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Wildfire-induced mortality of Australian reptiles

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In fire-prone ecosystems, effective conservation of reptile species requires an ability to predict how populations will respond to varying fire regimes (Whelan et al., 2002; Bradstock, Bedward and Cohn, 2006). Considerable research has documented reptile responses to fire, but the mechanisms behind the observed patterns are poorly understood making generalisations difficult (Driscoll et al., 2010). A key gap in our knowledge is the fate of reptiles during wildfire: do they survive by fleeing or sheltering underground, or are they killed by fire? Do certain ecological traits make some species more susceptible than others to mortality during fire? Answering these questions is critical to understand how fire management will affect different reptile species. Published accounts of fire-induced mortality of vertebrates are rare in many parts of the world (Woolley et al., 2008), particularly Australia (Whelan et al., 2002). Some studies assume that rates of direct mortality are low (e.g. Rochester et al., 2010) while others assume higher mortality from absences of tagged individuals after fire (e.g. Driscoll and Roberts, 1997). In Australian reptiles, the season of burning (Griffiths and Christian, 1996; Kuchling, 2007) and burrow use (Fenner and Bull, 2007) may influence mortality rates during fire. Observations from a wider range of species will help determine if there are ecological traits that could influence mortality during fire. Here, we report results from a brief survey undertaken less than five weeks after a widespread, severe summer wildfire in which mortality of reptiles was recorded.

The survey took place in Pinkawillinie Conservation Park, South Australia (32°54‘25“ S, 135°51‘08“ E), a 130148 hectare reserve with a semi-arid climate, dominated by mallee woodlands (multi-stemmed Eucalyptus species with a shrubby understory). As part of a broader study of reptile fire ecology, six pitfall trapping stations had been established throughout the reserve. On 27th December 2005 a lightning-caused wildfire burned 28154 hectares of the reserve, including four of our trapping stations. Maximum temperature on the day of the fire was 44ºC, with 15 % relative humidity and 57 km/hr winds (Bureau of Meteorology/J. Tilley, South Australian Department of Environment and Natural Resources). The fire began WSW of our trapping stations, initially covering 37 km in 9 hr under a WNW wind. Our survey site burnt under subsequent SW then SE winds at approximately 1-2 km/hr forward rate of spread, and although fire intensity was not quantified it was likely high (J. Tilley, pers. comm.). On 28th January 2006, 32 days after the fire, we surveyed an area adjacent to one of the trapping stations. The area, previously unburnt since 1986, was completely incinerated by the December 2005 fire and was approximately 500 m from the northern fire edge. Ten people, spaced 1-2 m apart, walked from an access track (also within the burned area) approximately 400 m towards the trapping station then back to the track along the same path, over a total survey time of 10-15 min.

During the survey, we recorded six dead individual reptiles from six species (Fig. 1): *Acanthophis antarcticus* Shaw and Nodder (common death adder, Elapidae), *Ctenotus atlas* Storr (Scincidae), *Delma petersoni* Shea (Pygopodidae), *Demansia reticulata cupreiceps* Storr (yellow-faced whipsnake, Elapidae), *Moloch horridus* Gray (thorny devil, Agamidae), and *Pygopus lepidopodus* Lacépède (common scaly-foot, Pygopodidae). *Acanthophis antarcticus* was blackened and scorched indicating direct mortality from fire. The other specimens were dried and shrivelled and may have been killed by fire, or died shortly afterwards. *Ctenotus atlas* and *P. lepidopodus* also had signs of predation. Two of the dead species were recorded in traps at the trapping station near our survey site prior to the fire (*C. atlas* and *M. horridus*). The remaining species (all snakes or legless lizards) were never recorded at that trapping station despite 1400 trap nights. These cryptic, litter-dwelling species can be hard to detect with pitfall traps (Driscoll et al., 2012). We do

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not know the number of animals that survived the fire so our results cannot be translated into mortality rates, but they do suggest a wide range of species are killed by fire. Our survey was brief and covered a small area so the number of dead reptiles found could be considered high. Prior to the fire, dead reptiles were rarely (< 1 per week) encountered during daily walks to the trapping stations, even in other areas that had been recently burnt in prescribed fires or wildfires.

There was one common trait among the species we recorded: they were all non-burrowing species that shelter in low vegetation and leaf litter (Wilson and Swan, 2010), although some may occasionally use burrows of other species. Other reptiles commonly recorded from the trapping station near our survey site, but not found dead after the fire, included several burrowing species (*Brachyurophis semifasciatus*, *Liopholis inornata*, *Lucasium damaeum*, *Nephrurus stellatus*,

