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Establishment and potential spread of the introduced spotted-thighed frog, *Litoria cyclorhyncha* (*Ranoidea cyclorhynchus*), in South Australia

C. M. Taylor, G. Keppel, S. Peters, G. R. Hopkins and G. D. Kerr

*School of Natural and Built Environments, University of South Australia, Adelaide, South Australia, Australia; *Biodiversity, Macroecology and Conservation Biogeography, University of Goettingen, Goettingen, Germany; *School of BioSciences, University of Melbourne, Melbourne, Victoria, Australia; *Department of Environment, Water & Natural Resources, Natural Resources Eyre Peninsula, Port Lincoln, South Australia, Australia

**ABSTRACT**

*Litoria cyclorhyncha* is a hylid frog native to southwest Western Australia (WA). It was first recorded in South Australia (SA) in 2000 and has established a breeding population in Streaky Bay on the western Eyre Peninsula since at least 2011. *L. cyclorhyncha* is a relatively large predatory frog that presents a potential threat to fauna and ecosystem processes in SA and eastern Australia. This study examines the invasion history and current and potential future distributions of this frog using historical records, field surveys and species distribution modelling (SDM). The historical records in SA suggest human-assisted dispersal through transport networks. Field surveys throughout the Eyre Peninsula during 2016–2017 detected three native species of frogs but no additional breeding populations of *L. cyclorhyncha* outside of Streaky Bay. Within Streaky Bay, frog abundance appears to be concentrated around permanent water bodies, but the species is also well established in urban habitats. SDM suggests that suitable environmental conditions exist for *L. cyclorhyncha* in southern and eastern Australia. This, and the frog’s ability to disperse over long distances, suggests considerable potential for the species to become invasive. As *L. cyclorhyncha* has potential to significantly impact biodiversity and ecosystems, management strategies are urgently needed.

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Distribution extension; Eyre Peninsula; invasive amphibian; frog surveys; species distribution modelling; Biodiversity and Climate Change Virtual Laboratory (BCCVL)

**Introduction**

Invasive species are a major cause of biodiversity loss on a global scale (Ficetola, Thuiller, & Miaud, 2007). Invasive amphibians can have serious ecological and evolutionary impacts on other species and ecological communities (Kraus, 2015; Shine, 2010, 2014). Furthermore, invasive amphibians can have social impacts on humans by adversely affecting economies, health and scientific knowledge (Kraus, 2009). Conservation efforts may be
hindered by the loss of scientific knowledge that may occur when invasive species alter the original ecology of the environments they invade (Kraus, 2009).

Distribution records accompanied by environmental and habitat data are important for the study of amphibians (McDiarmid & Inger, 1994). Such information can verify the habitat preferences of species. Furthermore, long-term distribution data can help to identify changes to ecosystems caused by invasive species, climate change, human interactions, pollution and biological factors such as disease (Heyer, Donnelly, McDiarmid, Hayek, & Foster, 1994; Lindenmayer & Likens, 2009). Understanding a species’ fundamental ecological niche of temperature, rainfall, salinity tolerance and habitat preferences can also help predict where the species may occur under future climatic conditions (Kearney et al., 2008).

*Litoria cyclorhyncha* is a large hylid frog (males to 66 mm, females to 80 mm snout-vent length) (Cogger, 2014; Ehmann, 2013; Tyler & Knight, 2011). The distinguishing features of *L. cyclorhyncha* are the colouration of the thighs, groin, tibia and axilla (yellow and white spots on black; Figure 1), and its call that sounds like the distant sound of wood being sawn (Main, 1965). Recent taxonomic treatments of the genus *Litoria* reclassify the species as *Dryopsophus cyclorhynchus* (Duellman, Marion, & Hedges, 2016) and *Ranoidea cyclorhynchus* (Dubois & Frétey, 2016), with the latter accepted by Frost (2018). However, we use *L. cyclorhyncha* here, as this remains the name commonly used in Australia.

