Husbandry Guidelines
for the

SPOTTED-TAILED QUOLL

(Tiger Quoll)

(Photo: J. Marten)

Dasyurus maculatus

(MAMMALIA: DASYURIDAE)

Date	By	From	Version
2014	Julie Marten	WSI Richmond	v 1

DISCLAIMER

Please note that this information is just a guide. It is not a definitive set of rules on how the care of Spotted-Tailed Quolls must be conducted. Information provided may vary for:

- Individual Spotted-Tailed Quolls
- Spotted-Tailed Quolls from different regions of Australia
- Spotted-Tailed Quolls kept in zoos versus Spotted-Tailed Quolls from the wild
- Spotted-Tailed Quolls kept in different zoos

Additionally different zoos have their own set of rules and guidelines on how to provide husbandry for their Spotted-Tailed Quolls.

Even though I researched from many sources and consulted various people, there are zoos and individual keepers, researchers etc. that have more knowledge than myself and additional research should always be conducted before partaking any new activity. Legislations are regularly changing and therefore it is recommended to research policies set out by national and state government and associations such as ARAZPA, ZAA etc.

Any incident resulting from the misuse of this document will not be recognised as the responsibility of the author. Please use at the participants discretion. Any enhancements to this document to increase animal care standards and husbandry techniques are appreciated.

Otherwise I hope this manual provides some helpful information.

Julie Marten

Picture J.Marten

OCCUPATIONAL HEALTH AND SAFETY RISKS

It is important before conducting any work that all hazards are identified. This includes working with the animal and maintaining the enclosure. All attempts to eliminate or reduce hazards must be taken to prevent injures in the workplace.

It is the responsibility of ALL workers to contribute towards Work Health and Safety in the workplace!!!

BEFORE WORK, the institute must:

- comply to all WHS (Work Health and Safety) legislation standards
- have existing:
  - Current Standard Operating Procedures (SOPs) and risk assessments
  - Orientation information
  - Training guidelines to sign off once completed
  - Supply all equipment available to work safely
  - Emergency procedures in place

Before work all staff must be inducted into the facility. New employees need to be made aware of:

- Institution policies and employee responsibilities
- Emergency procedures including evacuation
- First aid including officers and reporting procedures.
- Hazardous substances including training, handling, storage, and MSDS (Material Safety Data Sheet)
- Workplace safety and hazards including animal management, manual handling, heat and sun protection etc.

The responsibilities of employers and employees for workplace safety are covered by legislation under the '***Work Health and Safety Act 2011'***.

All accidents, hazards and 'near-misses' must be reported following institute procedures and if possible, corrected as soon as possible. Records must be kept up-to date.

EQUIPMENT:

- Staff must have adequate equipment to complete their duties.
- All tools and other equipment must be maintained and stored to recommendations.
- Training to use equipment must be performed before use and where required, worker must have correct licencing e.g. drivers licence, forklift licence etc.
- All MSDSs (Material Safety Data Sheets) and Safe Operating Procedures must be available for viewing.
- PPCE (Personal Protection clothing and equipment otherwise known as PPE) must be available and used at all times. PPE includes:
  - Headwear – hats and helmets
  - Hearing protection – muffs and ear plugs (NOT audio ear plugs e.g. MP3)
  - Eye protection – goggles
  - Masks e.g. dust masks, gas masks
  - Face barriers / shields
  - Sun safe clothing - long sleeve shirt and long pants
  - Enclosed steel cap footwear
  - Gloves – disposable / single use, gardening, thick leather

ANIMAL:

SPOTTED-TAILED QUOLL

This male Spotted Tailed Quoll showed aggression to me walking past.
Photo J. Marten

CRITERIA: HAZARDOUS! (Medium danger)

Description: The Spotted Quoll is an Australian cat-like marsupial with strong wide jaws with long, curved sharp canine-like teeth. The Spotted-Tailed Quoll is terrestrial but is an excellent climber for hunting.

Hazard: The Spotted-Tailed Quoll has the potential to bite and scratch.

Keepers must be given orientation training before working in enclosures about how to conduct work safely including restraining and working with the animal.

Work Experience and Volunteers: Employers need to make sure that volunteers and work experience students have a safe working environment. This is known as '**duty of care**'. (Workcover)

Contractors: any tradesperson such as electricians, plumbers, contractors or other visitors conducting work on the premises must abide to all park regulations regarding safety. Employees must also abide by construction etc. rules of safety and if major construction work is to be completed and employees still need to work in the area, employees need to have completed the Workcover "General construction induction training". Once completed, employees receive a "*Construction induction card*" (White card). For more information visit the Workcover website at http://www.workcover.nsw.gov.au to view the ***Work Health and Safety Act 2011***.

Biological:

Hygiene: Regularly wash hands to prevent spreading diseases between animals and keepers contracting any zoonosis including toxoplasmosis and endoparasitic worms.

Quarantine and holding facilities: All new quolls need to be quarantined to monitor for illness before introducing them into the regular enclosures. Alternate temporary caging must be supplied to provide a location to administer medical treatments or monitoring or temporary housing if unable to be housed in regular enclosure e.g. renovations

Quarantine and holding enclosures are only for temporary holding so should have solid floors (e.g. concrete) and minimal easily removable substrate for quick cleaning and easy decontamination.

Environmental:

- **Sun and Weather Conditions**: For outdoor enclosures, keepers are exposed to varied weather conditions. Sun protection (such as sunscreen, hats, long sleeves and sunglasses) must be work at all times to prevent sunburn. Keepers must also protect themselves from other weather conditions such as cold and rain. Weather protection (including sunscreen) is supplied by most institutions for employees.
- **Communication**: There MUST be adequate forms of communication throughout the park. If an emergency arises workers must be able to alert others and call for assistance. A common form of communication found in zoos and wildlife parks are two-way radios and are carried by most staff.

Layout of enclosure: Hazards for the keeper include:

- Supplies such as furnishings and enrichment need to be carried in and out; and moved around enclosure, increasing risk of manual handling injuries e.g. logs.

- Uneven surfaces create slip and trip hazards
- Ergonomics – keeper must be able to move and work naturally in enclosure (see ergonomics below).

Physical:

- The Spotted-Tailed Quoll has the potential to bite and scratch. Biting is more likely to occur during feeding times when keeper enters the enclosures to place food (see 9.5 behaviour problems). Even walking past holding yards at Featherdale, the male quolls would race to the front of the enclosure and hiss and growl as me.

  To avoid being bitten it is best to work in the enclosure when the quoll is likely to be asleep in its nesting box. If the quoll is active and there is a chance of being bitten expose the sole of your boot (see picture right) or lift heal. If carrying something like a bucket, you can place it between you and the quoll as protection.

A keeper at Devils @ Cradle puts her foot up to protect her from a curious quoll. Picture J.Marten

- Fighting is likely to occur between quolls. Males cannot be returned to an enclosure with other males after breeding. It is best to house breeding quolls individually. Fighting will increase in males during breeding season, so keepers must show due care if entering enclosure. Any female with offspring MUST be housed alone as she is highly likely to kill any other quolls in her enclosure or be killed protecting her young.
- **Stress**: If a spotted-tailed quoll is stressed it can result in the animal becoming more aggressive towards other quolls and to keepers. Keepers must monitor animal health and behaviour, consider fright, flight and fight (FFF) responses if working in enclosure and provide enrichment towards maintaining animal welfare.
- **First Aid**: First aid supplies and First aid officer training must be kept up to date and renewed if expired. All records must be kept up to date and follow legislation.
- **Other**: Facial and other exposed piercings are not recommended as piercing can get caught and tear out during work in enclosure or with animal.

PUBLIC:

When regarding members of the public, security measures must be maintained to ensure the safety of the public. These measures include:

- Barriers to prevent the public being bitten or scratched e.g. fine mesh, glass side of enclosure for viewing, a barrier approx. 1m in front of enclosure to prevent public from standing directly in front of enclosure etc.
- Signage in front of cage with warning words such as “I Bite!”
- Spotted-Tailed Quoll enclosure has double door / ‘air-lock’ system in place; and enclosure security (e.g. padlocks etc.) is maintained to prevent animal escape.
- Walking terrain around enclosures must remain as even as possible to prevent trip hazards

Double door entrance prevents escape Photo J. Marten

Ergonomic:

Manual Handling: Keepers must be trained in and conduct correct manual handling techniques such as:

- Lifting and lowering e.g. moving items around and in and out of enclosure.
- Pushing and pulling e.g. trolleys with supplies such as furnishings
- Loading e.g. filling wheel barrows
- Holding e.g. furnishings placement such as drilling nesting boxes to walls.
- Moving e.g. Standing upright / straight if raking substrate
- Restraining animal e.g. pouch checks
- Carrying e.g. feed bowls
- Bending: must be able to enter, exit and work in enclosure without having to bend under branches, rock formations, doorways etc.

Chemical:

- **Cleaning**: chemicals chosen for cleaning (including dishwashing detergents) must be safe enough that both the keeper and animal are not poisoned or otherwise affected (e.g. burns, strong odours causing discomfort etc.). When using more toxic cleaning agents such as Bleach; are used all residue MUST be removed. Less toxic cleaning agents should be used e.g. F10; or replaced with natural / non-toxic substitutes.

  All new furniture and other enclosure supplies must be sanitised and parasite free before entering enclosure. All toxic chemicals such as Bleach or insecticidal sprays; must be thoroughly rinsed off before items enter enclosure.
- **Pest Control**: Spotted-Tailed Quolls are carnivorous, so consideration must be made when choosing pest control that could poison and kill the quoll. Rodenticide baits must not be placed within the enclosure. It is recommended that multi-feed bait is used in any nearby bait stations. Multi-feed baits means that a rodent must eat the baits over several days to become affected by them, and Spotted-Tailed Quolls are less at risk because they either have to consume a large quantity of bait in one sitting or consume rodents with small quantities of bait over a long period.
- **Medicines / treatments**: medicines can include any:
  - preventative treatments such as endoparasites and ectoparasites (e.g. Ivermectin injectable or Carbaryl for fleas, tick and sarcoptic mange)
  - antibiotics – can be topical, oral or injectable

  Some Medicines / treatments can be given / applied by keepers but are mostly given by veterinary trained staff. Management and / or veterinary staff should be consulted if unsure what treatments should be used.
- **Other**: Paints, Glues, Cements etc. must be completely dry and deemed safe before introducing animals to new enclosures.

Any chemicals used in a facility must:

- Have an accompanied MSDS (Material Safety Data Sheet) available for viewing by all workers. All workers should read and remember information listed on MSDSs before use. MSDS list the hazards of chemicals etc. and what first aid is required.
- Be stored according to legislation and list of all chemicals should be recorded and kept up to date.
- have clear, easily read labels

- PPE should be worn wherever appropriate and chemicals should be disposed of according to legislation.

Psychological

Keeper Psychological hazards need to be considered. These could include:

- Workload –have more than one staff is completing larger tasks like refurbishing enclosure.
- Threat of danger – If animal poses a hazard have a 2 keeper system to conduct work in enclosure
- Dealing with the public – general ignorance about species of animals result in members of the public approaching keepers about the animals. These encounters can sometimes cause stress upon keepers. For example, there are members of the public that will believe they know how the animal "should" be kept or have concerns about regular behaviour. Animal liberationists can also variously affect the welfare of staff and the animals.
- Discrimination and Harassment e.g. bullying by other staff will NOT be tolerated
- Emotional (dealing with grief e.g. death of an animal)
- Spotted-Tailed Quolls can be locked together for up to 72 hours during copulation which could be stressful to view by some staff and members of the public.

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1.0 Introduction

The Spotted-tailed Quoll is a cat like carnivorous marsupial belonging to the Family Dasyuridae. The Spotted-Tailed Quoll is the largest marsupial carnivore in mainland Australia and second largest in Tasmania following its closest relative the Tasmanian Devil (Sarcophilus harrisii).

"Kilogram for kilogram, the Tiger Quoll has the second strongest bite of any predatory mammal in the world, beaten only by Australia's Tasmanian Devil. Imagine the jaw strength of a Spotted Hyena or African Lion – proportionally the Tiger Quoll has more bite than both!"(CEC)

There are 4 species of Quoll in Australia – the Northern Quoll (*Dasyurus hallucatus*), Eastern Quoll (*Dasyurus viverrinus*), Western Quoll (*Dasyurus geoffroii*) and the Spotted-Tailed quoll (*Dasyurus maculatus*).

Spotted-Tailed quolls are typically solitary animals which only interact with other Spotted-tailed Quolls to mate. It is nocturnal and crepuscular but has been seen foraging during the day or basking in the sun. The Spotted-Tail Quoll is extremely agile. It spends a great deal of time on the ground but is a capable climber, hunting and seeking shelter above the ground.

It can be easily identified by its rusty or chocolate brown coloured fur covered in distinctive white or cream spots that extend from head to tip of its tail. It has a thick neck and solid head with an elongated snout with a wide gape and ending with a round pink nose.

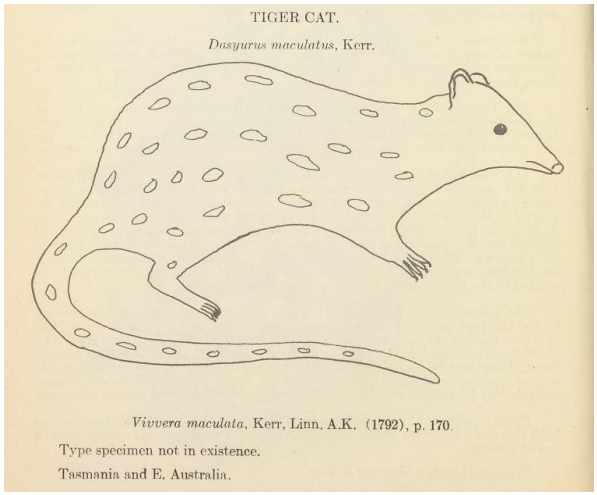
The Spotted-tail Quoll is also commonly referred to as the "Tiger Quoll". It was observed by earlier settlers including Arthur Phillip; and labelled names such the 'spotted marten', 'native cat', 'tiger cat' and 'native polecat'. During his voyages in 1770, Captain Cook recorded "quoll" as their Aboriginal name.

Settlers compared the Spotted Tail Quoll to animals that knew from their homelands. This resulted in the Spotted Tailed Quoll originally being placed in two families:

- "**Viverridae**" (includes Civets, Genets etc.) and given the name of "*Viverra maculata*". (Kerr, 1792); or
- "**Mustelidae"** (includes weasels, ferrets, martens etc.) and given the name "*Mustela novaehollandiae*" (Meyer, 1793); amongst other scientific names.

The official name of '***Dasyurus maculatus'*** was established by Étienne Geoffroy Saint-Hilaire in 1796. The name *Dasyurus* means "hairy-tail" in Greek (***dasys*** "shaggy or hairy", ***oura*** "tail") and *maculatus* is Latin meaning "spot or spotted".

Since early settlement it is believed that the overall distribution of the Spotted-Tailed Quoll have declined by 50%. Spotted-Tailed quolls were found in Tasmania and along the east coast of Australia extending from the Queensland coast to South Australia. It is now believed to be extinct in South Australia and fragmentation of populations in Queensland resulted in the creation of a smaller subspecies, ***Dasyurus maculatus gracilis***, in North-east Queensland. The other subspecies is the ***Dasyurus maculatus maculatus,*** found from south-Eastern Queensland to



(2x Pictures above from "A synopsis of the vertebrate animals of Tasmania" (1924))

the south-western Victoria and Tasmania.

Australia wild, total numbers are unknown due to the secretive nature of Quolls and to the lack of broad scale surveys. Numbers are estimated to be greater than 2000 but no more than 10,000 individuals. See http://www.youtube.com/watch?v=lcHVrgi1guw&feature=em-share_video_user

The numerous factors that have impacted on Quoll populations including land clearing (for urbanisation or timber harvesting), introduction of pest fauna (dogs, cats, foxes, rabbits, cane toads etc.), strychnine poisoning (to kill feral dogs and foxes); persecution, cars / roads and fires.

Numbers of Spotted-Tailed Quolls in zoos and similar institutes are limited. Featherdale, Trowunna Wildlife Park, Devils @ Cradle and a few other zoos in Australia have active breeding programs to assist in breeding.

The Conservation Ecology Centre (CEC) in Victoria (Cape Otway) has a range of programs in research and breeding to work towards improving Spotted-Tailed quoll numbers including:

- breeding insurance populations of Spotted-Tailed Quolls
- training sniffer dogs to detect Spotted-Tailed Quolls for detecting the species in the wild, with a view to identifying low density populations
- partnerships with companies such as Prickly Moses selling a brand of ale "Spotted Ale" for fundraising to quoll research and breeding
- public involvement programs including accommodation options; where funds contribute to their work

For more information about the work done by the Conservation Ecology Centre check out their website at www.conservationecologycentre.org/ or video about their work at http://www.youtube.com/watch?v=Kfku3kzxGbk

1.1 ASMP Category (Australasian Species Management Program)

- **TAG**: Australian Mammal TAG.
- **CITES** – unknown

  Note: the ***Dasyurus geoffroii*** (Western Quoll) and the ***Dasyurus viverrinus*** (Eastern Quoll) are both Near threatened as are classified under Appendix I.
- **ASMP Species Management category:** MON / ASMP Area Australian Flora

Zoos under ZAA (Zoo Aquarium Association) Census and Plan include: (Taken from the 2013 Census and Plan (Page 418))

Spot-tailed Quoll (*Dasyurus maculatus*)

Australia Walkabout Wildlife Park	0	3	0	0	3	0	Maintain
Australia Zoo	0	0	0	2	2	0	Acquire long term
Ballarat Wildlife Park	2	5	0	2	4	0	Delete excess; new genetic stock required during 2012
Billabong Koala and Wildlife Park	2	1	0	2	1	3	Breed to reqs; exchange with other institutions
Billabong Sanctuary	0	0	0	0	0	1	Maintain
Currumbin Wildlife Sanctuary	0	0	0	1	1	0	Acquire and breed
Darling Downs Zoo	0	0	0	1	1	0	Acquire as available; breed
Devils @ Cradle	4	5	0	4	6	0	Breed to reqs; exchange with other institutions during 2013
Halls Gap Zoo	4	6	0	0	0	10	Breed to requirements; delete excess
Hartleys Crocodile Adventures	1	1	0	2	3	0	Acquire and breed to requirements
Ipswich Nature Centre	2	0	0	1	1	0	Acquire unrelated pair during 2013
Lone Pine Koala Sanctuary	0	0	0	1	2	0	Acquire long term

Moonlit Sanctuary Wildlife Conservation Park	1	0	0	1	1	0	Acquire
Rainforestation	2	1	0	1	4	0	Acquire unrelated animals; delete excess
Symbio Wildlife Park	0	0	0	1	1	0	Acquire medium term
Taronga Zoo	0	0	0	0	0	2	Acquire long term
Tidbinbilla Nature Reserve	0	0	0	2	6	0	Acquire during 2015
Trowunna Wildlife Park	4	11	0	2	6	0	Breed to reqs; exchange with other institutions during 2013
Walkabout Creek Wildlife Centre	1	0	0	2	2	4	Acquire and breed
WILD LIFE Sydney Zoo	0	2	0	0	1	0	Delete excess during 2013
Wildlife Habitat	0	2	0	1	1	0	Maintain for display
Totals	**23**	**37**	**0**	**26**	**46**	**20**	

IUCN : NT

ASMP Australian Mammals TAG; Population Management Program

TAG Notes: TAG decision to manage this species from a priority quoll. Northern Quolls will continue to be the region's priority. However, there seems to be quite an interest in acquiring individuals within the region.

ZAA Species Coordinator - Vacant

NOTE: TAG notes for the Spotted-Tailed Quoll list species is managed from a priority quoll – **Northern Quoll**. Notes from the 2013 Census and Plan for Northern Quoll are: (Pg. 423). The ARAZPA Program Outline for the Northern Quoll can be found in the Appendix of this Husbandry manual

TAG Notes: Established program. National Recovery Plan (prepared by Brydie Hill and Simon Ward, for the Northern Territory Department of Natural
Resources, Environment, The Arts and Sport) available on-line.

ZAA Species Coordinator: Lynda Veyret, Territory Wildlife Park, Scope of data: Australasia.

1.2 IUCN Category

The **2009 International Union for the Conservation of Nature** (IUCN) **Red List of Threatened Species** classifies the Spotted-Tailed Quoll (*Dasyurus maculatus*) as: Near Threatened ver 3.1.

Previous rating in 1996 was VULNERABLE.

