

Short Communication

## Raising Awareness of Amphibian Chytridiomycosis will not Alienate Ecotourists Visiting Madagascar

Katharina C. Wollenberg,<sup>1</sup> Richard K. B. Jenkins,<sup>2,3,6</sup> Roma Randrianelona,<sup>3,4</sup> Mahefa Ralisata,<sup>3</sup> Roseline Rampilamanana,<sup>3,4</sup> Andrianirina Ramanandraibe,<sup>4</sup> Olga Ramilijaona Ravoahangimalala,<sup>4</sup> and Miguel Vences<sup>5</sup>

<sup>1</sup>Department of Organismic and Evolutionary Biology and Museum of Comparative Zoology, Harvard University, 26 Oxford St, Cambridge, MA 02138

<sup>2</sup>School of Biological Sciences, University of Aberdeen, Aberdeen AB24 2TZ, UK

<sup>3</sup>Madagasikara Voakajy, B.P. 5181, 101 Antananarivo, Madagascar

<sup>4</sup>Département de Biologie Animale, Faculté des Sciences, Antananarivo, Madagascar

<sup>5</sup>Zoological Institute, Division of Evolutionary Biology, Technical University of Braunschweig, Spielmannstraße 8, 38106 Braunschweig, Germany

<sup>6</sup>Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Canterbury, Canterbury, Kent CT2 7NR, UK

**Abstract:** Chytridiomycosis (*Bd*) is contributing to amphibian extinctions worldwide but has so far not been detected in Madagascar. The high likelihood for *Bd* to spread to the island and efface this amphibian diversity and endemism hotspot requires respective conservation policies to be developed. *Bd* could be introduced by the large number of tourists that visit protected areas; therefore, increasing awareness among tourists and encouraging them to participate in safety measures should be a priority conservation action. However, concerns have been raised that tourists would not be able to distinguish between an amphibian disease harmless to humans and emerging diseases that would imply a danger for human health, invoking a negative image of Madagascar as an ecotourism destination. We evaluated whether informing tourists about this infectious animal disease would cause health scare and diminish trip satisfaction. Based on 659 respondents we found that most ecotourists favored to be informed about *Bd* and were proactive about participating in prevention measures, refuting previous concerns.

**Keywords:** *Batrachochytrium dendrobatidis*, Chytridiomycosis, global amphibian decline, Ecotourism, Madagascar

Almost half of all amphibian species are threatened with extinction (Stuart et al., 2004; ACAP, 2005; Gewin, 2008; Wake and Vredenburg, 2008). A proximate driver for these declines is the amphibian chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*), causing the disease chytridiomycosis (Berger et al., 1998; Longcore et al., 1999; Daszak et al., 2000; Fisher et al., 2009; Voyles et al., 2009). *Bd* exhibits the

epidemiological characteristics of a recent panzootic invasion, making spreads to unaffected places in the immediate future likely (Fisher et al., 2009). Although *Bd* is globally widespread, a few hotspots of amphibian biodiversity so far appear to be *Bd*-negative, such as the island of Madagascar, which harbors up to 465 species of amphibians (Weldon et al., 2004; Vieites et al., 2009). In the first published *Bd* survey conducted in Madagascar, Weldon et al. (2004) sampled localities in the northeast, central-east, and central

Correspondence to: Katharina C. Wollenberg, e-mail: kwollenberg@oeb.harvard.edu

highlands of Madagascar. Using histological methods, they did not find *Bd* among 527 frog specimens belonging to 79 species of all 4 Malagasy frog families, and these results are confirmed by molecular screenings performed by V. T. Vredenburg (personal communication, 2009), which will be published in forthcoming papers. Frogs of the Mantellidae, a family endemic to Madagascar and the Comoro islands, are the only species-rich frog radiation that has not suffered rapid declines at the family level yet (Stuart et al., 2004), and to us currently no (published or unpublished) cases of Malagasy frog populations showing clinical symptoms of chytridiomycosis are known. However, this apparent absence of *Bd* in Madagascar likewise implies a high likelihood for *Bd* to spread to Madagascar and efface this amphibian diversity and endemism hotspot (as reported for other biodiversity hotspots, such as Panama; Lips et al., 2006); therefore, urgent measures of biosecurity need to be taken (Andreone et al., 2008; Lötters et al., 2008; Fisher et al., 2009).

Ecotourism is one of the three important pillars of Madagascar's economy, and its focus has always been the island's unique fauna and flora. Although the international amphibian trade is undoubtedly a plausible driver for the worldwide spread of *Bd* (Kriger and Hero, 2009), a human-mediated introduction of *Bd* to Madagascar, as for example by ecotourists, is likely to happen in the near future (Mazzoni et al., 2003; Weldon et al., 2004; Garner et al., 2005; Fisher and Garner, 2007; Skerratt et al., 2007; St-Hilaire et al., 2009). In fact, the pattern of global *Bd* dispersal suggests that it survives independently from amphibian hosts (Rosenblum et al., 2010), and the *Bd* zoospore that eventually infects the amphibian host has been found to survive in water bodies and on substrates (Johnson and Speare, 2005; Walker et al., 2007), therefore sharing equipment between sites poses the risk of pathogen transfer (St-Hilaire et al., 2009). Pathogen transmission risk assessment methods and recommendations for equipment cleaning procedures for researchers involved with amphibians exist (Johnson et al., 2003; Webb et al., 2007; St-Hilaire et al., 2009), but these measures have not been implemented in tourism yet. In theory, global travellers (specifically ecotourists) could spread active zoospores attached to substrate from *Bd*-prevalence sites on their shoes or equipment to novel sites within a short time frame. Even if the risk of exposure of tourists to *Bd* compared with researchers working with amphibians is relatively low, the high numbers of ecotourists versus researchers visiting

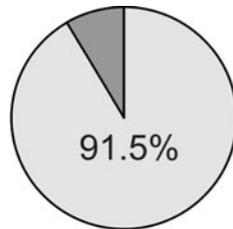
Madagascar increase the net likelihood of anthropogenic introduction of *Bd*.