The species’ native range in southwest Western Australia (WA) (Figure 2) is bound by the arid zones to the north and east and the ocean to the south and in the west from near Albany inland to Broomehill and Lake Varley (Atlas of Living Australia (ALA), 2017a; Cale, 1991; Cogger, 2014; Tyler & Knight, 2011; Tyler & Slack-Smith, 2013). At the western margin of its range, *L. cyclorhyncha* is replaced by *Litoria moorei*, which it is closely related to (Burns and Crayn, 2006) and possibly conspecific with (Cale, 1991; and Tyler and Slack-Smith, 2013). *L. cyclorhyncha* is semi-aquatic and favours open heath, swamps and other permanent water bodies, tolerating hot, dry and saline

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**Figure 1.** Colouration, including spotted thighs, displayed by *Litoria cyclorhyncha* (photo credit: CMT).
conditions (Cogger, 2014; Janicke & Roberts, 2010; Main, 1965; B. Roberts & Roberts, 2012; Tyler & Knight, 2011).

It is believed that intentional and unintentional human-assisted dispersal through transport networks and artificial water bodies have facilitated an eastward spread of *L. cyclorhyncha*. Introduced populations of the species now exist in artificial water bodies in Eucla on the Nullarbor Plain and at Streaky Bay on the western Eyre Peninsula in South Australia (SA), and there have been sightings of individual frogs in other parts of SA (Figure 2) (Ehmann, 2013). Concern exists about populations of this species becoming established and spreading to other wetlands on the Eyre Peninsula and beyond, including the Murray–Darling basin (Ehmann, 2013). Understanding the potential detrimental impacts of *L. cyclorhyncha* on invertebrate and vertebrate fauna, and ecosystem processes, is a priority for natural resource management (NRM) (Ehmann, 2013).

An important first step in invasive species management is to ascertain the distribution of the species of concern (Kraus, 2009). Our objectives therefore were to determine the historical and current distribution of *L. cyclorhyncha* in SA, particularly on the Eyre Peninsula and at Streaky Bay, and to forecast potential future spread of *L. cyclorhyncha* for conservation planning and management strategies.

**Methods**

**Historical occurrence of *L. cyclorhyncha* in SA**

Historical (before this study) occurrences of *L. cyclorhyncha* in SA were collated from electronic records, literature, and reports from community members prior to early
2016. Electronic records of the South Australian Museum and South Australian Fauna (Biological Database of SA) were sourced through the ALA (2017b). Reports from community members were validated from photographs. The historical records were mapped for a visual representation of the spatial and temporal attributes of the range of *L. cyclorhyncha* in SA. All mapping was done in ArcMap (Version 10.5, ESRI, 2011).

**Present distribution of *L. cyclorhyncha* and native frog species on the Eyre Peninsula**

**Regional frog surveys of the Eyre Peninsula**
This study was conducted between 12 July 2016 and 26 February 2017, as *L. cyclorhyncha* is most active and breeds in the spring and summer when males can be heard calling (Main, 1965; Tyler & Slack-Smith, 2013). Frog surveys followed the methods of the South Australian frog monitoring program, Frogwatch SA (http://www.frogwatchsa.com.au/) and Heyer et al. (1994). Surveys were conducted at 29 locations on the Eyre Peninsula to search for *L. cyclorhyncha*, as historic occurrences of the species in SA were mostly reported there, and to record native frog species opportunistically.

The climate of the Eyre Peninsula is semi-arid and Mediterranean (Specht, 1973). Natural surface water bodies are uncommon and mostly ephemeral and brackish or saline (Shepherd, 1985; Williams, 1985). In addition, an increasing number of artificial freshwater bodies (e.g. wetlands, pools, treatment ponds and tanks or dams to capture water run-off) have been established. Sites selected for frog surveys included locations where *L. cyclorhyncha* had previously been reported. Due to *L. cyclorhyncha*’s purported tolerance to high salinity (Janicke & Roberts, 2010), brackish and saline wetlands were surveyed.