1.3 EA Category

EPBC Act (Environment Protection and Biodiversity Conservation Act 1999) (SPRAT) Status:

- D. maculatus maculatus SE mainland - **Listed as Endangered**
- D. maculatus maculatus Tasmania - **Listed as Vulnerable**
- D. maculatus gracilis - **Listed as Endangered**

Note: there is no general Dasyurus maculatus listing. For state listings see Chapter 3.3

1.4 NZ and PNG Categories and Legislation

N/A

1.5 Wild Population Management

The Australian "Action Plan for Australian Marsupials and Monotremes" (for both subspecies of Spotted-Tailed Quoll) can be found in the Appendix of this Husbandry Manual. Australian state governments have their own action plans to manage wild populations. Key actions include: (SPRAT)

- Determine the distribution and status of Spotted-tailed Quoll populations throughout the range.
- Increase knowledge of the biology and ecology of the Spotted-tailed Quoll throughout its range to refine management of the species and its habitat.
- Reduce the rate of habitat loss and fragmentation on private land.
- Evaluate and manage the risk posed by silvicultural practices.
- Determine and manage the threat posed by introduced predators, such as Foxes (Vulpes vulpes), Cats (Felis catus) and Wild Dogs (Canis lupus familaris), and predator control practices on Spotted-tailed Quoll populations.
- Determine and manage the impact of fire regimes on Spotted-tailed Quoll populations.
- Reduce deliberate killings of Spotted-tailed Quolls.
- Reduce the frequency of Spotted-tailed Quoll road mortality.
- Assess the threat Cane Toads pose to Spotted-tailed Quolls and develop threat abatement actions if necessary.
- Determine the likely impact of climate change on Spotted-tailed Quoll populations.
- Increase community awareness of the Spotted-tailed Quoll and involvement in the Recovery Program.
- Link suitable habitat fragments with corridors.
- Continue predator and competitor control (e.g. The Cat Threat Abatement Plan (Environment Australia 1995b).

To see more details from the NATIONAL RECOVERY PLAN go to http://tasmaniantimes.com/images/uploads/Spotted-tailed_Quoll_Recovery_Plan_Draft_August_20081.pdf

Advised amendments to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) for the Spotted-Tailed Quoll (*Dasyurus maculatus*) can be found at http://www.environment.gov.au/node/16523 - this reference provides an excellent summary about the conservation status of the species and the reasons for its listing.

1.6 Species Coordinator

Position is currently vacant (no ZAA Species Coordinator)

1.7 Studbook Holder

Position is currently vacant (no ZAA Studbook Holder)

2 Taxonomy

2.1 Nomenclature

Kingdom ANIMALIA
Phylum CHORDATA
Class MAMMALIA
Order DASYUROMORPHIA
Family DASYURIDAE
Genus DASYURUS
Species maculatus
Subspecies maculatus
Subspecies gracilis

2.2 Subspecies

There is 2 subspecies of the Spotted-Tailed Quoll:

- ***Dasyurus maculatus maculatus*** - The more commonly found subspecies of the Spotted-Tailed Quoll; is found along the East coast of Australia from southern Queensland to Victoria; and Tasmania.
- ***Dasyurus maculatus gracilis*** – There are few small isolated populations of the *Dasyurus maculatus gracilis* found only in Northern Queensland.

2.3 Recent Synonyms

Dasyurus maculatus	-	*Dasyurus ursinus* (Giebel, 1874)
	-	*Dasyurops maculatus* (Strahan 1983)
Dasyurus maculatus maculatus:	-	*Viverra maculata* (Kerr, 1792)
	-	*Mustela novaehollandiae* (Meyer, 1793)
	-	*Dasyurus macrourus* (Geoffroy, 1803)
Dasyurus maculatus gracilis:	-	*Dasyurus gracilis* (Ramsay, 1888)

2.4 Other Common Names

The Spotted-Tailed Quoll is also known as the:

- "Tiger Quoll",
- "Spot-tailed Quoll",
- "Spotted-tail Quoll",
- "Tiger cat",
- "Yarri" (Herbert River District),
- "Bunjim" and
- "Burrumbil" (Mulgrave River and Atherton Tablelands, North Queensland).

During the Discovery of Australia, early settlers also called the Spotted-tailed Quoll the "tiger cat", "native-cat", the "native-polecat" and the "spotted marten".

3 Natural History

The Spotted-tailed Quoll is a cat like carnivorous marsupial belonging to the family Dasyuridae. The Spotted-Tailed Quoll is the largest marsupial carnivore in mainland Australia and second largest in Tasmania following the Tasmanian Devil (*Sarcophilus harrisii*).

The cat-like Spotted-Tailed quoll
(Photo: J.Marten)

The Spotted-Tailed quoll is a carnivore that is an excellent hunter but also known as a scavenger of carrion. Spotted-Tailed quolls regularly scavenge carrion of animals that have been hit by cars and often become victim to cars themselves.

They are exceptional climbers and are often silently sitting or travelling in trees or rocky surfaces to hunt and forage. Spotted-tailed quolls are secretive, solitary animals that hunt and travel between dusk and dawn but may be seen out during the day especially to bask in the sun.

The species is readily identified by its rusty or chocolate brown coloured fur covered in distinctive white or cream spots that extend from head to tip of its tail. It has a thick neck and solid head with an elongated snout with a wide gape and ending with a round pink nose.

"Kilogram for kilogram, the Tiger Quoll has the second strongest bite of any predatory mammal in the world, beaten only by Australia's Tasmanian Devil. Imagine the jaw strength of a Spotted Hyena or African Lion – proportionally the Tiger Quoll has more bite than both!"(CEC)

3.1 Morphometrics

3.1.1 Mass and Basic Body Measurements

The head and body length of the Spotted-tailed Quoll ranges from 350mm-759mm. The tail is approximately the same length as the head and body combined, ranging 340-550mm. Adult average / mean weights can vary between 1.5kg and 4.6kg but male weights can get up to 7kgs. Upper weight ranges are mostly found in captive individuals.

3.1.2 Sexual Dimorphism

Males are larger than female Spotted-tailed Quolls, with females only being 60% of the size of males.

Head and Body Length	Tail Length	Weight
380-759 mm (males) 350-450 mm (females)	370-550 mm (males) 340-420 mm (females)	- up to 7 kg (males) Mean weight of 2.8–4.6 kg - up to 4 kg (females) Mean weight of 1.5–2 kg

3.1.3 Distinguishing Features

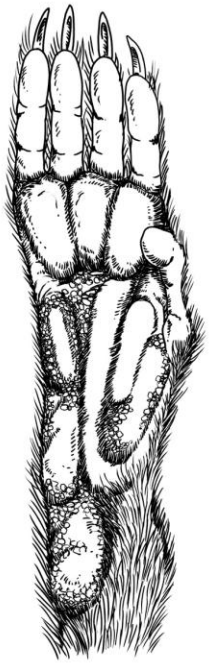
The Spotted-Tail Quoll has a cat like appearance. The Northern subspecies ***Dasyurus maculatus gracilis*** is considerably smaller than the southern subspecies ***Dasyurus maculatus maculatus*** but is still identified by its thick neck, large rounded head with an elongated snout with a round pink nose. The Spotted-Tailed Quoll has strong jaws. The wide jaw gape displays long, curved sharp canine-like teeth. Ears are small and rounded.

(Pic. http://dpipwe.tas.gov.au/)

Above: The head and gaping jaws of a Spotted-tailed Quoll.
(picture: http://sydkab.wordpress.com/)
Right: a skull of a Spotted-tailed Quoll.
(Jones 2001 picture by J. Leeming)

Fur colour is generally reddish brown to chocolate brown but can be found in gold or almost black colouring. Fur on the underside is usually a creamy white colour. Distinctive white spots cover the body, sides and legs. Unlike the other 3 species of quoll, the spots extend down the length of the Spotted-Tail Quoll's tail. All other species of Quoll only have spots along the length of their heads, backs and legs.

Photo J. Marten



Far left: Spots on Spotted-Tailed quoll down body and tail
Left: back foot
Below: Front foot.
(Feet pictures www.saveeumundi.org/2008/12/quolls/)

The Spotted-Tailed Quoll's legs are short and feet have elongated pink ridged pads which are adapted for climbing. The length of tail is approximately the same length as the head and body length combined, but is not prehensile. The Spotted-tailed Quoll is 2 times larger than other species of Quolls.

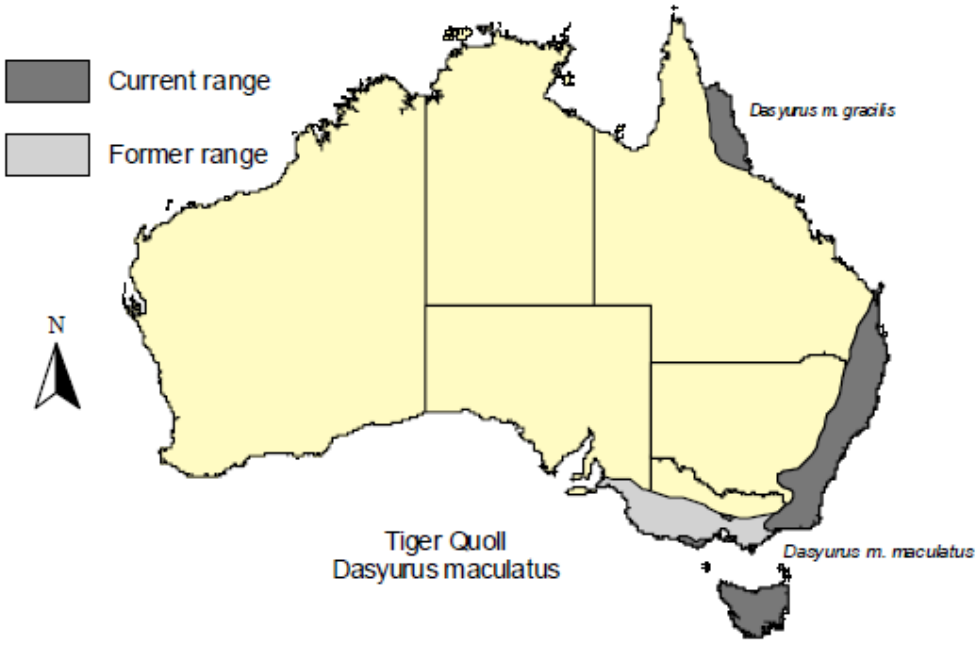
3.2 Distribution and Habitat

DISTRIBUTION:

(map D. Andrews 2005)

The Spotted-tailed Quoll is mostly found in Tasmania and along the east coast of mainland Australia, ranging from South-East Queensland to the South-East Border of South Australia.

Small isolated populations of ***Dasyurus maculatus gracilis*** can be found in North-East Queensland. It is believed that the Spotted-tailed quoll is extinct in South Australia.



HABITAT

Spotted-Tailed Quolls are terrestrial animals that are also very agile climbers, especially to hunt. Spotted-Tailed Quolls can be found in a wide range of habitats including sclerophyll forests and woodlands; coastal heathlands and rainforests. Occasionally the Spotted-tail quoll can be sighted in tree-less areas such as open grazing fields, beaches, open country, and rocky outcrops. Larger numbers of Spotted-Tailed Quolls can be found in areas with abundance of prey species. Tracking surveys have shown that Spotted-tailed Quolls will avoid living in areas that have been recently cleared but will live in previously cleared areas where significant regrowth and prey establishment have occurred (Belcher 2008).

Spotted-Tailed Quolls are generally solitary except when mating. Spotted-Tailed Quolls den alone except when females rear young. Dens consist of hollow logs and trees; rock crevices, small caves and even old wombat (Vombatus ursinus), rabbit (Oryctolagus cuniculus) or other animal burrows. Burrows are generally only used by females as "maternal dens".

Spotted-Tailed quolls like hollow logs for dens (picture www.greatoceanecolodge.com)

The Spotted-Tailed quoll will use numerous dens. A CSIRO radio-tracking study recorded some Spotted-Tailed Quolls using up to 15 dens. Many females change dens daily and will use dens no longer used by other quolls.

Spotted-tailed Quolls have allocated areas in their home range which it uses as "latrines" to defecate and are communal. Latrine sites are used by various Spotted-Tailed Quolls and are usually found in rocky creek beds, at the bases of cliffs, and on roads (Belcher 1995) and where various quoll home ranges intersect. Spotted-tailed quoll faeces have strong distinctive smelling scats - often described as "fishy", "smelly" or "cheesy" (per comm. A.Claridge) scats and (latrines) are believed to define territorial borders, communication and perhaps reproductive status.

Male Spotted-Tailed Quolls are not territorial and home ranges will overlap with those of other males and females. Surveys have noted that during breeding season males will move back and forth across female territories covering several kilometers a night. Female Spotted-Tailed Quolls are territorial and will tolerate female offspring but display intra-sexual territorial behaviour towards other female Quolls (Belcher 2004).

3.3 Conservation Status

Internationally:

The **2009 International Union for the Conservation of Nature** (IUCN) **Red List of Threatened Species** classifies the Spotted-Tailed Quoll (*Dasyurus maculatus*) as:

Previous rating in 1996 was VULNERABLE.

- **Nationally:**

EPBC (Environment Protection and Biodiversity Conservation Act 1999) **ENDANGERED**.

- **State Conservation Status:**

The conservation status of the Spotted-Tailed Quoll varies across jurisdictions under different legislations, as follows: of Australia. Each state is classified under each State Government Legislation Acts, as follows:

- ACT: **Vulnerable** (Nature Conservation Act 1980)
- NSW: **Vulnerable** (Threatened Species Conservation Act 1995)
- QLD: **Vulnerable** (Nature Conservation Act 1992)
- SA: **Endangered** (National Parks & Wildlife Act 1972)
- VIC: **Threatened** (Flora and Fauna Guarantee Act 1988)
- TAS: **Vulnerable** (Threatened Species Protection Act 1995)

Under State and Territory wildlife legislation it is an offence to 'take' a protected native animal without the required license or permit.

For more information go to the Australian Government – Department of Environment: SPRAT profiles:

- Dasyurus maculatus maculatus (SE mainland population) http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=75184
- Dasyurus maculatus maculatus (Tasmanian population- http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=75183
- Dasyurus maculatus gracilis - http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64475

3.4 Longevity

3.4.1 In the Wild

The Spotted-Tailed Quoll has a relatively short lifespan in the wild averaging at 3 years of age but can reach a maximum of 4-5 years (SPRAT).

3.4.2 In Captivity

The lifespan of the Spotted-Tailed Quoll in captivity is relatively the same as wild Spotted-Tailed Quolls but with the potential to live an extra 1-2 years. The average age in captivity is approximately 3-4 years but can reach 5-6 years. The oldest specimen in captivity has been recorded living until 6 years and 3 months.

3.4.3 Techniques Used to Determine Age in Adults

Possible techniques to estimate age include:

- **Dentition** – checking for levels of wearing of teeth.
- **Morphometric measurements** - males are larger than females
- **Weight**
- **General appearance**- hair loss, scars, etc.
- **Teat checks** – females can have their teats checked. If minute, then it is nulliparous (hasn't had offspring) and therefore under 1-2 years of age. If the teats are swollen and crusted then the female is parous / has at least one litter and therefore over 1-2 years of age.

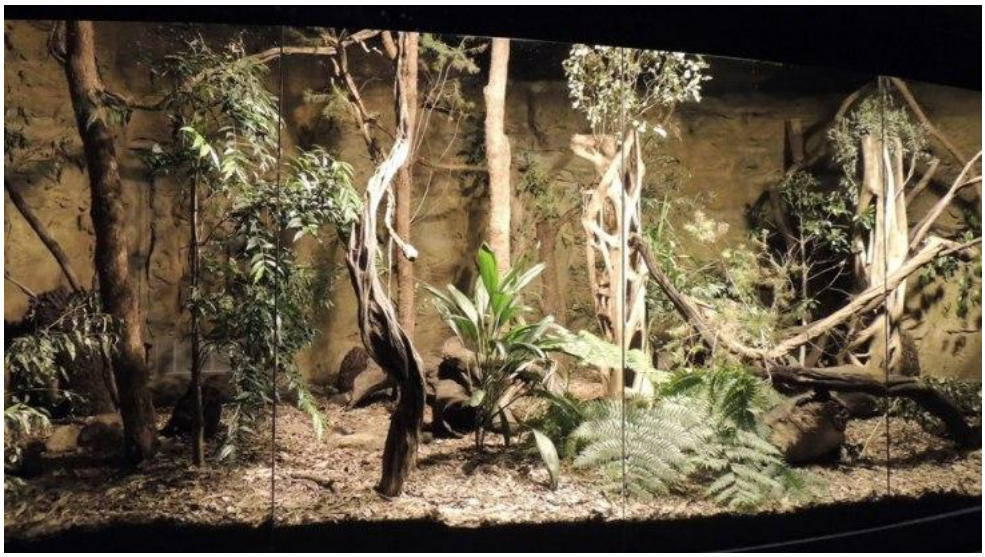
Teats (swollen) of a female Spotted-Tailed Quoll

Identification factors of age in captive Spotted-Tailed Quolls

Age Female weight (k) / Male weight (k) Characteristics
1 year 0.7 – 1.0 / 1.2 – 1.6 • Fine build • Unscarred • Teeth unworn and are extremely sharp
2 years 1.2 – 2.0 / 2.0 – 2.7 • Heavier in body condition • Teeth unworn and canines are sharp
3 years 1.4 – 2.1 / 2.5 – 4.2 • Muscular, well developed body • Teeth intact but are rounded or have missing tips
4 years Maintained or decreased body condition. • Teeth may be missing and canines are worn and round
5 years Poorer body condition • Lost and broken teeth, particularly canines

4 Housing Requirements

4.1 Exhibit/Enclosure Design



Spotted-Tailed enclosure at Wildlife Sydney (lights on) Photo J. Marten

General principles:

Captive enclosures are representative of the animal's natural environment to educate visitors in understanding the species and its environment. Quolls can be kept in either outdoor enclosures or indoor nocturnal housing. Working in facilities with both indoor and outdoor enclosures, I have found that quolls that are used for public viewing should be kept in nocturnal houses (indoor) as the quolls are more active compared to outdoor enclosures. Therefore the public take more interest in this species that is not widely known about.

During construction consideration must be taken that Spotted-tail Quoll enclosures provide basic behavioural, physical and spatial requirements.

PHYSICAL AND BEHAVIOURAL REQUIREMENTS:

- Provisions to provide food and water (see chapter 6).
- **Space** to move (horizontally and vertically) and live comfortably in its surroundings and adhere to EAPA spatial requirements (see 4.3)
- **Light settings** – Spotted-Tailed Quolls are **nocturnal**, so indoor enclosures should have adequate **nocturnal** lighting settings. "Nocturnal" settings must be timed to allow keepers to clean first thing in the morning and turn off when the public start to enter the facility.
- **Basking Opportunities** – indoor enclosures should be given opportunities to bask and provided heat lamps during "day-time" settings.
- **Shelter** – Outdoor enclosures should have areas that are covered to protect the animal from the weather (including heat, rain and wind). Additionally all enclosures must have suitable hiding and resting places including nest boxes and other furniture such as hollow hogs, vegetation etc.

An outdoor (previous) enclosure at Trowunna Wildlife Park
http://www.wildliferescuemagazine.com

- **Temperature and ventilation** – indoor facilities must provide adequate air flow / ventilation and regulate temperatures. Outdoor facilities must provide adequate shelter to hide from weather elements.
- **Foraging and exploring opportunities** – places to hide feed, scatter feeds, mulch substrates and climbing opportunities. Give quolls opportunities to forage and explore. Regularly changing the layout of enclosures gives quolls environmental enrichment.
- **Social or solitary** – Spotted-Tailed Quolls are generally housed singularly except when paired for mating. Groups of male siblings can be housed as bachelor groups and separated from the group if used for breeding (per comm. P. Ralley).
- **Furniture** – such as nest boxes, plants, rocks features etc. should be provided to provide climbing, hiding, resting, basking etc. opportunities.
- **Plants** - Potted plants can be rotated around or in and out of enclosures more easily that planted ones. Plants can be used as nesting materials, climbing opportunities, shelter / privacy and for general enclosure aesthetics. Research before putting plants in that they are not toxic to the quolls.

  Australian species of plants should be used. Some examples of good native plants to use include:

- Stout Bamboo Grass (*Austrostipa ramosissima*),
- Tussock Grass (*Poa labillardieri*),
- Kangaroo Grass (*Themeda triandra*)
- Lomandra species
- Kangaroo Apple (*Solanum aviculare*)
- Fountain Grass (*Pennisetum alopecuroides),*
- Paperbark Tea-tree *(Leptospermum trinervium),*
- Barbed Wire Grass (*Cymbopogon refractus),*
- Soft Tree Fern (*Dicksonia antarctica*),
- Fishbone Fern *(Nephrolepis cordifolia),*
- Australian Grass Tree *(Xanthorrhoea australia).*

Quolls in Trowunna Wildlife Park like to sleep in the middle of a Lomandra plant. Picture J.Marten

SECURITY:

I have seen the female spotted-tailed quoll, Lisa, (housed on display at Wild Life Sydney) climb from ground to ceiling up the mock rock within seconds. This shows how agile they are in climbing and how easy it is for a quoll to escape if the correct measures are not taken. Therefore spotted-tailed quolls must be kept in:

- fully enclosed exhibits (indoor or wire fence roof), OR
- in open exhibits that have smooth non-climbable sides, tall enough to prevent escape; and not have any furniture or vegetation that is tall enough and / or close to the barriers to allow animal to escape.
  - Any wire mesh used for enclosure must be strong enough and small enough that animal cannot push its head through or chew through (fine mesh).
  - Entry into the enclosure must be via double door system to minimise the risk of escape. I have seen quolls regularly waiting near the entrance especially when expecting food.

