

Captive breeding programs and their contribution to *Western Shield: Western Shield* review—February 2003

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SUMMARY

Objectives

The objectives were to establish a number of captive breeding facilities throughout the State of Western Australia to minimize the risk at any one facility and to captive breed up to 11 species of fauna.

Achievements

Three Department of Conservation and Land Management (CALM) captive breeding facilities (Project Eden, Return to Dryandra and Gilbert's potoroo) have been established with financial support provided to a further two breeding programs (Perth Zoo and Kanyana Rehabilitation Centre). A fifth facility has been established by the CSIRO to produce animals for release at Heirisson Prong.

Fourteen threatened species have been, or are being bred to produce animals for release into the wild at suitable locations.

Difficulties

Some species have proven difficult to breed in captivity with little or no net production (e.g. Gilbert's potoroo). For other species there are clear differences in the net production of animals using different husbandry techniques (i.e. intensive versus extensive rearing facilities).

A small number of species have proven relatively easy to breed under one or other husbandry system but there is a shortage of safe translocation sites that these animals can be released into. This has resulted in some species being held in captivity in higher numbers, and for longer periods of time than would be preferable. This problem has been further exacerbated by the extensive impacts of the drought that has affected south-west Western Australia for the last two years.

Release of all of these threatened species invariably requires intensive monitoring for the first and often subsequent translocations. The considerable resources (radio transmitters and staff time) required to adequately monitor the translocated animals to ensure that they survive and to promptly identify any threats also provide a serious impediment to timely releases of animals.

Unforeseen problems, such as those affecting the captive breeding of western barred-bandicoots have led to the suspension of the breeding program for this species pending the resolution of the disease issues encountered in wild and captive stocks. Even when this issue has been resolved consideration should be given to restricting captive breeding of this species to intensive breeding situations, with progeny being transferred direct to the wild.

The extensive pen arrangement used to breed banded hare-wallabies and mala at Dryandra do not appear to suit these species given the problems associated with predation. Consideration should be given to discontinuing the breeding of these species at Dryandra and focusing on those species that do well in extensive pen situations (e.g. bilby and boodie).

The very large in-kind contribution that the Kanyana Rehabilitation Centre provides towards the breeding of bilbies and western barred-bandicoots relative to the current financial contribution provided by the CALM is cause for concern. It is probably unreasonable to expect this level of contribution to continue in the future and efforts should be made to better compensate the Kanyana operation for its contribution.

Potential Economies

The results provided in Table 3 clearly indicate that some species breed better under particular types of husbandry management. Therefore consideration should be given to rationalizing the range of species kept under particular types of husbandry techniques at some of the facilities. Specifically western barred bandicoots should be removed from any captive breeding program until a clear resolution of the disease issues is achieved. The use of volunteer labour should be tempered with a consideration for the need to establish health monitoring procedures to ensure that information recorded on the status of captive animals is of a consistent quality.

Potential Improvements

Conduct a detailed analysis of costs of the Peron and Dryandra facilities to identify where the major cost items are. If staff labour costs are the major item consider outsourcing basic tasks such as feeding animals and cleaning pens. This can help reduce costs while providing an opportunity for greater community involvement.

Discussions should also be held with the Perth Zoo to determine which additional species could be bred at the Zoo and then compare those cost estimates to figures for comparable CALM programs.

Experience with numbats and dibblers suggests that consideration needs to be given to preparing captive bred animals for release with respect to their level of predator awareness, familiarity with more natural food items and an avoidance of providing food at standard times of the day.

INTRODUCTION

The original *Western Shield* document (Burbidge *et al.* 1995) did not make any mention of the possible need to captive-breed native animals to provide founding stock for fauna translocations. Shortly thereafter the need for captive breeding was appreciated and this was reflected by its inclusion in the Priorities section of the draft 'Western Shield Strategic Plan' (CALM 1999).

