Disease risk analysis for the Western barred bandicoot (*Perameles bougainville*)


Source:Australian Wildlife Conservancy 2018

Rebecca Vaughan-Higgins, Andrea Reiss, Simone Vitali

Murdoch University

Perth Zoo

Wildlife Health Australia

Department of Biodiversity, Conservation and Attractions

Parks and Wildlife Service

Western barred bandicoot

- Small (190 - 250g) insectivorous Australian marsupial found in the Shark Bay region of Western Australia (WA)
- Listed as endangered (EPBC, IUCN) & vulnerable in WA
- Key threats: predation (cats & foxes), habitat & resource loss/ modification & possibly infectious disease

- Prior initiatives - captive breeding & reintroduction of individuals into predator proof enclosures, or fox & cat baited habitat, in historic distribution range.

Future translocation

- Proposals for the future translocation to various island & mainland (fenced) sites.
- **Aims** - to establish a new self-sustaining, genetically diverse population or to supplement an existing population to improve genetics.

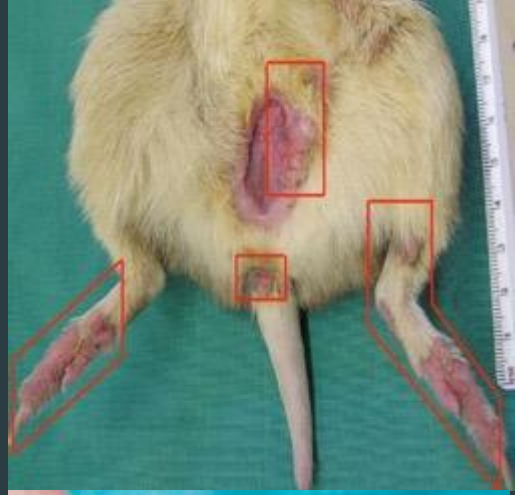
- DBCA AEC recommended further consultation due to possible disease risk of Bandicoot papillomatosis & carcinomatosis syndrome (BPCVS)

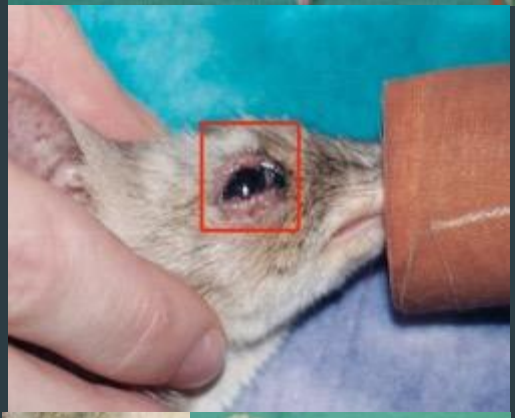
- Stakeholder mtg Oct 17 recommended qualitative Disease Risk Analysis (DRA) to provide a holistic risk assessment of infectious & non-infectious hazards of concern to WBB translocation based on IUCN guidelines for translocation

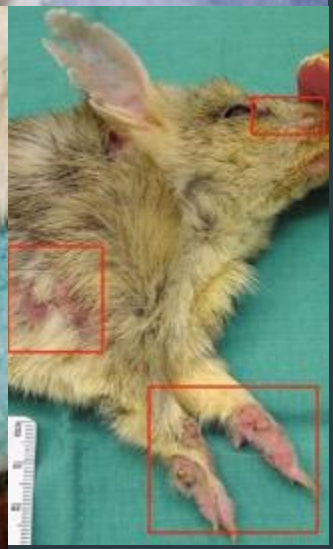
Bandicoot papillomatosis & carcinomatosis syndrome

- Proliferative lesions cutaneous & muco-cutaneous surfaces, increase in size with time
- Grossly & histologically - smaller epithelial lesions resemble papillomas, whereas larger lesions carcinoma *in situ &* squamous cell carcinomas.

- Paws, distal limbs, eyelids & lips commonly affected
- Lesions cause deficits in vision, locomotion & ability to eat, drink depending on anatomic location
- Lesions become abraded, ulcerated & secondarily infected, with sometimes fatal complications





