on serow in the Coastal Mountain Range and at elevations <700 m in the Central Mountain Range and the lack of southern expansion beyond the known historic range.

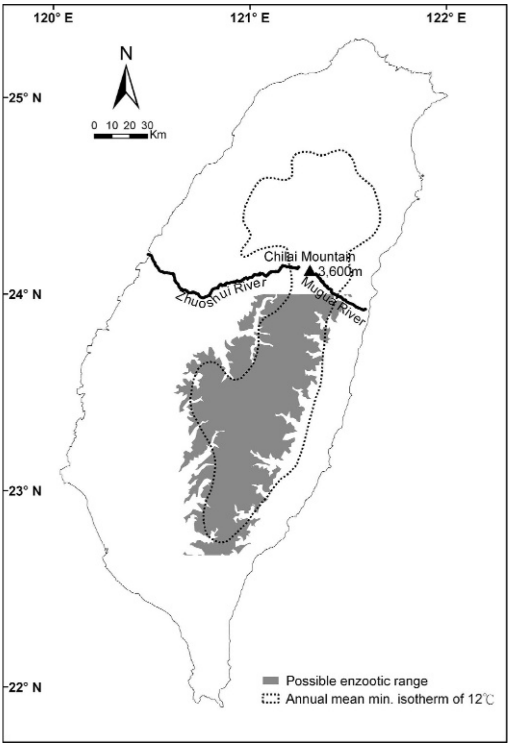


FIGURE 3. Projected enzootic range of sarcoptic mange in Formosan serow (*Capricornis swinhoei*) on Taiwan compared to the 12 C annual mean minimum isotherm.

Global mean temperature is increasing (IPCC, 2007); this trend was also observed in Taiwan (Hsu and Chen, 2002). In the past 100 yr, the temperature has increased 1.0–1.4 C in Taiwan and increasing temperature is projected to continue under several climate change scenarios (Hsu and Chen, 2002). Warming temperatures can expand (or shift) the spatial and temporal distribution of pathogens or increase the intensity of disease occurrences (Lafferty, 2009). However, warming temperatures might also decrease the occurrence or have limited effects on a subset of pathogens. Those include pathogens that occur in high elevations or latitudes or that prefer cooler temperatures and directly transmitted pathogens (Harvell et al., 2002; Rohr et al., 2011). Therefore, climate warming could decrease the intensity of sarcoptic mange in serow populations and its spatial and

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temporal distribution. Nevertheless, the influence of climate change on other factors, such as habitat loss, host abundance, and host susceptibility, might indirectly affect disease occurrence (Harvell et al., 2002; Lafferty, 2009).

At the northern boundary of the projected range, however, the climate is favorable and there is no evidence to suggest serow population density or general health are factors limiting the northern distribution (Chiang and Pei, 2008; Pei, pers. obs.). It is also unlikely that *S. scabiei* is dispersing northward given the long history of observations in the enzootic range.

A recent phylogenetic study of serow in Taiwan identified two genetically distinct groups with a geographic boundary at the Zhuoshui and Mugua rivers (Horng et al., 2003). These rivers are approximately at the northern boundary of the projected sarcoptic mange enzootic range (Fig. 3). It is possible that the geographic barrier responsible for the distinct serow populations also acts as a barrier to mite dispersal. A second more likely explanation is that serow susceptibility to mites is lower in the northern population. A similar spatial phenomenon was reported in coyote populations in Texas, USA, where two populations had different susceptibility to sarcoptic mange (Pence and Windberg, 1994).

Wild boar was the only other wildlife species observed with skin lesions. However, there were very few observations and no direct evidence to confirm sarcoptic mange. Other sympatric wildlife species have not been found with similar skin lesions in Taiwan. Sarcoptic mange is considered to be caused by a single species of mite that diverged into many morphologically indistinguishable strains on different host species. These strains usually show a high degree of host specificity and little cross infectivity (Bornstein et al., 2001; Pence and Ueckermann, 2002). This has also been demonstrated in the laboratory (Samuel, 1981; Arlian et al., 1988; Arlian et al., 1996). Infestation by *S. scabiei* on serow in Taiwan might be host specific. Further study of phylogenetic relationships and potential cross-species infestation by *S. scabiei* strains isolated from different wild and domestic species in Taiwan is needed (Walton et al., 2004; Soglia et al., 2007).

As a point of comparison, enzootic information on *S. scabiei* reported in this study is quite different from that in Japan. Many wildlife species in Japan have been identified with sarcoptic mange (Wildlife Management Office, Inc., 1998), including raccoon dog (*Nyctereutes procyonoides*), red fox, wild boar, Japanese badger (*Meles anakuma*), sika deer (*Cervus nippon*), masked palm civet (*Paguma larvata*), and raccoon (*Procyon lotor*). However, only a few cases of sarcoptic mange (Takahashi et al., 2001) have been confirmed in Japanese serow. The solitary, territorial, and predominantly monogamous behaviors of Japanese serow (Kishimoto and Kawamichi, 1996) may limit transmission of the mite.

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