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A Behavioral Analysis of the Pre-release Tasmanian devils (Sarcophilus harrisii) Currently at Devils@Cradle: An assessment of the impacts of captivity on the wild behaviors of Tasmanian devils that are important for their reintroduction, survival, and inclusion in wild populations

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SIT Study Abroad

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An assessment of the impacts of captivity on the wild behaviors of Tasmanian devils that are important for their reintroduction, survival, and inclusion in wild populations

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ISP Ethics Review

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ABSTRACT

The Tasmanian devil, *Sarcophilus harrisi,* is in danger of extinction in the wild due to the emergence of Devil Facial Tumor Disease (DFTD). In an attempt to save the species the Save the Tasmanian Devil Program (STTDP) has initiated the creation of an 'Insurance Population'. These insurance animals are a part of the captive breeding population (CBP) designed to conserve the genetic diversity of the species to preserve their ecological function for their future reintroduction into the wild. CBPs are located at various bio-secure zoos, wildlife parks, free-range enclosures (FREs), Tasmanian islands and peninsulas and sanctuaries like Devils@Cradle - Tasmanian devil Sanctuary. The goal of this study was to compare the behaviors of the juvenile devils recently moved to Devils@Cradle from Bridport FRE to the behaviors of wild devils to see if they were retaining wild characteristics in a more intensively managed captive situation. Using footage of devils from the wild and from Enclosure 13 a comparison was made to determine whether these devils destined to be released back into the wild were preserving their natural instincts vital to their survival and inclusion in wild populations. After analyzing almost 900 videos using an ethogram and a Chi square analysis this study has concluded that the pre-release devils in enclosure 13 do not appear to be behaving differently than their wild counterparts. The only behavior of concern found was a trend in the increase of daytime activity. However, this is believed to be associated with a recent shift to earlier feeding times and could be easily corrected. This serves as a promising sign for the preservation of this species through the use of captive breeding and managed populations until DFTD has been removed from the devil population and it is once again possible for their recovery in the wild.

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1. INTRODUCTION

1.1 Devils@Cradle - Tasmanian devil Sanctuary

Devils@Cradle, located adjacent to the Cradle Mountain National Park and World Heritage Site, is a species specific conservation facility specializing in Tasmania's three largest carnivorous marsupials: Tasmanian devils, spotted-tail quolls, and eastern quolls. Along with the general husbandry that is involved with ensuring the best possible care for the animals the sanctuary also works on field monitoring programs throughout the Cradle Mountain area, rehabilitates orphaned marsupials, and is a part of the nation-wide Captive Breeding Program (CBP) for Tasmanian devils called the 'Insurance Population' which is discussed further later on. All of the sanctuaries Tasmanian devils are a part of the CBP which is managed by the Zoological and Aquariums Association in coordination with the Tasmanian governments Save the Tasmanian Devil Program (STTDP). The quolls at the sanctuary are also included in their respective CBPs and are coordinated with support from the State Government Agency Department of Primary Industries, Parks, Water and Environment (DPIPWE). The sanctuary is committed to the long term conservation of these species and hopes to educate the public about their life cycles and current threats to the species. The overall goal at Devils@Cradle is to help ensure the long term survival of these truly unique species (Devils@Cradle, 2008).

1.2 Pre-release devils in Enclosure 13 at Devils@Cradle

Nine juvenile devils were brought to Devils@Cradle on the evenings of January 14th and 15th, 2015. Basic identification information on these devils can be found in the appendix in table four and pictures of each devil can be found in figure six. Their mothers were a part of the wild devil population on the Forestier Peninsula that was removed as a part of the peninsula's depopulation and quarantined at Bridport free-range enclosure (FRE). The nine were born at the Bridport FRE and moved to

Devils@Cradle at approximately 10 months of age to be held in a pre-release setting for around 12 months. They were moved to Devils@Cradle because of the lack of space at Bridport, concern of inbreeding, and to identify the mothers of the young before they naturally separated from each other. The hope is that while in enclosure 13 these young devils will grow strong enough to compete for resources in the wild while preserving their natural, wild instincts so that they can be released back onto the Forestier Peninsula to maintain the original genetic diversity of that area (Chris Coupland, pers. comm.).

Devils@Cradle has implemented many husbandry techniques to ensure that these wild behaviors are preserved. These techniques include: feeding the devils at random times at night or in the evenings away from the general viewing areas, using a feeding regime that varies from day to day, and limiting human contact with the devils by only conducting routines, cleaning up scat and food scraps, twice a week on Sundays and Wednesdays (Chris Coupland, pers. comm.). A more detailed account of the feeding regimes used through April 2015 can be found in the appendix in tables five and six. The enclosure itself was also fenced off for the most part from the general public to keep the devils from associating with people and becoming confident and aggressive towards them. Enclosure 13 is located along the perimeter fence within Devils@Cradle. The habitat within the enclosure is mostly temperate rainforest with a few intruding eucalypts and contains many fallen trees and other manmade and natural denning options as well as a small stream.

