

OBSERVATIONS OF BEHAVIOURAL CHANGES IN WILD-CAUGHT TASMANIAN DEVILS BROUGHT INTO INTENSIVE CAPTIVE MANAGEMENT AS PART OF THE FORESTIER PENINSULA DEPOPULATION PROJECT.

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Introduction

The Tasmanian devil, *Sarcophilus harrisii*, is the world's largest extant marsupial carnivore and its distribution is limited to the island state of Tasmania. Tasmanian devils are efficient scavengers, fulfilling the ecological role of removing dead carcasses, but are also opportunistic predators.

Tasmanian devils typically live for five or six years, adult males weighing between 7 and 13kg and females between 4 to 9kg (Guiler, 1978). Tasmanian devils usually reach sexual maturity in the second year of life, but some females can produce young at one year old (Guiler, 1970). Female devils can rear up to four young in a breeding season, but the average number of young raised to weaning age is three (Pemberton, 1990). The first four months of a devil's life are spent in its mothers pouch, as the young are born furless and undeveloped. Devils are typically weaned at around eight months of age, and are independent from their mothers by one year old (Guiler, 1980).

Wild devils are strongly nocturnal, and shy of humans (Guiler, 1983). Devils are known for their scream-like vocalising and aggressive interactions with each other, but wild devils, when approached by humans, tend to respond by either 'freezing' or running away. Devils often bite one another while fighting over food or mates, usually resulting in minor wounds although it can result in more serious injury (Hamede et al., 2012).

In the past two decades, the Tasmanian devil population has been decimated as a result of Devil Facial Tumour Disease (DFTD) (McCallum and Jones, 2006; Lachish et al., 2007). DFTD was first

recorded in 1996 when photographs were taken of several devils in north-eastern Tasmania with mysterious and highly disfiguring facial tumours (Hawkins et al., 2006). DFTD has spread from the north-east across most of the devil's distribution, leaving the west and north-western regions of Tasmania the only areas where devil populations have not yet been affected by DFTD (McCallum et al., 2007). The total Tasmanian devil population has declined by over 60% since the emergence of DFTD, and the local populations in areas where DFTD is prevalent have declined by as much as 90% (Hawkins et al., 2006; McCallum et al., 2007).

DFTD is a transmissible cancer that spreads directly between individual devils through biting (Pearse and Swift, 2006; Hamede et al., 2012). DFTD tumours are most commonly found on the face, head, and neck of infected devils, although they can also occur on the body and tail (Loh et al., 2006; DPIW, 2008). Secondary tumour metastases to the lung, adrenal gland, spleen, kidney, and other organs are common in late -stage DFTD (DPIW, 2008). DFTD is consistently fatal, with death occurring within 12 months from the first clinical signs of a tumour (Hawkins et al., 2006; McCallum et al., 2009).

There is a strong possibility that DFTD will cause the extinction of the Tasmanian devil in the wild within 20-30 years (McCallum et al., 2007). In order to secure populations of healthy wild devils in the Tasmanian ecosystem, the Save the Tasmanian Devil Program, a program implemented by the Australian and Tasmanian governments in 2003 to prevent the extinction of the Tasmanian devil, have proposed several landscape isolation projects. The aim of these landscape isolation projects is to remove the existing devil population from an area, isolate the area by means of fencing and other devil proof barriers, and release healthy devils once the area is secure from DFTD. In 2012 and 2013, a population of captive-raised devils were successfully released onto Maria Island off Tasmania's east coast, an area which had not previously been inhabited by devils, but was deemed to be suitable habitat and geographically secure from DFTD. The Forestier and Tasman Peninsulas in Tasmania's south-east were chosen as the site for the first landscape isolation attempt using an area already inhabited by devils due to its suitable geography and the considerable amount already known about the devil population in that area from previous monitoring by the Save the Tasmanian Devil Program.

