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Regional extinction, rediscovery and rescue of a freshwater fish from a highly modified environment: The need for rapid response

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ABSTRACT

There are high rates of regional and global extinctions among freshwater species and few chances for recovery. We report here on the rediscovery after 30 years of a small fish, the southern-purple spotted gudgeon (*Mogurnda adspersa*), once widespread in the southern Murray–Darling Basin of south-eastern Australia. The rediscovery was in a region, the Lower Murray, where temperate riverine and wetland habitats are modified by a broad spectrum of changes including intensive flow regulation and diversions. There was some doubt whether the rediscovered population was a true remnant or a recent introduction, particularly as there was a translocated population in a nearby artificial habitat. Fortunately, a non-government organisation acted to rescue into captivity about 50 specimens as the remaining wetland habitat dried completely, soon after rediscovery, as a consequence of a decade-long drought and water diversions. We describe the habitat and ecology of fish in the rediscovery site, and provide genetic data, both nuclear (50 allozyme loci) and mtDNA (1141 base pairs; two genes), to show that they were true remnants of the regional native population. This information allows clear planning for future recovery including reintroductions, and is a case study that provides strategies, and hope, for conservation and management concerning other modified habitats. Specifically, it highlights the need for a rapid response to conserve threatened species, the recognition of remnant natural values in altered environments, and the treatment of new finds as native until there is alternate evidence.

1. Introduction

Global extinction rates are escalating in response to human impacts, and the effects are intensified in freshwater habitats (Dudgeon et al., 2006; Vörösmarty et al., 2010). As biodiversity is diminished (e.g. high extinction rates in freshwater fishes: Duncan and Lockwood, 2001), vital ecosystem processes are undermined, leading to potentially irreversible changes (Dudgeon, 2010). Occasionally, however, there may be a reprieve, and an opportunity for recovery, when species presumed extinct are rediscovered (i.e. after all reasonable searches have previously failed to locate individuals: IUCN, 2012). Most rediscoveries are reported in tropical climates (Scheffers et al., 2011), typically in remote, inaccessible or more pristine areas; on a single bush, positioned on a steep rock face, of a remote island being an extreme example (Lord Howe Island stick-insect (*Dryococelus australis*): Priddel et al., 2003). Here we report on the rediscovery of a major regional population of a freshwater fish from a highly modified, temperate environment as an aquatic case study that epitomises issues confronted during a period of unprecedented global environmental change (Strayer and Dudgeon, 2010).

The southern purple-spotted gudgeon (Eleotridae: *Mogurnda adspersa* Castelnau, 1878) is one of many freshwater fishes to have undergone a dramatic decline in the highly-modified Murray-Darling Basin (MDB) of south-eastern Australia (Lintermans, 2007; MDBC, 2004). Until recently, it was known to occur only in a few small populations in tributaries of the Darling River in the northern MDB. The small (<150 mm Total Length) colourful species was popular as an aquarium fish, even being used as a 'bait' fish, and common in the southern MDB (Murray River system) until the 1970s. Subsequently, several regional surveys failed to detect the species. This is reflected in jurisdictional threatened species legislation which considers the MDB conservation

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unit of *M. adspersa* (Adams et al., 2013; Faulks et al., 2008) as endangered (New South Wales), critically endangered (South Australia) or presumed extinct (Victoria). We report the rediscovery of southern MDB *M. adspersa* in late 2002 (Fig. 1), from a single isolated population in Jury Swamp, a small wetland alongside the River Murray between Murray Bridge and Mannum (35° 03′ S, 139° 19′ E), South Australia. This was 2500 km from the nearest known extant populations in the northern MDB (Fig. 2).

A fleeting sighting of southern MDB *M. adspersa* was made in 1995–1996, when a few individuals were recorded from an off-channel irrigation lake complex (Cardross Lakes near Mildura, Victoria), but subsequent intensive survey effort demonstrated that a population was not present owing to major water-level drawdown and salinization (Ellis et al., 2013; Raadik, 2001). Events such as this highlight that new finds may be short-lived, involving a few individuals in a limited area and potentially with a high risk of true extinction (Altaba, 1990; Laurance et al., 1996; Telcean et al., 2011). Information about threats and the ecology, population status and trends of rediscovered species often will be lacking, and needs to be gathered quickly to facilitate management and recovery (Ostrovsky and Popov, 2011; Wanzenböck, 2004). Indeed, only a few years after the rediscovery at Jury Swamp, the habitat dried completely, as a result of protracted drought and upstream diversions and the population was extirpated. Historic data from the southern MDB suggests the species appears to prefer slow-flowing, sheltered areas with dense aquatic vegetation (Blewett, 1929; Hammer et al., 2009).