1.3 Background on Tasmanian devils and their Behavior

1.3.1 Distribution

The Tasmanian devil, *Sarcophilus harrisii,* is the largest marsupial carnivore alive today. As the name suggests, devils are endemic to Tasmania. However, Tasmanian devils could once be found throughout the mainland of Australia but died out there approximately 430 (+/- 160) years ago (Watts, 2002; Archer & Baynes, 1972). It is

generally agreed upon that the introduction of the Dingo 3,500 years ago and the following interspecies competition lead to their extinction on the mainland (Archer & Baynes, 1972). Their survival in Tasmania can be attributed to the islands creation and isolation from the mainland after the last ice age 12,000 years ago (Strahan, 1995). Distribution of the species occurs across the majority of the island as devils can live from mountainous, alpine environments to coastal habitats though they prefer open woodlands, dry sclerophyll forests, and agricultural areas where prey is abundant (Watts, 2002). Tasmanian devils were considered common across Tasmania about 20 years ago, but currently the population is considered endangered at the state level (*Threatened Species Protection Act 1995),* national level (*Environment Protection and Biodiversity Conservation Act 1999),* and is listed as endangered on the IUCN's Red List.

1.3.2 Ecological Importance

Tasmanian devils are an ecologically important species to Tasmania as they are the top predator. By providing controls for prey species and competing with introduced predators like feral cats devils stabilize the ecology of the ecosystems (Department of Primary Industries, 2010). Devils are also important scavengers in their ecosystems, cleaning up carrion that may otherwise rot or become a food source for invasive species.

1.3.3 Diet

Carnivorous devils have physiological features such as large canine teeth, a wide gape, and powerful jaws that allow them to consume most of any carcass including the bones (Watts, 2002). Tasmanian devils are opportunistic predators that will hunt prey that is their size or smaller as well as larger animals that are debilitated by age, disease, or injury (Kelly, 2006). Diets commonly include pademelons, wallabies, possums, any other meat available, and even the occasional berries (Kelly, 2006). Food is also often stolen from other predators like quolls or scavenged.

1.3.4 Physical Characteristics

Weighing in at an average of 10.5kg for males and 7kg for females with approximate head and body lengths of 63cm and 57cm respectively and a height to shoulders of about 30cm, the Tasmanian devils appearance resembles a stocky, sturdily built small dog with short legs and a long stiff tail (Kelly, 2006). Devils have black fur all over and typically have irregular white markings on either their chest, shoulders, rump, or a combination of the three that can be used to distinguish between devils. Males typically have broader, squarer foreheads and chests where females and juveniles have more pointed jawlines and narrower chests.

1.3.5 Life Cycle

Mating season typically occurs in March and birthing follows about three weeks later in April (Watts, 2002). Female devils have four teats and can raise up to four young. Young remain in the pouch for 15 weeks and are completely weaned within 40 weeks (Watts, 2002). Young devils naturally disperse from their mothers around 10 months of age. Devils typically begin breeding at the end of their second year and can live for seven to eight years in captivity and five to six years in the wild (Kelly, 2006; Hamede et al., 2009).

1.3.6 Wild Behaviors

Tasmanian devils are nocturnal, solitary, and non-territorial in the wild. However, they are also known for group feeding frenzies at large carcasses that commonly lead to rowdy displays that often involve vocalizations, gaping, jaw wrestling, chasing, and shouldering but rarely physical clashes (Kelly, 2006; Pemberton & Renouf, 1993). Studies have shown that communication behaviors while feeding involve 20 different visual postures, 11 vocalizations, and most likely chemical signaling via urination and cloacal drag (Pemberton & Renouf, 1993). Though tolerance of other devils is

customary at group feedings dominance in areas with many devils is commonly established through these interactions (Kelly, 2006). Home ranges of 8-20km^2 have been recorded and are communicated by devils via scenting through actions like cloacal drag but extensive overlap of ranges is common (Strahan, 1995). During the day time devils will shelter in anything that creates a suitable den like caves, old burrows, or thick scrub and typically use three to four different dens (Watts, 2002). When moving around devils will often follow roads, tracks, and riverbanks (Watts, 2002).

