IRCF REPTILES & AMPHIBIANS
CONSERVATION AND NATURAL HISTORY

INTRODUCED SPECIES

Asian Black-spined Toads (*Duttaphrynus melanostictus*) in Australia: An Invasion Worth Avoiding

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Photographs by the author.

Abstract.—With increasing numbers of Asian Black-spined Toads (*Duttaphrynus melanostictus*) found at Australian seaports and airports since 1999, this species could become Australia's second invasive toad. Introductions of *D. melanostictus* have already occurred in other countries, with inadvertent stowaways the principal cause. Three recent incursions have been documented in suburban areas of Sydney and Melbourne.

Keywords: Australia, biosecurity incursions, exotic amphibian, stowaways

The serious and negative effects of invasive fauna in Australia are not understated in the scientific literature (Davis et al. 2016; Lethbridge 2016; Towerton 2016; Mutze 2017), especially for the Cane Toad (*Rhinella marina*; Phillips et al. 2007; Shine 2010; Jolly et al. 2016). Released in a failed attempt to control crop damage attributable to Greyback (*Dermolepida* sp.) and Frenchi Beetles (*Lepidiota frenchi*) following a brief captive-breeding program using Hawaiian stock, the liberation of Cane Toads in Australia is one of the country's most well-documented species introductions (Tyler 1989; White 2007). From the initial release in 1935, *R. marina* has come to occupy much of northern and north-eastern Australia (Taylor and Edwards 2005). The invasion front, somewhat held back by the arid interior, has currently reached the Northern Rivers region of New South Wales and the Kimberley region of Western Australia (Radford and Fairman 2015; Pettit et al. 2017; Southwell et al. 2017).

Why *R. marina* is of such concern in Australia is that many native predators cannot survive exposure to its toxins. While a toad may not harm a predator until it itself has been ingested and killed, the venom has been a successful defense from the perspective of established populations (Griffiths and McKay 2007; Ujvari and Madsen 2009). The general public of Australia is quite aware of concerns regarding *R. marina*, and many persons anticipate that another poisonous amphibian would not be easily controlled if established. Recently, alarm bells have rung over incursions of a different toad, this one from Asia.

Natural history of the Asian Black-spined Toad

The Asian Black-spined Toad or Asian Common Toad (*Duttaphrynus melanostictus*; Figs. 1 & 2) has a broad natural distribution, ranging from the Indian Subcontinent and southern China (including Taiwan, Hong Kong, and Macau) through much of southeastern Asia (van Dijk et al. 2004; Ngo and Ngo 2013; Rout et al. 2016). These toads are characterized by a relatively small head in proportion to its body, black-tipped warts and ridges, and prominent toxin-exuding parotoid glands. Different color morphs exist, and recent genetic work suggests that these toads represent a species complex (Vences et al. 2017). Ecologically versatile, *D. melanostictus* occurs in most lowland habitats below 1,800 m asl, including disturbed forests, agricultural lands, and urban areas.

Duttaphrynus melanostictus is often the most abundant amphibians where it occurs (Daniels 2005; Kaiser et al. 2011a; Sanchez et al. 2012; Pradhan 2014; pers. obs.), although populations in denser forests do not appear to be as dense (van Dijk et al. 2004). It breeds opportunistically in various permanent and temporary bodies of water, and readily exploits cisterns and gutters in urban areas (Saidapur and Girish 2001). In tropical climates, breeding occurs throughout the year with peaks during monsoon seasons (Jørgensen et al. 1986).