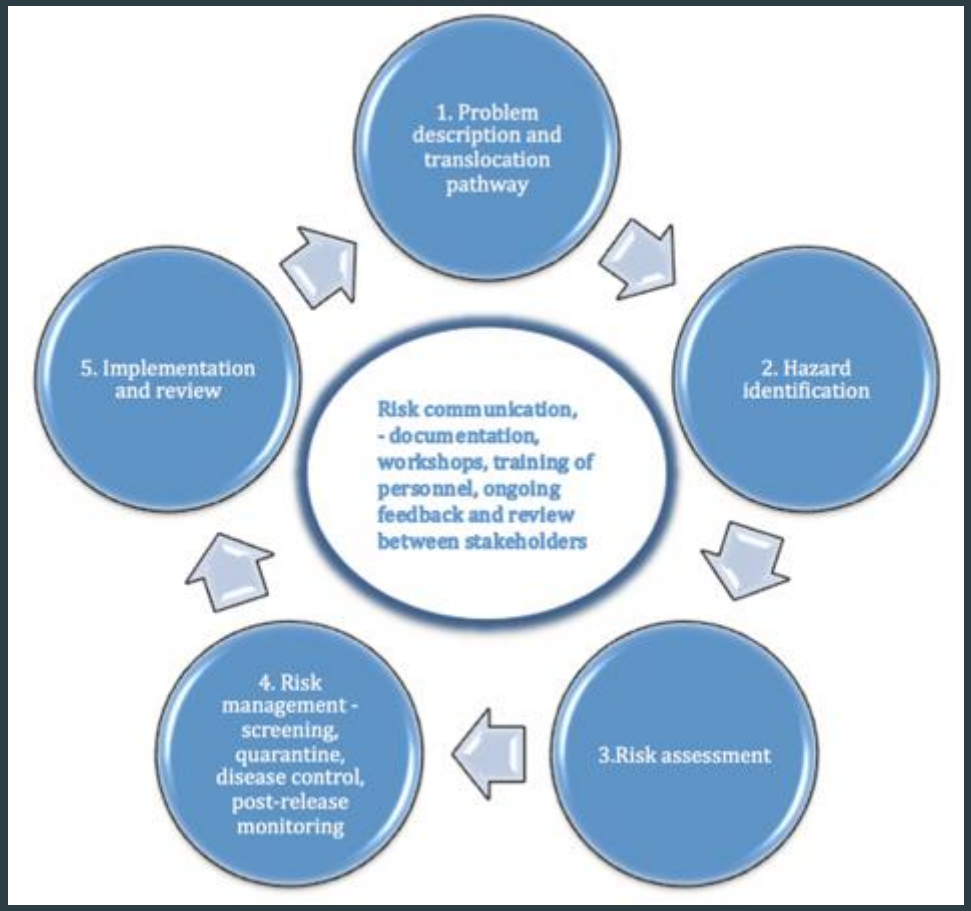


Photos courtesy L.Woolford (2008)

Disease Risk Analysis (DRA)

- Process for identifying significant disease risks & proposes measures to mitigate these risks.
- Ensures costs & benefits of translocations considered from a disease perspective
- Followed IUCN Manual of Procedures for Wildlife Disease Risk Analysis (Jakob-Hoff *et al*. 2014a) &
- Institute of Zoology (IoZ) method incorporating Sainsbury & Vaughan-Higgins (2012) & Masters & Sainsbury (2011)
- **BUT** modified owing to time, & logistical constraints

Disease risk analysis framework (Jakob-Hoff *et al*. 2014a)



Translocation pathway

- Source & destination sites
- Species, numbers, age, sex
- Capture, transport, housing
- Other resident sp. at source & destination
- Barriers
- Habitat, climate, vegetation type

Workshop goals & aims

- To formulate a translocation pathway (s), including source populations, destination environments, transport methods
- To articulate translocation risks (e.g. genetics, expense, logistics) which may impact how disease risk assessed
- To present the hazard list to stakeholders, provide information on the diseases & get feedback on perceived & actual significance to the translocation
- To facilitate communication amongst stakeholders
- Seek advice & opinions for inclusion in the DRA

Project summary

Problem description

- Western barred bandicoot (WBB) extinct on mainland, now restricted to Bernier and Dorre Islands in Shark Bay (WA).
- WBB included in the Shark Bay Mammals Draft Recovery Plan, Western barred bandicoot (*Perameles bougainville*), burrowing bettong (*Bettongia lesueur*) and banded hare wallaby (*Lagostrophus fasciatus*) National Recovery Plan. Schedule 3 WA Wildlife Conservation Act (1950) [fauna that is rare or is likely to become extinct as vulnerable fauna D2], EPBCA Act 1999 & IUCN Red List of threatened species listed as endangered
- Translocations have occurred to Heirisson Prong (Shark Bay, WA), Arid Recovery (SA) and Faure Island (Shark Bay, WA).
- Translocation to the captive Kanyana Wildlife Rehabilitation Centre for breeding ceased 1998 and to the Peron breeding facility ceased 2005.
- Translocations and active management to the semi-captive Dryandra fenced enclosure ceased in 2010.
- Key identified threatening processes - predation by cats and foxes, habitat destruction, environmental stochasity.
- Health & disease issues have been summarised 10 years previously (Bennett 2008, Woolford 2008)
- Proposals exist for the translocation of WBB to various island and mainland (fenced) sites.
- Aim of translocation: to establish a new self-sustaining, genetically diverse population or to supplement an existing population to improve the genetics.