Survey sites were visited once or up to several times (during the day or night) and 79 surveys were completed. Sites comprised 15 different types of wetlands, grassy areas and roads. Active searches were completed by walking or driving around an area of interest searching for frogs and by using a torch or spotlight at night. Individual frogs of all species were counted and the presence of tadpoles recorded. Water conductivity (mS/cm) was recorded for sites visited from 5 to 7 December using Hanna conductivity meters (Combo pH/Conductivity/TDS tester [Low Range] Model: H198129; and a Multimeter EC/TDS/NaCl/°C Model: HI9835) and converted to salinity (parts per thousand [ppt] Cl\(^-\)) using http://www.chemiasoft.com/chemd/salinity_calculator. The locations of the survey sites and the presence of all frog species recorded on the Eyre Peninsula were mapped.

**Distribution of the *L. cyclorhyncha* population at Streaky Bay**
The small town (human population: 1150; township area: ~3 km\(^2\)) of Streaky Bay (District Council of Streaky Bay, 2017) has several large artificial water bodies in the township and four were surveyed for frogs. Water bodies include an artificial wetland (~2200 m\(^2\)), effluent (~2440 m\(^2\)), recycled water (~7500 m\(^2\)) and stormwater ponds (~3450 m\(^2\), ~2108 m\(^2\)).

*L. cyclorhyncha* were observed or captured for a dietary study (results will be presented elsewhere) at Streaky Bay between September 2016 and February 2017. The methods of the Biological Survey of SA (Owens, 2000), Frogwatch SA (http://www.
frogwatchsa.com.au/) and Heyer et al. (1994), were adapted to record environmental conditions, occupied habitat and behaviour of individual *L. cyclorhyncha* and to describe the distribution of the population. We recorded the location, date and time of frogs observed or collected and their behaviour (foraging, hopping/moving, calling, sheltering, in amplexus, resting or roadkill); strata occupied (<0.5 m, >0.5–<5 m or >5 m); macrohabitat (shrub, on ground, tree, water body or man-made structure) and microhabitat (in/on/under and description of the feature). The locations of breeding ponds, survey sites and individual *L. cyclorhyncha* occurrence at Streaky Bay were mapped.

**Potential future distribution of *L. cyclorhyncha* in SA**

The potential distribution of *L. cyclorhyncha* in SA was explored using correlative species distribution modelling (SDM) in the Biodiversity and Climate Change Virtual Laboratory (BCCVL) (Hallgren et al., 2016). The biological data used for the model were the locations of occurrence records of *L. cyclorhyncha* in the native range in WA and from the invaded range at Streaky Bay (Figure 2) (Atlas of Living Australia (ALA), 2017c). Records from Streaky Bay were used because the population is well established in the area. The historical records in SA were not used because they appeared to be single individuals that had been transported by humans and not indicative of established populations (see the Results section).

Records in the ALA include preserved specimens, material samples, human observation and machine observation (audio recordings of frog calls), mostly from WA. Human and machine observation records of frogs in WA where the ranges of *L. cyclorhyncha* and *L. moorei* overlap were excluded because the calls and morphology of these two species are similar (Cale, 1991) and could be confused by non-specialists. The locations recorded for preserved specimens and material samples of *L. cyclorhyncha* in WA were downloaded from the ALA (2017c). Several missing or incorrect latitude and longitude records, outliers and duplicates were removed and 11 locations of preserved specimens collected from Streaky Bay were added to the dataset.