There were five key points defined in the draft 'Western Shield Strategic Plan' that related to captive breeding.

- Only those species that could not be readily translocated from existing wild populations will be bred in captivity;
- Threatened species will be favoured over non-threatened species for captive breeding;
- Species will only be bred in captivity if release sites within suitable habitat are available;
- Captive breeding facilities will be maintained at several sites to manage the risk of failure or loss; and
- Species will be bred for release in Western Australia unless required by a species recovery plan to be released elsewhere.

These points were combined in Objective 1 of the strategic plan as 'Develop captive breeding facilities where necessary for threatened fauna.' Specific targets were also set with respect to captive breeding with 'Up to eleven species of fauna (mala, boodie, banded hare-wallaby, bilby, western barred-bandicoot, malleefowl, chuditch, numbat, dibbler, djoongari (Shark Bay mouse), Gilbert's potoroo) will be in captive breeding programs at the Peron and/or Dryandra facilities or another appropriate facility such as Perth Zoo.' No performance indicators were specified for the captive breeding component of the draft 'Western Shield Strategic Plan'.

This review will examine the breeding outputs for the various captive breeding facilities that have been established in Western Australia, including those managed by organizations other than CALM. The data presented here are as accurate as possible and are derived from a number of sources both within and external to CALM.

WHERE ARE THE CAPTIVE BREEDING FACILITIES IN WESTERN AUSTRALIA?

There are currently five facilities in Western Australia that are breeding, or have bred species of threatened fauna for

the purpose of providing founding stock for fauna translocations. These are considered in a separate review paper on fauna translocations for Western Shield (Mawson, this issue).

CALM has constructed two purpose-built multi-species captive breeding facilities; one at Francois Peron National Park near Denham and the other at Dryandra Forest near Narrogin. The program at Francois Peron National Park is run under the name 'Project Eden' and an overview of this program is provided in a separate review paper (Morris *et al.*, this issue). The facility at Dryandra is run under the project name 'Return to Dryandra' and an overview of this program is also provided in a separate review paper (Friend and Beecham, this issue). For the purpose of this review paper the outputs of these facilities are presented here along with those of the facilities identified below in order to allow direct comparisons between the different types of facilities and the breeding performance of the various species under different regimes.

CALM also runs a single-species captive breeding facility at Two Peoples Bay Nature Reserve (near Albany) as part of the recovery plan for the critically endangered Gilbert's potoroo (*Potorous gilbertii*).

In addition to those facilities CALM also provides financial support for the captive breeding of two species of threatened fauna at the Kanyana Rehabilitation Centre in Goosberry Hill (an outer suburb of Perth), however the day-to-day management of the Kanyana facility is organized by a voluntary wildlife carers.

The Perth Zoo, the statutory zoo in Western Australia, runs captive breeding facilities for a number of species in collaboration with CALM. The CSIRO and the Useless Loop community (located on the Heirisson Prong on the western edge of Shark Bay), in conjunction with Shark Bay Salt Joint Venture run a captive breeding facility for three species of threatened fauna.

TYPES OF CAPTIVE BREEDING FACILITIES

The captive breeding facility at Francois Peron National Park is an intensive breeding facility that utilizes small mesh-covered pens as well as larger outdoor pens that accommodate breeding pairs or small family groups of animals (Morris *et al.*, this issue). The facility at Dryandra is an extensive breeding facility consisting of two 10ha pens, with animals of several species kept in the pens simultaneously (Friend and Beecham, this issue).

The Gilbert's potoroo captive breeding facility consists of a series of small open-air pens. The captive breeding facilities at Kanyana Rehabilitation Centre are similar to those at Francois Peron National Park and cater for pairs or family groups of animals in open-air, but roofed facilities.

The captive breeding facilities at the Perth Zoo included both outdoor and indoor facilities for different species, with specialized indoor incubation facilities for the western swamp tortoise eggs. Chuditch, numbats and

greater stick-nest rats were maintained in outdoor pens, while Shark Bay mice and dibblers were maintained in indoor facilities.

