Oryx Vol **40** No 4 October 2006

Short Communication

Loss of habitat through inundation and the conservation status of two endemic Tasmanian Syncarid crustaceans: *Allanaspides hickmani* and *A. helonomus*

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Abstract Extant representatives of the ancient crustacean family Anaspididae are restricted to the island State of Tasmania, Australia. *Allanaspides hickmani* and *Allanaspides helonomus* were first described in the early 1970s from surface pools in buttongrass moorland in two adjacent watersheds in south-west Tasmania. Both of these catchments have since been inundated for hydroelectric power generation (Lake Gordon and Serpentine Impoundments). Surveys indicate that both species persist in a small number of highly fragmented populations on the margins of the two impoundments. *A. hickmani* and *A. helonomus* have extant Areas of Occupancy of *c.* 21 and 54 km^2, respectively. We estimate that inundation resulted in the loss of 85–94% of the original range of *A. hickmani* and *c.* 78% of the original range of *A. helonomus*. Under IUCN Red List guidelines and National threatened species legislation *A. hickmani* but not *A. helonomus* may qualify for listing as Vulnerable (Area of Occupancy <20 km^2). At the present time only *A. hickmani* is listed as Rare under Tasmanian (State) threatened species legislation but *A. helonomus* merits the same listing under State legislation. Global warming appears to pose the most significant potential threat to *Allanaspides* species.

Keywords *Allanaspides helonomus*, *Allanaspides hickmani*, Australia, buttongrass moorland, global warming, inundation, Red List, Syncarida, Tasmania.

The superorder Syncarida is a group of tiny freshwater crustaceans dating from the Carboniferous period (Schram, 1984; Dawson, 2003). The Syncarida were known only from fossil representatives until the first living representative, the shrimp-like *Anaspides tasmaniae* (family Anaspididae), was discovered in mountain pools in Tasmania (Schram, 1984). Since the description of *A. tasmaniae* a further two extant genera of Anaspididae (*Paranaspides* and *Allanaspides*) have been described from Tasmania, including the so-called pygmy mountain shrimps, *Allanaspides helonomus* and *Allanaspides hickmani* (Swain, 1999; Dawson, 2003). All extant representatives of the Anaspididae bear a close resemblance to the fossil syncarids (Schram & Hessler, 1984; Dawson, 2003).

The two *Allanaspides* species are similar in general appearance and size (15 mm in length), but differ in the shape and colouration of the unique ion-exchange organ (fenestra dorsalis) found on the cephalothorax of both species. Both *A. hickmani* and *A. helonomus* have adopted a semelparous life cycle lasting 14–15 months and with little overlap in generations (Swain, 1999; M. Driessen, unpubl. data). Juveniles first appear in February–March (early autumn) and reach sexual maturity several months later. Reproduction and egg laying occur over several months from June onwards, with eggs dormant over the summer months (December–February) until hatching the following year (M. Driessen, unpubl. data). Because both species are effectively univoltine, the survival of eggs over the dry summer months is of critical importance for populations to persist into the following year.

A. helonomus and *A. hickmani* were first recorded from shallow surface pools on buttongrass moorlands in south-western Tasmania (Swain *et al.*, 1970, 1971). These moorlands form extensive tracts in Tasmania's south and west on shallow, nutrient-deficient peat soils dominated by the sedge *Gymnoschoenus sphaerocephalus* or buttongrass (Brown, 1999). The peatland systems of Tasmanian buttongrass moorlands are distinct from the *Sphagnum*-dominated blanket bogs of the Northern Hemisphere and appear to have no analogues elsewhere (Balmer *et al.*, 2004). The surface pools that form between the buttongrass hummocks are highly acidic (pH 3.5–4.5), and frequently open into the subterranean

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Received 18 July 2005. Revision requested 19 September 2005. Accepted 29 March 2006.

 Oryx, **40**(4), 464–467 doi:10.1017/S0030605306001165 Printed in the United Kingdom

burrow systems of the freshwater crayfish *Parastacoides* spp.. These subterranean burrows appear to provide a refuge for *Allanaspides* in the summer months when the majority of surface pools dry out (Swain, 1999).