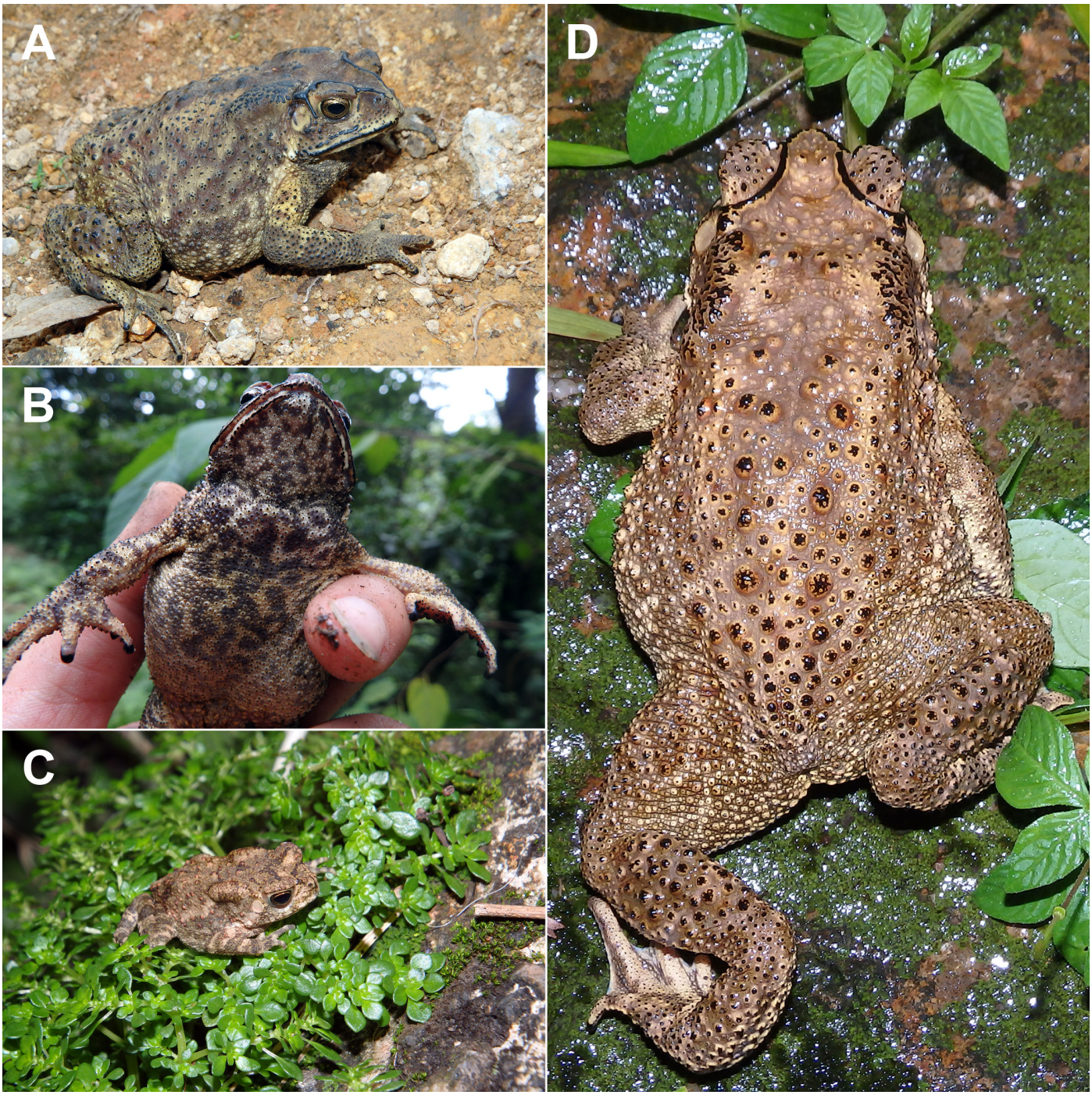

Fig. 1. The Asian Black-spined Toad or Asian Common Toad (*Duttaphrynus melanostictus*) has a relatively small head in proportion to its body, black-tipped warts and ridges, and prominent toxin-exuding parotoid glands. Different color morphs exist, and recent genetic work suggests that these toads represent a species complex. (A) A yellow-and-brown morph; (B) ventral view showing the dark and light colored patches and black-tipped warts and ridges; (C) juvenile; (D) dorsal view showing crests, warts and ridges, and parotoid glands.

Like most species in the family Bufonidae, these toads are dietary generalists (e.g., Smith et al. 2011; Crnobrnja-Isailovic et al. 2012), feeding on a variety of invertebrates (Berry and Bullock 1962; Mathew 1999; Yap 2015; Döring et al. 2017). The Brahminy Blindsnake (*Indotyphlops braminus*) is the only recorded vertebrate prey (Hahn 1976; O'Shea et al. 2013; Henderson and Powell 2018). Döring et al. (2017) questioned whether toads can actually digest these snakes, and suggested that predation on blindsnakes occurred because they resemble invertebrates.