Barriers help distance visitors from getting bitten through wire. Enclosure at Bonorong Wildlife Park. Photo J.Marten

- The public must not be able to be bitten through fencing. Glass barriers, a second fenced barrier or fine mesh can be options to prevent harm to the public. Signage is also important if there is a risk to people getting bitten. I prefer glass window barriers as the public can view the animal easily without looking like it is in a cage. It also totally prevents the public getting bitten.
- Only experienced staff should enter and work in the enclosure.

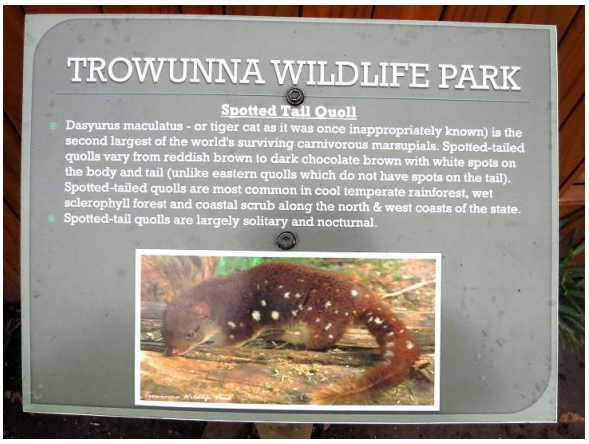


Photo: J.Marten

Signage: Enclosures should also have some signage to notify the public about the animal housed within. Information should ideally include common name/s, scientific name, a picture (preferably a photo) of the species and a distribution map.

Other facts can also be included. Other signs can include "I BITE!" signs.

KEEPER DESIGN ISSUES:

Areas to consider regarding a keepers ability to set up and maintain an enclosure include:

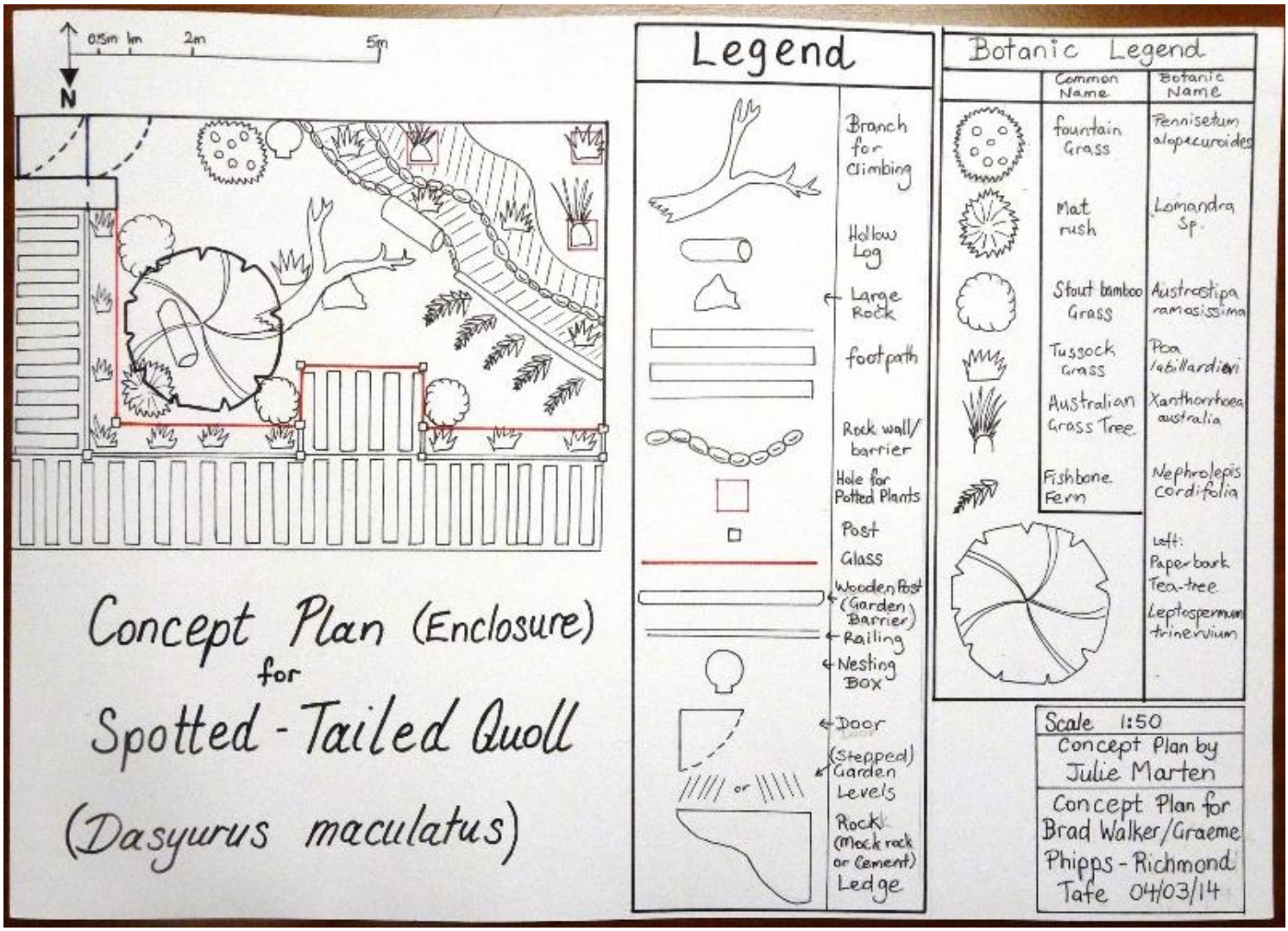
- Preventing animal escaping. I found double door system good to prevent escape. An emergency procedure should also be devised in case of escape. Care should be taken not to have both doors open at the same time such as when carrying larger items into the enclosure.
- Ability to carry supplies (especially large / heavy) in and out of enclosure. More than one person should be employed to carry large furniture etc. into the enclosure to prevent injuries.
- Ability to catch animal for transportation, routine and medical checks. A net or another method of capture should be kept nearby in case of escape.
- Ability to safely clean enclosure (e.g. does not need to step over or bend under furniture)
- All natural logs, branches etc. collected must be treated before moving into enclosures. All pesticides and other chemicals must be washed off thoroughly to prevent poisoning the quolls.
- Furniture should be chosen for hardiness or wear and tear over time and attractiveness to enclosure. **FURNITURE MUST NOT BE OBTAINED FROM NATIONAL PARKS!**
- **Drainage** – enclosures must have an adequate form of drainage e.g. through substrate, sloped floor, absorbed by plant roots etc.

Below is a concept idea I made for an outdoor enclosure for a spotted-tail quoll on display. The design could similarly be used in indoor enclosures as well. It includes:

- A rocky ledge (top right corner) or stepped garden provides shelter and climbing opportunities. This can be made of cement or mock rock with drainage points to slide in potted plants; or levelled gardens where drainage would go into the soil. This raised area is facing east to get morning sun (if an outdoor enclosure) for basking.
- A range of grasses and the grass trees are added to hide in, add to aesthetics and be used by the animal as nesting materials. Logs are added for hiding / shelter and aesthetics.
- There would also be a tree (left bottom corner of enclosure) for shade and climbing. I chose a paperbark Tea-tree as it has wide branches for climbing, bark can be used by the animal as nesting

material and the size of this species should fit ok in the enclosed enclosure especially if occasionally trimmed.

- Garden and rail outside of the enclosure to add to the aesthetics. If wire is used instead of glass (except for indented viewing platform) as a barrier then the garden will provide a space barrier to prevent people getting too close to the wire and possibly getting bitten through the wire.
- A walk in section (mid bottom edge of enclosure) was included so people could "get closer to the animals". Viewing can be through glass or clear Perspex.
- 2x door system adds to security and slightly hidden by a wall (top left of picture).



A photograph of a concept plan I created for a Spotted-Tailed quoll enclosure. Note: as it is a photograph it is not to the actual scale of 1:50. There is a scale above the enclosure drawing to give an approximation of size. Photo J.Marten

4.2 Holding Area Design

Holding enclosures are used to:

- Temporarily act as a quarantine to house new quolls that are recently acquired and need monitoring for health issues before moving to other on or off-display exhibits.
- Temporarily house animals before disposition (transporting out of facility) and health needs to be accessed before transport and / or animals receive acclimatisation training to transport container.

- Males are kept separate and off-exhibit from females
- Extra / surplus quolls are held off-exhibit
- A quoll is sick or injured and needs medical treatments
- Quolls are separated for fighting, at weaning etc.

"Off-exhibit enclosure should stimulate the animal's natural environment and allow and encourage natural behaviours" (DAFF). Off display holding areas are usually not as "pretty" as on-display enclosures but must still fulfill the spatial, behavioural and physical needs as listed above (4.1). The animal must still have:

- Adequate room to move vertically and horizontally and adhere to EAPA spatial requirements (see 4.3).
- A place to hide and rest – A nesting box or substituted pet pack, crates with straw or similar bedding etc.
- Opportunities to climb – branches are mostly used
- Shelter from varied weather conditions – usually consists of ½ of the walls of the enclosure (1x full wall and 2x ½ walls) and the entire roof consisting of colourbond fencing. The remaining walls are constructed from strong wire mesh for adequate ventilation.
- A water supply
- A place to position food e.g. a platform, bowl etc.
- Substrate varies between institutions. Concrete flooring is common for quolls as they spend their time mostly in their nest boxes or other resting structures (e.g. crates), it is easier to clean and is often more exposed to the elements.

  Concrete flooring can be beneficial to monitor amounts of urination and state of faeces if the holding yard is acting.
- The enclosure must also be constructed so that the quoll is unable to escape.

This smaller holding enclosure at Devils @ Cradle is on-display and has a sliding trapdoor on the floor that can be opened to allow the quoll to use this enclosure and another enclosure below. Picture J.Marten

I really liked the enclosure for Maggie, the off-display spotted-tailed quoll at Wild life Sydney. It did not need to be fancy but there was many sources of climbing consisting of thick rough barked branches, a cylindrical nesting box as well as 2x pet packs (one was used for containing her during cleaning see chapter 9.7) and browse. Additionally she was given several sources of enrichment daily (for ideas see 9.7).

4.3 Spatial Requirements

Under the Exhibited Animals Protection Act, 1986 the spatial requirements for Quolls are:

Genus	Common Name	Head-Body Length (cm)[1]	Total Length (cm)	Minimum Enclosure Area (m^2)	Minimum Enclosure Height (cm)	Additional Floor Area for Each Extra Animal (m)
Dasyurus – Large	Spotted-tailed Quoll	75	130	30.00	240	3.00 x 3.00

Table 1. Minimum enclosure sizes required for up to two animals of each genus of Australian mammals.

This means the first pair of Spotted-tailed Quolls needs a minimum enclosure size of 30m^2 floor space with 2.4m height. Every additional Spotted-tailed quoll needs 3.00m x 3.00m = 3m^2 floor space.

4.4 Position of Enclosures

- Outdoor enclosures - Barriers and plants should be placed to block unfavourable weather conditions and provide shade but still provide opportunities to bask in the sun.
- Outdoor enclosures should not be placed near common prey species that could get stressed from sensing (sight, smell etc.) predators nearby.
- For multi-continent zoos (that display animals of many different nations e.g. Taronga) quoll enclosures should be placed with other Australian animals.
- Spotted-Tailed Quolls held in nocturnal settings should be kept with other nocturnal enclosures in a common nocturnal house.
- Some institutions house females and males in separate areas. However they can be housed in enclosures next to each other. Housing a male and female together can either cause fighting or become familiar to each other and therefore will not breed (per comm P.Ralley).
- Spotted Tailed Quolls should have a high surface such as "cliffs" or mock rock to climb. For outdoor enclosures this should be placed in a position in the enclosure so that the animal could use this area to bask in the morning sun.

4.5 Weather Protection

- Outdoor enclosures - Barriers and plants should be placed to block unfavourable weather conditions and provide shade but still provide opportunities to bask in the sun.
- Indoor enclosures do not experience outdoor weather but must still provide adequate temperatures to live comfortably, provide opportunities to bask and provide an adequate source of UV, airflow and ventilation.

4.6 Temperature Requirements

Spotted-Tailed Quolls must have basking opportunities via direct sunlight or heating lamps or mats. Natural lighting (and temperatures) is preferred as they provide more accurate light cycles which appear to increase success rates during breeding seasons. Heating lamps can be used but it is not known if they provide sufficient amounts of heat and light compared to natural lighting.

4.7 Substrate

Substrate will vary between institutions. Mulch is favourable as it provides a more natural look to enclosures but also provides the animal opportunities for foraging. Softer mulches consisting of leaf litter also can be foraged and taken into nesting hollows by the quoll as natural nesting material. I have witnessed the female quoll at Wild Life Sydney Zoo digging in mulch and then running into hollows with certain pieces of soft mulch / leaves.

Sand or loose dirt is easy to clean and is easier to spot and clean faeces and urine from regular latrine sites.

Quarantine and holding yards are generally used short term so substrate is often concrete flooring:

- Easy to clean out entire closure when animal leaves
- Can monitor faeces and urination
- Easy to spot clean

4.8 Nestboxes and/or Bedding Material

Spotted-Tailed quolls are generally given a brown wooden nesting box with a liftable lid to allow keepers to access and / or capture the quoll when inside and to check for young.

Box measurements: 710mm long x 530mm wide x 500mm deep.

Nesting boxes can:

- also be used to transport quolls when the front hole is covered and lid held firmly in place.
- be placed on the ground and hidden behind rocks or plants; or
- raised and attached to the wall (mostly in male enclosures) with access via climbing
- the hole is faced away from public viewing to allow the quoll to have privacy and in a position that rain cannot enter box.
- be substituted with boxes such as pet packs. This can be good for Quolls that:
- need to be acclimatized to regular moving
- Assist in cleaning where the quoll is given food in its carrier and closed in during cleaning holding enclosures without risk of injury to the keeper.
- Paralysed or semi-paralysed quolls in veterinary caging, can access box without needing to climb into a smaller hole

Typical design of a nesting box. Photo: J. Marten

Hollow logs look natural and provide great nesting opportunities. This hollow log at Bonorong has straw added as nesting material. Photo J.Marten

Additionally quolls can be provided with hollow logs / tree stumps as areas to shelter away for public viewing.

In veterinary caging an upside down cardboard box with an entry cut out can provide shelter and be easily removed if quolls needs to be removed from cage. Another method could be to cover the cage door with a towel to provide privacy and a dark environment for a sick or injured quoll.

BEDDING MATERIAL

Bedding material used in nesting boxes vary between institutions but can include straw, native grass tussocks, commercial nesting grass (right) or shredded paper. Quolls in enclosures with mulch substrate may forage in the mulch and collect softer leaf litter to line their own nest boxes and other hiding holes. Bedding should be changed fortnightly but checked daily and replaced if soiled.

Commercial nesting material
Photo: J. Marten

4.9 Enclosure Furnishings

When choosing furniture for the spotted-tailed quoll, an attempt to replicate their natural environment should be made. Spotted-tail quoll must have suitable:

- **Den sites** which can include hollow logs, rock formations, caves and nesting boxes, so that the quolls can rest, nest and hide away from viewers if needed.
- **Climbing opportunities** – large hollow logs, hollow trees, branches, etc.

The Spotted-Tailed Quoll is a terrestrial mammal adapted to climbing. Climbing structures can include fixed or removable thick branch structures, potted plants (thick enough to climb) or rock formations.

Wall surfaces that are made of wire mesh or mock rock can also provide good climbing opportunities as long as they are unable to escape over a barrier.

Large horizontal and vertical hollow logs are good in that they provide a surface to climb but also provide a hiding and nesting place.

Removable pot-plants or browse can be used to create a more natural look and hide unnatural structures such as nesting boxes.

Featherdale Spotted-Tailed Quoll enclosure. Photo J. Marten

Tree for climbing
Photo J. Marten

Other furniture can include:

- Feeding platforms to place scraps of feed onto e.g. day old chicks.
- Water features or water bowls shaped like ponds, rock grooves etc. give a more natural look to the enclosure.
- Potted plants, vines etc. are useful to add to the natural look of the enclosure and hide and unnatural features such as wooden nest boxes, doors, etc. and can be rotated.
- Mock rock – can give walls a more natural look compared to wire, metal or cement walls.

Hollow log den
Photo J. Marten

Left: Devils @ cradle Spotted-Tailed quoll enclosure

Right: a newer spotted-tailed quoll enclosure at Trowunna Wildlife Park

Both pictures J.Marten

5 General Husbandry

5.1 Hygiene and Cleaning

Note: only trained staff should work with spotted-tailed quolls. No untrained volunteer should work alone in enclosures holding these animals.

Daily:

- Excrement is removed on a daily basis. This should be easy as spotted-tailed quolls routinely use latrines and therefore all faeces will be found around the same areas of the enclosure (S.Jackson). Faeces will just need to be picked up.
- Any remaining food from day before should be removed. If food is hidden as enrichment, keepers must check and remove any hidden food that remains the next day.
- Water bowls must be cleaned and fresh water supplied daily. Water in permanent fixtures must be replaced daily and thoroughly scrubbed out on a weekly basis.
- During daily cleaning keeper also need to monitor:
  - General health of animals including recording if animals display any health issues or irregular behavior; or record any training conducted.
  - General enclosure maintenance including soiled or damaged vegetation, furnishings and security
- Water plants daily or every second day

Weekly / fortnightly

- Water in permanent fixtures must be thoroughly scrubbed out on a weekly basis.
- All bedding in nesting boxes or any other artificial "den" needs to be checked fortnightly and changed earlier if soiled. Quolls will not urinate or defecate in nesting boxes.

Other:

Whenever an enclosure is emptied of all individuals it should be thoroughly cleaned and scrubbed if possible before adding any new Spotted-Tailed Quoll to the exhibit.

"A program designed to monitor the health and well-being of animals should be implemented and overseen by a veterinarian. A preventative medicine program should be designed and implemented to protect animals from disease. Sick animals, new arrivals or animals of unknown disease status should be quarantined until shown to be free of contagious disease." (DPI). An example of this is regular screening (generally monthly) of faecal samples for intestinal parasites.

"Pens should be well drained. Sick or injured animals should be removed from public viewing areas into isolation or treatment facilities supervised by the veterinarian and examined at least once daily." (DPI)

Plants in the enclosure must not be toxic to either the animals or the keepers. If mulch is used as a substrate it needs to be maintained for cleanliness or needs replacing. Other furnishings must be kept clean and replaced if soiled or damaged.

Chemicals:

"The use of strong-smelling disinfectants is not recommended except in exceptional circumstances, as these chemicals can cause discomfort and sickness in some animals. Herbal disinfectants may be an appropriate alternative." (DPI) Bleach is a commonly used in many institutions but care must be taken to wash away residue to feed and water containers and any other toys and furnishings to prevent discomfort and poisoning

of animals. Any toxic and / or strong smelling chemicals must be thoroughly rinsed off and surfaced allows to dry.

Note: All MSDS's for chemicals must be read by all staff before use and readily available to all times. All relevant PPE must be worn while using chemicals.

Some institutes use alternate cleaning methods. These may include:

- Thorough scrubbing with hot water and thorough rinsing.
- F10 is an effective against bacteria, fungi, viruses and spores and is safe for many animals and people. It is non-toxic, non-corrosive and biodegradable. It does not need to be rinsed off surfaces but recommended to rinse all food and water containers after being left to disinfect for the recommended time stated on the label. A copy of the F10 MSDS (Material Safety Data Sheet) can be found in the appendices.
- Bicarbonate Soda helps neutralises odours, is environmentally safe, absorbs moisture and has great cleaning properties.

Parasites, both external and internal, and vermin, including rats and mice, should be controlled. (DPI) The use of pesticides in and around enclosures must meet with veterinary advice and chemical registration and label requirements (EAPA). Pesticide maintenance and record logs must be kept up to date.

Personal hygiene:

It is good practice to wash hands after handling animals and between species including cleaning and maintenance procedures to prevent transmitting disease including zoonoses. Cuts and abrasions should be covered before cleaning enclosures and handling animals and their supplies.