1.3.7 Stereotypical Captive Behaviors

Stereotypical behaviors in captive animals are defined as behaviors lacking in any obvious goal or function and having an unvarying presentation (Garner, 2005). When in captivity it is of particular concern that devils intended for release back into the wild do not develop these kinds of unnatural behaviors. Pacing in a circular pattern or making non-random movements within the enclosure, anticipation of feeding times, diurnal activity, and confidence or aggression towards humans are the major captive behaviors of concern (Kelly, 2006). Actions of self mutilation such as excessive grooming and biting, excessive aggression towards other devils or humans, and destructive behaviors like chewing on fences and trying to smash out of enclosures are also concerning behaviors that can be developed in captivity (Chris Coupland pers. comm.).

1.4 Devil Facil Tumor Disease (DFTD)

DFTD is an infectious, lethal, contagious cancer unique to Tasmanian devils that is the driving force behind recent Tasmanian devil conservation and the underlying reason for this study. The disease was first documented in photos taken in Northeastern Tasmania in 1996 (Department of Primary Industries, 2010). Since then, it has spread over the majority of the species range (Jones et al., 2007). A map of DFTDs distribution as of 2014 can be found as Figure Two in the appendix. Biting is the primary means of tumor transmission as Tasmanian devils most commonly bite each other around the head region during feeding interactions and sexual encounters (Hamede et al., 2009).

Transmission of the cancerous cell line as an allograft directly between devils is most likely possible because of the low genetic diversity of the current devil population (McCallum, 2008). There also appears to be a latency period of an undetermined length after infection in which the disease is not apparent but can still be transmitted to other devils (Hamede et al., 2009). The tumors then appear and increase in size over the course of two to three months and death usually follows within six months of their appearance due to starvation, dehydration, and breakdown of bodily functions (Hamede et al., 2009). There is currently no vaccine, treatment, or cure for the disease. Since the diseases arrival annual spotlight surveys have estimated an overall decline of 80% in devil populations and some populations where the disease first appeared have declined by over 95% (Department of Primary Industries, 2010; Jones et al., 2007). Therefore, this disease poses a great threat and extinction in the wild has been projected to occur in the next 25-35 years if declines continue at their current rates (Department of Primary Industries, 2010).

1.5 Insurance Populations

In 2005 the Australian and Tasmanian government's Save the Tasmanian Devil Program (STTDP) decided that insurance populations needed to be established to protect the Tasmanian devil from extinction and to preserve as much of the species genetic diversity as possible for future re-establishment of healthy wild populations (Lees & Andrew, 2012). A meta-population of 500 breeding devils would be needed to maintain the genetic diversity and behavioral integrity of the species over a period of 50 years (STTDP, 2014). 'Insurance' devils have now been established throughout Australia and is managed between a number of bio-secure zoos, wildlife parks, free range enclosures (FREs), and Tasmanian islands and peninsulas (Lees & Andrew, 2012). The insurance population consists of captive bred and wild sourced founder animals from Tasmanian Government's devil quarantine facilities (Jones et al., 2007). As of February 2012 the insurance population had reached this goal of 500 and was comprised of 516 devils, 37 in FREs in Tasmania and 479 in other facilities across Australia and 99.34% of wild source genetic diversity had been retained (Lees & Andrews, 2012).

The establishment of captive and highly monitored free range devil populations is advantageous as it allows for the management of breeding and genetics to ensure the greatest diversity is preserved (Jones et al., 2007). In an effort to establish more free range populations less intensely managed native habitat for insurance populations are being created on certain Tasmanian peninsulas such as the Tasman, Forestier and Freycinet Peninsulas. These peninsulas have been depopulated and isolated from the mainland to allow for future reintroduction of healthy populations (STTDP, 2014). Devils removed from the peninsulas were then quarantined to ensure they are disease free before they are released back onto the area they or their parents originated from (STTDP, 2014). This is the end goal for the pre-release devils being housed at Devils@Cradle currently.

1.6 Project Aims

The goal of this study was to determine if the movement of Tasmanian devils from an FRE into the more captive setting of a Wildlife Sanctuary would alter their wild behaviors in a way that would negatively impact their chances of successful reintroduction and survival in the wild.

2. METHODS

2.1 Cameras around the Devils@Cradle Sanctuary

Over the course of about three weeks three *ScoutGuard ZeroGlow*® infrared and motion detection camouflaged field cameras were used to collect data on wild Tasmanian devils around the sanctuary. Each camera was used for varying lengths of time due to need within the sanctuary. Each camera was set to take 20-second videos which were recorded onto 8GB or 16GB memory cards within the cameras. As the cameras were checked every one to two days the memory card size was not an important variable. Cameras were attached to either trees or wood posts at between

one and two meters in height, out of reach of any passing animals. Sites were only baited at the initial set up of the cameras with sardines in vegetable oil. This was to attract animals promptly to ensure cameras were working properly. Cameras were angled downwards towards areas thought to see the most wildlife movement. Camera maintenance included removing and reviewing memory cards every one to two days when videos were moved onto a computer and cleared from the memory cards, replacing batteries, and ensuring that the camera was functioning properly.