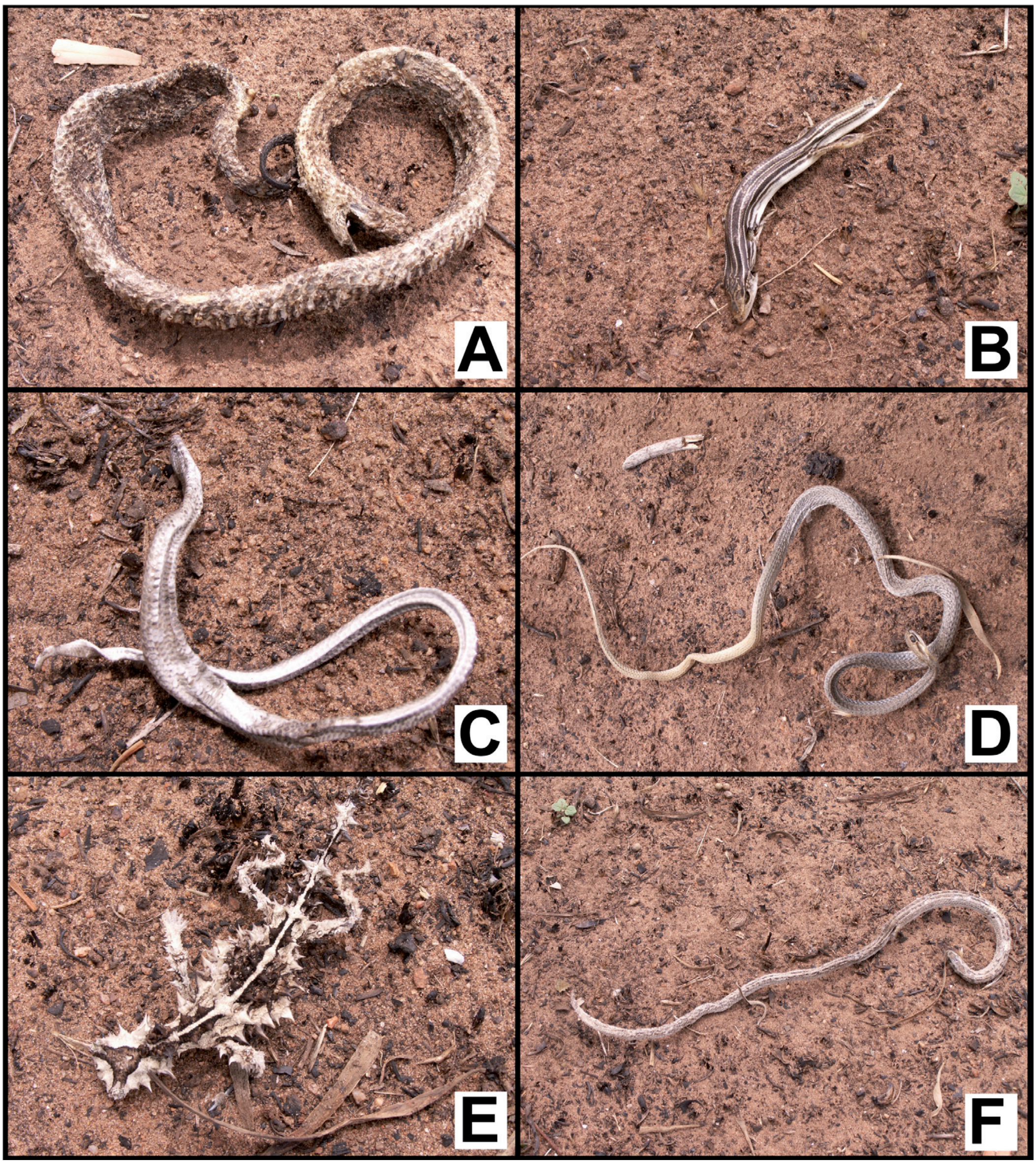

Figure 1. The dead specimens of six species that were found during a brief survey of mallee four weeks after a wildfire: (A) *Acanthophis antarcticus*, (B) *Ctenotus atlas*, (C) *Delma petersoni*, (D) *Demansia reticulata cupreiceps*, (E) *Moloch horridus,* and (F) *Pygopus lepidopodus* (photos: B. Meulders).

Ramphotyphlops bituberculatus). Our observations support the suggestion that burrowing species have lower mortality than non-burrowers during, or shortly after wildfire. In a previous report, no mortality was recorded in one species of burrow-dwelling skinks during a fire (Fenner and Bull, 2007). However, in another study, tortoises in burrows experienced 50 % mortality during wildfire (Kuchling, 2007) so burrowing does not always offer protection from fire. We do not know the time of day that the fire burnt our survey area, but the dead animals recorded included diurnal species (*C. atlas*, *D. petersoni*, *D. r. cupreiceps*, *M. horridus*, and *P. lepidopodus*) and one nocturnal species (*A. antarcticus*). Daily activity patterns may therefore not be useful predictors of reptile mortality during fire, but more data are needed to confirm this.

In monsoonal Australia, Griffiths and Christian (1996) found that early dry-season fires did not directly kill Frillneck Lizards (*Chlamydosaurus kingii*), but late dry-season fires (which have higher intensity and severity) caused 29 % mortality. The fire that burnt our survey site was severe (all above ground vegetation was scorched). Some of the species we found dead are very slow moving (*A. antarcticus* and *M. horridus*) thus unlikely to escape fire by fleeing. However, *D. r. cupreiceps*, a swift predator, was similarly unable to escape the fire. High movement ability may have little benefit during summer wildfires.

In summary, we found that six species of Australian reptiles suffered mortality during, or shortly after wildfire. Traits based on shelter sites may be better predictors of mortality during fire than daily activity patterns or movement ability, but further research is needed to confirm this. To enhance our understanding of fire-induced mortality of reptiles, researchers should conduct controlled experiments during prescribed burning and take advantage of survey opportunities following wildfire (Lindenmayer, Likens and Franklin, 2010). Studies of a wide range of species will allow relationships between ecological traits and mortality to be more rigorously tested, ultimately assisting the development of a predictive framework for fire management.

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