The two *Allanaspides* species were first recorded from adjacent watersheds (Gordon and Serpentine catchments) in south-west Tasmania prior to the two catchments being inundated for hydroelectric power generation (Swain *et al.*, 1970, 1971; Fig. 1). Subsequent surveys in and around these two catchments (Horwitz, 1988, 1989, 1990; M. Driessen, unpubl. data) have now provided a reasonably complete picture of the species' extant distributions (Fig. 1). Both species appear to have had a naturally restricted (pre-inundation) distribution in areas of flat buttongrass moorland within and immediately adjacent to the Gordon and Serpentine River valleys (Fig. 1). Despite the paucity of pre-inundation records it is apparent from the species' extant distributions that inundation has resulted in the loss of a significant proportion of the species' original range (Fig. 1).

We quantified the loss of habitat through inundation for the two *Allanaspides* species. Buttongrass moorlands in south-west Tasmania occur within a mosaic of scrub, woodland and rainforest. Based on published and unpublished location records for *Allanaspides* (Swain *et al.*, 1970, 1971; Horwitz, 1988, 1989; M. Driessen, unpubl. data; R. Swain, unpubl. data), we estimated the extant Areas of Occupancy of *A. hickmani* and *A. helonomus* as the sum of all patches of non-inundated

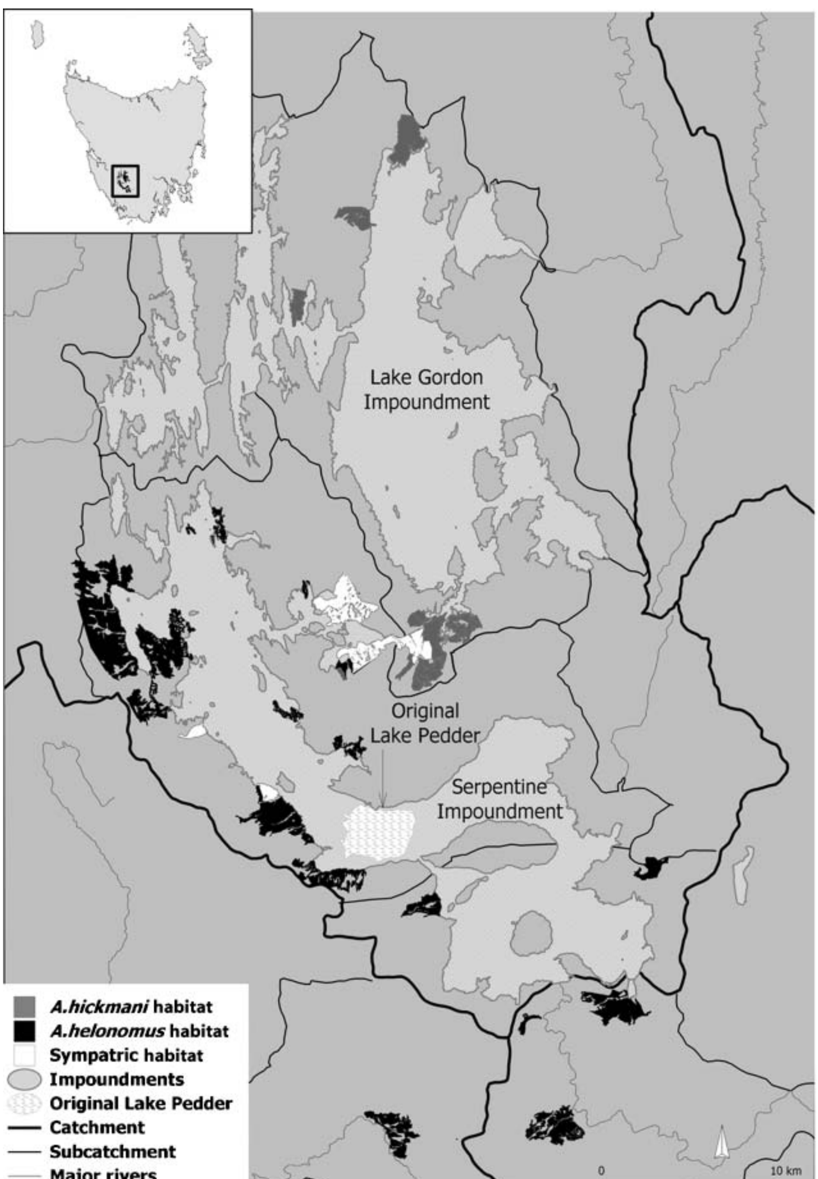

Fig. 1 The extant distributions of *A. hickmani* and *A. helonomus*. Also shown are the location of the Gordon and Serpentine Impoundments, the original Lake Pedder, and the location of the major catchment boundaries and principal rivers of the area. The inset shows the location of the main figure in Tasmania.

buttongrass moorland containing at least one record of either species. Patches of moorland were derived from the TASVEG mapping system, Department of Primary Industries and Water, Tasmania. We assumed that all the moorland within a patch is utilized by the *Allanaspides* species occurring in the patch, which could be an overestimate of the area of habitat actually occupied by both species. The extant Areas of Occupancy for *A. hickmani* and *A. helonomus* were thus estimated to be 21 and 54 km^2, respectively (Fig. 1).

To estimate the area of *Allanaspides* habitat lost through inundation we identified areas of low-gradient land supporting treeless or almost treeless vegetation within the inundated areas using 1:100,000 topographic maps and aerial photographs of the pre-inundation landscape. This assumes that all flat buttongrass moorland within the inundation area is potential *Allanaspides* habitat and is therefore likely to be an overestimate of the actual area of habitat occupied prior to inundation. The total areas of moorland within the Lake Gordon and Serpentine Impoundments were estimated to be 117 and 191 km^2, respectively.