BCCVL provides options to include several environmental and climate layers for SDM. The environmental layers Annual Global Potential Evapo-Transpiration (PET) and Annual Global Aridity (Zomer, Trabucco, Bossio, Van Straaten, & Verchot, 2008, http://www.cgiar-csi.org) were used in the BCCVL because evaporation and aridity would be the most likely environmental attributes to affect frog distribution (Crump, 1994; Main, Littlejohn, & Lee, 1959), and layers for water bodies and their salinities are not provided. Several climate data layers, generated by aggregation of monthly data from 1976 to 2005 and interpolation from a resolution of 2.5 arcmin to 30 as (Vanderwal, 2012), are also available (Supplemental data, Table S1).

To determine collinearity between predictor variables, a MaxEnt model was created using all environmental and climate variables and 116 locations of occurrence records. From this model, Pearson’s correlation coefficient was calculated among the values of all variables for the 116 locations (Supplemental data, Table S2). For correlated variables \((r < -0.7 \text{ or } > 0.7; \text{Dormann et al., 2013})\), only one was retained for use in the subsequent model (Supplemental data, Table S2). The environmental variable Annual Global PET and the climate variables isothermality \((B03); \text{quantifies day-to-night temperature}\)
differences relative to summer-to-winter [annual] oscillations; Hallgren et al., 2016), mean temperature of driest quarter (B09), mean temperature of coldest quarter (B11) and precipitation seasonality (B15) were retained.

SDM was run online in the BCCVL (Biodiversity and Climate Change Virtual Laboratory (BCCVL), 2018) environment using the machine-learning algorithm MaxEnt (Phillips, Anderson, & Schapire, 2006). The inputs to the model were the occurrence records dataset (116 locations for 467 records of preserved specimens and material samples) and the retained environmental and climate variables datasets (PET, B03, B09, B11 and B15) and the model trained in the environmental envelope in the extent of Australia (11,506 background points). A map of the model was produced, predicting locations in which suitable environmental conditions exist for *L. cyclorhyncha* distribution. The percentage contribution and permutation importance of each retained variable were calculated to determine the variables’ importance for the predicted species distribution (Phillips et al., 2006).

**Results**

**Historical occurrence of *L. cyclorhyncha* in SA**

A population of *L. cyclorhyncha* was established with human assistance in artificial ponds at Eucla on the Nullarbor Plain around 1990–1998 (Ehmann, 2013; Low, T, 2003). Since then, rare and sporadic observations and collections of single *L. cyclorhyncha* in SA occurred between 2000 and 2010 (Figure 3) (Ehmann, 2013). One frog was recorded at the Nullarbor Roadhouse in 2000; another specimen was collected from a caravan park at Ceduna in 2005 (ALA, 2017b), and another frog collected from a car park in Port Augusta in 2010 (Ehmann, 2013).

On 15 November 2011, a breeding population of the frog was discovered at an artificial wetland at the Streaky Bay Area School on the western Eyre Peninsula by the Victorian Wader Study Group. Frogs could be seen floating in the water, calling and displaying white vocal sacs. A sound recording was made, sent to the South Australian Museum and the frogs identified as *L. cyclorhyncha*. Numerous accounts of *L. cyclorhyncha* presence and behaviour have been reported from the Streaky Bay community since. The origin of the Streaky Bay population is unknown and is thought to have been founded through transportation by vehicles from WA. A caravan park is located near the school wetland and frogs may have stowed away in vehicles and equipment. Alternatively, frogs or tadpoles may have been intentionally placed into the wetland.

Since the establishment of the breeding population at Streaky Bay, several sightings have been reported from other places on the Eyre Peninsula (Figure 3) (ALA, 2017b). Three frogs were found at Ceduna in gardens and on a road. In January 2015, a frog was discovered on the foreshore at Port Kenny, 65 km from Streaky Bay. Another was found in December 2015 in a farm shed at Mortana, 42 km from Streaky Bay. At Port Lincoln, specimens of *L. cyclorhyncha* have been found near the racecourse, on Orabanda Drive and on the tarmac of the airport (ALA, 2017b). A single specimen was recorded at the Adelaide Airport in 2012 (Ehmann, 2013), presumably having stowed away on a plane.
Present distribution of *L. cyclorhyncha* and native frog species on the Eyre Peninsula