DRA questions	What are the risks of disease from identified health hazards, as a consequence of wild-to-wild translocations, that constitute a threat to the recovery of -living WBB populations? How can these risks be minimised?
DRA goal	Develop a disease risk management strategy for WBB being translocated from yet to be determined source/s and destination/s based on stru ctured, evidence-based analysis of current information.
Scope and focus	SCOPE: known infectious and non-infectious diseases of Peramelidae and other infectious and non-infectious diseases of marsupials known to h to have a d host range. To conduct a qualitative analysis of relevant literature (and other available information) on the susceptibility of WBBs to infectious or non- infectious disease at the DESTINATION ENVIRONMENT/s and / or the risk of WBB passing disease on to existing vertebrate DESTINATION ENVIRONMENT fauna (including humans and domestic animals). Prioritisation of these identified hazards will occur with stakeholder consultation. Identification, assessment and mitigation of all known significant health risks (to WBB and existing DESTINATION ENVIRONMENT fauna) the associated the translocation
Assumptions	WBBs are susceptible to health hazards reported in Peramelidae and are susceptible to pathogens demonstrated to have a broad host range in marsupials and other mammals. There are no other novel, unknown or yet to be determined disease risks. Available data combined with the analytical and decision-making processes will enable reasonable decisions to be made to minimise health risks.
Limitations	Limitations of baseline data, limitations of existing knowledge of disease and health in Peramelidae. Limited data and information available in peer-reviewed publications and open access sources. Limited funds and time allocation to complete project. Owing to prior PhD thesis (Bennett 2008, Woolford 2008) reasonable understanding of the range and epidemiology of potential pathogens of WBB.

Project summary

Translocation pathway

To be confirmed

Hazard identification and prioritisation

- Review literature and other available data to identify hazards (infectious and non-infectious).
- Collate information against key prioritisation questions
- Categorise hazards, in terms of likelihood and consequence of exposure. (low, medium or high).
- Exclude hazards with low probability of release or exposure. Only high and medium risk hazards will have a risk assessment undertaken.

Present and review at March workshop with stakeholder input

Risk assessment

- All medium and high priority hazards (not excluded) will have detailed information summarised on key areas such as host range, impact, transmission, and consequence. These findings will be collated and tabulated into the following sub-headings.
- **Entry assessment** – an estimate of the likelihood of the translocated animals introducing the hazard into an area.
- **Exposure assessment** – estimates the likelihood of susceptible animals being exposed to the hazard, becoming infected (parasite hazards) and disseminating the hazard at the release site.
- **Consequence assessment** – estimates the likely magnitude of potential biological, environmental and economic consequences associated with the entry, establishment or spread of the hazard and the likelihood of their occurrence. Includes consequences for the individuals moved, population of same and other species and for the wider ecosystem at the destination.
- **Risk estimation** – summarises the entry, exposure and consequence assessments to provide an overall measure of risk.

Risk management

- **Identify and evaluate** the most practical and effective management options to minimise each risk e.g. disease screening, establishing maximum stocking densities, animal or environmental treatments, pre-release isolation, biosecurity practices.
- **Option evaluation** – expert consideration of options for feasibility and effectiveness. Ideally, options should be feasible and highly effective.

Risk communication

- Communicate the rigour of DRA process and key results with stakeholders, actively e.g. through stakeholder meetings, presenting findings at the Shark Bay Mammal Recovery Team or passively, e.g. through information sheets outlining processes and key results, for example DBCA, and the broader community.
- Full detailed report also to be made available to interested parties and available online.

Hazard identification & prioritisation

- We identified 44 possible hazards of concern & categorised into ‘infectious’ & ‘non- infectious’

- Published literature & unpublished reports of Peramelidae
- Review national electronic wildlife health information system (eWHIS)
- Review of the ARWH electronic pathology database
- Contacted experts involved with Peramelidae in the wild & captivity.

- Attempted to prioritise in the workshop

What can impact the translocated & destination species?

What can cause disease in translocated & destination species?