If it is assumed *A. hickmani* occurred in flat buttongrass moorland throughout the Gordon catchment prior to inundation the total area of original habitat is 138 km^2 (117 km^2 inundated + 21 km^2 extant habitat), and the area of extant habitat is 15.2% of the original range of the species. The presence of *A. hickmani* at a number of locations around the margins of the Serpentine Impoundment (Fig. 1) suggests this species also occurred within parts of this catchment prior to inundation. If the pre-inundation range of *A. hickmani* also included the Serpentine catchment (308 km^2 total inundated habitat), the total area of original habitat is 329 km^2 and the area of extant *A. hickmani* habitat represents 6.4% of the original range of the species. Similarly, if *A. helonomus* occurred throughout suitable habitat within the Serpentine catchment prior to inundation, the total area of original habitat is 245 km^2 (191 km^2 inundated + 54 km^2 extant habitat) and the area of extant *A. helonomus* habitat is 22.0% of the original range of the species. Therefore, creation of the Gordon and Serpentine Impoundments is estimated to have inundated 85–94% of the original range of *A. hickmani* and *c*. 78% of the original range of *A. helonomus*.

Current IUCN Red List criteria (IUCN, 2001) for threatened species include a reduction in population size over the recent past (10 years) or a projected population reduction in the near future (10 years), a restricted geographic range, a small population size, and/or a high likelihood of extinction. Both *A. hickmani* and *A. helonomus* have suffered a >70% reduction in range and a probable proportionate reduction in numbers but the loss of habitat occurred >30 years ago and the 10-year limit for listing has therefore passed.

The IUCN currently categorizes both *A. hickmani* and *A. helonomus* as Vulnerable (IUCN, 2006) under criterion D2 of the 1994 Categories and Criteria (IUCN, 1994), which specifies an acute restriction in Area of Occupancy (<100 km^2) or number of locations (<5), such that a taxon would be prone to becoming Endangered or Extinct because of stochastic and/or human activities over a short period of time. However, the most recent IUCN Categories and Criteria (2001) have a Vulnerable (criterion D2) threshold Area of Occupancy of <20 km^2. Therefore, under these guidelines *A. hickmani* would probably qualify for Vulnerable (Area of Occupancy = 21 km^2), whereas *A. helonomus* would no longer qualify for listing (Area of Occupancy = 54 km^2).