Four species of frogs, *L. cyclorhyncha*, *Neobatrachus pictus*, *Crinia signifera* and *Limnodynastes tasmaniensis*, were recorded at 16 of 29 survey sites (Figure 4; Supplemental data, Table S3). *L. cyclorhyncha* was found only at sites in Streaky Bay. *N. pictus* was heard or observed at six survey sites between 30 September and 8 December. *C. signifera* were recorded calling at three sites on 30 September and 1 October. *L. tasmaniensis* was recorded at four sites between 27 September and 24 February and three frogs and tadpoles were observed in a roadside pool at North Shields.

*L. cyclorhyncha* were recorded in Streaky Bay at 5 of the 29 survey sites; a wetland, three ponds and the golf course, as well as at numerous non-survey sites throughout the community (Figure 5; Supplemental data, Table S3). No native frogs were recorded at the survey sites. *L. cyclorhyncha* were not calling from any sites on 15 and 17 July. Many frogs calling and the presence of numerous tadpoles were reported on 8 September. Calling was continuous from 8 September at sites and frogs were most abundant at the school wetland. The highest count during an active search at night at the school wetland...
was 99 frogs on 15 December. One hundred and six individual *L. cyclorhyncha* records were made from frogs collected for a dietary study (76) and observed specimens and reports by community members in the Streaky Bay area (30), including areas in the vicinity of the five survey sites.

Based on aural surveys, active searches, opportunistic sightings and frogs collected, frogs appeared to have greatest density in the vicinity of the school wetland and the area around the recycled water pond, but relatively low density in the town. The records suggest a distribution pattern of frog movement between the permanent ponds near the school and the stormwater pond at Wallschutzky Rd., 1.6 km to the southeast (Figure 5). Male *L. cyclorhyncha* calling from water bodies at full chorus could be heard up to 1 km away.

*L. cyclorhyncha* was found in vegetation surrounding the ponds and the artificial wetland and in urban habitats (Figure 5; Supplemental data, Table S3). They were observed on bitumen and dirt roads and in home gardens, shade houses and garden ponds, in containers holding water, in plant pots and under a bin on concrete. Frogs were seen in and around pump sheds, tanks and pipes, around drains or leaky pipes with moisture or puddles present and on lawned areas or in vegetation near irrigated grassy areas. Frogs were observed at night in bushland and revegetated areas, on the ground, on low ground-cover plants, sitting on sticks or leaf litter, in low branches of shrubs and trees, or on tree trunks.

**Figure 4.** Survey sites and frog presence – Eyre Peninsula 12 July 2016–26 February 2017 (Frogwatch, 2017a; Supplemental data, Table S3).
The MaxEnt species distribution model suggests that environmentally suitable conditions for *L. cyclorhyncha* exist across parts of southern Australia (Figure 6). Mid-to-high probabilities of suitable environmental conditions for *L. cyclorhyncha* exist in the west and mid Eyre Peninsula, Adelaide Hills and the southeast of SA and into the Murray–Darling basin. Low probabilities exist in the Port Wakefield area in the mid-north of the state.

Annual Global PET was the most important variable influencing the species distribution with 31.9%, followed by precipitation seasonality at 27.2% and isothermality with 26%. Precipitation seasonality had a permutation importance of 46.4% and mean temperature of coldest quarter, 26.8%.