Disease	Parasite	Hazard description
INFECTIOUS		
- VIRAL		
Bandicoot papillomatosis & carcinomatosis syndrome (BPCS)	**Bandicoot papillomatosis & carcinomatosis virus (BPCV1)**	**Host range** – virus & disease identified in captive & wild WBBs only **Impact** - lesions involve cutaneous & mucocutaneous surfaces, the smaller epithelial lesions resemble papillomas, & the larger lesions are most commonly carcinoma in situ & squamous cell carcinomas (Woolford et al. 2008). Lesions increase in size over time. Involvement of the feet, eyes & mouth can lead to problems with ambulation, vision, & eating. Affected animals may die due to secondary infection or have been euthanased on humane grounds. No large scale population declines noted with trapping at Dorre or Bernier islands to date (N Thomas pers comm March 18) despite adverse environmental events however, only small numbers trapped & difficult to detect in early stages. Prevalence currently unknown. **Transmission** - BPCVs thought to be transmitted between individuals through direct (& indirect) contact. Based on the two most similar virus families, *Papillomaviridae* & *Polyomaviridae*, BPCVs likely to resist desiccation & persist in the environment for extended periods of time (Bennett 2008a). **Consequence** - Activation of infection reported with immunosuppression of the host. Potential disease risk for translocated WBBs being exposed in the wild & developing disease during or after translocation & exposing destination WBBs & their offspring. Medium likelihood of carriage & transmission & medium consequence of disease to population.

How can this happen?

What are the potential consequences?

Likelihood and consequence

- **LIKELIHOOD** that a translocated WBB could act as a carrier of the disease hazard and assist in its transmission to another animal (or human)
  - **LOW, MEDIUM OR HIGH** LIKELIHOOD

- **CONSEQUENCE of disease transmission**
  - **LOW – individual morbidity/ mortality but no population consequences**
  - **MEDIUM – temporary detectable population decline without risk of extinction from this disease**
  - **HIGH – high risk of local extinction due to significant population decline (at unsustainable levels) from this disease**
- For humans or domestic animals (pets & livestock), any individual morbidity/mortality was considered a high consequence.

Disease	Parasite	Hazard population	Likelihood rating	Consequence rating	Final rating
INFECTIOUS					
VIRAL					
Bandicoot papillomatosis and carcinomatosis syndrome (BPCVS)	Bandicoot papillomatosis and carcinomatosis virus (BPCV1)	1	M	M	M
[illegible] (EMC)	[illegible] virus (EMCV)	1	L	H	L
		2	L	H	L
		3	L	H	L
Herpes disease	[illegible] & a novel [illegible]	1	L	M	M
		2	L	M	M
Ross River virus disease	Ross River virus (RRV)	1	L	L	L
		2	L	L	L
		3	L	M	M
BACTERIAL					
Chlamydiosis	Novel [illegible] Chlamydia pneumoniae, *Chlamydia* [illegible]	1	M	L	M
		2	L	L	L
		3	L	L	L
Q fever	*Coxiella burnetti*	1	L	L	L
		2	L	L	L
		3	L	M	M
[illegible] infection	*Escherichia coli*	1	M	L	M
Erysipelas	*Erysophilothrix rhusiopathiae*	1	L	L	M
		2	L	M	M
		3	L	L	L
Leptospirosis	*L. interrogans* serovar Perameles	1	L	L	L
		2	L	L	L
		3	L	M	M
Atypical Mycobacteriosis	Atypical *Mycobacteria* sp.	1	L	L	L
		2	L	L	L
		3	L	L	L
Pasteurellosis	*Pasteurella multocida*	1	L	L	L
Salmonellosis	*Salmonella* spp.	1	M	L	M
		2	M	L	M
		3	M	L	M
FUNGAL					
Cryptococcosis	*Cryptococcus gattii* or *Cryptococcus neoformans*	1	L	M	M
Dermatophytosis – (ringworm)	*Trichophyton* spp.	1	L	L	L
		2	L	L	L
		3	L	L	L
PROTOZOAL					
Cryptosporidiosis	*Cryptosporidium* sp.	1	L	L	L
		2	L	L	L
		3	L	L	L
Coccidiosis	*Eimeria* sp.	1	L	L	L
Giardiasis	*Giardia* sp.	1	L	L	L
		2	L	L	L
		3	L	L	L
	Klossiella quimrensis	1	L	L	L
	Intracellular haematozoa	1	L	L	L
Sarcocystosis	*Sarcocystis* sp.	1	L	L	L
		2	L	L	L
Toxoplasmosis	*Toxoplasma gondii*	1	L	M	M
		2	L	M	M
		3	L	M	M
Trypanosomiasis	*Trypanosome copemani*	1	L	L	L
ENDOPARASITES					
Helminthiasis (worms)	Helminths	1	M	L	M
ECTOPARASITES					
	Fleas	1	M	L	M
		2	M	L	M
	Ticks	1	M	L	M
		2	M	L	M
		3	M	L	M
	Mites	1	M	L	M
		2	M	L	M
NON-INFECTIOUS					
DEGENERATIVE					
Arthritis		1	L	L	L
Intervertebral disc protrusion		1	L	L	L
Ocular disease		1	L	L	L
Periodontal disease		1	L	L	L
INTOXICATION					
Heavy metal intoxication		1	L	L	L
Industrial chemical intoxication		1	L	L	L
Pesticide intoxication		1	L	L	L
Other toxins		1	L	L	L
OTHER					
Benign & malignant neoplasms		1	L	L	L
Heart disease		1	L	L	L
Kidney disease		1	L	L	L
Skin disease		1	L	L	L
Low level of MHC diversity		1	M	M	M
Environmental stressors		1	M	M	M
Predation		1	H	H	H
Resource competition		1	M	M	M
		2	M	M	M
Trauma		1	M	M	M
Vitamin E / Se deficiency		1	L	L	L