The latent period between infection with DFTD and the appearance of tumours may be as long as 12 months (Lachish et al., 2007). As there is currently no diagnostic tool to detect DFTD before the clinical signs of tumours, the only way to determine if a devil has been infected with DFTD is to quarantine the devil and perform regular manual health checks, examining the devils for tumours by sight and feel. To establish a disease-free population of devils that could eventually be released back onto the Forestier and Tasman Peninsulas, the devils removed from the peninsulas needed to be individually quarantined in an intensive captive management facility for a minimum of 12 months. An essential aspect of the landscape isolation project was ensuring that the devils brought into captivity for quarantine remained as wild as possible to give them the best chance of thriving once they were released back onto the peninsulas and to avoid creating nuisance devils that would approach humans.

In general, wild devils and long-term captive devils show significant differences in behaviour. Devils that have been held in captivity for a prolonged period tend to be more diurnal and more gregarious around humans. Captive devils are also more likely to be aggressive towards humans and more difficult to handle. Wild devils, in contrast, tend to either freeze or run away when approached by humans and are mostly nocturnal. The change in behaviour from wild-type to captive-type is a gradual one, usually taking several months to occur.

Capture and transfer into captivity stresses Tasmanian devils. However, they can adjust to captive conditions, shown by a reduction in stress levels, within one to two months. Jones, Lockhart, and Rose (2005) found that wild females brought into captivity on average remained stressed for four weeks, while the wild males stress levels were highest at initial capture but had declined significantly after 48 hours in captivity.

Stereotypic behaviours commonly occur in captive Tasmanian devils. These behaviours may be due to stress, anxiety and/or a lack of mental stimulation and include the animal moving in repetitive patterns such as pacing in circles, figures of eight, and/or backwards and forwards (Jackson, 2003; Edwards, 2006). These patterns differ from normal devil activity, where movements are random and non-repetitive. Some devils may be more prone to displaying stereotypic

behaviours than others. Wild born devils seem to be particularly prone to stereotypic pacing behaviour when they are brought into captivity. Enrichment may provide enough mental and physical stimulation to prevent stereotypic behaviours in some individual devils, but the enrichment schedule must be constantly varied in order to engage the devil's interest and enrichment items may cease to be novel within a few hours leaving a large amount of the devils' time unoccupied (Albion, 2006).

Depopulation Project

In mid 2012, staff from the Save the Tasmanian Devil Program undertook to depopulate devils from the Forestier Peninsula as the first stage in isolating the Forestier and Tasman Peninsulas from DFTD. The aim was to remove the entire wild Tasmanian devil population from the Forestier Peninsula. The area was to be physically isolated using man-made barriers with the aim of preventing the incursion of devils potentially infected with DFTD. This would allow the possible future release of known healthy Tasmanian devils, in order to establish a large, disease free wild population of animals.

Following extensive monitoring, the first devils were caught and translocated on the 11th of May 2012. After several weeks of trapping, a total of 33 animals were removed from the Peninsula and taken to the department's captive management facility at Cressy. A number of these animals were confirmed with DFTD on arrival, others were diagnosed through the fortnightly health checks that followed. At the completion of a 12-month quarantine period, 23 of these adult animals remained DFTD free and continued to be housed at the Cressy facility. In addition, many of the females were carrying pouch young at the time of arrival, eight pouch young were lost prior to weaning and a further nine were euthanased on welfare grounds along with their severely DFTD affected mothers. The 26 remaining young, having reached independence from their mothers, continued to be housed at captive management facilities at the conclusion of the quarantine period.

Housing and Health checks

On arrival at Cressy, most animals were housed in permanent pens of average size 70m², however some were placed in temporary pens

64m² in size due to the permanent holding capacity of the Cressy facility being insufficient. All devils were housed individually due to quarantine requirements for the duration of the 12-month quarantine period. Each enclosure was furnished with two nest boxes, a climbing structure, several dens, and cover from vegetation. For the first four months the devils were visually sighted, checking presence and health daily, this was then reduced to three times weekly. Although keepers minimised disturbance while checking and performing basic husbandry tasks, for wild devils even small disturbances such as opening the nest boxes or filling water bowls could be quite stressful. It has previously been found that wild devils are particularly likely to be stressed by noises, especially by manmade noises and metallic sounds (Edwards, 2006). The temporary pens, in particular, were prone to making metallic clanging and rattling noises in the wind due to the portable, panel based nature of their construction. This is likely to have been a source of considerable stress for the devils housed in these enclosures.