Toads as stowaways

Frogs and toads are regularly discovered in airports and seaports (e.g., O'Dwyer et al. 2000; Wiles 2000). They prefer

to shelter in dark, moist areas in natural habitats, which causes them to seek artificial shelters in non-natural environments and become inadvertently transported (e.g., White and Shine 2009; Sherman and Leaché 2013). Like *R. marina*, *D. melanostictus* frequently functions as a human commensal, thriving in rural and urban areas and often seen ambushing insects under street lamps (e.g., Daniels 2005; Purkayastha et al. 2011; Döring et al. 2017). Such behaviors can bring *D. melanostictus* close to shipping containers, international vessels, and personal carriers such as bags, boxes, and cartons, in which they inadvertently become stowaways (Tingley et al. 2017). Toads wandering into shipments destined for overseas locations become potential invaders of new lands.

A *D. melanostictus* intercepted at the Darwin airport in 1988 was the only known incident prior to 1999 (Tyler and Knight 2011; Tingley et al. 2017). However, since 1999, over 110 of these toads have been intercepted at airports and seaports in Australia (Agriculture Victoria 2016), most of them alive at detection in 88 border interceptions and 24 on-shore detections analysed by Tingley et al. (2017). Stowaways in shipping containers have been more common than air transport and mail.

Examples of multiple stowaways include the transportation of earth-moving equipment. In April 2003, three *D. melanostictus* originally misidentified as *R. marina* were intercepted by Australian Quarantine and Inspection Service (AQIS) officials in Perth in a shipping container of mining equipment returning from West Papua (White 2007). Correct identification was made after further inspection of the euthanized specimens. In October 2003, toads were found in another container of mining equipment returned from Indonesia to Cairns, mirroring a subsequent occurrence at the same site in May 2010, during which two individuals were detected in freight from West Papua (Williams 2010). In 2004, a number of *D. melanostictus* were retrieved from a container in Sydney (Frog and Tadpole Study Group, unpubl. data; White 2007).

Shipping records have been used in efforts to identify geographical sources, but are not always conclusive. In one