5.2 Record Keeping

Record keeping is essential in the captive animal care of Spotted-Tailed Quolls in recording animal details, monitor health and breeding statuses as well as keep a track of other routine procedures including:

- **Identity of species** or subspecies,
- **Individual animal identification** methods (see 5.3 Methods of Identification)- application and name / number,
- **Gender**
- **Diet** (including changes to diet)
- **Weights and measurements** e.g. weighing weekly
- **Quarantine** – systems in place to care and monitor health statuses of all new or sick animals e.g. treatments and / or health screening (e.g. faecal checks).
- **Veterinary history** - current and previous examinations and treatments
- **Routine medical screenings** e.g. faecal collections to check for endoparasites
- **Movements** – moving and recording dates and locations between enclosures and / or quarantine, or institutions.
- **Behaviour** including normal, changes and problems
- **Reproduction** – history, behaviour, pouch checks, setting up and separating breeding pairs
- **Births / weaning** – date of birth, parentage and litter status, monitoring pouch status, recording new litters, and organising weaning

- **Deaths** – recording deaths and organising post mortem results and disposal
- **Animal counts** – daily animal and annual counts of numbers of animals including acquisitions, residing and leaving premises over an annual period
- **Seasonal physical changes** (e.g. shedding of hair, females necks thickening pre-breeding season)
- **Pest control** – routine checks and maintenance or pest prevention and control must be organised and logged

Methods of animal record keeping vary between institutions. Methods of record keeping can include:

- **Cage cards** – All individual animals must have some form of individual record keeping. A common form can consist of a paper or card per animal and are generally kept with the animal.
- **Diaries** – blank diaries often cover groups (e.g. all quolls or all carnivores etc.) or rooms or zones of animals. Security checks and issues; specific health issues, or work is recorded and monitored.

  The advantage of cage cards and diaries is that they are readily available for keepers to review previous days' issues, and then are able address or monitor any problems.
- **Computerised systems –** are the recommended form of record keeping. Events recorded on cage cards and diaries are given specific codes and recorded on a computerised record keeping system created the International Species Information Systems **(ISIS)** and is shared between institutions. Daily report sheets are set up as:

CODE	SEX	SPECIES	ID.	ENCL.	INFORMATION/NOTES

Information collected and correlated by numerous institutions contributes to improving the standards of behavioural and physical needs of Spotted-Tailed Quolls in captivity and assist in its conservation. Information collected and sent to larger institutions such as:

- **ARKS** – (Animal Records Keeping System - for general information on births, transfers and deaths)
- **SPARKS** – (Single Population Analysis and Records Keeping System - breeding studbook species)
- **MedARKS** (Medical Animal Records Keeping System - veterinary information)

5.3 Methods of Identification

To maintain records efficiently all individual Spotted-Tailed Quolls must have some form of identification. Methods to identification can include:

- **Passive Integrated Transponder (PIT) tags / Microchip** – implantation is between the scapulae of individuals larger than 10grams in weight, using a 12gauze needle. Advantages are that PIT tags are permanent and an excellent way of identifying many animals.

  Disadvantages are that tags can track out along injection site (this can be overcome by using skin glue or pinching injection site between finger shortly after implantation), and animals need to be caught and restrained to read the information on the tag.
- **Tattoos** – numbers can be tattooed on the inside pinna of the ear. This method is permanent and an excellent

Microchips and implanter picture J.Marten

form of identification. However, if ears are damaged (especially for females being bitten during mating) the numbers can become unreadable. The animal needs to be restrained to read the tattoo.

- **Visual Identification** – differences in physical traits are recorded. The most commonly recorded visual differences in Spotted-Tailed Quolls is the unique distribution and shape of an individual's spot formations. Photographs are the best way to show such differences especially for new keepers.
- **Ear Tags** – small metal tags with engraved numbers can be placed on the pinnae. Ear tags are not recommended as tags can get caught and tear out of the ear and possibly get infected. Care must be taken when applying an ear tag, as not to hit blood vessels in the ear.
- **Ear notching** – Ear notching is the method where a small notch is taking out of the ear – right ear for males and left ear for females. Notching can be useful to identify individuals from a distance especially when monitoring behaviour during mating time. Complications arise if the ear is damaged especially for females being bitten during mating.

I hold the head through the catching bag while keeper Paul Ralley implants a microchip under the skin in nape of the neck. Picture J.Marten

5.4 Routine Data Collection

Information collected and correlated by numerous institutions contributes to improving standards of behavioural and physical needs of Spotted-Tailed Quolls in captivity and assist in its conservation.

However, records need to be maintained also on a local scale as institutes vary from one another and have different schedules and needs. Therefore, each facility needs to have their own policies and procedures in place so that record keeping and animal welfare is maintained. See 5.2 for list of details recorded.

6 Feeding Requirements

6.1 Diet in the Wild

The Spotted-Tailed Quoll carnivorous. It is a capable hunter but also known to scavenge / forage for food. Spotted-Tailed Quolls are solitary and are generally nocturnal and crepuscular hunters, but can be sometimes seen foraging during the day.

It is an arboreal hunter using its excellent climbing skills for raiding nests and hollows or knocking sleeping birds from trees; or using the trees as a viewpoint for observing prey.

The Spotted-Tailed Quoll kills its prey by biting its prey on the back of the neck.

A quoll with its meal of chicken wing (picture J.Marten)

The diet of the wild adult Spotted-Tailed Quoll mostly consists of vertebrate prey of medium sized mammals (500g-5kg) including the common brushtail possum (*Trichosurus vulpecula*), common ringtail possum (*Pseudocheirus pererinus*), bandicoots, small wallabies and the introduced rabbit (*Oryctolagus cuniculus*) (Belcher 1995).

A quoll eating a pilchard
(picture J.Marten)

Other commonly eaten animals include the antechinus species, bush rats, echidnas, wombats, macropods, birds, invertebrates, and reptiles. Additionally crayfish, frogs, fish, plant material and refuse discarded by humans may be consumed by the Spotted-tail Quoll.

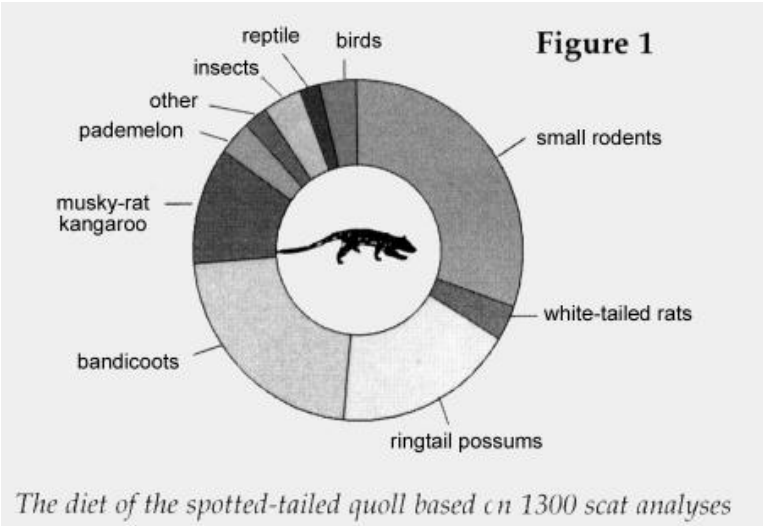
Larger animals such as macropods and wombats are generally eaten as carrion. Spotted-Tailed Quolls are also known to occasionally steal domestic and farmed poultry and eggs (Jones 2001).

Juvenile / Sub adult Quolls will eat smaller prey such as smaller ringtail possums, reptiles and invertebrates. The range of prey items eaten by male and female quolls in the same locations does not appear to vary significantly (Belcher 1995).

Diets will vary in abundance of prey available and will vary between locations found.

Studies of scats in South-Eastern Australia (Belcher 1995) have found that 51.01% of the diet of Spotted-Tailed Quolls in tall wet forests of NSW consisted of the Greater Glider (*Petauroides volans*).

The Common Brushtail possum is one of the most consumed species in dry woodland habitats such as Kosciusko National Park. Lagomorphs (Rabbits and Hares (*Lepus europaeus*)) were found to be mostly consumed after fires (Dawson / Claridge 2007).



The diet of a spotted-tailed quoll

Abundance and variety of prey will vary due to:

- The productivity of a site, including rainfall.
- Disturbance history. For instance, in sites recently logged or burned the availability of prey may be lowered.
- Competition with introduced predators; and in Tasmania with the Tasmanian Devil (*Sarcophilus harrisii*) and Eastern Quoll (*Dasyurus viverrinus*).

6.2 Captive Diet

Water: Water should be available at all times and changed daily.

General Routine (Food):

Amount:

Approx. 120grams of small animal or part of animal carcasses with additional supplements (see 6.3 supplements) per day except during breeding season (see below).

One day a week spotted-tailed quolls should have a starve day (the regular meat based diet is withheld but water is ad lib), except during breeding season for breeding quolls, to mimic wild conditions and prevent obesity. Wild Life Sydney Zoo sometimes offer some fruits or vegetables on starve days.

Pilchard (picture J.Marten)

Methods of feeding:

Diets and methods of feed (including amounts of feeds per day) vary per institution. Below is a list of diets given every week by different institutions.
See 6.4 (presentation of food) and 9.7 (Behaviour enrichment) for ways how to distribute food to quolls.

Types of feed:

- **General diet** can include (part or whole) day old chicks, rabbit, rats, mice, chicken (wings, necks, etc.) kangaroo, mince (chicken, beef or kangaroo), quail, fish (Pilchard / Whiting / White bait), mussels, yabbies', eggs (boiled or raw) etc.
- **Weight-loss** - Spotted-Tailed quolls may be fed leaner meats like fish is they are beginning to become overweight.
- **Meat mix** – see below
- **Rearing** - For diets of hand-reared quolls see Chapter 11.

Meat Mix

An alternate diet to fresh meat can be created. Meatballs consisting mostly of a mixture of minced meat, dog kibbles and eggs is mixed and frozen into small portions and then thawed as needed. Portions should never be refrozen.

Note: it is not recommended to give a meat mix as a sole diet as quolls can develop dental issues from always eating soft foods.

Taronga Conservation Society Australia has developed a Dasyurid and omnivore meat ball recipe consisting of 2kg Kangaroo or Beef mincemeat, 250g Shelled hardboiled eggs and 300g Supercoat kibble.

Directions: Mash eggs in blender then mix by hand into mince. Crush kibble in blender then mix into egg/mince mix. Roll into 25g balls. Store in Freezer.

Breeding season: If your institution is breeding spotted-tailed quolls the amount of food should be increased by at least 20% (24 grams or more) in February – March (or earlier) because:

- Some males have been known to kill and partially eat the female during copulation.
- The female needs to develop a thick roll of fat around her neck to protect her when the male bites into her neck during copulation and support her when she spends more time in a den with young.
- As offspring grow so should the quantities fed to replenish the female of lost calories and calcium supplied to feed her young and to accommodate when the young start eating for themselves. A lack in food can result in the female eating some or all of her offspring.

Examples of different captive Quoll diets are listed below:

Healesville Sanctuary diet

Daily diet per animal

- Monday Pilchards + 1x bone
- Tuesday 1/2 Rat
- Wednesday Starve day
- Thursday 1/4 Rabbit
- Friday 75g Pet health food *
- Saturday 2 mice
- Sunday 2 day old chicks

Supplements

- 3 crickets – 3-4 /week as available
- 5 mealworms – 3-4 / week
- 3 Eukanuba ® pet food kibble – once per week
- 15g pet health food – once per week

* If pet health food is unavailable, a portion of meat mix could be substituted.

Wildlife Sydney Zoo Diet

Below is a diet plan Wildlife Sydney wrote up for the Australia Walkabout Wildlife Park (Hunter Valley) when they transported their juvenile Spotted-Tailed Quolls. One day per week is a starve day.

Daily ration of 120grams (adult) including: **

- 1 Chicken ball * (human grade chicken mince)
- 1 chicken neck
- ¼ cup Science Diet kibble
- Plus 1 additional piece (see right)

Additional pieces

- Day old chick
- Kangaroo tail
- Quail
- Chicken carcass
- Pilchard / Whiting / White bait
- Mussels
- Yabbies
- Eggs boiled or raw

Enrichment:

- Squirt of blood or fish juice in enclosure
- Browse from other animal enclosures.

* Chicken ball can be replaced with meat balls made of beef mince or Kangaroo mince; or kangaroo steak or a Quoll ball (made from beef mince mixed with bird seed and dry cat food).

** Young quolls are gradually weaned onto an adult diet minus the additional piece.

Other additives / replacements to the above diet but may include meal worms, egg / cheese mix, rats, or mice. Food is rolled in Wombaroo carnivore mix as an additional supplement.

Featherdale Wildlife Park

At Featherdale, Spotted-Tailed Quolls are basically fed 4 day old chicks per day. During breeding season this can go up to 6-8 chicks per day and up to 10 chicks when juveniles (housed with the female) also start eating solid meals for themselves.

Day old chicks may be substituted with other meats depending on what meats are available and all meats are sprinkled with a calcium and vitamin mix powder before feeding out. Featherdale Starve day is Sunday.

Trowunna Wildlife Park – Quoll balls

Trowunna Wildlife Park gives a different quoll ball which contains fruit, vegetable and wombaroo supplement diet. This mix attempts to represent the natural nutrients gained such vegetable and oils from eating their prey's intestinal contents. The following ingredients are mixed and made into small balls that are fed out every 2-3 days.

A similar quoll ball is given at Devils @ Cradle (Cradle Mountain, Tasmania).

- 4 apples grated
- 4 carrots grated
- Grated cheese (~1 handful)
- Small handful of cat biscuits
- 2 eggs
- Small scoop of bird seed
- 2 tablespoons of oil
- 1 tablespoon of Wombaroo carnivore mix (if out, use Wombaroo insectivore mix)

Quoll eating a (fruit and vegetable based) quoll ball at Devils @ Cradle. Picture J.Marten

6.3 Supplements

Feeding platform – log (picture J.Marten)

Supplements shouldn't need to be given if given a balanced diet. Calcium carbonate should be added if given a meat diet without bones (meat mix or flesh only) to prevent MBD. Vitamins can be added such as one drop of Pentavite per 50ml water. Calcium and vitamins are ideally added via commercial formulated diets and / or the use of good quality kibble (e.g. Hills or Eukanuba brands).

Commercial formulated diets - Commercial diets such as Wombaroo Small Carnivore or Insectivore mix can be added to their daily diet to provide the additional nutrients / vitamins needed (See appendix). Other foods can be added to their diet such as grated fruit / vegetable (see Trowunna quoll balls), seafood, bones, kibble or eggs for behavioural enrichment and nutrients such as fibre, fats and calcium.

Other info: Softer diets such as meat mixes or flesh meat should have bones or other sources to chew to prevent poor oral (dental) health. **It is illegal to feed live vertebrates to captive animals.**

Additionally nocturnal housed Spotted-tailed Quolls need to have a source of vitamin D to absorb the calcium provided. UV lamps should be supplied in these enclosures.

6.4 Presentation of Food

Regularity: Spotted-tailed Quolls can be fed once a day but it is better to vary the regularity and times for when the quoll is fed. Other forms of feeding enrichment should be implemented (see chapter 7) so that quolls do not pace their enclosures waiting feed times or become aggressive to keepers entering enclosures at feed time.

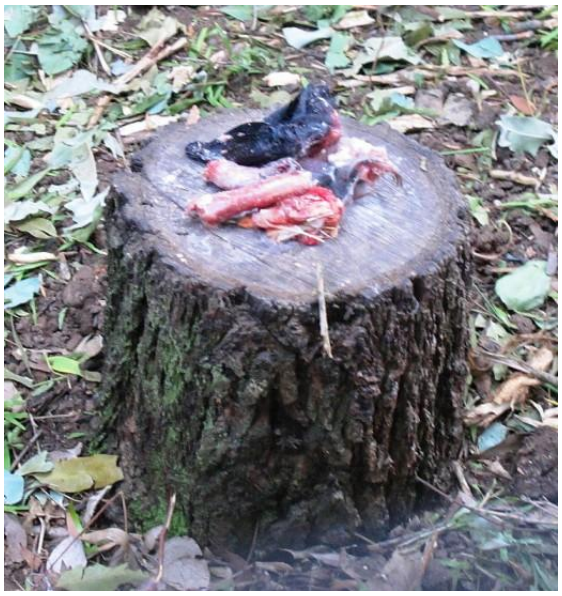
Feed bowls are not commonly used in Quoll enclosures. Feed can be placed on platforms such as a small log; on the ground or feed can be scattered around the enclosure to encourage foraging and hunting behaviour.

Quolls are generally housed alone but if more than one quoll occupies the enclosure (e.g. bachelor groups) food
should be placed in multiple locations if feeds are not otherwise scattered or trained to sit at a location before given food.

It is recommended to scatter feeds around enclosure and even hide feed up branches to encourage natural hunting and scavenging behaviour and prevent obesity. Supplementing live insects such as crickets and meal worms can encourage natural hunting and foraging behaviour.

Water features or bowls should be shaped like rocks look more aesthetic to the enclosure than metal water bowls. Water should be replaced every day and bowls / permanent features thoroughly cleaned weekly. Water should not be placed in full sun and should not be able to tip over.

Occasionally small amounts of animal blood or fish juice can be squirted or bedding from other animals can be added to the enclosure to give the quoll additional enrichment and encourage hunting foraging behaviour.



Feeding platform – log

(picture J.Marten)

7 Handling and Transport

7.1 Timing of Capture and Handling

Capture should be done during cooler times of day such as first thing in the morning; and when there is little or no public around. Capture and restraint should be done as quickly and efficiently to reduce stress on animal and prevent injuries to both keepers and animal.

Timing should be arranged for when the quolls are asleep in their nesting boxes and consideration should be taken to times of feeding as it likely that the quolls will be awake and pacing their cages awaiting their next meal.

Being mostly nocturnal, it is best to catch spotted-tailed quolls during the day for outside enclosures or if kept in nocturnal houses, first thing in the morning before the lights switch off for nocturnal settings.

7.2 Catching Bags

Larger bags such as thick canvas, cotton, calico or hessian bags are recommended for capturing larger dasyurids. Care must be taken to not get bitten through the bag. All bags must be in good condition and inspected before use to ensure that bags are clean, free of loose threads that can tangle around digits or limbs and free of holes or thin patches that have the possibility to tear or also cause injury. Hessian or dirty bags have the potential to lose dust / fibres that could get into the animal's eyes or nose. Alternatively a spotted-tailed quoll can be placed into a pet pack for short term capture and / or transportation. A new bag per animal is recommended to prevent the transfer of disease and parasites (per comm D.Andrew). See 7.3 for techniques on how to use catching bags. Wash after each use.

Fig 7 Holding a quoll in a catching bag
Photo: Doug Beckers

7.3 Capture and Restraint Techniques

PHYSICAL AND MECHANICAL CAPTURE AND RESTRAINT:

Capture of a Spotted-Tailed Quoll unaccustomed to handling or capture:

Spotted-Tailed Quolls can be caught by grabbing and picking up the quoll by the base of the tail and holding away from the body (see figure 7a-right). A snake hook (or similar) can be used to lift the tail first to get a good hold of the tail then lift. Face the legs away from your body to prevent the quoll from attacking you. Gently shake or rotate the quoll's body if it attempts climb up on itself.

Do not hold the quoll by the tail for extended lengths of time. If the quoll is not struggling you can slide one hand under the stomach to support the body (see fig7b).

Place the quoll into a catching bag or pet pack and securely close pet-pack / tie or use cable ties to securely close the bag.

Ideally it is best to trap an untrained / unhandled spotted tail quoll while it is still in its nesting box. This can be achieved by blocking the hole to the nesting box. The box (with quoll inside) can be held closed and transported to another location. Otherwise the hole can be covered with a

Figure 7a S.T. Quoll restraint

Fig 7b. Supporting the body of the quoll while still holding the tail. Picture J.Marten

catching bag, the lid of box gently lifted and quoll coaxed to leap out of box and into catching bag. The top of the bag is then quickly closed and tied off.

Alternatively boxes can be designed that once the quoll is trapped in its nesting box, a bolted sliding door can be removed and the quoll will fall directly into a catching bag placed around the door space.

If the quoll is actively moving around enclosure or has escaped its enclosure the quoll can be surrounded / herded by 2 or more keepers and caught with a large hooped net. It can then be transferred to a pet pack or catching bag.

Capture of a trained Spotted-Tailed Quoll:

It is ideal to train Spotted-Tailed Quolls for capture such as:

- Enter pet packs using food training. Wildlife Sydney trains their off-display quoll to enter a pet pack by placing part of its meal in a carrier cage on the floor of the enclosure. When the quoll enters the cage to access its food the door is closed. The keepers will then clean and perform other maintenance tasks in the enclosure. When finished the door to the pet pack is then opened (pet pack is otherwise undisturbed) and keepers leave the enclosure. The quoll can leave the pet pack in its own time.
- Enter restraining devices such as clear Perspex tubes approx. 600mm long and 100mm in diameter that is covered at time of entry. The covering is then removed and keepers are able to visually check the Spotted-Tailed Quoll. Following visual checks the keepers can use the Perspex tube to restrain the front half of the body, while checking the posterior half of the body to be physically checked as well as pouch check female quolls.