WHICH SPECIES ARE CAPTIVE BRED AND WHY?

Fourteen species of native animal are being, or have been bred in captivity to provide founding stock for translocations to the wild (Table 1). All 14 species are listed as threatened species under the Western Australian *Wildlife Conservation Act 1950* and are also listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. All of these species are ones that occur in such low numbers or at such low densities in the wild that capture for wild to wild translocations would not be feasible, or they are species that are now restricted to off-shore islands and the costs and logistics associated with visiting those islands to trap and relocate animals are prohibitive. In the case of the mala, this taxon is currently listed as Extinct in the Wild and captive stocks are the only source of animals for translocations. The current IUCN threat categories for these species are shown in Table 1 below. This conforms with the first key point in the draft 'Western Shield Strategic Plan'.

TABLE 1

IUCN threat category for the 14 species of native fauna subject to captive breeding programs in Western Australia (EW=Extinct in the Wild, CR=Critically Endangered, EN=Endangered, VU=Vulnerable).

SPECIES	IUCN THREAT CATEGORY
Chuditch	VU
Dibbler	EN
Numbat	VU
Western barred bandicoot	EN
Bilby	VU
Gilbert's potoroo	CR
Boodie	VU
Mala (mainland taxon)	EW
Banded hare wallaby	VU
Shark Bay mouse	VU
Greater stick-nest rat	VU
Malleefowl	VU
Western swamp tortoise	CR
Lancelin Island skink	VU

Ninety-three percent of species listed in Table 1 have already been the subject of translocation proposals into the wild on islands off the coast or onto the mainland. The outcomes of those translocations are dealt with in more detail in a separate review paper (Mawson, this issue). Gilbert's potoroo is the only exception as it currently occurs in such low numbers in the wild and has proven so difficult to breed in captivity that insufficient animals have been produced to facilitate a translocation. Additional potential release sites for these species have been identified and translocations will be attempted as and when animals

become available and when the significant threats to the species (e.g. feral cats) can be adequately managed.

To date no animals from any of the captive breeding facilities have been provided as founding stock for translocations to other States. All translocations to other States have involved wild-caught stock or the wild progeny of animals bred in captivity.

ANIMAL PRODUCTION FROM CAPTIVE BREEDING FACILITIES

The principal objective of captive breeding facilities is to produce animals that are surplus to the maintenance requirements of the various breeding facilities, and that can be used to found or supplement other facilities and to provide animals for release into the wild as part of approved translocation programs. The specific changes in stock numbers within facilities can be difficult to monitor in larger, open air facilities or in cases where the monitoring process can represent a risk to the pouch young of the species being bred. As a consequence some species are monitored at the individual animal level infrequently or irregularly, and not all births and deaths that occur within the facilities may be recorded. What is of more relevance is the total number of animals produced surplus to the maintenance of breeding stock that can be removed from the facilities for translocation. The data presented in Table 2 show the net output of animals that have been or could be made available for translocations.

Costs of producing captive-bred animals at the various facilities

Calculating the costs associated with producing animals in captive breeding facilities can be difficult and any comparisons between the production costs for the same species at different facilities can be equally difficult. For the purpose of this review paper the costings provided in individual species recovery plans have been used, while known budgets from the Peron and Dryandra facilities have been applied. Kanyana Rehabilitation Centre receives \$6,000 per annum from CALM towards the food costs for the bilbies and western barred bandicoots maintained there. Advice from June Butcher indicates that the volunteer staff at the centre spend 40 hours per week cleaning cages and feeding bilbies and western barred-bandicoots (i.e. 80 hours per week total). This labour is provided by volunteers, but for the purpose of this review that labour has been costed at a conservative \$15 per hour.