**Discussion**

**Current distribution, dispersal and future spread**

Our study detected *L. cyclorhyncha* only around Streaky Bay. The verified reports of single individuals belonging to the species from Port Lincoln and Ceduna in the last...
4 years may imply additional populations there. However, several site visits were unable to verify this, and the sightings could be individual frogs that hitchhiked to these centres and do not necessarily imply a nearby breeding population. A well-established breeding population is likely to be noticed, due to the species’ high visibility and audibility. Over 600 surveys submitted to Frogwatch SA since February 2016, conducted mostly around Adelaide and, in the southeast of SA, did not record the species outside of Streaky Bay (Frogwatch, 2017b). Nonetheless, it is possible that our surveys missed additional breeding populations. In particular, the incidences of frog sightings in Port Lincoln suggest that this area should be monitored closely in the future for a possible breeding population.

*L. cyclorhyncha* appears to have a high propensity for dispersal, whether autonomously or with human assistance, based on the frequent and widespread sightings of individuals throughout the Eyre Peninsula and kilometres from breeding grounds at Streaky Bay. The species has now been observed in four NRM regions of SA, including the Alinytjara Wiluṟara, Eyre Peninsula, Northern and Yorke and Adelaide and Mount Lofty Ranges. However, only a single breeding population has been confirmed, suggesting that *L. cyclorhyncha* may not readily establish new populations. Founding individuals of the population at Streaky Bay may have come from the population at Eucla, but genetic analyses are required to determine the founding population. The breeding population at Streaky Bay, discovered in 2011, could have existed several years earlier, with lower numbers of frogs. *L. cyclorhyncha* reported at Port Kenny and Mortana...
could have been transported from the Streaky Bay population or the frog may have the ability to move long distances independently.

Human-assisted dispersal may be particularly important for *L. cyclorhyncha*, as suitable habitats are separated by large distances in the semi-arid Eyre Peninsula. Sightings in the vicinity of caravan parks, airports and roads imply hitchhiking by frogs in vehicles. Furthermore, *L. cyclorhyncha* is of relatively large size, has colourful skin patterns and is easily caught, making it attractive to collectors. Therefore, the deliberate transfer of eggs, tadpoles or frogs by humans appears to be another likely means of dispersal for *L. cyclorhyncha*. However, records from rural properties on the outskirts of Streaky Bay show an ability of the frogs to move across agricultural paddocks containing pasture, crop or bushland independently (Figure 5). For example, we observed a frog in a dry, disused well, 3.6 m deep, 710 m southeast of the Wallschutzky Rd. stormwater pond. Frogs are capable of moving up to several hundred metres in one night and have the capacity to move on their own accord up to 3–5 km and possibly for over 40 km (Cale, 1991; Ehmann, 2013). In the urban setting, home gardens and the irrigated golf course and public lawns may allow frogs to remain hydrated and to disperse and feed.

Although *L. cyclorhyncha* has the ability to disperse large distances and tolerates hot, dry and saline conditions (Janicke & Roberts, 2010; B. Roberts & Roberts, 2012), the frog seems to favour permanent fresh to brackish surface water as suggested by high densities around water bodies recorded in this study. We recorded brackish water (~2.0 ppt) at the Streaky Bay school wetland, supporting previous observations (Janicke & Roberts, 2010) that the frog has the ability to tolerate and breed in somewhat saline conditions. The artificial wetland and various ponds in the township of Streaky Bay provide opportunities for breeding in an otherwise semi-arid environment, highlighting the importance of suitable water bodies for *L. cyclorhyncha* to establish breeding populations.

Natural water bodies are sparse and ephemeral on the Eyre Peninsula, whereas artificially created wetland ecosystems are present throughout. In the natural range of *L. cyclorhyncha*, rainwater tanks (Main, 1965), gardens, farms and dams (Western Australian Museum, 2017) are utilised. Therefore, gardens, artificial water bodies, and stock watering points may provide suitable habitat for *L. cyclorhyncha* and assist in movement between natural water bodies. The southern Eyre Peninsula has a wetter climate and higher human population than the north, which could reduce distances between suitable habitats and increase dispersal rates for *L. cyclorhyncha*.