RESTRAINT:

- Spotted- Tailed Quolls are picked up by the base of the tail as depicted in figure 7a. For further restraint, the head of the Spotted-Tailed Quoll is grasped from behind between the keeper's thumb and forefingers while its (base) tail is restrained with the other hand (see fig 7c)
- The best way to take hold of the head is by pinning the spotted-tailed quoll down whilst in a catching bag or net (see 7d). Care must be taken not to be bitten through the bag.

  They can be kept in their catching bag and pinned down to the ground or table. The eyes and head can be kept covered and limbs and other parts of the body can be exposed for examination, injections etc. Stress levels must be monitored at all times and procedures kept to as minimal time as possible. Juvenile Spotted-Tailed Quolls can be held by the scruff and by the base of the tail (see fig 7e).

  To watch a video on quoll capture, handling and release see https://www.youtube.com/watch?v=Fbs9286BoBM

Fig7c Full restraint of an adult spotted-tailed quoll (picture Mt Rothwell Biodiversity Interpretation Centre)

CHEMICAL RESTRAINT:

For Chemical Restraint see "Chapter 8 Health Requirements - **8.2.1 Chemical Restraint"**.

Left: Fig 7d. Restraint of a spotted-tailed quoll while getting out of a catching bag. Photo: Doug Beckers

Right: Fig 7e. Restraint of a juvenile quoll Photo: wildlifesydney.com

7.4 Weighing and Examination

Weighing:

Spotted-tailed quolls are placed in:

- A catching bag and placed onto a set of digital scales,
- A catching bag and bag is placed into a box or tray and placed onto a set of digital scales,
- A catching bag and bag is hung from hanging scales (see fig 7f) ; or
- A pet pack or Perspex tube (see fig 7e) and weighed.

Spotted-tailed quolls can be trained to enter pet packs or even catching bags. This can reduce stress the animal and reduce risks of injuries to either quolls or their handlers.
The weight of the bag or box is deducted from the overall weight or placed empty on scales prior to weighing and scales are tarred (zeroed) to not include the weight of the bag / box at weighing. Take care that additional bedding, substrate (e.g. sticks and bark from mulch) etc. can also be in bag post-capture and can corrupt correct weights.

Fig 7e. Devils @ Cradle weighs their quolls in PVC tubes. Picture J.Marten

Examination:

Ideally the first form of examination should be visual during daily cleaning first thing in the morning and when passing the enclosure during the day. Keepers should monitor:

- Behaviour,
- Fur quality,
- Skin, eyes, nose, head, legs, and feet condition – any discharges?
- Posture, walking and physical activity
- Condition of faeces during spot cleaning
- Amounts or condition of any lost fur
- Any other notable abnormalities e.g. wounds, visible patches of fur loss.
- Eating and drinking

Fig 7f. Weighting a quoll using hanging scales
Photo: Doug Beckers

Physical examination:

One keeper should restrain the spotted-tailed quoll while another keeper or veterinary staff conducts the physical examination. Spotted-tailed quoll pouch muscles are extremely strong so two hands are required to open the pouch during pouch checks. Spotted-tailed quolls can be restrained in a catching bag with the head

and eyes continually being covered while limbs and other body parts being individually uncovered to be examined and / or procedures such as injections to be conducted.

7.5 Release

Spotted-tailed quolls are released directly onto the ground or into their nesting boxes. Pet packs can be left in the enclosure and door opened, allowing the quoll to exit its cage in its own time.

Returning to its enclosure:

- Spotted-tailed quolls are generally singularly housed so there in no risk of a returning spotted-tailed quoll being attacked by a cage mate.
- When returning a spotted-tailed quoll to its enclosure, hold the opening of the pet pack or catching bag away from the keeper to allow animal to run into enclosure. The spotted-tailed quoll should not be directed towards walls, glass, trees or other surfaces which the animal can run into if trying to escape in a hurry.
- Care should be taken that quoll doesn't try to attack the keeper releasing it.
- The quoll should be released in cooler times of the day and when there are little or no members of the public around. Ideally release should be timed at the beginning of the day so keepers can monitor the quoll during the day. Outdoor quolls may be more inclined to go sleep in its nesting boxes, while quolls kept in nocturnal houses could be active during their normal "awake" hours and therefore more easily observed by keepers during the day.

Other considerations:

Animal should be monitored post capture for general (as well as declines or improvement of) health and behaviour and be aware for signs of stress such as:

- Not eating or drinking,
- change or non-normal behaviour,
- lethargy, depression or listlessness
- additional aggression to keepers or other animals
- loud (unusual) vocalisation,
- rough fur and alopecia
- excess urination and defecation

7.6 Transport Requirements

Short term transportation:

Transferring quolls around a zoo / wildlife park or for short drives can be conducted in a catching bag and / or pet pack. Spotted-tailed quolls can be trained with food rewards to enter pet packs. Alternatively they can be transported in their nesting boxes with the hole closed up but box must be secured that the quoll cannot escape.

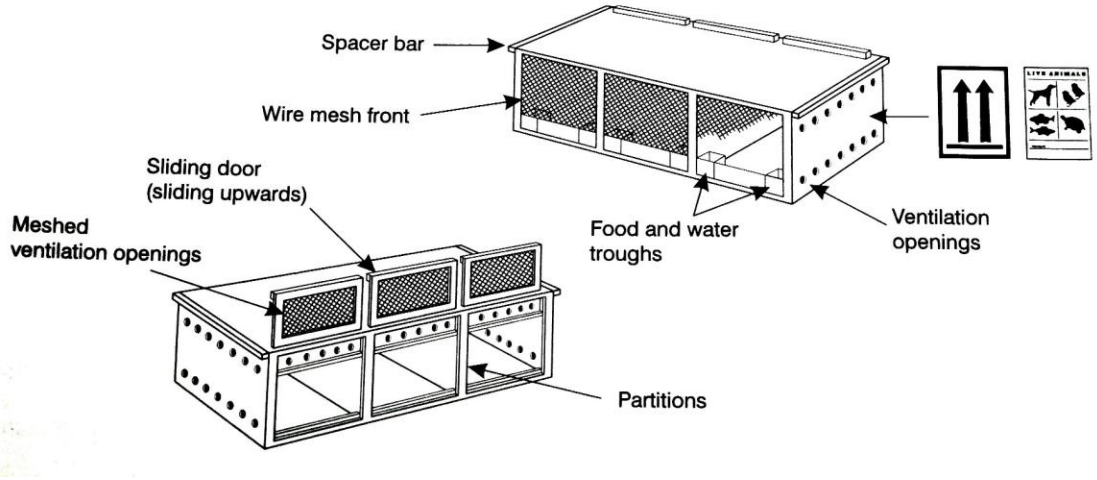
Any shorter transportation (within a few hours) by vehicle:

- Vehicle should be quiet and cool (air-conditioned).
- Cage should be covered to darken box and calm animal but still must have adequate ventilation.
- Cage must be secure without the possibility of rolling or sliding
- Animal should have enough head room and enough room to move around and stretch out.

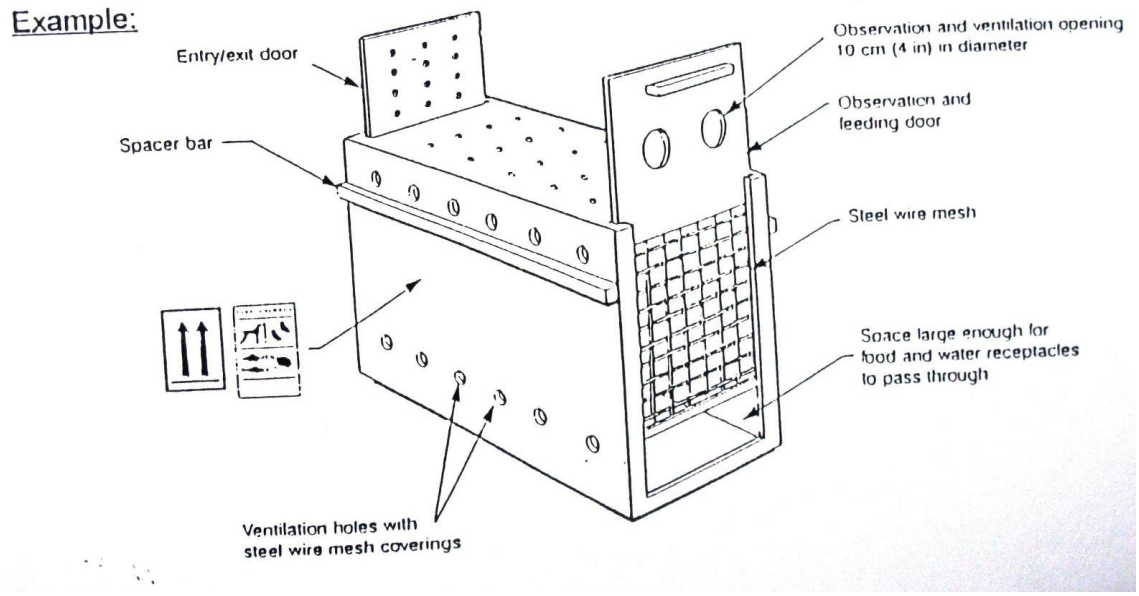
- For longer trips it is recommended that spotted-tailed quolls are transported in containers such as those specified for transport by air (see below).

Transport by air

Any animal being transported by air must boxed according to IATA (International Air Transport Association) standards. The Dasyurus spp. comes under the IATA Container requirement 81. However, in Container Requirement 81 points outlined are specified for smaller dasyurids, rodents and other smaller species. Container requirement 79 is more suited to the larger spotted-tailed quoll as is covers the same guidelines as 81 but for larger species such as the marten family, weasels, ferrets and other similar carnivorous species. The same applies with container requirement 80, which is also suitable.



Left: container requirement #79 (IATA)



Left: container requirement #80 (IATA)

7.6.1 Box Design

- Animal must be able to move around freely in cage and have adequate space above its highest body part (head)
- Must be strong enough to withstand being stacked, handled and moved for transportation i.e. won't collapse, or come apart.
- The container must be correctly labelled (see labelling next page).

Materials:	Wood, fibreglass or rigid plastic. Lined with wire mesh to prevent chewing.
Frame:	Made out of the materials listed above. Wood frames (roof, sides and base) must be screwed together. Any glue used to bind joints must be strong, non-toxic, and waterproof.
Sides:	Sharp edges must be rounded off. All edges inside the box must be smooth and absent of sharp edges and protrusions. Mesh with a maximum hole diameter of 2.5cm (1 in.) must cover all openings, small enough that the animal's snout or feet cannot protrude from the openings. Mesh holes should be reduced for smaller / juvenile quolls.
Ventilation:	Ventilation MUST be provided. The front of the container must be made of mesh no larger than 2.5cm (1 in.). Nylon mesh can be placed over opening to reduce light but must still provide adequate ventilation.
Floor:	Must be solid, non-slip, leak proof and lined with a layer of absorbent material.
Roof:	See Materials.
Doors:	A sliding door must be fitted at the rear of the container and have a secure fastening at both the top and bottom that cannot accidently open.
Spacers:	Spacer bars must be provided to each end of the box to prevent items being placed up against the sides and blocking ventilation holes. Spacers must be made to a depth of 2.5cm (1 in.)

Labeling

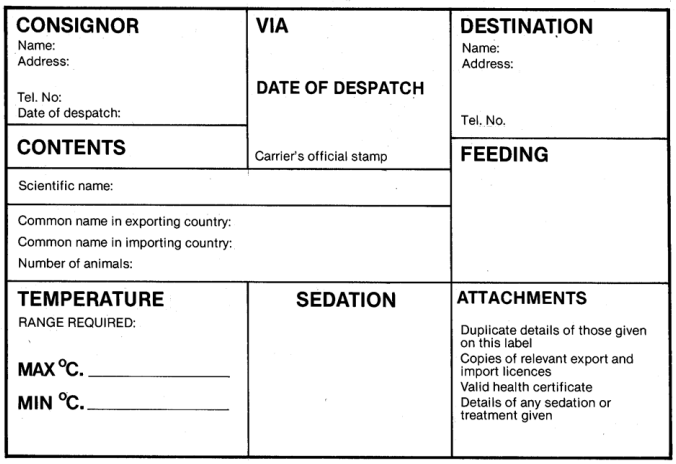
The label/s right must be durable and waterproof and placed on the side of the transport container to notify handlers and receivers:

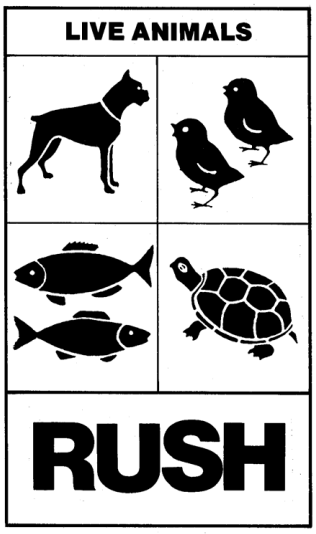
(Durable, waterproof means of containing the following documents and other essential information should be firmly attached to the container.)

- LIVE ANIMALS are in the container
- THIS WAY UP!!! The box needs to stay upright and not laid on its side or upside down
- Time and date of transport
- Official stamp of carrier showing date of his receipt of consignment
- Required transport temperatures
- Numbers of animals in container
- What kind of animals are in the box (mammal, avian, fish / aquatic or reptile / amphibian.

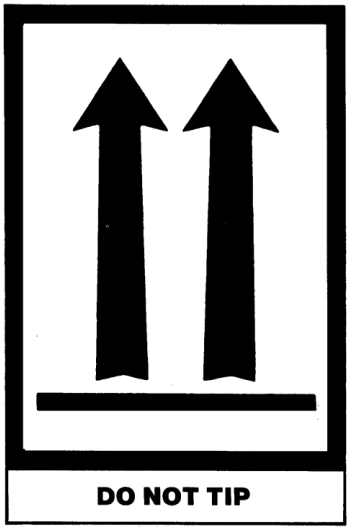
Additionally the following detailed should be provided on or attached to the container:

- Senders name, address and telephone number
- Receivers name, address and telephone number
- If the animal is sedated and details





Minimum dimensions 10 x 15 cm.



Minimum dimensions 10 x 15 cm.

- Feeding instructions if longer than 24hours
- Animal's details / ID including scientific and common species name.
- Other details such as history of training, enrichments, dietary procedures, etc. if available.

7.6.2 Furnishings

Spotted-tailed quoll transport boxes must be lined with wood shavings, shredded paper or similar to absorb moisture, insulate against heat and cold and minimize animal sliding around in box.

7.6.3 Water and Food

For trips up to 24 hours in length, spotted-tailed quolls do not need to have food or water provided. Feeding days prior to transport could be planned that the day of transport is a starve day and only a small amount of food possibly given is to lure quoll into transport container. Quolls can be trained to use a drinking bottle and a small amount of food can be provided but is not necessary.

Despite not being given food or water, metal (not soldered tin) food containers must be provided. They must be able to be accessed from the outside from fitted slots in the front of the container, in the case of an unforeseen delay. If there is an unforeseen delay, a small amount of meat or fish and water can be provided. Feeding instructions must accompany the container at all times and must be followed by handlers.

7.6.4 Animals per Box

Spotted-tailed quolls should be transported individually. Females with older pouch young should not be transported as there is a risk that they may eject her young from her pouch.

7.6.5 Timing of Transportation

Animals should be transported when it is cooler such as early morning or later afternoon. Ideally transportation should occur in the early morning as spotted-tailed quolls are nocturnal and may be more inclined to sleep during diurnal hours, unless the quolls are normally housed in nocturnal houses and therefore transportation is ideally done in the evening when it is cool and they are normally asleep.

Health should be accessed before transportation and sick animals should not be transported. It is preferred not to sedate quolls for transportation but if needed sedation of Diazepam (Valium) can be given IM at a dose of 1-2mg / kg.

7.6.6 Release from Box

New acquisitions should be placed into quarantine and monitored for health issues and allowed to recover from the travel in a quiet location. Once animal is deemed healthy and clear of health issues, the quoll can be transported to its new enclosure.

Spotted-tailed quolls are released directly onto the ground or into their nesting boxes. Cages can be left in the enclosure and door opened, allowing the quoll to exit its cage in its own time. When releasing, follow the same principles as listed in *7.5 Release*.

8 Health Requirements

8.1 Daily Health Checks

Ideally the first form of examination should be visual during daily cleaning first thing in the morning, during feeding times and when passing enclosure. Keepers should monitor individual animals:

- Behaviour – monitor for signs of depression, aggression etc.
- Eating and drinking – gorging? Not eating / drinking?
- Posture, walking and physical activity
- Skin and fur condition – including amounts or condition of any lost fur
- Eyes and nose- cloudiness (eyes), any discharges
- Condition and amount of faeces during spot cleaning
- Any other notable abnormalities e.g. wounds, injuries (e.g. lame).
- Stereotypic behaviour
- Monitoring for development of pouch young / bulge

8.2 Detailed Physical Examination

8.2.1 Chemical Restraint

Spotted-tailed quolls should be fasted 6-8 hours prior to anaesthetics.

Gaseous Anaesthesia:

Isoflurane (gaseous anaesthesia) is the safest and preferred form of chemical restraint. Halothane can also be used if Isoflurane is unavailable but is not as safe and close monitoring is needed. It is recommended to have the quoll physically restrained and then induce Isoflurane by a mask using a non-rebreathing circuit such as a T-piece.

Isoflurane: Induction at 5% and maintenance averaging at 2%. Oxygen level should be at 200ml / kg/min with a minimum of 1L.

Wal the quoll is anaesthetised after arriving with extensive wounds. Photo: Sandy Webb Stories - WIRES

Injectable Anaesthesia

Diazepam (Valium) can be given IM at a dose of 1-2mg / kg, for minor manipulative procedures such as x-rays; as well as transportation. (Johnson 2007)

General Anaesthesia can be induced using Zoletil (Telazol) at a dose of 7-10 mg/kg IM. Zoletil induces quickly but can prolong recovery in some dasyurids. Alternatively Xylazine at 4mg/kg IM can be combined with Ketamine at 20mg/kg IM.

<u>Injection Sites:</u> (and some blood collection sites)

S/C – Dorsal / back– generally the scruff / scapular area.

I/M – Hind legs (thigh area)

I/V – the main veins to use are the Cephalic vein and jugular veins - see Venepuncture sites below (Dasyurid venepuncture sites from IVS "*Restraint and Anesthesia of Dasyurids (Dasyuromorphia)*")(Holtz2002)

Venepuncture Sites:

Cephalic vein - This vein is present on the dorsal surface of either foreleg. It can be used in Tasmanian devils and quolls.

Jugular vein - This vein is suitable for blood sampling in all dasyurids.

Ventral coccygeal vein - Insert the needle perpendicular to the tail, in the ventral midline, and advance it until the vertebrae are reached. Withdraw the needle slightly and blood should enter the needle hub. This vein is useful for smaller dasyurids (Fig. 3).

Femoral vein/artery - Direct the needle at the pulse felt in the groin region. Arterial blood is often obtained and digital pressure is required to prevent hematoma formation.

Medial metatarsal vein - This is a small vein running along the medial aspect of the hind leg.

8.2.2 Physical Examination

One keeper should restrain the spotted-tailed quoll while another keeper or veterinary staff conducts the physical examination. Spotted-tailed quoll pouch muscles are extremely strong so two hands are required to open the pouch during pouch checks. Spotted-tailed quolls can be restrained in a catching bag with the head and eyes continually being covered while limbs and other body parts being individually uncovered to be examined and / or procedures such as injections to be conducted.

- **Temperature** (normal 36.9ºC / 98.4ºF (Jones 2003)) via cloaca
- **Weight** – compare to previous – conducted monthly
- **Body Condition** / scoring over the spine and temporal fossa (side of head behind eyes)
- **Presence of wounds or lumps** (possible tumours)
- **Discharges** – eyes, nose, ears, cloaca
- **Eyes** – check for cloudiness / cataracts; normal reflexes (bilateral pupillary light response and corneal reflex)
- **Behaviour** – depressed / not resisting restraint, stressed, additional aggression etc.
- **Fur quality** / condition – alopecia, fungal infections and ectoparasites
- **Skin condition** – body, head, legs, and feet. Also check for parasites.
- **Cloaca** – clean / free of faeces
- **Posture and muscle condition** – lame / Depressed / hunched / bow-legged etc.? Could indicate injuries or abnormalities (e.g. Metabolic Bone disease)
- **Pulse rate** – will increase during restraint
- **Respiratory rate** – will increase during restraint
- **Females** – pouch check – presence of young, health of young, condition of pouch, young size and teat condition e.g. producing milk; red / swollen etc.
- **Males** – check:
  - Testes - size and consistency
  - Penis – condition during manual extruding
  - Sternal Gland – condition (use of) and size
- Any other notable abnormalities e.g. lameness, visible patches of fur loss.