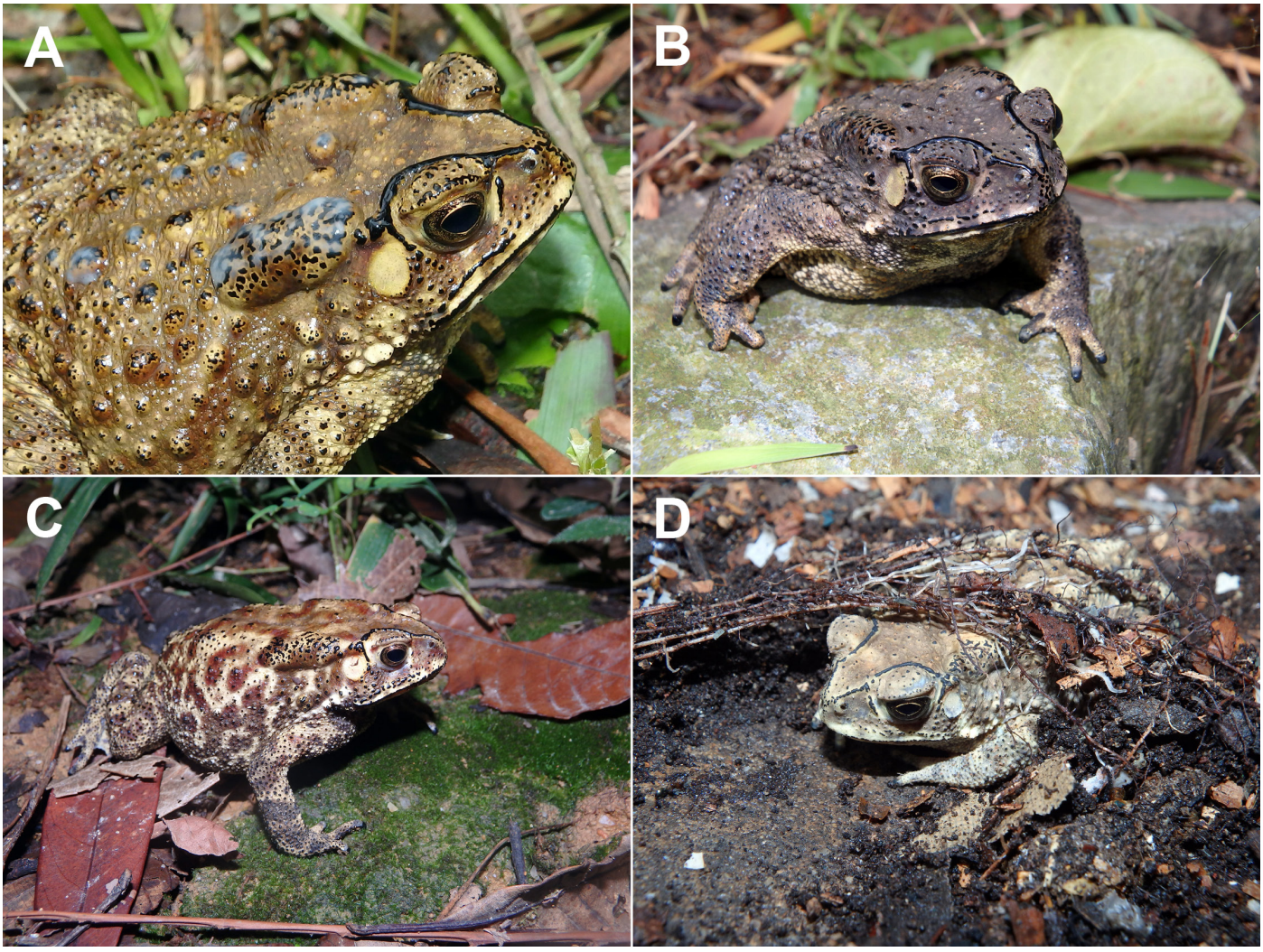

Fig. 2. Asian Black-spined Toads or Asian Common Toads (*Duttaphrynus melanostictus*). (A) Venom exuded from the parotoid glands as a defense mechanism; (B) gray morph; (C) red-brown-and-cream morph; (D) pale-cream morph nestled in ground debris.

such example, a lone *D. melanostictus* was intercepted at New Plymouth, New Zealand in a container loaded with bags of silica exported from Lang Lang, Victoria in June 2009. Agriculture Victoria carried out track-back investigations; however, shipping records showed the container originated in Germany, where the species is not known to occur, then docked at Malaysia, although it was not opened there, thus providing no logical point of entry. Prompted by this incident, Agriculture Victoria and the University of Melbourne conducted separate monitoring programs of wetlands in Lang Lang from 2009 to 2010; these included active searching, deployment of light traps, and listening for calls. None generated any evidence of *D. melanostictus*.

Perhaps due to the recent incursions of *D. melanostictus* in Sydney and Melbourne (discussed below) and publicity regarding the establishment of the species in Madagascar (Kolby 2014; McClelland et al. 2015), recent interceptions at airports have received more media attention, also elicited in part by the unusual circumstances of a recent find at the Cairns airport. On 24 March 2017, a *D. melanostictus* was found inside a passenger's shoe following a response from a detector dog (Mitchell-Whittington 2017). The flight originated in Indonesia, and the toad was thought to have been alive when the shoe was put on, but became squashed or suffocated during travel (Wray 2017; Young 2017). Williams (2010) reported that AQIS officials intercepted six *D. melanostictus* stowed away in shoes arriving at the Sydney airport in 2007 and 2008. Most of these were from Thailand, where shoes are habitually left outside accommodations. The most recent interception in January 2017 at the Melbourne airport was in luggage also originating in Thailand (Mitchell-Whittington 2017; Volling 2017; Wray 2017).

Most stowaway toads arrived from Indonesia and Thailand; however, animals also have originated in China, Hong Kong, Taiwan, Malaysia, India, Brunei, Singapore, and Papua New Guinea (Tingley et al. 2017). Interestingly, one record of *D. melanostictus* was traced to Christmas Island, Australia, despite the fact that the species is not known to occur there.

Invasions in other countries

The date when introductions to many nations occurred is not known due to the continuous nature of trade and transportation and a lack of quarantine protocols. *Duttaphrynus melanostictus* was apparently introduced to the island of Mauritius before 1837 but was no longer present by 1914 (Lever 2003). Gardiner (1906) was the first to report an invasion of the Maldives. Das (1999) included *D. melanostictus* as a species transported to the Andaman and Nicobar Islands by boat, but when the invasion occurred is not known.