Health checks were carried out fortnightly on all 23 adults as well as their offspring up until July 2013. From this date onwards, checks were performed monthly. The devils were handled and restrained by a vet while conscious and examined for signs of DFTD. The pouch young were especially exposed to human contact during these checks. At the beginning of their time in captivity, each of the devils was easy to examine without anaesthesia and remained motionless while being handled. As the devils became accustomed to handling, they gradually began to struggle during health checks and became harder to restrain. A final check was conducted under general anaesthetic at the end of their one year quarantine period.

Behavioural Adaptation to Captivity

As was to be expected, initially all of the animals that had been brought into captivity from the Forestier Peninsula displayed typical wild-type behaviours. They were fully nocturnal and reacted to human contact by 'freezing' and were very easy to handle for health checks. Most individual devils took some time to adjust to the captive feeding regime, and as a result many lost significant body condition. Females on average lost only 1% of their initial body weight during their first month of captivity, although this result is confounded by the fact that most females were carrying growing pouch young during this time and their weights were included in the overall

weight recorded. In contrast, the male devils lost an average of 6% of their initial body weight within the first month. In addition to the weight loss, many devils appeared extremely uncomfortable with confinement, with numerous devils escaping enclosures which had proved largely devil-proof when housing captive-raised individuals. Many other unsuccessful escape attempts were made, along with large amounts of digging around enclosure perimeters. Keepers noted that the wild devils, unlike captive devils, urinated consistently in their nest boxes. This may indicate an elevated level of fear and stress, preventing them from leaving their nest boxes during the day to urinate. This behaviour was apparent in all the devils for the first few months in captivity and persisted for the duration of the quarantine period in some individuals.

During the first 12 months in captivity the devils displayed numerous behavioural changes. Some behavioural changes were positive; the animals in general adapted to their captive diet well and gained significant body condition, began to respond more enthusiastically to novel enrichment activities, and ceased attempting to escape their enclosures. Unfortunately, some negative behaviours also developed, in particular an increasing aggression response to human contact or disturbance. In a number of individuals other issues have arisen or persisted, such as excessive digging, regular urination in the nest boxes, or stereotypical pacing of the enclosure.

Using motion sensor cameras, keepers were able to gain an insight into devil behaviour overnight and when not disturbed by human presence during the day. Once the camera footage was reviewed, stereotypic or 'problem' behaviours were able to be addressed for individual devils. For example, one male devil exhibited particularly severe pacing behaviour overnight. This activity was physically evident in the enclosure, but the cameras revealed the extent of the behaviour and he was found to be spending the majority of the night running repeatedly around the enclosure, following the same path through the enclosure hundreds of times an hour. Keepers were then able to address this concerning behaviour through the use of enrichment activities and assess its effectiveness. The cameras allowed the keepers to use all the tools available to them to address 'problem' behaviours before they became ingrained.

After 12 months in captivity, the male devils had gained an average of 1.4kg (23% of their bodyweight) and females an average of 1.5kg

(30% of their bodyweight) (Figure 1). This high percentage increase could be attributed to their normal growth from juvenile to adult combined with the consistent provision of ample food in the captive environment. Only one individual, a female, had not gained weight at the end of the year in captivity and was one kilogram lighter than her first recorded weight.