In order to capture the most footage of wild devils possible in a short period of time camera sight suggestions from Chris Coupland were taken and the two initial cameras were set up in locations that had been used in the past and known to be successful sites. Site one was near the meat preparation area facing the park's perimeter fence. This site was more successful at capturing videos of herbivores than devils and the camera was removed after three days to be used within the park. Site two was placed on a known wildlife game trail along the sanctuaries perimeter fence near the road at a site that was near enclosure 13 where the pre-release devils were kept. This camera remained there for the duration of the study. Site three's camera was set up during the final week of the study near an Off Display spotted-tail quoll enclosure known to attract wild devils and had frequent evidence of devil scat. Locations of these cameras can be seen in Figure Three in the appendix.

2.2 Cameras at the Vale of Belvoir Conservation Area

Devils@Cradle in association with the Devils of the Alpine field monitoring project have set up ten field cameras at five different sites at the Vale of Belvoir conservation area to monitor devil populations there. Each site had two cameras no more than ten meters apart facing one focal point in order to get images of animals from multiple angles to allow for proper identification. Cameras at these sites were never baited, but were sometimes scented. The data collected by these cameras is used by Devils@Cradle for an ongoing field monitoring project, but they were generous enough to allow the videos

of wild devils to also be used for this analysis. Locations of these cameras can be seen in Figure Four in the appendix.

2.3 Cameras in Enclosure 13

Devils@Cradle has had camera traps in enclosure 13 since the pre-release devils arrived. Initially there were many cameras in 13 to observe how the new devils were adjusting and to ensure no one escaped. After a few weeks the camera numbers were scaled back to three and then two cameras. The majority of the footage used in this analysis came from the final two cameras that are in the enclosure now. The locations of these cameras can be seen in the appendix in Figure Three. Cameras were maintained in the same way as the cameras located around the sanctuaries perimeter except for the fact that memory cards were removed and checked on Wednesdays and Sundays when routines were conducted to minimize interference with the animals.

2.4 Analysis of Behaviors

2.4.1 Ethogram

After discussions with Chris Coupland, a review of literature on Tasmanian devils and their behavior, and three weeks of observing Tasmanian devils at the Devils@Cradle sanctuary an ethogram was developed to be used in this behavioral analysis. These behaviors were selected as they offer a representation of important natural devil behaviors and can be identified in short videos. Behaviors included in the ethogram and how they can be identified can be found in Table One.

Table One. Ethogram for the Tasmanian devil (*Sarcophilus harrisii*)

Behavior	Identifying Characteristics
Scenting	Cloacal drag, chest marking, tail swishing
Gaping	Wide opening of the mouth baring teeth, threat display
Confrontation	Any aggressive interaction between two devils ex. jaw wrestling
Daytime Activity	Devil is active in the enclosure roughly between the hours of 7am and 6pm
Tail Lift	Tail is lifted and curved in an attempt to make the devil look larger,

All videos of wild Tasmanian devils, regardless of age or gender, captured on the field cameras around the sanctuary from April 12, 2015 to May 2, 2015 and the cameras at the Vale from December 2, 2014 to February 4, 2015 were analyzed for the selected behaviors found on the ethogram. Each time a behavior was observed in a video clip it was recorded as one tally in that category for that date.

The same ethogram and methods were used for the analysis of the video data collected from enclosure 13. Videos captured between the dates of February 13, 2015 and May 3, 2015 were analyzed. The videos analyzed for this aspect of the study do not account for every single day between those dates as all of the data generated within that time was not available during the period of video analysis. Therefore, a selection of videos were analyzed based on their availability during the period of data analysis. Dates from each month were included to account for potential changes over time. The videos analyzed were from February 13, 2015 through March 23, 2015 and April 22, 2015 through the 24th.

2.4.2 Statistics

A Chi Square test of independence was done to determine whether the behaviors analyzed in the two populations are related or not. For this test the null hypothesis

states that the wild and captive behaviors are independent of each other and the alternative hypothesis states that the behaviors are related. A table was generated with the categorical data collected from the video analysis of wild and captive devils and a subsequent contingency table was created with observed and expected values to find the Chi square value for this study. As some of the expected cell frequencies are below ten the Yates correction was used to calculate the final Chi-square values. The final equation used to calculate Chi square can be found in Figure One.