In the 20th Century, *D. melanostictus* had reached parts of Indonesia outside its natural distribution. The invasion of Bali is believed to have occurred in the 1950s, at which time the western tip of Bali was the easternmost part of the Indonesian Archipelago inhabited by the species (Church 1960). The invasion subsequently reached Sulawesi via at least two separate introductions (Menzies and Tapilatu 2000). A large population had spread through northeastern Sulawesi (Malkmus 1993), while a separate population had become established near Ujung Pandang in southwestern Sulawesi (Lever 2003). In West Papua, a high density of *D. melanostictus* is confined to the narrow coastal plain east of the Arfak Mountains, and is believed to have become established sometime between 1995 and 1999 (Menzies and Tapilatu 2000). Populations have since become established in Borneo (Inger and Stuebing 2005), Lombok (Trainor 2009), Sumbawa (McKay and Lilley 2012), and the Maluku Islands (Van Dijk et al. 2004). Ujvari et al. (2014) expressed concern that if *D. melanostictus* reached the few islands inhabited by the Komodo Dragon (*Varanus komodoensis*), such an invasion would result in high mortality of the predators, similar to the response recorded in Australian varanids exposed to *R. marina* (Griffiths and McKay 2007; Jolly et al. 2016).

Kaiser et al. (2011a) collected the first voucher specimens of *D. melanostictus* in Timor Leste and noted that the invasion was believed to have occurred during the 1999 war even though the presence of the species was not confirmed until a decade later (Trainor 2009; Kaiser et al. 2011b; Sanchez et al. 2012). These toads initially were confused with *R. marina*, probably due to Australian military personnel being familiar with the latter. In Timor Leste, *D. melanostictus* has reached all western districts and has been recorded as far east as the Viqueque District (Trainor 2009).

The previously mentioned invasion of Madagascar has been widely publicized (Kolby 2014; McClelland et al. 2015; Pearson 2015). The earliest sightings of *D. melanostictus* may have occurred in 2010; however, formal identification was not made until March 2014 (Kolby 2014). The center of the incursion is in Toamasina Province in eastern Madagascar, where a major seaport exists (Crottini et al. 2014). As such, the invasion pathway is believed to be via freight from Asia (Pearson 2015). Moore et al. (2015) estimated that *D. melanostictus* had occupied a 108-square-kilometer area south and west of the Toamasina city center.

Incursions in Australia

Melbourne, Victoria.—Parris and McCarthy (2014) characterized a number of *D. melanostictus* found in an opened shipping container in southeastern Melbourne in October 2009 as a potential incursion. That incident was controlled by the then Victorian Department of Primary Industries, guided by amphibian experts from the University of Melbourne. No escaped *D. melanostictus* were found in the vicinity.

In late April 2014, a local resident discovered an adult *D. melanostictus* in a dog's water bowl in Sunbury, a suburb

located 15 km northwest of the Melbourne Airport (Parris and McCarthy 2014). This incursion is the earliest known discovery of *D. melanostictus* outside a seaport or airport in Australia. By early June, the Victorian Department of Environment and Primary Industries announced that a surveillance operation carried out in the vicinity did not find further evidence of an incursion; however, further surveillance was slated for later in the year in warmer weather (Evershed 2014). No additional animals have been reported near this location.

Sydney, New South Wales.—To date, only one *D. melanostictus* has been recorded in New South Wales outside an airport or seaport (Malpass 2015). On 2 March 2015 in Belrose in the Warringah area of the Northern Beaches, staff of the Belrose Veterinary Hospital, located at 70 Pringle Ave., discovered the toad in the garden and handed it over to local council staff. The following day, the live animal was delivered to the Taronga Zoo for formal identification, euthanasia, and necropsy. It was a female carrying over 1,000 unfertilized eggs.

The Taronga Zoo notified the NSW Department of Primary Industries of the incursion, which led to a request that the NSW National Parks and Wildlife Service (NPWS) investigate whether a population existed or the animal was a lone escaped stowaway. New neighbors of the veterinary hospital had just moved from Singapore (Deare 2015), which made the stowaway scenario a possible and likely explanation.

NSW NPWS conducted visual and call surveys in an area of bushland adjacent to the Hews Reserve on 5 March 2015. Fears of further animals occurring were exacerbated by the proximity of large tracts of natural bushland in the Garigal National Park surrounding Belrose. However, no additional *D. melanostictus* have been located.