- **44 hazards identified**
- One high risk
- 17 medium risk - Nine of these were considered to warrant closer consideration & full risk assessment: **Bandicoot papillomatosis and carcinomatosis syndrome (BPCVS), chlamydia, cryptococcosis, erysipelas, fleas, herpesvirus, mites, ticks and toxoplasmosis**.
- 26 low risk - determined that no further risk assessment currently required

Detailed risk assessment 9 hazards

- to analyse 44 hazards would be time prohibitive

- Detailed, referenced to highlight transparency
- acknowledged limitations & lack of knowledge of current disease status

Appendix 3.1 Disease risk assessment of the Bandicoot papillomatosis and carcinomatosis virus 1 (BPCV1)

Justification of hazard

BPCV1 the virus & disease has only been reported in WBB's. BPCV2 has only been reported in SBB in WA (Bennett 2008). WBBs from Bernier Island, Dryandra Woodland, Kanyana Wildlife Rehabilitation Centre & the Peron Captive Breeding Centre have been diagnosed with BPCV1 infection; WBBs are no longer bred at the latter three locations & the current prevalence in the wild population on Bernier Island is unknown. Two WBBs from Redcliff Bay, Bernier Island (2/15 (~13%)) had suspicious eyelid lesions and have had virus isolated from swabs taken in 2018 although the ID is yet to be confirmed (C Simms pers comm. July 2018). Previous reported prevalence of clinical signs seems to range from 0% – 42%. (C Simms pers comm. July 2018, unpublished report 2001). WBBs from Dorre Island & Faure Island have not yet been detected with clinical signs associated with BPCV1. The infection status of WBB's from Arid Recovery is not known. BPCV-like viruses may not be limited to peramelid hosts (Woolford et al. 2008). Involvement of the feet, eyes & mouth can lead to problems with ambulation, vision, & eating. Affected animals may die due to secondary infection or have been euthanased on humane grounds. BPCV1 is a potential disease risk for translocated WBBs being exposed in the wild & developing disease during or after translocation & exposing destination WBB's & their offspring & possibly other destination sp. to a disease which progresses in severity and ultimately seems fatal. However, experimental transmission studies have yet to be undertaken

Risk assessment

Entry assessment	Exposure assessment	Consequence assessment
Known to infect WBBs & therefore possible that at least one of the translocated WBBs will be infected. Thought to be transmitted between individuals through direct and indirect contact (Bennett 2008a). The process of translocation will typically involve solitary individuals being placed in close proximity facilitating direct contact & the possibility of fomite transmission. Given the proportion of affected individuals increases with age (Woolford et al. 2008) and that the diseases has a latent period of approx. 10 months, translocating young WBB's lacking clinical signs may give a false representation of absence of infection. Screening prior to translocation may not be efficacious as presently we can only detect virus when lesions are present & infection may not be clinically apparent during the latent period (Woolford 2008). However, no apparent large scale population declines have been noted with trapping at Dorre or Bernier islands to date (N Thomas pers comm March 18), despite adverse environmental events which might be expected to evoke disease expression in stressed or immunosuppressed animals. Activation of infection is	WBB's are typically solitary, territorial, nocturnal marsupials that shelter by day in nests of litter under shrubs, with seasonal breeding typically related to environmental conditions (Richards 2012). Upon release WBB's will forage for resources, mate & rear offspring & possibly fight for territory, & if infected could excrete BPCV1 through direct or indirect contact. The likelihood of exposure to other WBB's is dependent on the chosen destination environment, the presence of resident WBB's & other sp. which may be susceptible to disease. BPCV1 has genomic properties of both the Papillomaviridae and Polyomaviridae. The mammalian papillomaviruses tend to be species-specific viruses; however, the mammalian polyomaviruses typically cause subclinical infections in their natural and immunocompetent hosts but may cause severe disease in the immunocompromised host (Woolford et al.2007). They also may cause tumour formation when introduced into novel hosts (Bennett 2008a). Overall there is a medium likelihood of exposure due to the natural foraging behaviour of WBB's. If exposed it is likely that the individual will disseminate BPCV1 through direct &	There is a medium likelihood of exposure through direct or indirect contact e.g. mating behaviour, females raising offspring, territorial fighting behaviour & foraging behavior. If exposed, infection could result in severe disease which ultimately could inhibit colony founding of WBB's & possibly other sp. However, the overall risk of this occurring is MEDIUM as no large scale population declines have been noted with trapping at Dorre or Bernier Islands to date (N Thomas pers comm March 18) despite adverse environmental events likely to have invoked stress & therefore increased disease susceptibility (Dickens et al. 2010). However it is also important to understand that the low genetic diversity of WBB's, changing environmental factors & the presence of external stressor factors in the future could lead to changes in the clinical expression of this disease. Disease may therefore become more or less apparent
reported with immunosuppression of the host which may occur due to stressors related to translocation (Dickens et al. 2010). Likelihood of infection if sourced from a population where disease has occurred assessed as Medium. Likelihood of BPCV1 being present in WBBs sourced from Bernier Island assessed as Medium. If infection ensues there is a medium likelihood of developing severe disease which ultimately may be fatal.	or indirect contact to remaining members of the translocated WBB's & possibly other susceptible hosts. However, lesions are unlikely to develop immediately. The mean age at first lesion detection was 3.17 years with the proportion of affected individuals increasing with age from 2.6% (animals aged between 0.5-1 year old) to ~75% (animals aged >4.5 years) (Woolford et al. 2008). Although it is important to note that disease has occurred in animals as young as 10 months of age (Woolford 2008). Therefore, if young WBB's are translocated, disease may not be detected for years & the number of individuals affected will increase as the population ages. The lesions are generally progressively debilitating in nature, and affected individuals in the wild would not survive for long once severe lesions developed.	relative to environmental change & this needs to be considered when planning translocations and managing the species into the future.

