Vertebrate by-catch in invertebrate wet pitfall traps

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Abstract

Wet pitfall traps used to sample invertebrates, in particular, short-range endemic invertebrates for the purpose of supporting environmental impact assessments, killed, as by-catch, numerous small vertebrates. For the five surveys reported here, vertebrate by-catch rates varied between 0.4 and 15.6 individuals per 1000 trap nights using two litre plastic containers half-filled with ethylene glycol. No satisfactory alternative trapping strategy is available that provides quantitative data for sampling short-range endemic invertebrates (*e.g.*, terrestrial molluscs, spiders and millipedes), which are a focus of the Western Australian Environmental Protection Authority. We discuss the trade-off between catching short-range endemic invertebrates as part of an environmental impact assessment against killing small vertebrates as by-catch. We urge government environmental regulators to provide greater clarity on the specific locations of where short-range endemic invertebrate surveys should be undertaken as an interim measure for reducing vertebrate trapping deaths until improved trapping protocols are available and to be more cautious when requiring surveys for short-range endemic invertebrates.

Keywords: Short range endemics, reptiles, mammals, birds, fauna surveys

Introduction

Since the release by the Environment Protection Authority (EPA) of Position Statement No 3 *Terrestrial biological surveys as an element of biodiversity protection* (2002) and Guidance Statement No 56 *Terrestrial fauna surveys for environmental impact assessment in Western Australia* (2004), the Western Australian Department of Environment and Conservation (DEC) staff are requiring environmental consultants undertaking fauna assessments for major developments to sample for short-range endemic invertebrates. Much of this work has been stimulated by Harvey's (2002) paper on short-range endemics, which reported a prevalence of Gastropoda, Oligochaeta, Onychophora, Araneane, Schizomida, Diplopoda, Phreatoicidae and Decapoda that had natural ranges smaller than 10,000 km^2, and could therefore be significantly impacted on by large scale land clearing.

Staff in the Western Australian Museum are seen by the Department of Environment and Conservation as the authority on this issue, and environmental consultants are advised to seek their advice on sampling procedures. Museum staff recommended two approaches; hand-collecting and wet pitfall trapping. Wet pitfall trapping involves digging containers into the ground to ground level, and part filling each container with ethylene glycol. Ethylene glycol has a low evaporation rate and therefore lasts for some time. It kills and preserves both invertebrates and vertebrates that fall into the containers.

Wet pitfall traps are routinely used by researchers to sample for invertebrates (*e.g.* Brennan *et al*. 1999; Bisevac & Majer 2002; Andersen *et al*. 2003) and were also used by staff in the Department of Environment and Conservation in their regional biological surveys (Harvey *et al*. 2000; 2004). For example, Harvey *et al*. (2000) used five 300 mm diameter x 450 mm deep traps at each of their 63 sites in the Carnarvon Basin survey, and traps were left open for a period of 12 months (114,000 trap nights). Each container was unfenced, partially filled with a solution of glycol-formalin and covered with a sheet of wire mesh (10 mm square holes). This trapping program caught (and presumably killed) 1,462 individual vertebrates from 87 species of reptiles and amphibians. Subsequently, Harvey *et al*. (2004) used five 2 L pit traps partially filled with glycol-formalin at each of 304 quadrats in the Western Australian wheatbelt. Pit-traps were left open for 12 months to provide 554,800 trap nights of data. Over 6,000 individual vertebrates from 99 species were captured, most of which were presumed to have been killed by the glycol-formalin.

Other researchers have expressed concern about the vertebrate by-catch associated with large scale invertebrate sampling using wet pitfall traps (New 1999; Pearce *et al*. 2005). This paper quantifies the vertebrate by-catch from five invertebrate wet pitfall trapping surveys where a standard protocol was used. As required by the Department of Environment and Conservation, these surveys were undertaken to detect the presence of short-range endemic invertebrates.