8.3 Routine Treatments

The most routine treatments involve prevention of disease including:

- Quarantine of new animals
- Daily faecal removal and weekly scrubbing furniture with disinfectant and thoroughly rinsing
- All feeding etc. equipment is washed using correct sterilisation techniques (e.g. autoclave, chemical or dish washing)
- Supplementation of calcium and other vitamins to food to prevent bone disorders such as MBD.
- Supplementing indoor quolls with UV lighting as a source of Vitamin D3.
- Monthly weighing
- 1-2 yearly physical checks and faecal collections and testing for endoparasites.
- Anthelmintics (internal and external parasite control e.g. Praziquantel, Ivermectin, fibronil or carbaryl etc.) are recommended especially for outdoor quolls. Each varies on method of administration and doses. Doses are usually at domestic animal dose rates. Refer to product and veterinarian specifications for doses and methods of administration.
- Pest control programs for surrounding areas (for both indoor and outdoor animals).
- Pouch checks during breeding season (see Chapter 10) – refer institutional requirements.

8.4 Known Health Problems (Jones 2001)

Below is a list of health issues that may be found in spotted-tailed quolls. To help identify a disease I have listed the signs and the disease. Refer to information below for more details on cause (aetiology), how to diagnose, treatment and prevention.

Note: If a health issue has arisen keepers should seek the advice of a veterinarian. It is the responsibility a veterinarian to diagnose health issues and implement treatment.

Disease	Signs of disease
8.4.1 Endoparasites	No obvious signs. Possible worms or segments (proglottids) visible in feaces
8.4.2 Ectoparasites	heavy infestations around distal limbs, ears, groin, scrotum and face; causing scratching and hair loss.
8.4.3 Protozoans	Toxoplasmosis - incoordination and / or paralysis, behaviour change, Convulsions, Lethargy, Blindness, Anorexia, respiratory problems e.g. lung congestion, and Expothalmosis (bulging eyes). Some deaths may have no prior signs.
8.4.4 Calcium Deficiency	bone / growth defects, lameness, dragging of limb and other similar abnormalities.
8.4.5 Obesity	Quoll carries excessive weight.
8.4.6 Neoplasia (Growth tumours)	Internal tumours may not be obvious visually. Viral tumours are rare but can get up to 20cm in diameter and generally located around the head from fighting and bite wounds; restricting movement of the head and can impair sight, eating and breathing.
8.4.7 Trauma (Injury)	Visible wounds to skins, blood on fur, shock

8.4.8 Degenerative Skeletal Conditions	Could include sudden paralysis (especially in the hind legs), stiffness, difficulty rising, lameness, inactivity / reduced activity (especially in cooler weather / conditions), swollen joints, reduced appetite, bone deformities, behavioural changes
8.4.9 Dental issues	Difficultly eating or refusing certain foods (especially harder or larger food items such as bones), sudden illness or death (from infection).
8.4.10 Cutaneous Mycobacterial Infections	Lesions presented as thickenings, plaques, and abscesses within the subcutaneous tissue. Most commonly sighted in the subcutis and skin around the neck, throat and axilla (cervical and thoracic regions).
8.4.11 Ringworm	Circular lesions on skin and hairloss. Often has dry skin at source of infection

Known health issues for Spotted-tailed quolls include:

8.4.1 Endoparasites *(Jones 2001)*

Aetiology: The Spotted-tailed quoll is known to have at least 23 species of endoparasites including:

- flukes (5) (Trematoda)
- cestodes / tapeworms (4) (e.g. *Spirometra erinacei, Taenia ovis* and *Anoplotaenia*),
- nematodes / round worms (14) (e.g. *Ascarids, Cylicospirura, Strongyle spp., Mackerra strongylus, Trichinella spiralis*) and

Signs: No obvious signs. Possible worms or segments (proglottids) visible in feaces

Diagnosis: Worms or segments (proglottids) visible in feaces and / or faecal floation.

Treatment: Anthelmintics such as Droncit / Drontal (praziquantel)

Prevention: Regular faecal removal. Security and pest control to prevent pests from spreading disease, parasite eggs and contaminating supplies. Freezing meat for a minimum of one month prior to thawing and feeding.

8.4.2 Ectoparasites *(Jones 2001)*

Aetiology: At least 10 species of ectoparasites have also been identified for this species including:

- mite (1)(D*emodex*),
- ticks (2) (e.g. *Ixodes sp.*), and
- fleas (7) (e.g. *Echidnophaga* and *Uropsylla*)

Ectoparasites can also be carriers of other diseases.

Signs: heavy infestations around distal limbs, ears, groin, scrotum and face; causing scratching and hair loss. (Obendorf, 1993; Jackson, 2003).

Diagnosis: by sight (most ectoparasites) or for mites via skin scraping and viewing under a microscope.

Treatment: Ivermectin 1% injection subcutaneously (dose = 200mg/ kg) or Carbaryl topically.

A (paralytic) tick on a quolls ear (picture http://increasingdisorder.wordpress.com/)

Prevention:

- Regular changing of nesting material and washing nest boxes
- Freezing any collected plant / leaf nesting material for 4 days before distributing to animals.
- Laboratory rodents used as food can transfer mites to Quolls. Keep rodents frozen until the day prior to feeding.
- Frontline ® (fibronil) has been used successfully in some dasyurids against fleas, mites and ticks; but veterinary advise should be consulted for best dose rates, application methods, or use in pregnant or lactating females or in young quolls.

Wal was found with wound-like lesions that were diagnosed through a skin scrape as sarcoptes mange (*Sarcoptes scabiei* / mite) (pic: http://www.cv.wires.org.au/swebb.html)

- Security and pest control to prevent pests from spreading ectoparasites and their eggs.

8.4.3 Protozoans Toxoplasmosis

Aetiology: Toxoplasmosis (caused by *Toxoplasma gondii*) is the most common Protozoan and animals can infected by eating meat from warm blooded animals; by picking up cat parasites carrying the protozoan or passed from mother to foetus.

Signs: Toxoplasmosis - incoordination and / or paralysis, behaviour change, Convulsions, Lethargy, Blindness, Anorexia, respiratory problems e.g. lung congestion, and Expothalmosis (bulging eyes). Some deaths may have no prior signs.

Diagnosis: Toxoplasmosis - diagnosis is through blood serum tests to detect rising IgG *Toxoplasma gondii* titres. In post mortems diagnosis includes inflammation in the heart, brain, lungs and liver and occassionally in the adrenal, muscles of the gut and strap muscles of the neck, lymph nodes and bladder.

Treatment: Anti-protozoal drugs such as sulphonamides including amprolium and toltrazuil.

Dr. Rick Speare – Bvs Mscvs of diseases - Australian Native Wildlife treats by:

Daraprim 25mg (pyrimethamine) at 2mg/kg. Crush tablet in 3-5mls of water. Trimethoprim 40mg/sulphamethoxazole 200mg. EITHER Bactrim/Septrim .5ml per 30 kg –OR- Trisoprim 1.5ml per 30kg. Twice per day for the first 4 days, then once per day for the remaining 10 days.

Prevention: For Toxoplasmosis, freeze any raw sheep meat for at last one month before thawing and feeding. No access for feline species. All bedding and food sources should be kept away from access to cats (mostly feral cats).

8.4.4 Calcium Deficiency (Nutritional Osteodystophy)

Aetiology: Caused by feeding a diet with the incorrect calcium to phosphate ratio where the animal is receiving inadequate amounts of calcium.

Signs: bone / growth defects, lameness, dragging of limb and other similar abnormalities.

Diagnosis: radiography is needing to determine low bone density. Current diet should be reviewed.

Treatment: If a calcium deficiency is detected early, individual can receive high calcium and high vitamin D3 diet and kept on strict cage rest / placed into a reduced sized enclosure.

Prevention: do not give meat (flesh) only diets. Supplements such as eggs, whole carcasses / whole parts of carcasses to provide bones to chew on, good quality kibble etc. can be added to their general diet (see Chapter 6.2-6.3) as well as sprinkling food with calcium carbonate. During breeding season food rations should be increased 20% (especially to lactating females). Adequate sources of VitD3 should also be provided to assist in calcium absorption.

8.4.5 Obesity

Aetiology: Caused by feeding too much food or feeding a diet high in fat and not providing exercise opportunities. **Note**: some additional weight is acceptable for females prior to the breeding season. The female will store this extra weight in the scruff of her neck to prevent her being killed by the male as he grasps it with his teeth during copulation.

Signs: Quoll carries excessive weight.

Diagnosis: Obesity is measured through body condition / scoring over the spine and temporal fossa (side of head behind eyes).

Treatment: Quantity of food that is given is lowered and leaner foods (e.g. fish) are given.

Prevention:

- Quolls should have a starve day once a week*. (* not during breeding season)
- Processed foods should be given sparingly.
- Lean meats e.g. fish, kangaroo; should be part of the diet plan
- Whole carcasses e.g. day old chicks; or whole parts of carcasses e.g. chicken wings, rabbit etc. should be given as they don't have additional fat and quoll needs to use energy to chew.
- Scatter feed: introduce live insects or animal scents to encourage exercise through foraging.
- Other feeding techniques that encourage animal to 'work for food' e.g. bungee feeder, treat balls, ice blocks etc.
- Climbing structures should be provided and rotated regularly to provide exercise and enrichment

8.4.6 Neoplasia (Growth tumours)

Aetiology: A large range of neoplastic tumours (non-inflammatory growths of tissue) can be found commonly in quolls including:

- Malignant tumours (grow and spread quickly) – quickly destroy tissue. Mostly age related.
- Benign tumours – local, slow growing tumours. Mostly age related.
- Transmissable viral lymphosarcomas are found in both wild quolls and wild Tasmanian Devils.

Examples of such neoplastic tumours include lymphatic, haemangioma, hepatocellular carcinommas, osteosarcomas, mesotheliomas, pulmonary adenomatosis, lymphosarcoma, lymphatic leukaemia, mammary, cutaneous and papillomas (Arundel *et al* 1977; Reece and Hartley 1994).

Signs: Internal tumours may not be obvious visually. Viral tumours are rare but can get up to 20cm in diameter and generally located around the head from fighting and bite wounds; restricting movement of the head and can impair sight, eating and breathing.

Diagnosis: visual examination and biopsies of tumours. Internal tumours may need to be diagnosed through other veterinary procedures / tests such xrays and exploratory laparotomies.

Treatment: most tumours cannot be treated and individuals are given supportive care or euthanased.

Prevention: viral tumours can be controlled in captivity by separation of non-breeding quolls. Tumours are difficult to prevent. Viral tumours are mostly found in wild species. In captivity, any individuals found with viral tumours should be kept separate or euthanised to prevent transmission to other quolls.

8.4.7 Trauma (Injury)

Aetiology: Injuries in Spotted-Tailed Quolls are mostly due to fighting especially during the breeding season. For wild Quolls, trauma can also be caused by attacks from other predators, hit by cars when scavenging road kill etc.

Signs: Visible wounds to skins, blood on fur, shock

Diagnosis: presence of wounds and other injuries through visual and / or physical examination.

Treatment: varies depending on injury (seek veterinary advice). Treament can include flushing with sterile saline, monitoring, restitching, application of drains, applying topical ointments, amputation of limbs etc; or euthanisation.

Prevention: Quolls are separated as juveniles and kept in individual enclosures. Males and females are kept in separate areas. Enclosure should be regularly checked and maintained to prevent injuries from faulty enclosure barriers and other structures.

8.4.8 Degenerative Skeletal Conditions

Aetiology: osteoarthritis; and sudden hind limb paralysis from collapsed thoracic-lumbar intervertebral disks. Mostly found in older Spotted-Tailed Quolls. Causes may include trauma, general "wear and tear" and tissue and joint break down associated with age. Incorrect nutritional needs and obesity can be contributing factors.

Signs: could include sudden paralysis (especially in the hind legs), stiffness, difficulty rising, lameness, inactivity / reduced activity (especially in cooler weather / conditions), swollen joints, reduced appetite, bone deformities, behavioural changes

Diagnosis: visible observations and records. Physical examination. May need x-ray to diagnose some issues such as disc displacement.

Treatment: treatments vary depending on condition but may include anti-inflamatory (pain killers) medication, reviewing dietary needs, cage rest, euthanasia (especially older animals).

Prevention: often unavoidable for older animals (natural decline in condition with age). Provide correct nutritional needs including correct portion size and provisions of calcium and Vitamin D; provide exercise opportunities (climbing etc.), and regular physical examinations.

8.4.9 Dental issues

Aetiology: Broken teeth are common especially in older Spotted-Tailed quolls and more frequent compared to other quoll species. Gingivitis and Periodontal disease are infections and build up on the teeth and gums and is caused mostly by solely feeding soft foods (mince, meat flesh only etc.). Infections from gum disease or broken teeth can result in bacteria going into the blood stream and results in death.

Signs: Difficultly eating or refusing certain foods (especially harder or larger food items such as bones), sudden illness or death (from infection).

Diagnosis: through physical examination (often assisted with chemical restraint).

Treatment: If teeth are badly broken, broken teeth may need to be removed under anaesthetic. Large build-up on teeth will need to be removed via a dental under anaesthetic. Both techniques will require antibiotics (best given via injection).

Prevention: Diet should vary and not consist of just meat mixes or meat cuts that contain no bones. Broken teeth are generally unavoidable. Providing smaller carcasses (e.g. chicken, rabbit etc.) compared to providing very large bones to chew on, assists in cleaning teeth and provides calcium and enrichment.

8.4.10 Cutaneous Mycobacterial Infections (Raymond 2000)

Aetiology: The most common infectious disease in captive Spotted-Tailed Quolls. Transferred mostly through bite wounds especially to females as males bite the scruff of their neck during mating.

Signs: Lesions presented as thickenings, plaques, and abscesses within the subcutaneous tissue. Most commonly sighted in the subcutis and skin around the neck, throat and axilla (cervical and thoracic regions).

Diagnosis: biopsies and other pathology (e.g. smears) or postmortem.

Treatment: Antibiotics and often surgical debridement or euthanasia.

Prevention: Housing Spotted-Tailed Quolls separately to prevent fighting. Monitoring any injuries post-pairing / post-copulation and seek veterinary advice if wounds are particularly bad. Some topical antibacterial

spray such as Centrigen could be applied to wounds as soon as the male is removed but should not be required.

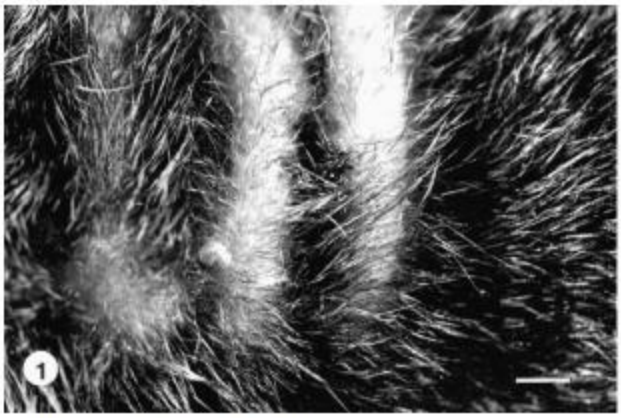


Fig. 1. Skin; tiger quoll. Gross appearance of thickened skin with alopecia from a tiger quoll with subcutaneous atypical mycobacteriosis. Bar = 5.0 cm.

Fig. 2. Skin; tiger quoll. Cross section of skin and subcutis from a tiger quoll with subcutaneous atypical mycobacteriosis. Subcutis is edematous and hemorrhagic (arrows) and contains exudative plaques that extend into the dermis (arrowhead). Bar = 5.0 cm.

(Above pictures from Raymond 2000)

8.4.11 Ringworm

Aetiology: *Microsporum caninum* - Fungal skin infection – ZOONOSES! Spread by spores in soil, air etc.

Signs: circular lesions on skin and hairloss. Often has dry skin at source of infection.

Diagnosis: plucking hairs at site of infection and culturing using fungassays (agar culture test)

Treatment: veterinary treaments. Cleaning out (e.g. changing substrate, furniture etc) and disinfecting enclosure. Could include miconazole based antifungal shampoo / washes (e.g. Malaseb - Dermcare ®) or topical ointments; or oral medication (e.g. Griseofulvin based medication).

Prevention: Highly contagious. Separates and isolate infected specimens. Regular substrate changes.

8.5 Quarantine Requirements

All new animals MUST be quarantined upon arrival to check for disease that could potentially be transferred to already residing animals.

Health screening while in quarantine: (Woodford 2000)

Testing and a quarantine period of **60 days** are required. Faecal floatations for gastric and intestinal nematodes should be carried out (at least 3 negative samples before deeming clear). Strongyles are common, while coccidia are uncommon. Positive *Campylobacter sp.* and *Yersinia sp.* cultures and positive Ziehl Neelsen staining are significant in this species. *Salmonella sp.* is a common isolate and may not be significant. Serology for *Leptospira interrogans*, *Toxoplasma gondii*, and *Chlamydia psittaci* is recommended. (Woodford, 2000)

9 Behaviour

9.1 Activity

- Spotted-tailed quolls are mostly nocturnal and crepuscular but have been seen foraging during the day or basking in the sun. The spotted-tail quoll is terrestrial but is an agile climber especially for hunting.
- Wild spotted-tailed quolls spend an average of 11% of the day above ground in trees, on rocky surfaces etc. (Jones 2001) 40% of their day is spent climbing, travelling / hunting and searching for food (Conway 1988)
- Females in the wild move daily to (up to 15) new dens except when offspring are no longer on the teats. The female will then stay in one den called a "maternal den" (Andrew 2005).
- Quolls kept in outdoor enclosures will generally rest during the day out of sight of the general public. Activity will decrease over winter. Quolls can be kept in nocturnal houses so that they are active during times when the public are present. When active spotted-tailed quolls are generally seen foraging in their enclosure and climbing enclosure furniture.
- Stereotypical behaviour can develop around feed times if feeds are conducted at the same time daily, in which the quoll can be seen pacing around its enclosure waiting to be fed.
- Spotted-tailed quolls are capable of ranging over large distances and require large areas of habitat in which to obtain resources. Debbie Andrew (NPWS) and Brad Walker recorded males travelling as far as 75km from its last recording via radio tracking collar. Another male was recorded as travelling 14km per week. (per comm. B.Walker)
- Spotted-tailed quolls are extremely quiet when moving through the bush but can make (quick and loud) vocalisations described as that of a "blast from a circular saw", low hissing or "cpp, cpp" noises during breeding (Jones 2001).

9.2 Social Behaviour

In the wild:

- Spotted-tailed quolls are solitary animals and generally avoid one another and will only interact with other spotted-tailed quolls to mate.
- Male spotted-tailed quolls are not territorial and home ranges overlap to those of other males and females. Surveys have noted that during breeding season, males move back and forth across female territories covering several kilometers a night. Female spotted-tailed quolls will tolerate female offspring until they reach sexual maturity but display intra-sexual territorial behaviour towards other female quolls (Belcher 2006).
- Spotted-tailed quolls have allocated areas in their home range where they use as "latrines" to urinate and defecate over a long period of time. These latrine sites are used by various spotted-tailed quolls, are usually found in rocky creek beds, at the bases of cliffs, and on roads (Belcher 1995) and where various quoll home ranges intersect. Spotted-tailed quoll faeces have strong distinctive smelling scats and (latrines) are believed to define territorial borders, communication and perhaps reproductive status.
- Spotted-tailed quolls den alone except when females rear young. Quolls do not share their dens, but will use another female's den once long unoccupied by the original quoll (Andrew 2005).
- Males do not assist in rearing offspring.
- Spotted-tailed quolls are generally shy natured animals that will run at the approach of humans.

In Captivity:

- Both male and female spotted-tailed quolls will actively defend their territories in captivity.
- Aggression will increase with age and fighting will result in extensive injuries and / or death.
- Spotted-tailed quolls are solitary animals and should generally only be paired for mating. Females may tolerate a female offspring in the same enclosure (usually until the younger female reaches sexual maturity). Some males can be housed in batchelor groups but not after being using in breeding.
- Juveniles can be kept together until needed for breeding (12-24 months of age) or separated earlier if fighting begins.
- Spotted-tailed quolls have allocated areas in their enclosure that they repeatedly use as "latrines" to urinate and defecate.
- Males do not assist in rearing offspring. Males and females will kill each other if offspring are also housed in the enclosure.
- Quoll / human interaction -While wild quolls are shy, captive quolls tend to approach and show aggression or approach but keep a distance observing the human activity. I find:
    - in some facilities spotted-tailed quolls approach a door awaiting food while others may run away but still linger somewhere nearby.
    - At Featherdale off-display male quolls showed territorial aggression if I walked past the front of their enclosures.
    - At Trowunna Wildlife Park many of the spotted-tailed quolls would approach a human standing near the fence of the enclosure and cautiously attempt to sniff the person. I do not know if they would bite if I put my finger through because I didn't try (I didn't want to be bitten if they did).