Risk evaluation

Preventative measures should be employed to reduce the disease risks.

Risk management options

No treatment currently available

Minimising exposure:

Ideally virus-positive individuals should be kept physically separated from negative individuals to prevent direct transmission, however currently it is only possible to diagnose the condition by swabbing lesions for PCR when clinical lesions are present & the latency period of approx. 10 months (Woolford 2008) complicates diagnosis. It would be ideal to have a serological test that could be used to screen populations to detect exposure, however in reality the logistical and financial obstacles associated with such research mean that it is unlikely that such a test will be developed prior to planned translocations.

Care must be taken to prevent indirect transmission through fomites. All bags, crates, equipment & tools used in the translocation process should be thoroughly disinfected prior to use & biosecurity guidelines for WBB translocation should be developed.

BPCV1 virus demonstrates greatest genomic and morphologic similarity to papillomaviruses and polyomaviruses (Woolford 2008). However given this is a novel virus, no reports of disinfection efficacy exist. From general principles both papillomaviruses and polyomaviruses are non-envelope type viruses which are generally considered to be harder to kill (Ryndock et al. 2016). Parvovirus is a non-envelope type virus and F10 *has been shown to be an effective disinfectant and killed the virus at a 1:125 dilution with 30 minutes contact time or a 1:100 dilution with 15 minutes contact. The use of F10 * at a 1:100 dilution with 15 minutes contact time is recommended for routine disinfection.

Minimise exposure of individuals to environmental stressors which may increase susceptibility to disease:

Management considerations prior to release may require parasite management, & pre-release husbandry & feeding protocols to minimise holding & stress.

Informed decision about habitat at release site: vegetation for shelter/nest-building, adequate food supply (e.g. invertebrate density).

Informed decision on season for release: based on food supply for release animals, temperature/rainfall and its impact on the animals themselves in order to reduce stress associated with the translocation.

Other recommended management practices

Increased trapping effort & monitoring & screening of wild populations for BPCV1, including Bernier, Dorre & Faure Island & Arid Recovery. While this is logistically difficult, unless this is undertaken it is very difficult to quantify the prevalence of the disease. The sample size of WBB's should be based on a power analysis of estimated population size to enable statistically sound conclusions to be drawn from the data. Any wart-like lesions should be photographed & swabbed as per the protocol provided by Dr Lucy Woolford, University of Adelaide Lucy Woolford lucy.woolford@adelaide.edu.au (Appendix 4) and samples forwarded for analysis.

Wild to wild translocations could continue from potentially disease free Faure Island & Dorre Island with strict attention to biosecurity & post release health surveillance involving periodic trapping & clinical examination for evidence of lesions & swabbing of any suspect lesions as per the protocol provided by Dr Lucy Woolford.