The SDM suggests that *L. cyclorhyncha* could spread widely. Suitable environmental conditions exist on the Eyre Peninsula and in southeastern Australia, suggesting that *L. cyclorhyncha* could colonise other areas in the region if given the opportunity through human-assisted dispersal or by independent movement. These predictions are based on the assumption that the species’ distribution will be restricted by its current environmental and climatic range. It is difficult to verify this assumption because we have limited ecological knowledge of *L. cyclorhyncha*. Furthermore, SDMs include uncertainties due to the accuracy of the data used in the model [including determining collinearity between environmental and climate variables (Dormann et al., 2013)], species’ capabilities to adapt to change, interactions between species, size of species’
home ranges and the influence of land use change (Guillera-Arroita et al., 2015; Huijbers et al., 2017). Therefore, results should be interpreted cautiously. In the future, SDMs could be used to explore the effects of forecasted climate change on the distribution of L. cyclorhyncha.

**Potential impacts on native frogs**

The native frog populations on the Eyre Peninsula and further east in southern Australia may be at risk if L. cyclorhyncha becomes established in wetlands (Ehmann, 2013). No other frogs were observed at Streaky Bay although the native species N. pictus and L. tasmaniensis were previously reported from the area (Cogger, 2014; Tyler & Knight, 2011). L. cyclorhyncha is known to consume Litoria adelaidensis (Archer, 2009) and its own young (Taylor et al., unpublished data). Therefore, it is highly likely that it will prey on other species of frogs. L. cyclorhyncha is larger than most native frogs of the Eyre Peninsula and establishment in wetlands on the Eyre Peninsula could be detrimental to native populations. Impacts by predation may be compounded by competition for resources such as food and space (Glorioso, Waddle, Crockett, Rice, & Percival, 2012). Frog species present on the Eyre Peninsula that could be affected by the introduction of L. cyclorhyncha are N. pictus, L. tasmaniensis, C. signifera, Litoria ewingii, Limnodynastes dumerilii and Neobatrachus sudelli (Cogger, 2014; Tyler & Knight, 2011). Should L. cyclorhyncha spread further east, it may also pose risks to the threatened, congeneric L. aurea and L. raniformis through hybridisation, competition and predation (Ehmann, 2013).

**Implications for conservation**

Given the potentially detrimental impacts on native frog species and ecosystems, policy makers and organisations responsible for invasive species at the local, regional and national levels need to be informed of the risks associated with an invasion by L. cyclorhyncha. The average time of first study of populations of invasive amphibians and reptiles is 42.3 years after invasion (Kraus, 2015). This study commenced approximately 5 years after the confirmed establishment of a breeding population and therefore provides timely insights for managing the species.

As a first step, the dispersal potential of the species should be reduced by educating the public not to move frogs, tadpoles and eggs (Cogger, 2014). Community members need advice about how to deal with frogs when encountering them and could be engaged to report sightings of the frog to assist in building knowledge of the species through citizen science programs (e.g. Frogwatch SA). However, long-term management plans also need to be contemplated to prevent the establishment of the species east of the Eyre Peninsula. Regular frog surveys of water bodies across the Eyre Peninsula would not only detect further spread of L. cyclorhyncha but also generate important baseline data for native frog species. L. cyclorhyncha may also continue to be transported from WA, and therefore, water bodies close to the Eyre Highway (including granite outcrops) should be searched for frogs. Finally, the feasibility of an eradication program should be evaluated and would benefit from more ecological knowledge about...
the frog, such as its ability to move over distance, its tolerance to salinity and its impact on ecosystems.

This study of the historical, present and potential future distribution of *L. cyclorhyncha* at local, regional and state-wide scales indicates that the frog appears to have a high propensity for dispersal, which demonstrates potential for the species to become invasive. Given the prominent role of humans in the recent spread of *L. cyclorhyncha*, programs of public and stakeholder education and engagement will be crucial for effective management.

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**ORCID**

S. Peters https://orcid.org/0000-0002-3604-4625

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