Calculating the 'cost per animal' of production at each facility has been achieved by dividing the total expenditure for that species by the net production of animals over the total period that each species has been bred in captivity. In those facilities where more than one species is maintained and bred, and the number of species bred has varied from one year to another the total expenditure has been divided by the number of species and the number

TABLE 2

Net production of the various captive breeding facilities described above. [WBB=western barred bandicoot, BHW=banded hare-wallaby, GSNR=greater stick-nest rat].

Summary of total resident population at the CALM Peron Captive Breeding Centre at May 2002, plus transferred and released animals.

		FOUNDERS	TRANSFERRED IN	TOTAL ANIMALS IN	TRANSFERRED OUT	RELEASED	RESIDENT	TOTAL ANIMALS PRODUCED	NET GAIN	% GAIN
WBB	Female	18	0	18	7	0	19	26		
	Male	12	0	12	4	0	21	25		
	Total			30				51	21	70%
BHW	Female	13	0	13	0	6	13	19		
	Male	12	0	12	0	12	17	29		
	Total			25				48	23	92%
Bilby	Female	6	1	7	1	24	17	42		
	Male	7	4	11	5	20	13	38		
	Total			18				80	62	344%
Mala	Female	18	0	18	0	7	21	28		
	Male	11	0	11	0	9	20	29		
	Total			29				57	28	96%
Malleefowl	Eggs collected	105								
	Chicks hatched	90	Net Gain	% Gain						
	Birds released	67	67	64%						

Summary of total resident populations the CALM Return To Dryandra facility at June 2002, plus transferred and released animals.

		FOUNDERS	TRANSFERRED IN	TOTAL ANIMALS IN	TRANSFERRED OUT	RELEASED	RESIDENT	TOTAL ANIMALS PRODUCED	NET GAIN	% GAIN
WBB	Female				0	0	8	8		
	Male				0	0	7	7		
	Sex Unknown	7	20	27	2	0		2		
	Total			27			15	17	-10	0%
BHW	Female	2			0	0	2	2		
	Male	3			0	0	0	0		
	Sex Unknown	13								
	Total			18			2	2	-16	0%
Bilby	Female	6		6						
	Male	7		7						
	Sex Unknown		35	35	1	46	37	84		
	Total			48				84	36	75%
Mala	Female	10	0	10	0	0	10	10		
	Male	9	0	9	0	0	4	4		
	Sex Unknown				4	0		4		
	Total			19				18	-1	0%
Boodie	Female	12	0	12	10	0		10		
	Male	6	0	6	2	0		2		
	Sex Unknown				10		39	49		
	Total			18	22		39	61	43	239%

Summary of total resident population of Kanyana Rehabilitation Center at June 2002, plus transferred and released animals.

		FOUNDERS	TRANSFERRED IN	TOTAL ANIMALS IN	TRANSFERRED OUT	RELEASED	RESIDENT	TOTAL ANIMALS PRODUCED	NET GAIN	% GAIN
WBB	Female	6	6	12	8	0	9	17	5	
	Male	10	5	15	10	0	8	18	3	
	Sex Unknown									
	Total			27				35	8	30%
Bilby	Female	5	11	16	30	23	12	65	49	
	Male	4	9	13	28	23	10	61	48	
	Sex Unknown							126		
	Total			29	58	46	22		97	334%

TABLE 2 (continued)

Summary of total resident population at the CSIRO/SBSJV Heirisson Prong facility at June 2002, plus transferred and released animals.

		FOUNDERS	TRANSFERRED IN	TOTAL ANIMALS IN	TRANSFERRED OUT	RELEASED	RESIDENT	TOTAL ANIMALS PRODUCED	NET GAIN	% GAIN
Boodie	Female	8								
	Male	4								
	Sex Unknown									
	Total	12	10	22	0	114	22	114	92	418%
WBB	Female	9	2			17				
	Male	3				34				
	Sex Unknown									
	Total	12	2	14		51	?	37?	37	264%
GSNR	Female	3	27							
	Male	5	13							
	Sex Unknown									
	Total	8	40	48	*	*		*	?	?