Methods

Sites

Five wet pitfall trapping programs aiming to catch short-range endemic invertebrates were conducted at Rockingham (32° 17'S, 116° 00'E), Armadale (32° 07'S, 115° 42'E), Pilbara (22° 18'S, 119° 24'E), Mid-west (29° 35'S, 117° 10'E) and Wiluna (26° 52'S, 120° 10'E) in Western Australia. Trapping occurred for between 58 and 153 nights during autumn, winter and spring with a total of 11600 to 61200 trap-nights for each survey.

There were four broad habitat types at the Rockingham site: Tuart woodland; Melaleuca/Banksia woodland; Acacia/Xanthorrhoea shrubland; and a degraded area that was mostly devoid of vegetation other than grasses. At the Armadale site there were three broad habitat types: open woodland of Marri, Jarrah, Banksia and Melaleuca; open tall forest of Marri, Jarrah and Wandoo; and a mixed low forest of Sheoak, Marri, Wandoo and Jarrah. The five habitat types in the Mid-west were: dense thickets of Mulga (*Acacia* sp.) on ridge tops; dense thickets of Mulga on the sand plain; Mulga woodland on the slopes; open mallee (*Eucalyptus* sp.) scrubland on the sand plain; and, an open mixed woodland on the sand plain. Five habitat types were surveyed at the Wiluna site: salt affected sand plain; sand ridges vegetated with spinifex; Mulga woodland with an understorey of spinifex; Mulga woodland without an understorey of spinifex; and sand plain with scattered shrubs and spinifex. The Pilbara site had three habitat types: thickets of Mulga woodland with an understorey of shrubs; open Mulga woodland with an understorey of shrubs and grasses; and open Mulga woodland with an understorey of grasses.

Wet pitfall traps

Two litre plastic containers (165 mm x 165 mm x 95 mm deep) were dug into the ground so that they were level with the ground surface. Each trap was approximately half-filled with ethylene glycol. Traps were cleared and topped up monthly with ethylene glycol.

Results

The vertebrate by-catch varied among surveyed sites (Table 2, Appendix 1). The highest number of vertebrates caught per trap-night was at Armadale, where 16.6 (15.3 of which were frogs) were caught per 1000 trap nights. *Helioporus eyrei* was the most commonly caught species (310). Mammals were caught at the Pilbara site (eight *Planigale ingrami*, eight *Mus musculus*, seven *Pseudomys desertor* and one *P. hermannsburgensis*) and at Wiluna (one *Ningaui ridei*), but were not caught at other sites. Birds were only caught at the Pilbara site (four *Taeniopygia guttata*; eight *Malurus lamberti*, two *Malurus leucopterus*, 10 *Coturnix pectoralis*, five *Coturnix ypsilophora* and one unidentified *Coturnix* sp.). Reptiles were caught at all sites and catch rates varied from 0.3 to 3.6 per 1000 trap-nights. Almost all vertebrates caught were dead when the traps were cleared.

Table 1

The trapping period and trapping effort for five wet pitfall trapping programs.

Site	Trapping period	No traps	No nights open	No trap-nights
Rockingham	1/7/ – 28/9/2005	200	90	18000
Armadale	27/4/ – 6/9/2006	200	133	26600
Mid-west	15/4/ – 11/6/2006	200	58	11600
Pilbara	29/4/ – 28/9/2006	400	153	61200
Wiluna	16/7/ – 18/10/2006	200	94	18800
Total				136200

Table 2

By-catch in wet pit-traps at five locations in Western Australia per 1000 trap-nights

	Mid-west	Armadale	Rockingham	Pilbara	Wiluna
Amphibians	2.3	15.3	0.1	0.5	1.6
Mammals	–	–	–	0.4	0.1
Reptiles	1.6	0.3	0.3	3.6	1.1
Birds	–	–	–	0.5	–
All	4.0	15.6	0.4	5.0	2.8

Discussion

Wet pitfall traps designed to catch invertebrates, specifically short range endemic invertebrates, can catch and kill numerous small vertebrates as by-catch. Small birds were only caught in one of the five surveys. In the hot and dry Pilbara, water can be a scarce commodity and it is possible that some small fairy-wrens and quails were tempted to drink the ethylene glycol. Birds that we found were either in the plastic container or nearby. It is unknown if other birds drank from the containers and died some distance away.