A gold standard option to increase genetic diversity would be to establish a captive breeding facility which could be used to attempt to breed disease-free individuals which would have Bernier Island genetics - and these individuals could then be translocated into new translocation projects to supplement the genetic pool (Woolford et al. 2008b). Such translocations would only be undertaken at a stage where there could be confidence that F3 generation individuals were disease free. For example - an initial founder colony could consist of 9 females from Faure Island and 3 juvenile males translocated from Bernier Island (captured at different, and preferably remote, locations other than Redcliffe). These males would be held in quarantine and monitored closely. Likewise, a carefully structured breeding program would be established with planned pairings. Offspring could be removed, held in separate enclosures and monitored closely. These F2 offspring could then be used for breeding and their offspring could be released. If F3 generation WBBs can be bred without any signs of the disease, then we could be fairly confident that the introduction of the three male Bernier Island bandicoots was successfully achieved without the introduction of the viral disease. F3 individuals from this colony could be translocated to supplement the genetics of newly established translocated populations. If such a colony could be established, it could play an important role in improving the genetic diversity of the translocated populations. If, however, lesions were detected in the F1 or F2 generations of this colony - then the project would be disbanded.

This option which may result in the creation of disease-free populations for translocation is costly, labour & time intensive, & may ultimately fail. However, given the number of knowledge gaps in relation to the epidemiology of BPCV1 in the wild this option should be a consideration. Although, the virus may have co-evolved with the Bernier Island population - it is important to understand that decreased genetic diversity, changing environmental factors & presence of external stressor factors including the process of translocation could lead to changes in the clinical expression of this disease, i.e. just because historically a disease agent was not a threatening factor for a particular population, doesn't mean that it can't become so, particularly when small populations with low genetic diversity are faced with changing environmental circumstances (M Bennett pers comm. 12 May 2008). Post release health surveillance through periodic clinical examination, swabbing of any suspect lesions & thorough post-mortem examination of any WBB individuals that die during the translocation should be undertaken as an additional means to improve surveillance & knowledge of this disease. Other marsupials, birds, reptiles, amphibians & eutherians from Australia and New Guinea with papillomas and carcinomas should ideally also be tested for BPCV infections (Woolford et al. 2008).

Risk management

- Increased **monitoring of source populations**
- Excellent **biosecurity and risk management practices**
- All translocated animals should be **examined** by an appropriately experienced veterinarian
- Any suspicious clinical signs or lesions should lead to **specific sampling and intervention**
- Strict **protocols during translocation** should be observed to maintain biosecurity & maximise animal health/welfare
- **Post-translocation management** & surveillance required

Increased monitoring

- Prior to **ANY** translocations occurring recommended
  - further disease monitoring, based on power analysis (to determine an adequate sample size to estimate the population prevalence of a particular infection or disease with good precision).
  - To assist in selection of source environments with lowest disease risk.

- Assess **cost – benefits of translocation** & to decide which source populations should be used in conjunction with genetic analysis.

- If BPCVS & Chlamydia are of low prevalence the risk of disease impacts as a result of translocation events could be managed to an acceptably low (but not zero) risk if general and specific disease risk management recommendations were implemented as described.

Examination, sampling & actions

Table 7. Recommended translocation health screening protocol

1) Identify – microchip interscapula region & tissue glue to close skin
2) Weigh

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3) Clinical examination			Sampling	Action
Body condition score (1-5)			n/a	Assess with weight - WBB of poor weight & body condition should be excluded from translocation
Check all body systems including:	Integument	Esp. for skin lesions associated with BPCVS, Mycobacteriosis & Erysipelas. Trauma related wounds esp. toes & feet	**Swab ALL suspicious BPCVS skin lesions** including a. abnormal areas of skin b. Lip commissure c. Skin around the eye/ eyelid d. Dorsal and palmar/ plantar surfaces of the feet (usually one or both of the front feet) e. Skin of the flank & take photographs as per protocol (see **Appendix 4** for full protocol)	Diagnostically sample or treat as indicated All WBBs with suspicious BPCVS should not be translocated & should be held in quarantine pending results
	Ears			
	Eyes	Esp. for chlamydia related ocular disease Evidence of traumatic corneal & lenticular disease & cataracts	**Swab ALL suspicious chlamydia cases** collect swabs from both conjunctiva, nares and cloaca for PCR analysis	WBBs with suspicious eye lesions should not be translocated, to reduce the risk of transmission of Chlamydia or other pathogens to naïve species at the destination environment. Individuals with clinical eye disease, who are also PCR positive for Chlamydia, should not be translocated. Animals with advanced bilateral cataracts should be excluded from translocation
	Oropharyngeal region	Esp. for evidence of periodontal disease	Assess age by degree of molar wear,	WBBs with advanced molar wear should be excluded from translocation
	Musculoskeletal system	Palpation of long bones & for any joint crepitus or instability		
	Abdomen			
	Thorough examination for ectoparasites			Assess severity – treat only if indicated (moderate to severe burden) Selamectin *(Revolution)* 6mg/kg topical & repeat in 4 weeks if indicated.