9.3 Reproductive Behaviour

- Sexual maturity in both males and females occur at 11-12 months. Females can breed at 1 year of age. Wild spotted-tailed quolls tend to have their 1st litter at 2 years of age while most captives will have a litter in first year (Andrew 2005).
- Males start searching for females in April - May and mating usually occurs in (May – August).
- Dasyurids are polygynous (multiple males to one female). In the wild males will enter several female territories for mating.
- Spotted-tailed quolls are polyoesterous - females can undergo a second oestrous if unmated or the first litter is lost prematurely (Andrew 2005, per comm P.Ralley).
- Both genders scent the ground and other surfaces by dragging cloaca. Males may be seen standing on hind legs smelling and females may be seen walking around with tail straight and raised prior to mating (Jones 2001).
- Females produce vocalisation (see chapter 10) to show receptiveness or non-receptiveness to males for mating. If receptive mating is often observed immediately afterward. (Jones 2001).
- Copulation <u>can</u> last up to 72 hours and the male will hold the female by holding onto her waist with his forearms and by biting on the scruff of her neck. Some females have been killed by males in the process of mating and partially eaten (Andrew 2005, per comm P.Ralley)

- Females will become aggressive toward the male during pregnancy. Females will dig, burrow or nest build - to construct a nest. Nesting materials included grass, paper bark, and occasionally bird feathers. May construct a nest even if no young are born (Andrew 2005).
- Pouch young June – August. Young are reared for 18 weeks until independent.
- Males do not assist in the rearing of young.

9.4 Bathing

Spotted-tailed quolls do not typically bathe in either water or sand / dirt. They will penetrate water with their paws to catch aquatic prey.

9.5 Behavioural Problems

Behaviour problems include:

- Fighting
- Stereotypic pacing especially at feed time from feeding at the same time each day.
- Biting – especially at feed time. This undesirable behaviour is often rewarded as keepers may tend to quickly drop the food in the enclosure in the attempt to not get bitten. Practices should be developed to vary routines and encourage behaviour enrichment (see 9.7).

Additionally, any changes in behaviour such as additional aggression or depression could indicate health issues and animals should be monitored closely.

9.6 Signs of Stress

Keepers should monitor quolls for signs of stress including:

- Not eating or drinking,
- change or non-normal behaviour,
- lethargy, depression or listlessness
- increased irritability and additional aggression to keepers or other animals
- loud / unusual vocalisation,
- rough fur and alopecia
- excess urination and defecation
- stereotypic behaviour e.g. pacing (especially around meal time)

9.7 Behavioural Enrichment

(Photo left: Wild Life Sydney These juvenile quolls at Wild Life Sydney woke up one day to find this very strange object (treat ball) in their enclosure.)

Photos below by J. Marten

Behaviour enrichment is essential to prevent stereotypic behaviour (see 9.5). There are so many different way to enrich spotted-tailed quoll living conditions in captivity. Enrichment can be divided into five categories: **Feeding Strategies, Manipulative, Environment, Sensory** and **Social**.

The most commonly used method are different feeding strategies. Some enrichment ideas can include:

- **FEEDING STRATEGIES including**:
  - **Scatter feeding** - hiding feed in various locations around the enclosure including high locations, in hollows, under a light plastic plate on the floor, hiding food in introduced items like hanging baskets etc.; to increase foraging and hunting behaviour.
  - **Vary feeding times** to prevent pacing.
  - **Feed whole or part carcasses** (eg. whole chicken wing) to replicate natural feeding behaviour in that the animal needs to chew, get past fur and feathers, needs to work on bones to access marrow etc. Chewing on bones also helps maintain dental health. A whole egg (raw or cooked) is good for enrichment and provides additional calcium and protein.
  - **Introducing live invertebrates** including insects e.g. crickets and mealworms; or crustaceans e.g. yabbies; to promote hunting.
  - **Varying feeding technique** such as letting them gorge on a larger amount of food one day and then starving them for a few days following. This is not recommended at breeding time as a male can kill the female or the female can kill and eat her offspring.
  - **Positive reinforcement food training**– animal has to conduct certain tasks before it receives its food or is rewarded with a smaller potion of food. Wild Life Sydney use this technique to prevent stereotypic food aggression as listed in 9.5. "Lisa" needs to station at a certain location before she is given any food. See appendices for the training sheet they use during training.

    Wild Life Sydney also train their quolls to go into pet packs by

Treat ball – food (e.g. kibble)

Quolls are trained to go into pet packs with small amounts of food at Wild Life Sydney.

placing a small amount of food in the cage. They use this technique with off display quolls. Once "Maggie" the quoll enter the pet pack, she is locked into the pet pack and then the keeper can maintain / clean her enclosure and hide the rest of her food in the enclosure.

- Pigs ears or raw hides to chew on.

- **MANIPULATIVE DEVICES: ideas for Feeding etc:**

  - Attach feed to a heavy duty "**Bungee feeder**" which creates resistance to encourage quoll to pull at food and provides additional exercise.

  - **Hanging** small bones such as chicken necks; in high locations.

  - **Freezing feed into blocks** during warmer seasons to provide refreshment and enrichment.

  - Use of **durable feeding toys** such as treatballs and kongs to make the animal work for it's food. Note: some quolls may be able to chew segments off kongs which can become choking hazards. Items like PVC piping can also be used to hide food in and it needs to be manipulated to get food out.

    Use of **non-durable items to hide food** that can be destroyed e.g. hiding food in cardboard boxes, egg cartons, paper mache balls (see below). ***Note: make sure it won't leave large amounts of mess that can look unsightly and the keeper the next day will be left to clean up. Also make sure it will not create a choking hazard e.g. sticky tapes or staples.***

  - **Tunnels** (like large versions of mouse tunnels) that quolls can run through, climb in and around etc. These could be made out of PVC plumbing pipes, wood, cardboard etc. and stationary or suspended.

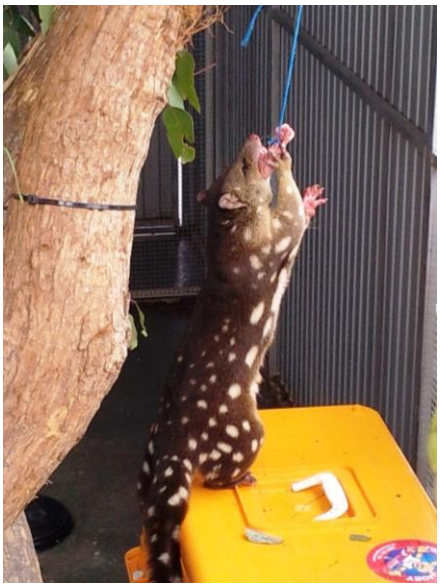
- **ENVIRONMENT:**

  - **Enclosure layout** – addition of varying surfaces including climbing surfaces, hollow logs, rocks etc. Periodically change the layout of the enclosure for enrichment. If pacing or climbing patterns are developing, blocking regular paths may stimulate change enrichment.

  - **Climbing items**- Furniture such as hollow logs (horizontal and vertical), large branches etc. promote climbing and exploring. Other items to promote climbing can also be used. Wild Life Sydney sometimes introduce hanging plant baskets with coconut fibre that can be used to rest or bask in the sun or to hide food or squirt animal scents inside. The baskets promote locomotion and climbing to get into.

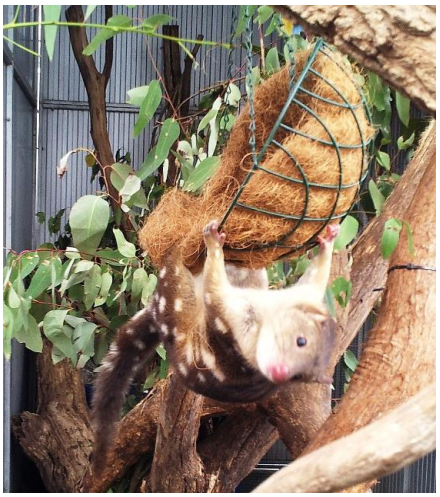
    I created a climbing enrichment item which has interchangable part to vary mobility. Refer Appendices for design how to make.

  - **Nestboxes and nesting opportunities**: shelter and privacy is an important physical and behavioural need. Hollow logs and nest



An off-display quoll at Wild Life Sydney finds a chicken neck hung from a cord.

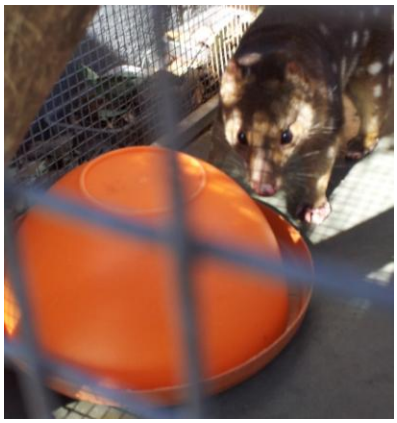
A wire plant basket with coconut fibre is great for basking / resting in or even hanging up and hiding food in...



… or just hanging from. "Maggie" at Wild Life Sydney is sure there must be food in this basket! Sorry Maggie you ate it already!

boxes should always be supplied (see chapter 4 Housing).

- **Planting various species of plants** especially tussock grasses; and mulch can provide foraging opportunities.



a bowl works well to hide food

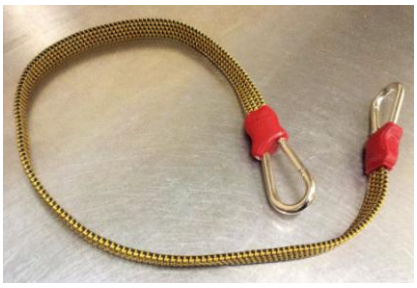
- **SENSORY**

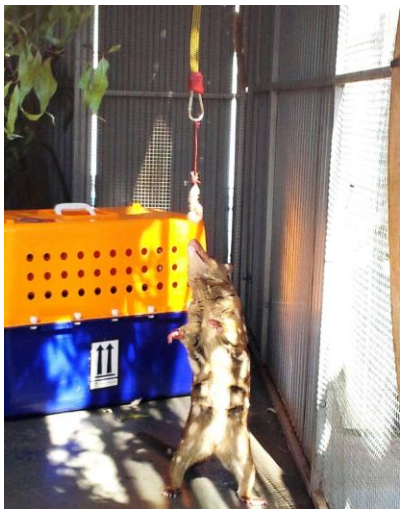
- **Placement of other animal scents in enclosure** – this can include old browse from typical prey enclosures, faeces from other animals, squirting small amounts of blood or juices in enclosures. Wild Life Sydney Zoo squirt small amounts of blood or fish juice in their Spotted-Tailed Quoll enclosure. Other smells such as spices or aromatherapy oils can also be used.
- **Introducing random items** such as toys (see picture above); into the enclosure to encourage the curiousness of the animal.
- **Sounds** – occasionally sounds of other animals, especially different prey can be introduced to induce hunting and other natural instincts.

- **SOCIAL -** See 9.2 and 9.9

OTHER IDEAS::

tussock grass





Left and above centre: A simple elasticised cord (left) ($6 @ Bunnings) can be used as a bungee feeder

Above right: Here I am pictured making a simple a paper mache ball made by sticking newspaper to a balloon using flour and water (instead of glue), allowing it to fully dry then popping and removing the ballon.

ENRICHMENT CALENDERS:

A schedule should be created to ensure that each Spotted-Tailed Quoll receive a minimum of **ONE SOURCE OF ENRICHMENT PER DAY!!!** Feeding should be the minimum enrichment given but many varied sources of enrichment is recommended (excluding starve days when another form of enrichment should be provided).

Below is one example of a calender of enrichment used by Symbio Wildlife Park, NSW to provide daily forms of enrichment for their Tasmanian Devils and (previously) Quolls.

LOGO

Symbio Zoo T. Devil & Quoll Enrichment Calendar

Paper mache as available

1	2	3	4	5	6	7	8	9	10
Newspaper balls (Hide insects/ blood/ kibble etc. in balls of newspaper)	Bloodicle	Cardboard Box with food inside	Meat lettuce (Puncture hole in lettuce head and place meat in)	Raw hide bone	One Whole fruit	Treat balls	Ice blocks	Fresh herbs or spices (crushed and scattered around exhibit, coriander, paprika, basil)	Newspaper balls (Hide insects/ blood/ kibble etc. in balls of newspaper)
11	12	13	14	15	16	17	18	19	20
Dried pig ear	Cardboard Box with newspaper + food inside	Meat smear (Species specific)	Blood + Egg Yolk Trail	Cardboard Box with blood inside	Newspaper balls (Hide insects/ blood/ kibble etc. in balls of newspaper)	Fresh herbs or spices	Bloodicle	Meat lettuce (Puncture hole in lettuce head and place meat in)	Raw hide bone
21	22	23	24	25	26	27	28	29	30
Treat balls	Meat smear (Species specific) Whole mice in afternoon	One Whole fruit	Cardboard Box with food inside	Newspaper balls (Hide insects/ blood/ kibble etc. in balls of newspaper)	Ice blocks	Dried pig ear	Mirror	Blood + Egg Yolk Trail	Raw hide bone

(note: Symbio Wildlife Park no longer house Spotted-Tailed Quolls but have given me permission to use this example)

9.8 Introductions and Removals

Timing of breeding - spotted-tailed quolls are generally housed solitarily and only get put together to mate. For reproduction introductions and removals see 10.6.

Juveniles should be moved to another enclosure at weaning (18weeks old) can be housed with litter mates of the same gender. Female juveniles can be housed with their mother and / or together until sexual maturity or beforehand if fighting occurs. Young males can be housed in batchelor groups unless fighting ocurs or until used for mating then they need to be housed separately.

9.9 Intraspecific Compatibility

Spotted-tailed quolls are generally housed solitarily and only get put together to mate. The only occasions where quolls are housed together are:

- Females with female offspring; or
- Males from the same litter or of similar age can be housed in batchelor groups from weaning and removed if fighting or used for mating.

Generally spotted-tailed quolls will show aggression (resulting in fights that may cause serious injury and / or death) to another quoll in their enclosure. Males and females will kill each other if offspring are also housed in the enclosure.

9.10 Interspecific Compatibility

Being a larger carnivorous species, spotted-tailed quolls cannot be housed with other species as any other species will be killed and eaten by the quoll.

9.11 Suitability to Captivity

- General husbandry is fairly simple as daily faeces and urine removal is located in the same spots (latrines). Daily husbandry tasks are minimal.
- Behavioural issues can occur but can be easily avoided or corrected with provisions of regular behavioural enrichment (see 9.7).
- Spotted-tailed quolls are generally housed singularly (unless for mating) so issues of fighting, spreading disease etc. are minimal.
- Males have been known to kill their female mate during copulation. This can be avoided by increasing feeds for both male and female prior to introductions. The female produces an adequate fat roll on her neck to help protect her from being fatally bitten by the male during copulation. In turn the male is fed adequately enough to prevent it from killing the female for food.
- Females can also endure lacerations to her neck during copulation when the male holds on to her by biting the back of her neck. These lacerations can result in infection or transmission of disease.

10 Breeding

Table 10. Reproduction and development of the carnivorous marsupials. d = days, m = months

Species	Litter Size (mean)	First detach (d)	Permanent Pouch Exit (d)	Weaning (days)	Sexual Maturity F (m)	Sexual Maturity (m)	Mating Period	Birth Season	Reference
D. geoffroyi	1–6	–	61	110–54	12	12	Apr–Jul	May–Sep	13, 14, 15
D. hallucatus	6–8 (7)	60–70	56–70	125–50	10–11	May–Aug	Jul–Sep	–	16, 17, 18, 19, 20
D. maculatus	4–6 (5)	35–49	96	125–150	12	12	Apr–Jul	Jun–Aug	21, 22, 23, 24
D. viverrinus	1–6 (6)	49–65	91	135–140	12	12	May–Jun	May–Aug	17, 25, 26, 27, 28, 29

* Note the animals referred to in these papers was named *A. flavipes* but was *A. stuartii* (Woolley 1966). References: 1 Fleay 1961; 2 Michener 1969; 3 Sorensen 1970; 4 Woolley 1971a; 5 Gibson and Cole 1992; 6 Dickman *et al.* 2001; 7 Mack 1961; 8 Aslin 1974; 9 Aslin 1980; 10 Fletcher 1983; 11 Meissner and Ganslosser 1985; 12 Woolley 1991a; 13 Soderquist and Serena 1990; 14 Strahan 1995; 15 Galkhorst 1999; 16 Fleay 1962; 17 Nelson and Smith 1971; 18 Woolley 1973; 19 Begg 1981a; 20 Braithwaite and Griffiths 1994; 21 Fleay 1940; 22 Collins 1973; 23 Settle 1978; 24 Green and Scarborough 1990; 25 Hill and O'Donaghue 1913; 26 Hill and Hill 1955; 27 Green 1967; 28 Fleay 1935b; 29 Bryant 1988; 30 Woolley 1971b; 31 Lambert 2000; 32 Begg 1981b; 33 Woolley 1988; 34 Woolley 1991b; 35 Gilfillan 2001; 36 Fleay 1935a; 37 Guiler 1970; 38 Friend 1985; 39 Fleay 1949; 40 Smith 1984; 41 Watt 1997; 42 Leung 1999; 43 Wilson and Bourne 1984; 44 Wilson 1986; 45 Horner and Taylor 1959; 46 Marlow 1961; 47 Woolley 1966; 48 Wood 1970; 49 Selwood 1982a; 50 Fleay 1932; 51 Wakefield and Warneke 1963; 52 Dickman 1982; 53 Williams and Williams 1982; 54 Kitchener 1981; 55 Bradley 1997; 56 Fleay 1934; 57 Cuttle 1982b; 58 Mills *et al.* 1999; 59 Denny 1982; 60 Whitford *et al.* 1982; 61 Davies1960; 62 Fleay 1965; 63 Heinsohn 1970; 64 Woolley 1974; 65 Archer 1976; 66 Aslin 1975; 67 Van Dyck 1979; 68 Fanning 1982; 69 Kitchener *et al.* 1986; 70 Dunlop and Sawle 1982; 71 Woolley 1984; 72 Lee and Cockburn 1985; 73 Fleay 1929; 74 Godfrey and Crowcroft 1971; 75 Morton 1978b; 76 Friend *et al.* 1997; 77 Crowther *et al.* 1999; 78 Woolley and Ahern 1983; 79 Lunney and Ashby 1987; 80 Godfrey 1969a; 81 Woolley 1990b; 82 Taggart *et al.* 1997; 83 Fox and Whitford 1982; 84 Guiler 1961.

Fig 10. (above) Quoll reproductive details

Breeding in captivity – Keeper routine

WHEN		TO DO / MONITOR FOR
1.	**12-24 months of age**	Quoll reaches sexual maturity at 11-12 months. Most breed at 2 years (some at 1 year / 12 months)
2.	**March (or earlier)**	**Up diet** (20% or more) – females will generally gorge to build up their own fat roll but extra food should be added at least from March
3.	**March / April**	**Male female contact** - one month prior to the breeding season (March / April) through: - placing scats or bedding in opposite gender's cage to provoke sensory reactions, and / or - Housing males and females in adjacent enclosures
4.	**Early May – July**	Monitor female for excess bulk especially around neck (fat rolls) then if female goes of her food.
5.	**May – mid June**	**Introduce male to female** – monitor female for cupping / clicking vocalisations towards the male (showing interest to male) and introduce - see 10.6 introductions and removals
6.		**Remove after copulation** is complete. Reintroduce if female shows interest (cupping / clicking vocalisations) in same male again or another male
7.		**Monitor for swelling** of abdomen area as young grow in pouch. Refer to institution if requested to conduct pouch checks
8.		**Remove young** from mother at approximately 18-20 weeks when weaned
9.		House weaned young in gender groups until needed for reproduction at 1-2 years of age. Do not return to collection post mating

For more details see the rest of Chapter 10 below.

10.1 Mating System

Dasyurids are polygynous (multiple males to one female) (Archer, 1982 / Jackson 2003). In the wild males will enter several female territories for mating (and the female with many males). Genetic testing has identified mixed paternity among young from the same litters (per comm A. Claridge). In Captivity, males can be rotated if females are not receptive to the male presented to them.

If a male and female spotted-tailed quoll is able to be housed together they do not mate well with individuals they are regularly housed with. Some female spotted-tailed quolls are not receptive to being re-mated with the same males. Females in the wild will meet various males, so captive females can become aggressive unless mated with another male.