In areas where there are a relatively high number of surface active frogs, the wet pitfall traps catch these in relatively high numbers. This was apparent in the surveys in the Pilbara and near Wiluna. The two Department of Environment and Conservation invertebrate surveys referred to above caught in excess of 10 vertebrates per 1000 trap nights. This catch rate was higher than four of the five surveys reported here, with the Armadale survey being higher (Table 2). Frogs made up a high proportion of the catch (58.1%) in the Department of Environment and Conservation Wheatbelt survey and our Armadale survey (98.1%). In arid areas, terrestrial frogs are only surface active after rain. So, in arid and semi-arid areas, if wet pitfall traps are not opened immediately after rain this will reduce the catch rate of frogs. However, this is problematic, as many of the short-range endemics being targeted by these surveys are also more active after rain.

Most of the reptiles caught in wet pitfall traps were small, but occasionally, a large skink (*e.g., Tiliqua multifasciata*) was caught. The comparatively high number of small mammals caught in the Pilbara survey may reflect either their abundance at this site compared to other sites or small mammals seeking out a source of water in arid conditions. Small mammals were not caught in the mesic areas of Armadale or Rockingham, but this might not be unusual as many of the small native mammals (perhaps with the exception of *Mus musculus*) are no longer present on the Swan Coastal plain near human habitation (How *et al.* 1996).

In recent years, the Western Australian Environmental Protection Authority (2004) has taken a keen interest in the possible presence of short range endemic invertebrates in development areas. The consequence is that environmental consultants are often required to undertake surveys of invertebrates as part of the terrestrial fauna surveys to support environmental impact assessments lodged by developers seeking government approval for vegetation clearing and ground disturbance. However, although the EPA indicated that Guidance Statement No 56 provides guidance on the standard of survey required, the document is silent on how to undertake surveys for short-range endemics, and EPA staff advise environmental consultants to take the advice of the Western Australian Museum. Invertebrate surveys reported here were undertaken in accordance with the general advice provided by the Western Australian Museum staff. It is understood the EPA is intending to release a Guidance Statement relating to surveying short-range endemic invertebrates.

The EPA is rightly concerned about protecting short-range endemic invertebrates from developments and vegetation clearing. However, if vertebrates are being killed as by-catch in these surveys, then there is a trade-off between identifying and protecting short-range endemic invertebrates and killing vertebrates in the process of detecting their presence in an area. The level and intensity of surveys for short range endemic invertebrates, and thus the number caught, must therefore be traded-off against the killing of small vertebrates caught as by-catch.

The Western Australian Animal Welfare Act (2002) indicates that a person must not use animals for scientific purposes unless they belong to a scientific establishment that holds a licence authorising the use of animals. The Act makes no mention of environmental consultants, and most currently do not seek animal ethics clearances for their field surveys. However, elsewhere in Australia, environmental consultants undertaking fauna surveys are required to obtain approval from an animal ethics committee. Although the legislative requirements in most Australian states are similar (see http://www.raa.nsw.gov.au/reader/arrp-legislation/other-aust-leg.htm) it is not clear whether environmental consultants require ethics approval in Western Australia to undertake fauna surveys or whether it does not occur because there is no mechanism to assess applications.

New (1999), in his editorial for the Journal of Insect Conservation, raised the ethical issue of the small number of frogs and juvenile skinks being caught in wet pitfall traps used to survey invertebrates. He went on to suggest that invertebrate surveyors would probably need to obtain animal ethics committee approval before they undertake wet pitfall trapping for invertebrates. The most recent edition of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (2004) indicates that wet pitfall traps used to capture invertebrates must be managed to minimise the inadvertent capture of vertebrates. As yet, there is little information on what strategies or protocols might be employed to minimise vertebrate catches.