Figure One. Chi square equation with the Yates correction

$$\chi^2_{Yates} = \sum^{k} \frac{(|f_0 - f_e| - 0.5)^2}{f_e}$$

2.4.3 Daytime Activity

The variable of daytime activity was recorded in more detail for the pre-release devils to assess changes in this behavior over time. All of the video footage from February 13, 2015 through May 3, 2015 was checked for devil activity between the hours of 7am and 6pm. These hours were chosen as they best encompassed daylight hours during the course of the study and therefore hours when nocturnal animals would normally not be active. If a video clip was found to fall between these hours it was checked to see that a devil had triggered the camera and that the activity did indeed occur in the daytime. Each time devil activity was confirmed to have occurred during the daytime it was counted as one tally for that day. If there were multiple clips in succession at the same time of the same animal that activity was counted as only one. Totals were added up for each day and a graph was created to show the changes in daytime activity over time.

RESULTS

3.1 Ethogram and Video Analysis

A total of 186 videos of wild devils and 718 videos of the pre-release devils in enclosure 13 were analyzed using the ethogram. Scenting was the only behavior that was recorded to appear about the same amount of times between the two groups with 17 observations in wild devils and 16 in the pre-release devils. The greatest difference occurred in the category of daytime activity where no wild activity was recorded (Table Two).

Table Two. Results of the behaviors found in the video analysis

Ethogram	Wild Devils: Times Observed Displaying Behavior	13 Devils: Times Observed Displaying Behavior	Totals
Scenting	17	16	33
Gaping	4	29	33
Confrontation	2	111	113
Daytime Activity	0	272	272
Tail Lift	1	28	29
Totals	24	456	960

3.2 Results of Statistical Analysis

The Chi square value with the Yates correction found for this study was 553.501 with four degrees of freedom and a p-value of < 0.00001 (Table Three). Referring to the probability level table found in the appendix in Figure Five the Chi square value calculated needed to be 9.488 or lower to show independence between the two data

sets. As the calculated Chi square value is greater than the expected value in the table the null hypothesis that the two data sets are independent must be rejected. Therefore, this data shows that the two variables of wild and captive behaviors are related to one another.

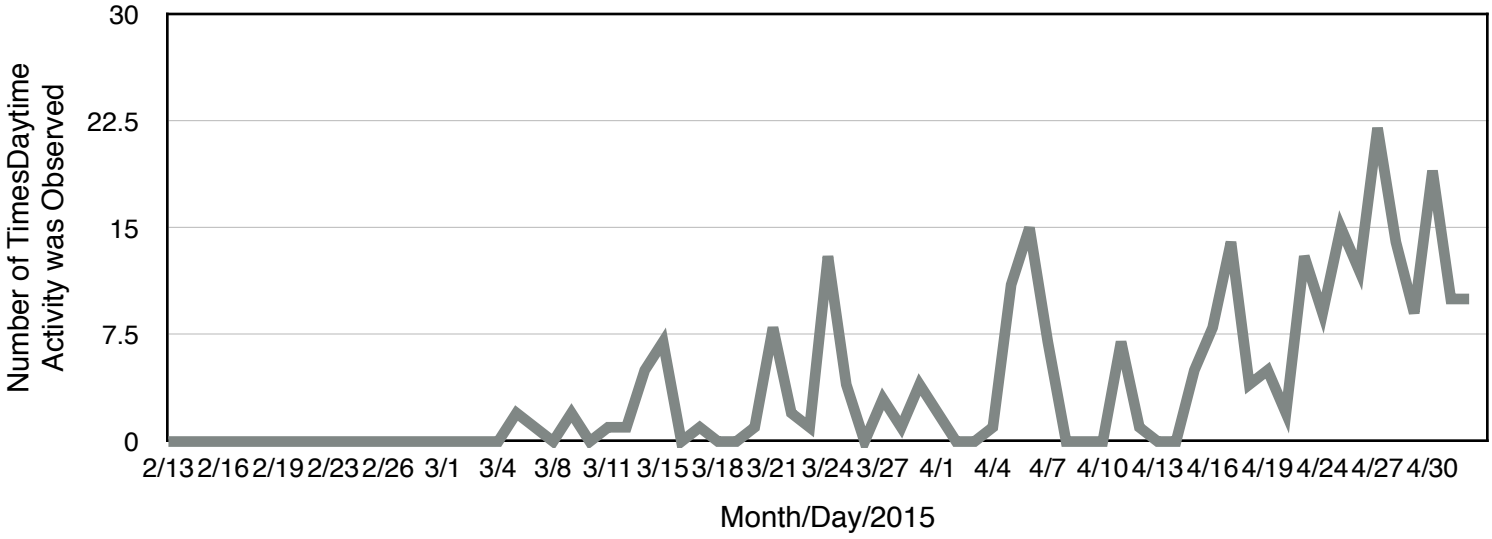
Table Three. Contingency table and results of the Chi square analysis