Summary of total resident populations at the Perth Zoo at June 2002, plus transferred and released animals.

		FOUNDERS	TRANSFERRED IN	TOTAL ANIMALS IN	TRANSFERRED OUT	RELEASED	RESIDENT	TOTAL ANIMALS PRODUCED	NET GAIN	% GAIN
Dibbler	Female	4	5	9	1	72	10	83		
	Male	4	9	13	0	57	9	66		
	Sex Unknown									
	Total	8	14	22	1	129	19	149	127	577%
Chuditch	Female	6	26	32	1	155	2	158		
	Male	2	28	30	3	165	2	170		
	Sex Unknown									
	Total	8	54	62	4	320	4	328	266	429%
Shark Bay mice	Female	3	15	18		104	49	153		
	Male	3	21	24		114	55	169		
	Sex Unknown									
	Total			42		218	104	322	280	666%
Numbats	Female	1	25	26	3	43	5	51		
	Male	1	28	29	1	48	6	55		
	Sex Unknown									
	Total	2	53	55	4	91	11	106	51	93%
Western swamp tortoise	Female	3	14	17		14	21	35		
	Male	10	12	22		12	26	38		
	Sex Unknown					218	158	376		
	Total	13	26	39		244	205	449	410	1051%
Lancelin Island skink	Female	9		9	6	21	12	39		
	Male	4		4	4	19	20	43		
	Sex Unknown				22	46	77	145		
	Total	13		13	32	86	109	227	214	1646%

Summary of total resident Gilbert's Potoroo population at the CALM Two Peoples Bay Nature Reserve at September 2002, plus transferred and released animals.

		FOUNDERS	TRANSFERRED IN	TOTAL ANIMALS IN	TRANSFERRED OUT	RELEASED	RESIDENT	TOTAL ANIMALS PRODUCED	NET GAIN	% GAIN
Potoroos	Female	5	0	5	1	0	4	5	-1	
	Male	3	0	3	1	0	2	3	1	
	Total	8	0	8	2	0	6	8	0	0%

years to provide proportional figure per species. This figure has then been divided by the total number of animals produced to generate a cost per animal estimate.

The expenditure figures for the Peron and Dryandra facilities include the capital costs of designing and building pens. Capital costs were not available for Kanyana or the Perth Zoo. This means that the production costs for each animal bred at the Kanyana and Perth Zoo facilities are conservative relative to those for animals bred at Peron and Dryandra. No expenditure figures were available for the Heirisson Prong facility, but the production data for this site are included in Table 3 as a comparison.

The information set out in Tables 2 and 3 clearly indicates that there are differences in the output of captive-bred animals at the various facilities, and that some species perform better under particular husbandry conditions than others.

The production costs per animal for a number of species (chuditch, dibbler, numbat and Shark Bay mouse) were reported by Bradley *et al.* (1999) during the early stages of the captive breeding process for those species at the Perth Zoo (1995–1997 inclusive). The method of calculating the capital costs, labour costs and feeding costs are not described by Bradley *et al.* but it is still useful to

examine the changes in costs per animal from 1997 to the current estimates at 2002. The cost of producing a chuditch fell from \$2,430 to \$1,262 per animal; for dibrblers it fell from \$5,439 per animal to \$2,165; for numbats from \$16,318 to \$9,411 per animal and for Shark Bay mice from \$1,483 to \$553 per animal. These results seem logical in that the longer a breeding program is run the better the return on capital investments and the greater opportunity for the staff husbanding the animals to perfect techniques that result in an increased output of animals. For programs that reach their end point and are wound up, such as the chuditch breeding program, there is the added benefit of being able to release the remaining breeding stock into the wild which bolsters the output and reduces the cost per animal.