Listing of threatened species in Australia can occur under State (Tasmanian *Threatened Species Protection Act 1995*) and National legislation (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*). Currently, neither *Allanaspides* species has been assessed under National legislation. Because this legislation adheres to the 2001 IUCN Categories and Criteria, *A. hickmani* but not *A. helonomus* would qualify for National listing.

The Tasmanian *Threatened Species Protection Act 1995* utilizes a subset of the IUCN categories (Endangered and Vulnerable), and a slightly modified set of criteria. In particular, the State legislation does not include a Vulnerable (criterion D2) criterion for species with a very restricted Area of Occupancy and small number of populations. Therefore, under current listing guidelines, neither *Allanaspides* species would qualify for listing as Vulnerable under State legislation. However, this legislation does include an additional category of Rare for species that are subject to stochastic risk of endangerment because of naturally small population size. Only *A. hickmani* has been listed as Rare under State legislation but both species qualify for Rare under the specific criteria for this category (Extent of Occurrence <2,000 km^2 and most individuals in <10 populations).

Any evidence for further declines of both *A. hickmani* and *A. helonomus* may warrant a reappraisal under IUCN, National and State legislation. Horwitz (1988, 1990) identified further inundation and fire as potential threats to the species. A relatively minor increase in the level of either impoundment would destroy significant areas of remaining *A. hickmani* and *A. helonomus* habitat (Horwitz, 1990). However, there are no current plans to increase the capacity of either impoundment, and further inundation does not pose an immediate risk to either species. Buttongrass moorland is a pyrogenic community that requires repeated burning for the community to persist (Brown, 1999), and the associated fauna (including *Allanaspides*) is presumably also adapted to repeated firing. However, hot or excessively frequent firing of buttongrass moorland has the potential to damage the underlying peat (Horwitz, 1990; Bridle *et al.*, 2003), and a broadscale, hot wildfire that burned a large proportion of the remaining *Allanaspides* habitat in a single event could pose a potential threat to both species.

Perhaps of greatest concern is the potential impact of global warming. The climate of south-west Tasmania appears to be marginal for the formation of the blanket bogs that support buttongrass moorland, and small shifts in prevailing conditions, such as a rise in mean annual temperatures, could potentially cause the peats to degrade (Bridle *et al.*, 2003). The size, depth and longevity of surface pools in buttongrass moorland are also strongly influenced by the dryness of a particular season, and surface pools can be scarce or absent in a dry summer (Swain, 1999; M. Driessen, unpubl. data). The subsurface water in crayfish burrows is presumably more buffered against drying out during summer, although in prolonged periods of summer dryness many crayfish burrows can be without free water for several weeks (Swain *et al.*, 1987). As a result, a climatic shift leading to even a small fall in the water table and subsurface drying out of the peat could have a major impact on the survival of *A. hickmani* and *A. helonomus*.

Acknowledgments

This study was funded by the Tasmanian Wilderness World Heritage Area fauna programme, Biodiversity Conservation Branch, Department of Primary Industries and Water, Tasmania. Tiffany Acreman, Pascal Chartrain, Maria Clippingdale, Skye Jacob-Miller, Matthew Jones, Dave James, Jennifer McCleod, Lydia Merino, Derek Turnbull and Josef Vukich assisted in the field.

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Biographical sketches

Michael Driessen has been involved in management of fauna of the Tasmanian Wilderness World Heritage Area since 1993, dealing with a range of issues including threatened and introduced species. His current research interests are the effects of fire on fauna of buttongrass moorlands and the ecology of cave fauna. Stephen Mallick has worked on a range of threatened species projects, including eastern barred bandicoots and swift parrots, and has investigated the impacts of commercial honeybees on Tasmanian leatherwood forests. Drew Lee's primary interests are marine bird and mammal conservation. Shaun Thurstans is a consulting zoologist who has worked on a diverse range of research and management programmes.