Observed	Expected	IO-EI	IO-EI	(IO-EI-0.5)
17.000	0.825	16.175	261.631	297.825
4.000	0.825	3.175	10.081	8.673
2.000	2.825	0.825	0.681	0.037
0.000	6.800	6.800	46.240	5.837
1.000	0.725	0.275	0.076	0.070
16.000	15.675	0.325	0.106	0.002
29.000	15.675	13.325	177.556	10.493
111.000	53.675	57.325	3286.156	60.160
272.000	129.200	142.800	20391.840	156.728
28.000	13.775	14.225	202.351	13.675
Results	**DF = 4**	**p-value = < 0.00001**		**Chi squared with Yates correction = 553.501**

3.3 Changes in Daytime Activity

Daytime activity was a behavior that no wild devil was observed displaying at the Vale or around the Devils@Cradle perimeter. Though there was an obvious difference between the two groups in this category the data for daytime activity were still important to consider more closely for the pre-release devils as diurnal activity is one of the behaviors of concern. A graph was generated to plot the changes in daytime activity over time (Figure Two). Though there was variation in the data an overall increasing trend of daytime activity was found during this time frame.

Figure Two. Changes in the amount of daytime activity observed in the nine pre-release devils in enclosure 13 from February 13, 2015 to May 2, 2015



4. DISCUSSION

4.1 Behavioral Analysis: a Comparison of Wild and Captive devils

The results of the Chi square test suggest that the behaviors of the two groups of devils are not independent of one another and are therefore related. Looking more closely at the data there appears to be some large differences between the number of times devils were observed displaying certain behaviors, particularly behaviors that involve aggressive interaction or communication with other devils. Gaping was observed 25 more times in the pre-release devils than in the wild devils. Tail lifts were observed 27 more times in the pre-release animals and general confrontation such as jaw wrestling was observed 109 more times in enclosure 13. These discrepancies show similarities with the results of previous studies that suggest devils raised in captivity that survive after release into the wild display more bold behaviors and were up to 3.5 more bold than other devils (Sinn et. al., 2014). This suggests that captivity may lead to more bold and aggressive behaviors in animals that are released into the wild. This study would then agree with previous suggestion that a variety of behaviors be promoted in captivity to promote a range of behaviors in the wild (Sinn et. al., 2014). The housing of nine devils in a relatively small defined area compared to a natural range could also have

had an impact on the results of the behavioral counts as there is a greater likelihood of devil interactions being caught on film than there is in the wild. The discrepancies in the number of videos analyzed for the pre-release devils compared to wild devils may have also been a contributing factor to these differences.

Communal feeding behaviors were observed in a number of the enclosure 13 videos during the analysis. The pre-release devils appeared to be congregating and interacting to feed together on nights of large and gorge feeds. This behavior has been identified as important for displays of communication and social behavior between devils including scenting, vocalizations, postures, and even some agnostic behavior (Pemberton & Renouf, 1993). Therefore, the participation of the pre-release devils in this kind of behavior shows promising signs for their development and usage of that behavior in the wild to communicate with and become included in wild populations.

Observations during the analysis of the videos were also made for stereotypical behaviors such as pacing and excessive grooming. No pacing was noted and when the devils were weighed in early April there were no signs of excessive grooming or self harm. Anticipation of feeding times may be at risk of becoming an issue as consistency in the times of feeding may be causing the increase in daytime activity which is discussed in the next section.

4.2 Daytime Activity

After analyzing the trends in daytime activity over the past two and a half months it appears as though the pre-release devils are becoming more active during day light hours. The cause for this is unclear as there is high variation in the data but one potential reason for the change could be a shift in feeding times from between 8pm and 11pm to between 5pm and 7pm. Gradually throughout March and at the beginning of April Devils@Cradle stopped offering their 8:30pm feeding tour. Keepers would typically feed the devils in enclosure 13 after this tour as it was at night when the devils would naturally feed and there were few people around. When this tour was no longer offered

a shift was made towards feeding the devils more often between the hours of 5pm and 7pm as keepers did not stay as late in the park. Some evenings the devils were also fed later than this time in April as one of the volunteers at Devils@Cradle lived on site and would feed the devils at a later hour. The variation in the data suggests that this shift towards daytime activity is not an irreversible behavior alteration and with a shift of feeding times back to a later hour the pre-release devils should revert back to a more nocturnal lifestyle.