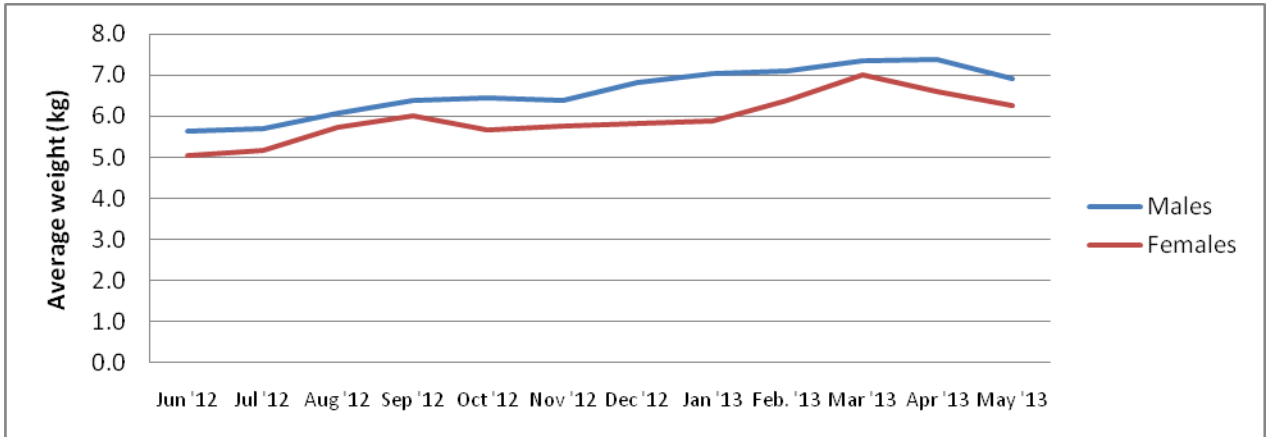


Figure 1. Average weight of male and female Tasmanian devils over their first year in intensive captivity.

Pouch Young

As previously documented, many of the females brought into captivity as part of the Forestier depopulation had very early stage pouch young or gave birth shortly after arrival at Cressy. Despite the obvious stress of transfer into captivity for these mothers, only eight of 43 pouch young were lost prior to weaning. This loss of pouch young is comparable to the rate of pouch young mortality in wild devils suggested by Guiler (1970). A further nine of the 43 pouch young were euthanased along with their mothers who were suffering from advanced DFTD. These nine pouch young were not able to be hand reared as they were at a very early stage of development. Seven young from two other DFTD positive mothers were able to be left with their mothers until they were at a suitable stage of development to be hand raised and were returned to the Cressy facility upon weaning. The remaining 19 young were left with their mothers and siblings until after weaning had occurred.

Unfortunately, it was necessary to expose these devils to a high level of non-contact human disturbance while they were young in order to comply with the requirement to check each devil daily. They were also regularly handled and checked by the vets during the monthly health checks. The captive management staff were very aware of

trying to minimise the amount of disturbance and handling that all the devils were exposed to, especially the mothers and young.

At one year of age, the sub-adult devils showed significant differences in behaviour from their parents. The young of the Forestier Peninsula devils, having spent their entire lives in captivity, were prone to captive-type behaviour despite being raised by mothers still exhibiting wild-type behaviours. This difference in behaviour was marked by their increased diurnal activity and their increase in aggression towards the keepers. Albion (2006) also noted that wild-born devils brought into captivity as early stage pouch young tended to be diurnal and gregarious around humans as juveniles and continued this behaviour into adulthood, while their mothers remained considerably more nocturnal and shy. It can be concluded that the experiences of captivity in early life can shape the behaviour of devils, and great care is needed to minimise the amount of disturbance and human contact of mothers raising young.

The seven orphaned young that were hand-raised were exposed to a much higher level of human disturbance, being handled and fed every three hours for the first few weeks in care. Interestingly, while there was initially a significant difference in behaviour between the hand-raised and mother-raised young devils housed at Cressy, this difference in behaviour became much less marked after the hand-raised young had been weaned from hand feeding for six months. At one year old, the hand-raised sub-adult devils behaved much like the young raised by their mothers.

Initiatives to Stimulate 'Normal' Behaviours

Captive Management staff undertook numerous initiatives to maximise 'normal' behaviours in the devils, and to minimise any negative ones. Regular and varied enrichments (both food and non-food based), enclosure swaps, furniture moves, and pen modifications were all trialled. The devils were handled as little as possible, and contact was limited to that necessary for basic husbandry and vet checks. Where possible, animals were moved into permanent pens, and temporary pens were increased in size and modified to reduce noise from wind. These approaches were highly labour intensive, but keepers have noted that employing these initiatives resulted in a marked decrease in the level of undesirable behaviours displayed by most individuals.