Carnivorous species such as chuditch and dibbler appear relatively easy to breed in numbers and can be produced at a modest cost relative to the length of time from mating to independence of the progeny. Specialist feeders such as numbats are labour-intensive and relatively costly to breed in captivity, but the production of numbats (as well as the carnivores) is still more cost effective than trapping wild stocks and relocating them given the numbers of animals required to found new populations.

TABLE 3

Net cost of producing animals for fauna translocations in Western Australia. [Notes: 1. The net production of animals includes animals currently held in captive facilities but surplus to maintenance requirements plus those animals already released into the wild under translocations. 2. The period over which animals were captive bred exceeds the period of operation for *Western Shield* for some species. 3. Expenditure data derived from various species Recovery Plans may not accurately reflect the total costs incurred. 4. Total expenditure for *Return to Dryandra* 1996-2002 = \$357,000: equates to \$71,400 for each of the five species maintained at this facility; Total expenditure for *Project Eden* 1996-2002=\$858,000 which equates to \$37,304 per species per annum.]

SPECIES	BREEDING FACILITY	NO. YEARS CAPTIVE BRED	TOTAL EXPENDITURE (\$)	NO. ANIMALS PRODUCED (NET)	COST (\$) PER ANIMAL PRODUCED
Chuditch	Perth Zoo	9	\$335,900	266	\$1,262
Dibbler	Perth Zoo	5	\$275,000	127	\$2,165
Numbat	Perth Zoo	8	\$480,000	51	\$9,411
Western barred bandicoot	Dryandra	4	\$71,400	0	(\$71,400)
	Peron		\$186,521	21	\$8,881
	Kanyana	4	\$148,800	8	\$18,600
	Heirisson Prong	4	?	37+	?
Bilby	Dryandra	4	\$71,400	36	\$1,983
	Peron		\$223,826	62	\$3,610
	Kanyana	4	\$148,800	97	\$1,534
Gilbert's potoroo	Two Peoples Bay	6	\$150,000	0	(\$150,000)
Boodie	Dryandra	3	\$71,400	43	\$1,660
	Heirisson Prong		?	114	?
Mala (mainland taxon)	Dryandra	3	\$71,400	0	(\$71,400)
	Peron	3	\$186,521	28	\$6,661
Banded hare-wallaby	Dryandra	3	\$71,400	0	(\$71,400)
	Peron	3	\$186,521	23	\$8,109
Shark Bay mouse	Perth Zoo	5	\$155,000	280	\$553
Greater stick-nest rat	Heirisson Prong	3	?	0	?
Malleefowl	Peron	2	\$74,608	67	\$1,113
Western swamp tortoise	Perth Zoo	10	\$327,900	410	\$800
Lancelin Island skink	Perth Zoo	3	\$31,000	41	\$756

Intensive breeding facilities appear to be the only feasible option for captive breeding of these species given their biology and the predatory nature of the chuditch and dibblers.

The production of western barred-bandicoots has been significantly and adversely affected by two endemic diseases that have been identified in both captive and wild stocks. These diseases singly or in concert result in mortalities in adult animals and appear to also significantly reduce the production of recruits. Consequently the net production of this species at the three facilities is well below what might have otherwise been expected, and accordingly the cost per animal is high at all three facilities. At this stage it is not possible to determine whether this species is better suited to intensive or extensive breeding facilities, but it appears that the species is density-limited in any facility and that aggression between cage-mates is important and that these factors may influence the process used to provide animals for translocation. In order to maximize production in any pens it may be necessary to remove small numbers of animals regularly and release them rather than wait until larger numbers are available for a single release event.

