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## AMPHIBIAN DISEASES

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### Detecting the Western Limits for *Batrachochytrium dendrobatidis* in Southeastern Queensland, Australia

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The fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) is implicated in the decline of worldwide amphibian populations (Berger et al. 1999), with new occurrences of the fungus being constantly reported (e.g., recent issues of *Herpetological Review*). Whereas the fungus has been detected in numerous locations, it is considered an invasive species (Weldon et al. 2004) and an emerging infectious disease (Daszak et al. 1999; Rosenblum et al. 2010), and hence its distribution is not at equilibrium. Niche modeling has predicted the potential of *Bd* to invade southern and central Africa, parts of south-east Asia, southern and central North America, Europe, and South America (Ron 2005). Within Australia the impact of the fungus is expected to be highest in the eastern and south-eastern mountainous regions along the eastern seaboard (Rödder et al. 2008), however it is expected to reach its physiological limits approximately 300–400 km from the coastline (Rödder et al. 2008).

Although numerous studies within Australia have detected *Bd* along the eastern coastline (Kriger et al. 2007a; see Ron 2005 appendix) there have been no studies aimed at detecting *Bd* west of the mountain range known as the Great Dividing Range in southeastern Queensland. Considering the impacts that *Bd* has had on amphibian populations worldwide it is essential to determine the presence of this fungus in untested areas. The aim of our study was to sample for *Bd* in the unsampled western

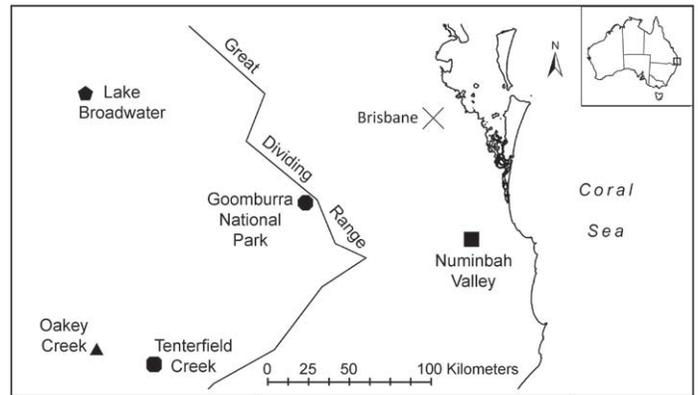


FIG. 1. Location of sites sampled for *Batrachochytrium dendrobatidis* east and west of the Great Dividing Range (approximate location represented by the left line), Queensland, Australia. The coastline (right line) and Queensland's capital city, Brisbane (X) are shown.

plains of southeastern Queensland, Australia.

We sampled for *Bd* in early September 2007 at four sites west of the Great Dividing Range (GDR) in southeast Queensland, including a previously known site of *Bd* on the GDR in Goomburra National Park (Ron 2005) (Fig. 1). We also sampled a well-studied site in Numinbah Valley (east of the GDR) as a reference site to address annual variation in prevalence (Kriger and Hero 2006; Kriger et al. 2007a) (Fig. 1). Sampling was carried out in spring (26 September 2007 to 10 October 2007) to maximize the probability of detecting *Bd* (Kriger and Hero 2007). We swabbed 212 adult frogs, with 145 sampled west of the Great Dividing Range and 67 sampled at Numinbah Valley (Table 1).

A standardized swabbing method was used (Kriger et al. 2007a), modified slightly as we did not swab the dorsal surface. Swabs were stored on ice and kept in a refrigerator until analysis (Van Sluys et al. 2008). Frogs were individually handled with clean 250 mm x 200 mm plastic bags, which were discarded after use to avoid the transfer of *Bd* and to minimize the chances of sample contamination. All frogs were swabbed by the same individual (JM) to avoid swabber bias. To circumvent sampling the same frog twice, individuals were not released until all frogs had been swabbed at each site.

Quantitative polymerase chain reaction techniques (qPCR), as described by Boyle et al. (2004) with modifications described by Kriger et al. (2006), were used to determine *Bd* presence. A positive infection was considered any frog which produced a result of one or more zoospores in the triplicate PCR analysis procedure (Kriger et al. 2007b). Prevalence for each species per site was calculated.