Table 8. Diagnostic testing & screening including sample collection, laboratory and storage details for identified disease hazards

Disease	Test	Sample required	Number of samples	Send to	Store
Bandicoot papillomatosis and carcinomatosis syndrome (BPCVS)	PCR	**Swab ALL suspicious skin lesions & photograph** including b. Lip commissure c. Skin around the eye/ eyelid d. Dorsal and palmar/ plantar surfaces of the feet (usually one or both of the front feet) e. Skin of the flank & take photographs as per protocol (see **Appendix 5** for full protocol)	5 individual swabs	Adelaide University – Lucy Woolford lucy.woolford@adelaide.edu.au	Hold at -20°C until couriered
Herpes disease	PCR Serum antibody level	Swab both conjunctival, nasal, oropharyngeal, cloacal, and preputial (in males) mucosal surfaces on one swab 0.5ml serum for antibody detection	1 swab for PCR 1 swab for viral culture in viral culture medium 0.5mL serum	University of Melbourne – Jo Devlin devlinj@unimelb.edu.au	Hold at -20°C until couriered For PCR only -20°C is fine. However if virus culture is desired -80°C is better & in a culture medium' (Stalder pers comm July 2018)
Chlamydiosis	PCR	**Swab all WBBs with ocular lesions** – both conjunctiva, nares and cloaca on one swab	1 swab for PCR	Charles Sturt University Qld – Shane Raidal shraidal@csu.edu.au	Hold at -20°C until couriered -80°C for long term.
Cryptococcosis	serum LCAT, nasal swab & cytology	Serum, nasal swab	1mL serum 1 swab for nasal cytology	Vetpath enquiries@vetpath.com.au http://www.vetpath.com.au/ContactUs.aspx	Hold at -20°C until couriered
Enteric protozoal pathogens	Faecal microscopy, possibly later genotyping	Fresh faeces - Fresh faeces is best and could be stored in fridge (4°C) for 2-3 days before analysis	4g	Murdoch University – Amanda Ash A.Ash@murdoch.edu.au http://www.murdoch.edu.au/Research-capabilities/Parasitology/Services/Diagnostic-services/Contact-us/	Fix at least 2g in 10% formalin & another 2g in 70% ethanol
Enteric helminthiasis		Fresh faeces, whole worms			Hold whole worms at room temp in 70% ethanol
Enteric bacterial pathogens (incl *Salmonellosis*, *Mycobacteriosis*)	Microbial culture & sensitivity (MC&S): incl Salmonella	Fresh faeces or cloacal swab; request acid fast staining	2-3g faeces or 1 cloacal swab	Department of Primary Industries & Regional Development +61 (0)8 9368 3351 https://www.agric.wa.gov.au/livestock-biosecurity/ddls-animal-pathology-laboratory-services	Hold at -20°C until couriered
*Intracellular haematozoa (*Babesia* sp. & *Theileria*) & Trypanosomiasis	peripheral blood smear	Fresh blood smear	1 blood smear	Vetpath enquiries@vetpath.com.au http://www.vetpath.com.au/ContactUs.aspx	Hold at room temperature
Toxoplasma gondii	serum MAT test	Serum	1mL serum	AHL Tasmania specimenreception@dpipwe.tas.gov.au http://dpipwe.tas.gov.au/biosecurity-tasmania/animal-biosecurity/animal-health-laboratories/animal-health-laboratory	Hold at -20°C until couriered
General health	ZP1 blood profile	EDTA and serum	2mL – 1ml EDTA & 1ml serum	Vetpath enquiries@vetpath.com.au http://www.vetpath.com.au/ContactUs.aspx	Hold serum at -20°C until couriered

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Disease risk management

- Biosecurity & use of barrier principals to reduce likelihood of parasite transmission to & from target species

- Protocols to maximise animal health & welfare

- Post-release health monitoring

- important when health & disease data lacking.

- Post-release clinical & pathological investigations

- may detect unknown or undetected hazards in target

- & related sp. found sick or dead at destination site.

Source: http://www.aridrecovery.org.au/arid-recovery-news/tag/feral_control/

Source: http://www.aridrecovery.org.au/arid-recover
news/tag/translocation/

Conclusion

A DRA is a living & evolving document reliant on stakeholder collaboration & communication to achieve its purpose. We recommend

- A structured, evidence-based & iterative approach.
- Clarifying the goal, scope & focus of the DRA from the outset.
- Accessing both published & unpublished information through expert & stakeholder consultation.
- Transparency in explicit listing of limitations & assumptions.
- Post-translocation monitoring to evaluate effectiveness of risk mitigation measures.
- Teach the process of DRA, why do we do it, what are the benefits?
- Tailor methodology & recommendations to financial, logistical & practical constraints
- Summarise key facts , be objective
- Provide key practical recommendations for management
- Be available to answer questions from stakeholders pre, during & post translocation

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