The production of bilbies at all three facilities has been a feature of the captive breeding programs. Bilbies appear equally suited to both intensive and extensive breeding arrangements. The production cost per animal as shown in Table 3 at the three facilities needs to be considered with caution for two reasons. First, the labour costs for the care and maintenance of bilbies at Kanyana Rehabilitation Centre have only been costed at \$15 per hour which is conservative. Second a significant number of the animals produced at Dryandra had been bred and raised at Kanyana and subsequently transferred to Dryandra for captive breeding or release into the wild. Those animals have effectively been provided at a discount to the Dryandra facility, resulting in the net cost per animal being lower at this facility than the costs for animals produced at Peron. If the labour costs at Kanyana were doubled, the production costs per bilby at Kanyana would almost double (ca.\$3,000 per animal) which would be comparable to those for the Peron facility. On this basis the cost of producing bilbies is probably in the order of \$3,000 per animal regardless of the type of facility.

Boodies appear to be a relatively easy species to produce and the cost per animal also appears low. This species seems ideally suited to extensive style captive breeding relative to the costs of trapping in the wild on Bernier and Dorre Islands and relocation to the mainland.

Mala appear susceptible to significant losses (due to predation) in extensive pen systems and cannot replace themselves, let alone provide recruits for translocation. In intensive pen systems mala appear to do well and can be produced at a higher cost than other species, but there is little or no opportunity to obtain further stocks from the Northern Territory and as such the existing program appears the only option until substantial wild populations can be established.

Banded hare-wallabies are another species that do not appear well suited to extensive pen systems and the only successful production has come from intensive pen programs. The high cost of production per animal is partly a function of the univoltine breeding system of this species and lower number of animals provided as founding stock. The only other alternative is to capture animals from Bernier and Dorre islands and transport them to the mainland, which is expensive and labour intensive (ca. \$10,000 per trip to the islands and a limit of ca. 15-20 animals can be captured and transported per trip).

Shark Bay mice are readily bred in captivity and can be produced in relatively large numbers sufficient for translocations within a short period of time (<1 yr). The low production costs per animal are a significant saving on capture in the wild (Bernier Island) and transfer to the mainland.

Greater stick-nest rats have been bred in the captive facility at Heirisson Prong but the progeny disperse out of the pens making monitoring difficult. The suitability of this species to captive breeding on the mainland remains unknown, but it may benefit from more intensive programs such as those applied to the Shark Bay mouse. The captive colony of Greater stick-nest rats at Perth Zoo suffered from kidney problems believed to be associated with the artificial diet the animals were fed and also from cataracts. Both of these health problems had a significant impact on the productivity of the colony.

Gilbert's potoroo has proven extremely difficult to breed in captivity and it is unlikely that many animals will be available for release into the wild in the near future. Further research is required and has been planned to improve the potential recovery of this species.

Malleefowl are relatively easy to rear (as opposed to breeding) in captivity when fertile eggs are collected in the field, incubated and the chicks raised to 6-8 months of age. The cost per animal was quite low, and the output from this program has led to the successful establishment of this species at the one release site used to date. The alternative of capturing adult birds from the wild has never been attempted and is not a viable one from a practical or financial standpoint.

Western swamp tortoises have been bred in captivity longer than any other species considered in this review paper (more than 10 years) and the current output reflects this extended learning period. The net cost per animal is quite low, largely a reflection of the reptilian ecology of this species and the limited amount of labour required to maintain captive stocks. Given the critical nature of wild stocks at present and the long maturation time (9+ years) for this species captive breeding remains the only viable option for the conservation of this species.

The Lancelin Island skink captive breeding program has performed very well and benefits from the lower labour and capital costs required to maintain and breed this species. Given the small number of wild Lancelin Island skinks (<300 adults) on Lancelin Island, the current program is a very cost effective one relative to other species considered in this review.