4.3 Observations from Working in Enclosure 13

After working in and around enclosure 13 for a month activity during daylight hours was only observed once around 5pm after the devils had been fed. When other volunteers who had been at Devils@Cradle for the duration of the pre-release devils time there were asked if they had observed any diurnal activity in enclosure 13 they said they had only seen devils out twice during the day.

It is also important to note that while doing routines twice a week for four weeks typically between the hours of 11am and 1pm and moving about within the enclosure for short periods of time to remove or replace memory cards in the cameras the pre-release devils were never seen. The only time a devil was ever actually observed within the enclosure was when it was spotted sleeping in its den. This excludes periods of trapping and weighing devils as they were brought into view involuntarily. Though this is only observational data it is important to mention that no abnormal activity was physically observed during the period of this study.

4.4 Past Successful Releases of Tasmanian devils from Captivity

In regards to this study it is also interesting to consider successful past releases of devils raised in captivity and released into the wild. In a five year review of the data collected through the Devils of the Alpine field monitoring project, which is organized by project director Wade Anthony who is also the manager and owner of Devils@Cradle,

two animals that were known to have been raised in captivity were monitored multiple times in the wild. R2, a female who was trapped and found to have pouch young, and Penguin, a male who was caught on camera with noticeable mating scars. Both are examples of successful integrations of captive raised devils into wild breeding populations. The release approach for these devils was different than the one being taken with the devils in 13 as they were released into the wild at the natural weaning age of 10 months. However, these devils provide some evidence that devils kept in suitably managed intensive captive breeding facilities can retain their wild instincts that enable their survival after release (Wade Anthony and Devils@Cradle, 2011).

5. CONCLUSION

The aim of this study was to assess the behavioral changes of juvenile devils being held in captivity prior to their release into the wild. After a statistical analysis of wild and captive behaviors, an assessment of diurnal activity, and personal observations made from the video analysis and work within the enclosure there appears to be little concern at present for the wild behaviors of the pre-release devils in enclosure 13. They are displaying natural confrontation behaviors while feeding, moving and running around, and denning for the most part during the day. There is slight concern for the persistent development of diurnal activity, but that can most likely be easily fixed with an alteration of feeding times to a later hour.

Finally, it is important to acknowledge that there are obvious dangers to a comparative study like this as wild to captive animal comparisons are difficult to validate. It has been pointed out in previous studies that there are many variables that are difficult to account for in this kind of study: sample size, observer bias, bias introduced due to natural variations in behaviors based on location and genetics (Veasey et al., 1995). However, as Tasmanian devils have such low genetic diversity (McCallum, 2008) and the entire wild population is located in Tasmania, an island state, some of the variation is naturally removed for this species. This does not completely validate the study, but it does make it a more compelling comparison.

6. LITERATURE CITED

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PERSONAL COMMUNICATIONS

Chris Coupland, Senior Keeper at Devils@Cradle and ISP Project Advisor, May 3, 2015

7. APPENDIX

Figure Two. A Map of DFTD Distribution as of 2014 (Save the Tasmanian Devil Program, 2014)