Fig. 1. Lower Murray *Mogurnda adspersa*: *inset* the first fish rediscovered by T. Goodman in December 2002, *top* a female captured during monitoring in February 2007 and *lower* a captive male guarding eggs in November 2007.

A further quandary concerning rediscoveries arises in habitats modified and frequented by humans, where rediscovered species may occur through accidental or deliberate introductions (Metcalf et al., 2007) rather than having persisted despite adverse conditions. Confusion regarding origin could evoke conflicting management priorities ranging from urgent conservation action, a 'do nothing' approach, to invasive species control (Crees and Turvey, 2015). As a response to presumed regional extinction, in circa 1997, *M. adspersa* were translocated from northern MDB tributaries to the southern MDB at a small, isolated artificial wetland, the Murray Bridge 'Army Range Wetland' (Pierce, 1997) (Fig. 2). A population was established and plans were made to release some fish to the wild, but it is unknown if these were implemented (Hammer et al., 2012; Wager and Jackson, 1993). The Army Range Wetland is only 10 km from Jury Swamp, suggesting that the rediscovered fish might have been derived from the translocated population. *Mogurnda* species are also sold as aquarium fish in nearby Adelaide (population of 1.25 million people) and could have easily been transported to the Murray.

The possibility of translocation provided reason to question the origin of the rediscovered population. Furthermore the rediscovery occurred in an area of intense human activity (angling, boating, houses, dairy farms, drains, levees and introduced plants). As a consequence, government agencies were not persuaded to implement a formal conservation programme. Fortunately, during wetland drawdown some of the last remaining fish were rescued into captivity by a non-government organisation as the basis of a captive breeding programme, on the assumption they could be native to the area (Hammer et al., 2013).

This paper documents a research programme that ran parallel to, and informed, evolving conservation measures for southern MDB *M. adspersa*. Our aims were to (1) assess the population status of *M. adspersa* in the field, and (2) investigate genetic divergence and population heterogeneity using both nuclear and mitochondrial DNA markers in order to determine population origin (Hickley et al., 2004; Miller et al., 1989; Waters et al., 2002). In retrospect, we consider how an effective precautionary management response might be developed for application to comparable situations in the future.

2. Methods

2.1. Study region and environmental change

The MDB is an expansive river system that covers an area of 1.06 million km^2 in south-eastern Australia (Fig. 2). The Murray and Darling rivers join and then flow to the Southern Ocean via the 830-km 'Lower Murray'. The Lower Murray includes four zones, namely: (1) broad floodplain tract (the 'Riverland'), (2) limestone gorge tract with a narrow floodplain, (3) swampland tract with only sparse wetland remnants in an area now reclaimed for pasture, and (4) the terminal 'Lower Lakes' region, including Lakes Alexandrina and Albert, the Murray Mouth and a coastal lagoon, the Coorong. Barrages along the seaward margins of Lake Alexandrina prevent sea water entering the Lower Lakes. The channel of the Lower Murray has a series of 10 low-level weirs, and the floodplain in some areas is protected by flood levees (Walker, 2006; Walker and Thoms, 1993).

The natural flow regime is highly variable, but has seen a dramatic alteration in streamflow volume, seasonality and flooding due to water extraction for irrigation (Leblanc et al., 2012; Walker and Thoms, 1993). Water levels in the Lower Murray below Blanchetown (Fig. 2) are influenced by wind-driven standing waves (seiches), causing changes up to ±0.3 m daily (Webster et al., 1997). These provide regular lateral river-floodplain flushing, and are unique to this river stretch, being less evident in the stable weir pools upstream (Walker, 2006). During this study (2003–2010), water in the Murray at Jury Swamp typically was turbid (Secchi transparency: 0.05–0.2 m), with relatively low salinity (electrical conductivity at 25 °C: 300–800 μS