Raising awareness of the disease and establishing prevention measures for tourists should be considered a top priority in conservation policy-making for Madagascar. During an amphibian conservation workshop in 2006 (A Conservation Strategy for the Amphibians of Madagascar—ACSAM) under participation of numerous Malagasy and international scientists and institutions (Andreone, 2008), especially the representatives of the Malagasy government raised concerns about informing tourists about the danger of introducing the amphibian chytridiomycosis by international travel. It was suspected that tourists would possibly not be able to distinguish between an amphibian disease that is completely harmless to humans, and emerging diseases that imply a danger for human health (such as Avian or Swine influenza for example), invoking a negative image of Madagascar, which in turn could have negative effects on the ecotourism industry. This prompted us to study whether these concerns were valid. In the course of a more general questionnaire survey on the importance of herpetofauna for ecotourism, conducted in five protected areas in Madagascar between January and September 2008 (Wollenberg et al., 2010 in press), we therefore assessed Protected Area (PA) visitor reactions toward raising awareness of chytridiomycosis and prevention measures (Box 1).

Of the 659 international tourists who were interviewed, 91.5% were not aware of the existence and the nature of chytridiomycosis before the interview. Subsequently, they were presented a statement informing about the chytrid fungus, the relationship between chytridiomycosis and amphibian decline, and specific recommendations to prevent the introduction and spread of chytrid fungus in Madagascar (Box 1). We asked whether they would feel irritated or scared about their own health if they saw such a statement at PA entrances or the international airports, which 95.6% denied; 98.6% of respondents said they would take some time to read the statement, and 96.6% of respondents stated that they would follow the recommendations displayed on such a sign. Asked if they had any other suggestions, two visitors requested that spray bottles or basins with disinfectant or bleaching solution should be offered at PA entrances to clean hiking shoes before entering the PA. Two visitors suggested that information signs on chytrid fungus should be set up that are short, illustrated with pictures and easily comprehensible for the general public.

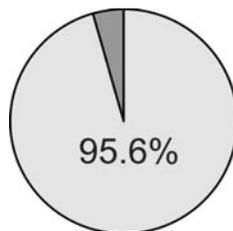
**Box 1.** Questions about chytridiomycosis used in the survey (available both in English and French). Answer proportions are depicted as pie charts: “yes” answers in dark grey, “no” answers in light grey

Have you ever heard about the amphibian disease “chytridiomycosis?”

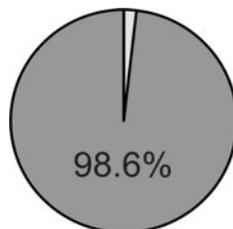


Read the following information about chytrid fungus that could be displayed at various sites (e.g., the entry of the airports, parks, etc.): “*Chytrid fungus causes a disease that is harmless to man, but is currently driving many of the world’s amphibians to extinction. It is widely distributed in the world, yet has not arrived in Madagascar so far. Its spores can stick to muddy hiking shoes and could thereby be introduced by visitors. Please clean and completely dry your hiking shoes before going into the forest for the first time to protect Madagascar’s unique amphibian fauna.*”

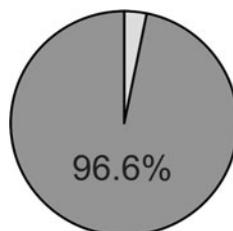
If you saw this or a similar sign at the entrance of the airport or the National Parks, would you feel irritated or scared about your own health?



Would you take some time to read this sign?



Would you follow the appropriate measures as demanded on the sign?



These results show that most ecotourists visiting PAs in Madagascar are not aware of *Bd* but would not experience health scare when being informed and furthermore would follow any specific recommendations to prevent the disease from arriving and spreading in Madagascar (which could include devices for shoe cleaning at PA entrances using protocols as described in Johnson et al., 2003 and Webb et al., 2007). There is evidence that the potential benefits for the endemic Malagasy frog fauna of raising awareness of chytridiomycosis and providing information on how to prevent the introduction of the pathogen to Madagascar is paralleled by an extremely low risk of creating unpleasant experiences for visitors—our study showed that adverse economic effects on Madagascar’s tourism industry will be negligible. A disease-free, species-rich, and individual-rich frog fauna has high ecotouristic potential (Wollenberg et al., 2010 in press), and we therefore urge conservation agencies in Madagascar to establish a series of appropriate measures to prevent *Bd* from entering the island, in particular to develop information panels and brochures to be displayed at the island’s main international airports in Antananarivo and Nosy Be and in protected areas of high tourist affluency located in highland and mid-altitude rainforests where the risk of chytrid establishment is particularly high (Lötters et al., 2008). We see these results as a showcase for conservation policy-making in other amphibian diversity hotspots frequently visited by ecotourists.

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