From an ethics perspective, if the vertebrate by-catch during invertebrate surveys is low, then the administrative burden associated with obtaining approvals and reporting the by-catch would suggest that the current arrangements are appropriate. In the scenario where there is little concern about current practices, then the stimulus to develop strategies and protocols to reduce vertebrate by-catch will be weak. However, if vertebrate catch rates are high, then there may be a compelling case to devise alternative protocols to sample invertebrates, and government officials might be more circumspect in recommending large scale invertebrate surveys when the justification for these surveys is not strong.

Is there a potential to modify the size, placement or type of wet pitfall traps to minimise vertebrate by-catch? Pendola and New (2007) recommended the use of shallower pitfall traps (15 vs 8 cm deep) for sampling invertebrates on the basis that the shallower traps were less likely to catch vertebrate by-catch. However, they were not able to demonstrate this difference in by-catch because they caught no vertebrates in either trap depth. Borgelt and New (2005) suggested that that smaller diameter test-tube type traps (ca 18mm) can be as effective as the wider (coffee cup) traps (ca 70mm) to sample for broad inter-treatment comparisons of on ants. However, ants are rarely the focus of short-range endemic invertebrate investigations in Western Australia, but these smaller diameter traps may also catch few of the targeted short-range endemic invertebrates (see Work *et al.* 2002). Lemieux and Lindgren (1999) compared the use of 1 L pitfall traps and Nordlander traps made from the same containers and reported that the cover over the trap and the restricted entrances to the Nordlander traps were superior to the pitfall traps in excluding small vertebrates. This investigation only considered Carabidae (beetles), and it is not known whether the Nordlander traps would be effective in trapping a range of short-range endemics, nevertheless, the issue is worthy of further investigation. Karraker (2001) examined a novel trapping strategy of attaching twine to the undersides of cover boards over pit-traps to provide an escape route for mammals to minimise the vertebrate mortality in pitfall traps. This twine might also be effective in enabling some smaller reptiles to escape.

Other possible solutions include not using a liquid to kill the invertebrate catch (see Thompson and Thompson 2007). However, in the Thompson and Thompson (2007) investigation, it was not known what invertebrates escaped from the PVC buckets by climbing up the sides, as some species of terrestrial mollusc, spider and millipede will readily climb out of pitfall traps. Placing a lid over the trap to limit the height of individuals able to pass between the lid and the lip of the pitfall trap is another possible solution. This might stop birds and perhaps some mammals and the larger lizards (*e.g., Tiliqua multifasciata*) from being caught. However, it may also restrict entry into the pitfall trap by molluscs and beetles. The cover might also provide temporary shelter for small reptiles which would become caught.

Pearce *et al*. (2005), concerned about the by-catch associated with wet pitfall traps, examined the potential to use alternative trap types to catch epigeal invertebrates (*e.g.*, Carabidae, Staphylinidae, millipedes, centipedes and woodlice). They used conventional pitfall traps, funnel pitfall traps, shallow pitfall traps, Nordlander traps and ramp traps in a mixed forest in Ontario, Canada and reported that vertebrate captures (mammals and amphibians) were significantly less in the four alternatives to pitfall traps. Carabid beetle catch rates varied among trap types, but were highest in the normal pitfall trap. The ramp trap appeared to sample a different component of the spider assemblage compared to the other trap types. Most spiders were caught in the ramp traps, and the funnel traps caught the fewest individuals and species of spider. This report suggested that alternative trap types could be used to effectively sample terrestrial invertebrates, and the use of alternative traps may reduce the vertebrate by-catch.