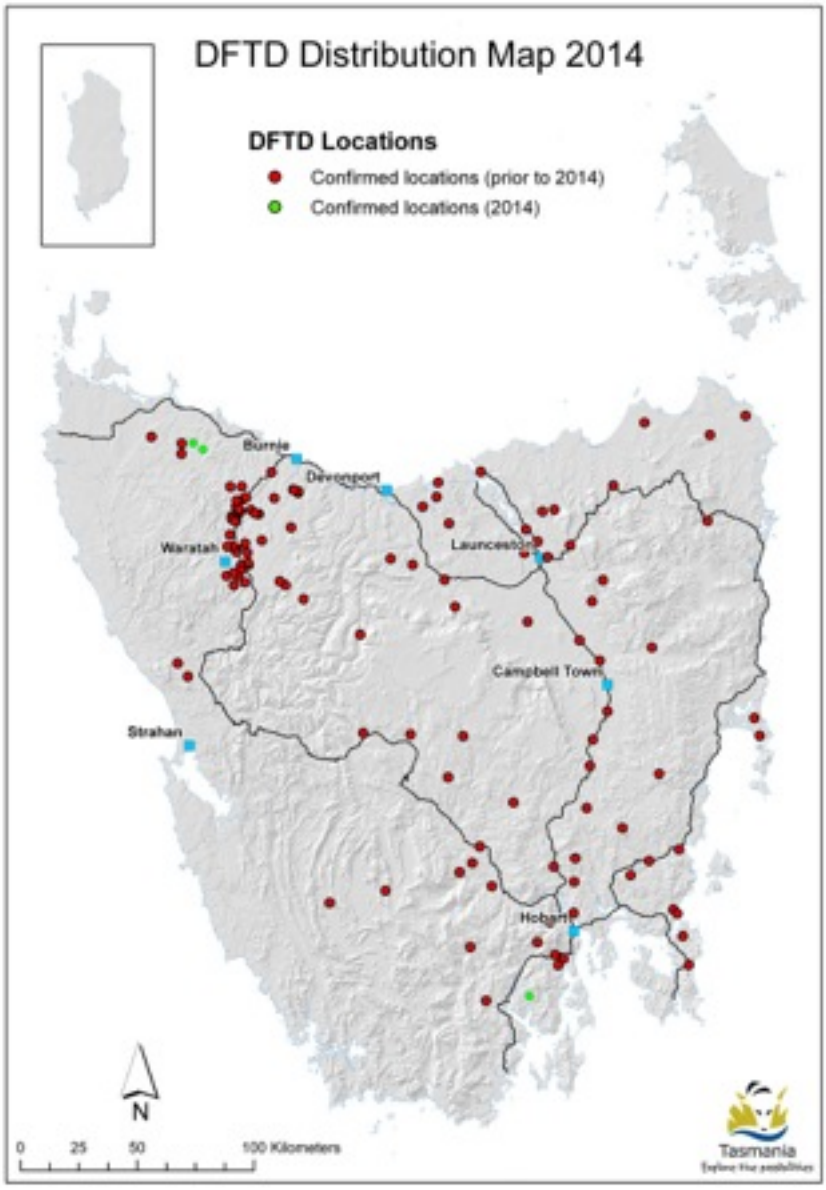

Table Four. Basic information on the pre-release devils in enclosure 13

Name	Stud Book Number	Sex	Chip NTD	Initial Weight (kg)	Arrival date/time	Mother's Stud Book Number	Weight (kg) 6/4/15
1. Wozley	1586	M	982009105826876	2.9	14/01/15 10pm	1431	5.1
2. Puzzle	1585	M	982009106030429	2.9	14/01/15 10pm	1431	4.2
3. Salacious Crumb	1579	M	982009106189342	2.8	14/01/15 10pm	1433	5.3
4. Sherlock	1584	M	982009106155239	2.9	14/01/15 10pm	1463	4.5
5. Thresher	1583	M	982009106202557	2.7	14/01/15 10pm	1463	4.2
6. Winnie	1581	F	982009106209321	2.9	14/01/15 10pm	1433	4.5
7. Jasmine	1591	F	982009106039716	2.5	15/01/15 9pm	1444	3.7
8. Icicle	1592	F	982009106160963	2.6	15/01/15 9pm	1444	3.9
9. Shadow	1686	F	982009106034891	2.5	15/01/15 9pm	1330	4.0

Table Five. The initial feeding regime from January 2015 (devils weigh 2-3kg)

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
G	X	L	SF	G	X	SC

Description	Detail	Code	Grams/animal
Starve	no food	X	0.00kg
Large	Legs/torso	L	up to 300g
Scatter Climb	100g small meat/bone chunks with supplement	S C	100g
Gorge	Hind legs/large torso/ small carcass	G	up to 800g
Scatter Forage	50g pellet, egg, 50g diced meat and bone	S F	100g

Table Six. March 2015 onward pre-release juvenile devil feeding regime (devils weigh between 4-5kg) approx. 50% body weight per animal

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
G	X	L	SF	G	X	SC

Description	Detail	Code	Grams/animal
Starve	no food	X	0.00kg
Large	Legs/torso	L	up to 400g
Scatter Climb	100g small meat/bone chunks with supplement	S C	150g
Gorge	Hind legs/large torso/ small carcass	G	up to 900g
Scatter Forage	50g pellet, egg, 50g diced meat and bone	S F	150g

Figure Three. The locations of three perimeter cameras around Devils@Cradle are in black and two cameras in enclosure 13 are in yellow (courtesy of Google Maps)

Figure Four. The Vale of Belvoir conservation area: 5 sites of 10 cameras were placed at this location (courtesy of Google Earth and Chelsea Walls, 2014)

Figure Five. Probability level table used in Chi square analysis

probability level (alpha)

Df	0.5	0.10	0.05	0.02	0.01	0.001
1	0.455	2.706	3.841	5.412	6.635	10.827
2	1.386	4.605	5.991	7.824	9.210	13.815
3	2.366	6.251	7.815	9.837	11.345	16.268
4	3.357	7.779	9.488	11.668	13.277	18.465
5	4.351	9.236	11.070	13.388	15.086	20.517

Figure Six. The devils of enclosure 13 after being weighed sans Thresher