COORDINATION BETWEEN CAPTIVE BREEDING PROGRAMS

Two of the species listed above (bilby and mala) are the subject of national recovery plans, and in both cases the recovery actions listed in those plans include captive breeding. Efforts are made to maximize the genetic diversity of captive collections around Australia and a small number of animals are routinely exchanged between facilities each year. The three captive breeding facilities in this State that hold bilbies carry out exchanges of breeding stock without difficulties. Further there are regular transfers of bilbies from the Kanyana facility to the Dryandra facility for release into the breeding pens or direct release into the wild. There is adequate opportunity for similar transfers of bilbies to and from the Peron facility.

With regard to mala, there have not been any exchanges of captive stocks with the Northern Territory since all of the animals held in Western Australia are derived from a single captive colony in the Northern Territory. To date there has not been any need to transfer any mala between the Peron and Dryandra facilities, but there is a ready capacity to do so if required.

Western barred-bandicoots have been transferred variously between Peron, Dryandra and Kanyana in the past. However, since the discovery of the two diseases amongst the captive animals no further transfers have taken place and nor will they until the management of the two diseases is adequately resolved.

Banded hare-wallabies have not been transferred between the Peron and Dryandra facilities that hold them, but there is a ready capacity to do so if required. Given the failure of the colony of banded hare-wallabies at Dryandra such an action would be desirable if the colony at Dryandra was to be re-established.

All of the species bred at the Perth Zoo have not been bred at any other facility and as such there has been no requirement for exchange of animals between facilities, although the Perth Zoo has demonstrated an efficient procedure for the movement of animals into and out of the captive breeding facilities in the past. An efficient system for the preparation (marking, vet checks etc.) of animals that are to be transferred out of the Perth Zoo for release into the wild under approved translocation programs has been developed.

The three species bred at Heirisson Prong have been introduced into that facility with the sole purpose of establishing populations in the wild at that site. There has not been any requirement for the transfer of any animals from Heirisson Prong to any of the other facilities described in this review, but animals established in the wild at Heirisson Prong have been translocated to South Australia and to Faure Island in Western Australia (see Review paper on fauna translocations).

SHOULD CALM BE INVOLVED IN CAPTIVE BREEDING AND IF SO WHICH FACILITIES SHOULD IT RETAIN?

The data presented in Tables 2 and 3 clearly indicate that the CALM currently has the expertise to maintain a range of native species in captivity and breed most of them with varying degrees of success depending on the species. The data also suggest that facilities such as the Perth Zoo may be more economical at such breeding programs, although the species that the Perth Zoo have bred to date have not been kept elsewhere, and the capital costs associated with accommodating those species were invariably not included in the production cost estimates provided in Table 3. The species that the Perth Zoo have bred have also been ones that can be kept at relatively high densities or are species that do not require much space to accommodate (e.g. Shark Bay mice, dibbler, chuditch, western swamp tortoise). In the event that the Perth Zoo was considered a preferred breeding facility there would be a requirement for the CALM and Perth Zoo to be able to ensure a continued supply of funds to run breeding programs, something that has proven more difficult to achieve in recent times.

In order to better assess the merits of CALM continuing any or all of its current facilities it would be prudent to obtain a more detailed breakdown of the production costs at each facility and for each species, with particular attention to the various costs of feed, capital items and staff labour. If the CALM labour costs are found to be the most significant component of the total costs then there may be some merit in outsourcing parts of the program and limiting CALM involvement to program management and animal handling (as opposed to feeding and cleaning of cages).

The involvement of the Kanyana Rehabilitation Centre in the captive breeding of bilbies has been a significant factor in the performance of the CALM Dryandra facility. The results at Kanyana indicate that with appropriate skills non-government groups could breed required animals as readily as any government facility. However, the issue of whether it is appropriate for CALM to continue to rely on the significant volunteer labour contribution in order to produce low cost bilbies (or any other species) does require urgent consideration. The current structure of the Kanyana facility cannot be expected to continue into the future for a number of reasons, foremost of which is the age of its principles.

Once a decision has been made about the merits of volunteer contributions to captive breeding programs consideration could be given to further captive breeding programs involving significant community (i.e. cheap or free) input.

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