Feasibility of establishment in Australia

No current evidence indicates that populations of *D. melanostictus* are established in Australia; however, a widely held belief thinks it would be possible. Climatic modelling by Page et al. (2008) matched the climatic conditions of locations within the current distribution of the species and that of Australian locations; these indicated that much of northern Australia is a moderate to high match. In contrast, species-distribution modelling by Tingley et al. (2017) instead suggested that *D. melanostictus* would be more suited to southern Australia, coincidentally where incursions have occurred (Parris and McCarthy 2014; Malpass 2015) and where most animals have been intercepted (White 2007). Regardless of the disparity between the two models, both suggest a real risk of the species becoming established. Further, the analysis by Tingley et al. (2017) alarmingly shows a feasibility for establishment by *D. melanostictus* in areas not yet occupied by *R. marina* (Phillips et al. 2007).

Both populations and numbers of *D. melanostictus* appear to be increasing within the natural range of the species (van Dijk et al. 2004). The species has a number of characteristics that could enable successful expansion within and beyond the existing distribution. These include a generalist invertebrate diet (Mathew 1999; Yap 2015; Döring et al. 2017), an apparent preference for degraded and non-natural habitats (Daniels 2005), and an ability to take advantage of non-natural opportunities (Purkayastha et al. 2011). As such and as seen elsewhere, this toad is a prime candidate to become an invasive species anywhere it can establish a foothold (Trainor 2009; Moore et al. 2015).

Potential impacts

Duttaphrynus melanostictus shares many of the characteristics that contributed to the successful invasion of *R. marina*. Consequently, the effects of established populations of the former in Australia could mirror at least some of the impacts of the latter. For this reason, much of the media attention on the incursions of *D. melanostictus* (e.g., Williams 2010; Evershed 2014; Aikman 2017; Volling 2017) draws comparisons to the invasion of *R. marina*. However, one important difference between the two species is that *D. melanostictus* appears not to prey on vertebrates (Döring et al. 2017), thus the potential impacts of predation and competition would likely differ.

Brown et al. (2011) noted a propensity for inaccuracies in predicting the effects of invasive species, and for that reason, I am careful not to insinuate that the potential impacts of *D. melanostictus* would be more or less severe than those of *R. marina*. Furthermore, many impacts of *R. marina* remain to be clarified by recent and ongoing research. For example, documented effects on predator and scavenger mortality, especially in regard to some varanids (Griffiths and McKay 2007; Ujvari and Madsen 2009; Jolly et al. 2016), appear to vary geographically (Shine 2010) and indirect positive effects (such as toad-induced mortality of predatory varanid lizards) could outweigh negative impacts on native snakes (Brown et al. 2011). Socio-economic impacts such as dangers to domestic animals and fouling of water sources have been suggested (Taylor and Edwards 2005), but many have either been disproved by current research (Beckmann and Shine 2010) or remain unquantified.

When anticipating the species' potential effects in Australia, considering reported impacts of *D. melanostictus* elsewhere might be instructive. In Timor Leste, Trainor et al. (2009) reported declines in native snakes (e.g., the Green Pitviper, *Trimeresurus insularis*) and varanids (e.g., the Timor Monitor, *Varanus timorensis*). Trainor et al. (2009) also reported incidents of *D. melanostictus* drowning and rotting in wells and other water sources. Although Taylor and Edwards (2005) suggested that *R. marina* might foul swimming pools and block drains in Australia, such scenarios have yet to be substantiated.

Current measures

Although Australia has no known population of *D. melanostictus*, one of the key challenges of investigating incursions and ascertaining whether additional animals are present is the reduction in detection effectiveness when dealing with low numbers of animals (McCarthy et al. 2013). Following the 2014 incursion in Sunbury, Agriculture Victoria (2016) deployed a mixed-methods approach to surveillance for any further *D. melanostictus*, using active searching, spotlight searches, auditory monitoring including using acoustic lures (call playback), toad light traps, and sampling water sources for eggs, tadpoles, and metamorphs. Community awareness and educational campaigns also play an important role when gathering intelligence (Larson et al. 2011; Agriculture Victoria 2016), especially given that both incursions of free-living *D. melanostictus* reported in this paper were detected by non-governmental individuals.

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