The site with the highest prevalence (25.4%) was Numinbah Valley, located east of the GDR. This was followed by Goomburra National Park (12.5%), located just west of the GDR, Lake Broadwater (7.1%), and Tenterfield Creek (2.2%; Table 1). We detected *Bd* at only one site sampled at Lake Broadwater. This site consisted of 19 of the 28 individuals surveyed for the Lake Broadwater Conservation Park. All frogs detected with *Bd* were from water bodies that are either permanent or temporary riverine systems (Table 1).

Our study has extended the known range of *Bd* west of the GDR, in southeast Queensland, Australia, by approximately

TABLE 1. Sites where frogs were sampled for *Batrachochytrium dendrobatidis* (*Bd*), both west and east of the Great Dividing Range (GDR) in southeast Queensland, Australia. *Bd* prevalence per site and per frog species sampled is shown. Habitat types of sampling locations were either permanent or ephemeral water bodies (streams or ponds).

Location (habitat type)	Lat / Long ° (approx. distance west (+) or east (-) of GDR (km))	Species	No. <i>Bd</i> - positive / No. frogs swabbed	Prevalence (%)
Tenterfield Creek (permanent)	-28.8600 151.4852 (+52)	<i>L. wilcoxii</i>	1/43	2.2
		<i>L. latopalmata</i>	0/3	0
<b>Tenterfield Creek Total</b>			<b>1/46</b>	<b>2.2</b>
Oakey Creek (permanent)	-28.7753 151.1705 (+80)	<i>L. wilcoxii</i>	0/17	0
		<i>L. latopalmata</i>	0/6	0
<b>Oakey Creek Total</b>			<b>0/23</b>	<b>0</b>
Lake Broadwater Surveyor's Gully Site 1 (ephemeral) 100	-27.3765 151.1088 (+85)	<i>C. alboguttata</i>	0/1	0
		<i>L. tasmaniensis</i>	1/1	
		<i>L. fletcheri</i>	0/3	0
		<i>L. latopalmata</i>	1/14	7
<b>Surveyor's Gully Site 1 Total</b>			<b>2/19</b>	<b>10.5</b>
Lake Broadwater Surveyor's Gully Site 2 (ephemeral)	-27.3765 151.1088 (+85)	<i>C. alboguttata</i>	0/2	0
		<i>L. tasmaniensis</i>	0/1	0
Lake Broadwater Quarry Dam Site 3 (permanent)	-27.3765 151.1088 (+85)	<i>L. tasmaniensis</i>	0/5	0
Lake Broadwater Historical Farm Dam Site 4 (permanent)	-27.3765 151.1088 (+85)	<i>L. tasmaniensis</i>	0/1	0
<b>Lake Broadwater Total (all sites combined)</b>			<b>2/28</b>	<b>7.1</b>
Goomburra N.P. Dalrymple Creek (permanent)	-27.9754 152.3153 (+6)	<i>L. wilcoxii</i>	6/48	12.5
Numinbah Valley Nerang River (permanent)	-28.1752 153.2258 (-60)	<i>L. wilcoxii</i>	17/67	25.4

85 km (Ron 2005). This range extension falls within the area predicted by the Rödder et al. (2008) model.

All *Bd*-positive samples were taken from frogs captured in riverine systems that have flowing water for at least some time of the year. The absence of detection of *Bd* from ponds/dams at Lake Broadwater may be due to low sample size (Table 1). However Kriger and Hero (2007) found low prevalence of *Bd* in anuran pond/dam breeders when compared with stream breeders. The low prevalence and lack of *Bd* within the other permanent river systems sampled in this study (Tenterfield and Oakey Creek) suggest the distribution of *Bd* in the drier inland parts of Australia may be patchy or absent.

Our results suggest that prevalence is lower at sites west of the GDR when compared with sites east or on the GDR, thus suggesting that prevalence decreases within populations of frogs with increasing distance west of the GDR in south-eastern Queensland. Prevalence was low west of the GDR when compared with our samples both east of (Nerang River, Numinbah) and

on the GDR itself (Dalrymple Creek, Goomburra). This is not surprising because *Bd* has been readily detected in areas with high rainfall and cooler temperatures (Kriger and Hero 2006; Kriger and Hero 2008, Kriger et al. 2007a), and the rainfall gradient decreases and average temperatures increase with increasing distance west of the GDR (Hijmans et al. 2005).

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