At the completion of the 12-month quarantine period, the isolation of the Forestier Peninsula through devil-proof barriers was still

underway and continued captive management of the Forestier Peninsula devils was required. Despite the successful efforts of the keepers to combat the undesirable behaviours developed by some individual devils, in general the devils were gradually becoming more diurnal, aggressive, and gregarious around humans. The keepers were concerned that if the devils were to remain in the intensive captive environment these behaviours would compound, eventually making them unsuitable for re-release into the wild. It was decided, therefore, that as the quarantine period had concluded and the devils no longer needed to be isolated to prevent possible spread of DFTD, as many of the devils as possible would be transferred to the Free-Range Enclosure (FRE) facility at Bridport. The remainder of these animals would continue to be housed at either the Cressy or Tarooma intensive management facilities, until a suitable free range facility became available.

The Bridport FRE is a 22 hectare, double fenced enclosure containing native bushland with areas of dense undergrowth and open grasslands. The FRE has a large dam and several small ponds as sources of drinking water, and approximately 30 large log piles for den sites. Husbandry visits to the FRE are conducted twice weekly to deliver food, remove scats, check on the integrity of the fences, and collect the footage from several motion-triggered cameras placed throughout the FRE. The camera footage is reviewed weekly to check for presence and health of all devils housed at the FRE. The only direct contact with the devils occurs when they are trapped quarterly for routine health checks.

In July 2013, 26 of the Forestier Peninsula devils were selected to be transferred into the Bridport FRE. This group consisted of both male and female adult devils and juveniles to mimic a natural population age structure and sex ratio. Two of the hand-raised orphan devils were also included in the number of juveniles transferred into the FRE.

The behaviour of the devils released into the FRE was closely monitored through the camera footage collected weekly, as well as at the routine husbandry visits. In the FRE, the Forestier devils are able to have a much more natural lifestyle than in intensive captivity, with a large space to roam, other devils to interact with, and very little human disturbance. The devils brought into captivity as wild adults appeared to revert to wild-type behaviours very soon after their

release into the FRE. From the day they were released into the FRE, the adult devils were almost exclusively nocturnal and not encountered by keepers while performing husbandry duties. The adult devils were only seen between dusk and dawn on the footage from the cameras at the feeding sites and were seen communal feeding and appeared comfortable in socialising with other devils.

The sub-adult devils that were raised in captivity continued to be more diurnal than their parents when they were released into the FRE. The sub-adults were occasionally sighted at the routine husbandry visits, and were regularly sighted in day-time footage from the cameras throughout the FRE. The sub-adults were also much more likely to be seen alone and appeared to be avoiding communal feeding. The two hand-raised orphan devils released into the FRE were the most diurnal and the most commonly encountered by keepers. Although these orphans were often sighted by keepers during husbandry visits, they never approached or showed any aggression towards the keepers. During the six months that these devils have been in the FRE, the offspring of the Forestier devils, now adults themselves, have started behaving more like their wild parents, but have continued to be more diurnal.

In early 2014, after six months in the FRE, the devils were trapped for a routine health check. The devils were handled by the keepers and veterinary staff without anesthesia in order to inspect and treat any wounds. Each of the devils behaved in the same manner as wild devils, remaining motionless during the examination. The only exceptions to this were the two hand-raised orphans, who struggled slightly, but were still easily restrained and handled. This was a very noticeable decrease in aggression and struggling from the health checks conducted during their final months housed in intensive captivity. It appears that during their time in the FRE, all the Forestier devils, including those that were raised in intensive captivity, were able to regain much of their wild behaviour.

At the time of writing, the 2014 devil mating season approaches, and with the Forestier devils and their female offspring reaching prime breeding age, it is anticipated that numerous young will be born and raised inside the FRE and will also exhibit favourable, wild-type behaviour.

Currently, construction of physical isolation barriers is underway, barring the incursion of DFTD onto the Forestier and Tasman Peninsulas. Trapping and monitoring of the peninsulas is also being completed to establish a confidence of absence of the disease. This is in preparation for a planned release of devils onto the Forestier Peninsula in October 2015. The keepers are confident that the attention to detail, innovative thinking, and additional effort given to the husbandry of the Forestier Peninsula devils during their stay in captivity will result in a healthy and self-sufficient population with a suitable age range and provide the best chance of a thriving DFTD-free devil population on the Forestier and Tasman Peninsulas.

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Emma has recently taken a break from working with the Devil Program, to travel to Africa and spend a month volunteering in Cheetah monitoring and conservation in Namibia