Another alternative that may be suitable in some situations is to collect leaf litter samples in the field and using either Berlese or Tullgren funnels, sort the invertebrates from the litter. Transporting large samples of leaf litter to the laboratory and adequately sampling the area are two problems that need to be addressed with this alternative, but it will probably reduce the number of vertebrates killed in wet pit-traps.

The obvious solution to reducing vertebrate by-catch is to only trap for invertebrates when the data are essential, and to limit the period wet pitfall traps are be left open.

In the absence of clear guidelines on when, where and how short range endemic invertebrates should be sampled as part of environmental impact assessments, we urge government environmental agencies to be more cautious in requiring that invertebrate fauna surveys be undertaken for short-range endemics, when there is little evidence to suggest that proposed developments will have a significant impact on these invertebrates (*e.g.*, when the disturbance area is small, or represents a small fraction of the available undisturbed habitat). We would also urge the EPA to revise its Guidance Statement No 56 *Terrestrial fauna surveys for environmental impact assessment in Western Australia* (2004) and to clearly indicate in what circumstances, geographical areas and habitat types surveys for short range endemics are required, and the protocols and intensity of the survey effort that is considered appropriate.

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Appendix 1

Species of vertebrates caught as by-catch during the five surveys for short range endemics

	Family	Species	Mid-west	Armadale	Rockingham	Pilbara	Wiluna
Amphibians	Hylidae	*Litoria rubella*				29	
	Myobatrachidae	*Crinia georgiana*		12			
		Crinia sp.		48			
		Heleioporus eyrei		310	1		
		Limnodynastes dorsalis		35			
		Neobatrachus sutor	21				
		Neobatrachus willsmorei	6				31
		Pseudophyrne guentheri		2			
Birds	Estrildidae	*Taeniopygia guttata*				4	
	Maluridae	*Malurus lamberti*				8	
		Malurus leucopterus				2	
	Phasianidae	*Coturnix pectoralis*				10	
		Coturnix sp.				1	
		Coturnix ypsilophora				5	
Mammals	Dasyuridae	*Ningaui ridei*					1
		Planigale ingrami				8	
	Muridae	*Mus musculus*				8	
		Pseudomys desertor				7	
		Pseudomys hermannsburgensis				1	
Reptiles	Agamidae	*Caimanops amphiboluroides*				2	
		Ctenophorus caudicinctus				8	
		Ctenophorus isolepis				13	1
		Ctenophorus reticulatus				1	
		Ctenophorus scutulatus	6				2
		Pogona minor		1	1		
		Pogona mitchelli				5	
		Rankinia adelaidensis			2		
		Tympanocryptis cephala				1	
	Elapidae	*Brachyurophis semifasciata*					1
	Gekkonidae	*Diplodactylus conspicillatus*				10	
		Diplodactylus pulcher				8	
		Diporiphora winneckei				1	
		Gehyra sp.				1	
		Gehyra variegata				1	
		Heteronotia binoei	1			7	
		Lerista muelleri	3				
		Lichenostomus virescens				13	
		Nephrurus wheeleri				2	
		Lucasium maini	2				
		Rhynchoedura ornata					1
		Strophurus elderi				1	3
		Strophurus spinigerus			1		
		Strophurus strophurus					1
		Strophurus wellingtonae				4	
	Scincidae	*Cryptoblepharus plagiocephalus*		7			
		Ctenotus helenae				12	4
		Ctenotus leonhardii					3
		Ctenotus pantherinus				22	1
		Ctenotus saxatilis				25	
		Ctenotus schomburgkii	6				
		Ctenotus sp.				26	
		Egernia inornata	1				
		Lerista desertorum					2
		Lerista elegans				7	
		Lerista muelleri				48	1
		Lerista sp.				1	
		Menetia greyii			1	1	
		Morethia obscura			1		
		Tiliqua multifasciata				1	
	Typhlopidae	*Ramphotyphlops* sp.				1	
	Varanidae	*Varanus bushi*				1	