Mating

- Average oestrous lasts 3 days every 21 days (3 weeks). Spotted-tailed quolls are polyoesterous - females can undergo a second oestrous if unmated or first litter is lost prematurely. (Andrew 2005, per comm P.Ralley)
- Male start searching for females in April – May, but mating usually occurs in winter between June – mid August. At Featherdale mating mainly occurs in May and June and most births occur in June.
- Both genders scent the ground and other surfaces by dragging cloaca (Jones 2001, Andrew 2005). Males may be seen standing on hind legs smelling and females may be seen walking around with tail straight and raised prior to mating.
- Males will also smell urine left in common latrines to detect if a nearby female is coming into oestrous.
- If receptive a female makes specific vocalisations for several minutes. Mating is often observed immediately afterward (Andrew 2005, per comm P. Ralley). Some people describe this noise as a "cpp, cpp, cpp" (cupping) noise while others debate that it is a "click, click, click" (clicking) vocalisation. I got to witness this noise (during my time at Trowunna) and thought it sounded like a clucking (not like a chicken) noise like when you pull your tongue away from resting on the roof of your mouth.
- Non-receptive females would make sharp "cak, cak" or "cha, cha" vocalisations, hissing noises and exhale breathes to refuse males.
- Observations by Brad Walker (ex-curator at Featherdale), noted that females often mated on the same day or within 2-3 days of each other, and could be receptive to one or more males over a 2-7 day period.
- The male grips the female with his front paws under the belly and grasps the thickened neck of the female with his teeth to hold her in place. He will occasionally let go and lick her neck (see fig 10a). The female will stand with her head down.
- Once copulation begins the male and female are locked together. Bouts last up to 3 days (72 hours) for 1st oestrous and 12-24 hours for 2nd oestrous and shorter if she comes into a third oestrous (per comm. P. Ralley)
- Sometimes the female is killed by the male during copulation and occasionally partially devoured.
- Some indications that copulation has occurred are hair loss on the female's belly and the male's forearms, as well as wet patches, bite marks and other lacerations to the female's neck (see plate 3.3).
  Males are removed post copulation. If housed in the adjacent enclosure to the female the male can

Fig 10a. Mating pair. (gregwatson.photoshelter.com)

be reintroduced if already mated and the female is still showing interest in the male (see 10.6 Timing of breeding).

- Females will become aggressive toward the male and keepers during pregnancy.
- Pouch checks – refer 10.12
- Once young observed in pouch – females examined weekly (refer to institution guidelines – some places prefer to not conduct pouch checks.
- **Gestation**: 21days (Jones 2001, Andrew 2005)
- **Parturition**: Marsupial – Born as embryonic state at approx. 7mm (crown to rump) and migrate into the pouch and attach to a teat. Litter born May to late August (most late July – mid August). For young development see 10.16 Growth and Development.

Plate 3.3 Adult female tiger quoll – reddened cloaca, distended pouch and bare patches on sides where the male has held the female during mating (Andrew 2005)

10.2 Ease of Breeding

Spotted-tailed quolls can be relatively easy to breed if overall health and surroundings are ideal (per comm C. Crowther).

- **Food: Both male and female are fed extra food so that the female is not killed by the male during copulation**
  - Female has developed an adequate fat roll on her neck
  - Male doesn't consider her food while gripping her neck during copulation
- **Possible Triggers:**
  - The female may need to have food withheld or need to be allowed to gorge to stimulate oestrous (see 10.6 timing)
  - The development of a fat roll around the female's neck is an indication to the male that the female is ready to mate.
  - Males and females have some contact (directly or via senses such as smell) at least 1 month prior to the breeding season (see 10.6 timing)
  - Experience changes in temperatures – a few very cold days prior to breeding season (per comm. L. Corke).
  - For institutes located closer to quoll territories, male quolls may linger around outdoor enclosures. This presence may trigger female to go into oestrous.
- Nesting boxes / hollows and nesting materials are provided.
- Males are introduced into and removed from the enclosure for mating only (see 10.6 timing)
- **KNOW YOUR SPECIES**! Institutes wishing to breed spotted-tailed quolls need to have an adequate understanding of the dynamics of the spotted-tailed quoll's breeding behaviours and needs. Research and advice should be sort BEFORE breeding proceeds.

10.3 Reproductive Condition

10.3.1 Females

- During non-mating times the pouch is indistinguishable with only a light fur covering and 2 rows of 3 small teats. Teats approx. 1.5-2mm for 1 yr. old mothers and 3mm for older (had 2 or more litters) females.
- As breeding season approaches the female increases in weight and fat deposits on the scruff of her neck to accommodate the male biting her neck and holding her in place during mating which can last as long as 72 hours. It also provides fat reserves for the female while lactating. It is also suggested that this may be a trigger to males that the female in coming into or is in oestrous.
- Female's weight varies through breeding season. Younger females tend to lose some weight during rearing young while older females are able to maintain their weight.
- Cloaca becomes swollen and reddened during oestrous (see 10.12 Oestrous Cycle and Gestation Period - plate 3.3)
- Breeding season – skin and hair in pouch reddens and pouch develops into a deep pocket. The pouch hair grows up to 2cm long and thickens. Numerous glandular white dots are noted on the skin and teats develop scaly skin from red secretions and become sunken into 3-4mm deep pits. Pouch changes occur if a litter is born or not.
- When a female spotted-tailed quoll has a phantom pregnancy, she will not go into 2nd or 3rd oestrous (per comm. P. Ralley).

Teats (parous) on a female quoll. Fig 10b

When measuring reproductive status, females are restrained, physically examined and placed in one of the following catagories (below S.Jackson):

- **Non-parous** - female has never had a litter. Pouch:
  - Clean and dry
  - No skin folds / pouch is small
  - Teats very small
- **Parous** - female has had a previous litter. Pouch:
  - Is present but small
  - Clean and dry
  - Teats are slightly elongated
- **Pregnant** - Pouch:
  - Pink and glandular in appearance
  - Skin fold may be be observed on the lateral margins of the pouch

Female Quoll with young. Fig 10c

- **Pouch young present** – young attached to teats
- **Lactating** – young still suckling but emerging / emerged from pouch. Pouch:
  - large flaccid pouch
  - hair stained and sparse
  - elongated teats
  - smooth dark pink skin

- **Post Lactating** – teats only express clear liquid and /or regressing.

10.3.2 Males

Testes of the male spotted-tailed quoll are measured. Males also have a sternal gland that becomes prominent during the breeding season. Males will actively search for females and regularly become aggressive to keepers.

10.4 Techniques Used to Control Breeding

Spotted-tailed quolls are kept singularly except when paired to mate.

10.5 Occurrence of Hybrids

N/A. Spotted-tailed quolls are not housed with other species.

10.6 Timing of Breeding

- **Sexual maturity** in both males and females occur at 11 -12 months. If born earlier in the breeding season, females can breed at 1 year of age but almost all have litters by 2 years of age. Wild spotted-tailed quolls tend to have their 1st litter at 2years of age while most captive quolls will have a litter in first year (Andrew 2005).
- **Seasonal Breeder** - Spotted-tailed quolls will have one litter per year. Spotted-tailed quolls females are polyoesterous (can undergo a second or third oestrous if unmated or first litter is lost prematurely).
- **Breeding season** for the spotted-tailed quolls extends over a 5 month period in the Autumn and Winter months between April and mid-August with births between May and August (refer table 10). **Featherdale – mate their spotted-tailed quolls in May and births occur in June (per comm C. Staples).**
- **Oestrous** cycle of 21 days - remain receptive 1-12 days / Average oestrous last 3 days. Bouts last up to 3 days (72 hours) for 1st oestrous and 12-24 hours for 2nd oestrous. Copulation bouts in 3rd oestrous are shorter (per comm. P. Ralley).
- 1st mating's typically during May and June, then if first mating is unsuccessful or litter is lost, 2nd 3rd oestrous occur late June – August.
- The female will go off her food during oestrous. If she does not go off her food and / or make "cpp, cpp, cpp" vocalisation she may not be in oestrous and a diet plan should be introduced. This involves either reducing the females food to a half of their feed every second day until the female stops eating or allowing her to gorge.

INTRODUCTIONS AND REMOVALS:

- Contact males and females (see below) from April - May.
- Introduce males into the female's enclosures in May-June.

Males and females should have contact up to <u>one month prior to the breeding season (per comm P. Ralley)</u>. This can be achieved by placing scats or bedding in opposite gender's cage to provoke sensory reactions. The males are are able to smell the female's "presence" and sense if she is coming into oestrous. More ideally males and females can be housed in adjacent enclosures (at least one month prior to the breeding season) where they can see, smell and communicate.

The male is introduced when the female starts making "cpp, cpp, cpp" / "click, click" vocalisation. Mating should occur immediately.

Trowunna Wildlife Park, Tasmania, (as per comm. P. Ralley) house a female in an enclosure between 2 male (typically brothers with similar genetics) enclosures. The female has 2x males to choose from and whichever male she is interested in and makes "cpp, cpp, cpp" or clicking vocalisation towards is the male that gets introduced to her. Instead of catching the male (and stressing him), a door is opened between the male and female's enclosure. The male or female can enter the other's enclosure and mating should begin shortly after.

Once copulation is complete and the female starts ignoring the male, the slide door is closed and the female or male is returned into its enclosure. The female is observed over the next 24 hours to see if she begins showing interest (making "cpp, cpp, cpp" or clicking vocalisation) to the same or other male. If she shows interest in either male, the slide door is opened and male is allowed access to her enclosure to see if she will mate again, increasing chances of pregnancy.

Once copulation has occurred, the female no longer shows interest and pouch young are observed, the males are returned to their regular enclosures away from the females.

Other parks (e.g. Featherdale) introduce the male into the female's enclosure and leave them in the enclosure until mating has occurred and reintroduce if the female goes into second oestrous.

10.7 Age at First Breeding and Last Breeding

Sexual Maturity at 11-12 months of age.

First breeding as early as 11-12 months of age. Spotted-tailed quolls take 2 years to get to adult size but can breed in the first year. Males are sexually mature at 11-12 months of age but rarely sire young or complications (such as phantom pregnancies, and smaller or weaker litters) occur. Males over 2 years of age produce better litters.

Females born earlier in the breeding season tend to breed in their first breeding season. In the wild it is rare for female to have a litter in the 1st year but almost all bred at 2 years old. In Captivity, most will have a litter at 1 year of age.

Last breeding Age: Spotted-tailed quolls have a relatively short life and will reproduce the length of their lives (as per comm. P.Ralley). Wild females have been recorded to breed up to the age of 4 years old (Belcher 2004). Females average 2x litters in their lifetime and the oldest male (in captivity) to sire young is recorded at 5.5 years of age.

10.8 Ability to Breed Every Year

Spotted-tailed quolls will have one litter per year but females can undergo a second or third oestrous if unmated or first litter is lost prematurely. In the wild it was observed that a proportion of females did not appear to breed in consecutive years (Belcher 2004). This depended on the female's general body condition and prey availability.

10.9 Ability to Breed More than Once Per Year

Spotted-tailed quolls will have only one litter per year but females can undergo a second or third oestrous if unmated or first litter is lost prematurely except if the female experiences a phantom pregnancy (per comm P.Ralley).

10.10 Nesting, Hollow or Other Requirements

- **Provide numerous nesting sites** including nest boxes, hollow logs, mounds with hollows (dug, piping or rocky). Females will dig or burrow to construct a nest, or nest build in nest boxes etc. Females may construct a nest even if no young are born (Andrew 2005).

- **Nesting boxes** - box measurements: 710mm long x 530mm wide x 500mm deep - should be provided year round not only for breeding but also for shelter and privacy. Nesting materials are changed regularly except when female has left offspring in the nest.
- **Nesting materials** can include soft leaf mulch, grass species (such as tussock grasses or stout bamboo grass), dry fern leaves, paperbark, and occasionally bird feathers. Some commercial suppliments can include nesting grasses, straw, shredded paper. Nesting materials can be supplied in the enclosure so that the female can make her own nest.

10.11 Breeding Diet

Both female and male's allocated amount should be increased 20% before breeding season (from March or earlier) as:

- The female can increase her weight and develop a thick roll of fat around her neck to protect her when the male bites into her neck during copulation and to provide fat stores for when she stays more regularly in her den while lactating.
- Some males have been known to kill and partially eat the female. Starve day is eliminated during breeding season.

The female will bulk up (fat reserves) especially in the neck, just prior to breeding season to accommodate when the male bites her neck during copulation. Picture J.Marten

The female will go off her food during oestrous and start vocalising to the nearby male. Food should be removed from both enclosures before introducing the male to the female; otherwise the male may become lazy and prefer the food over the mate.

Once copulation has occurred and the pair has been separated, the male can be fed. The female may show interest in another male and should not be fed for the next 24hours. If she does not show interest in any other male, the female can be fed as normal.

If she does not go off her food and / or make "cpp, cpp, cpp" vocalisation she may not be in oestrous and a diet plan should be introduced. This involves either reducing the females food to a half of their feed every second day until the female stops eating or allowing her to gorge.

The female should continue to have a higher feed rate while lactating / until the young have been weaned and removed from the female. A lack in food can result in the female eating some or all of her offspring. The male can return to the normal amount of food when he is no longer required for mating.

10.12 Oestrous Cycle and Gestation Period

- **Oestrous cycle** of 21 days – every 21 days remain receptive 1-12 days (average oestrous 3 days)
- **Mating** occurs in April – June.
- Observations by Brad Walker (ex-curator) at Featherdale, noted that females often mated on the same day or within 2-3 days of each other, and could be receptive to one or more males over a 2-7 day period.
- **Gestation**: 21days
- **Parturition**: Litters are born between May to late August.
- When a female spotted-tailed quoll has a phantom pregnancy, she will not go into 2nd and 3rd oestrous (per comm. P. Ralley).

- Second oestrous (if female didn't fall pregnant or loses the litter) usually occurs 50-55 days later. She will bulk up again, go off her food and start vocalising.
- **Pouch checks**: Pouch check procedures vary per institute. These variances include:

  Post copulation, pouches are checked weekly for pouch status and more frequently between 18-21 days (at end of gestation) for parturition. Once young observed in pouch – females are examined weekly (Andrew 2005).

  Note: Regular capture and handling during pregnancy or with pouch young can increase stress in the mother and increase chances of female failing in her pregnancy, ejecting her pouch young, eating her young and other complications. Acclimatising the female to pouch checks or training the female to climb onto a wire fence to allow her pouch to be checked may reduce stress and complications from arising.
- Leaving the female alone and observe. After 50-55 days she bulks up, goes off her food and vocalises she is in 2nd oestrous and should be re-introduced to males. If she doesn't she is monitored for swelling around the pouch area and visual sighting of young on her teats (per comm P.Ralley).
- Young can be checked more regularly once left in the nest.

10.13 Litter Size

Pouch young attached to their mother's teats
http://guytroughton.com/illustrations/

Spotted-tailed quolls have not been recorded giving birth but it is suggested that they will give birth to 12-15 young (other sources suggest as many as 30). Since they only have 6 teats they can only rear a maximum of 6 young. The unattached young are eaten by their mother.

Litter size: 4-6 (average 5) joeys. Joeys approx. 7mm at birth (Fleay 1940; Green & Scarborough 1990)

Litter born: mid-July - mid August

In pouch: approx. 7week

A litter raised by Wild Life Sydney Zoo
Photo wildlifesydney.com

- Deaths of pouch young generally occur with the first 3 weeks from birth and gender for dead individuals cannot be determined.
- There appears to be no gender bias in litters.
- Pouch young June – August (gracilis June – September)
- Spotted-tailed quolls have 6 teats – 1-6 joeys born in captivity / 4-6 joeys wild (but smaller in size)
- Older females had bigger litters than 1 year olds.
- Captive young tend to be larger than wild offspring (Andrew 2005).
- Drought affects offspring growth (Andrew 2005).

10.14 Age at Weaning

The average number weaned each year crudely represented by number of enlarged teats in the female's pouch is 4.6, representing a pre-weaning mortality of at least 13% (Jones 2001).

Female able to leave young in den to hunt: 8-10 weeks of age (approx. 35mm) (SPRAT) / approx. mid-August.

Weaning / completely independent: 18-20 weeks of age / Approx. Early November. Young are approx. 33% of mother's weight (SPRAT). Weaning starts at 18-20 weeks but young may stay with their mother and drink her milk up to 7.5months of age (see 10.15).

Female does not re-breed until next breeding season if a litter is born.

10.15 Age of Removal from Parents

In captivity, young are not removed from the pouch and are generally left with their mothers until weaning age of approx. 18-20 weeks. In the wild young start catching food for themselves at approx. 12-15 weeks and are weaned at approx. 18-20 weeks. At this stage they start to leave their mother's side but regularly stay within or near her territory and even keep drinking their mother's milk as late as 7.5 months.

In captivity, young are:

- Removed from their mother at weaning age (as early as 18-20 weeks) and housed in same gender, same litter groups.
- Housed separately, or
- Males young are housed in bachelor groups and females housed with their mother.

Note: males can be housed in bachelor groups as long as they are away from females. If either male or females are introduced in pairs for breeding, they cannot be reintroduced into their gender groups as it is likely to result in fighting (as per comm. P. Ralley).

Mother Spotted Tailed Quoll with babies going for a ride. Photo Courtesy of Devils@cradle

10.16 Growth and Development

When measuring pouch young the following development stages and measurements are recorded (S. Jackson):

Development Stages:	**Measurements:**
• Sex distinguishable • Tips of ears free • Papillae of facial vibrissae evident • Eyelashes visible • Eyes open • Fur visible – slight tinge, medium or well developed • Tips of first incisors through the gums • On back or in nest • Eating solids • Self-feeding • Independent	• Weight (g) – if not on teat • Head length (mm) – from occiput to snout tip • Head width (mm) – maximum width across the zygomatic arches • Crown rump length (mm) – primarily for very small neonates • Body length (mm) – from snout tip to cloaca • Tail length (mm) – from cloaca to the end of the last vertebra of the tail tip • Tibia length (mm) – from the hip to the bottom of the pes • Pes length (mm) – from the heel to the base of the longest toe, not including the claw

DEVELOPMENT STAGES: (Andrew 2005, Jones 2001)

- **MARSUPIAL** - Born as embryonic state at approx. 7mm (crown to rump)
- **Week 0-7** attached to teat
- **Week 4** – approx. 35mm in length
- **Day 41-48** (~5-7 weeks) – fine hair starts forming on head.
- **Day 48-59** (~7-8.5 weeks) – spots start appearing visible on body
- **Day 58-67** (~7-10weeks)- spots start appearing visible on tail
- **Week 7-11** – joeys release teat and mother is able to leave joeys in nest. First vocalisations.
- **Day 82-87** (~11-12.5 weeks) – eyes begin to open
- **Day 87-92** (~12-13 weeks) – joeys are fully furred with coarser fur
- **Week 12-15** - move around independent of mother and start venturing out of den – Start eating food brought by mother and can be observed catching small prey (crickets, insects lizards, mice etc. Social play is well developed by 13 weeks.
- **18-20 weeks** (approx.) joeys are weaned and may start leaving their mother. 33% of mother's size.

  Note: Wild young stay in close proximity of mother to approx. 5.6-6 months (170-180 days) and weaning can be as late as 6.7 months - 7.5 months. Captive young tend to be weaned at 120-150 days.

- Sexual dimorphism (males larger) - apparent at 250 days old
- Sexual maturity 11-12months
- Full size at 2 years of age.

Below are some **measurements** taken by Deborah Andrew during her research of Spotted-Tail Quoll Ecology (including breeding) conducted at Featherdale Wildlife Park, over 4 breeding cycles between 1991-1994 (1991 = litters 1-3; 1992 = litters 4-6; 1993 = litters 7-8; and 1994 litters 9-12). See plates 3.6 - 3.25 in Appendix.

Note: measurements taken from different litters. * Individual measurements

Day	Length (crown - rump) (mm)	Head width (mm)	Plate #	Litter #	Comment
0 (DOB)	6.5 – 6.7		3.6	10	
6	10.6-11.3		3.7	4	
20	16.4-21.7		3.8	2	Pinnae forming
26	21.3		3.9	5	Eyes and pinnae forming
39	32.3-33.5	13.2-14.3	3.10	2	Pinnae free now from head
49	40-44.5	16.4-17.2	3.11	4	Spots appearing on head and body. Tail is well formed but no spots
58	49.1-56.9	19.3-20.6	3.12	1	Fine fur over body and spots appearing on tail. Pinnae are becoming pigmented and lie flat on head.
60			3.13	2	Tail finely furred and spotted. Rudimentary pouch visible.
65	79.8-75.5	21.4-22.9	3.15	1	Course ginger fur appearing on head. Pinnae held against head
76	111.1-114.5	25-26.6	3.16	2	Coarse ginger hair extending down the back. Pinnae

					standing out from head.
84	150-175	28.3-37.8	3.17	1	Weight 136-152g. Eyes open. Coarse ginger hair on whole body including tail.
91	163-175	32-33.4	3.19	1	Weight 179-197g.
105	220-230	33.1-37	3.20	1	Weight 256-298g
116	260-275	36.8-40.1	3.21	2	Weight 388-434g
147*	320	44.2	3.22	1	Weight 750g
177*	320 300	41.6 42.7	3.23a 3.23b	4	Weight 750g Weight 900g
218*	360, 400	51.7,54.8	3.24	1	Weight 1575g + 1725g
376*		59.3	3.25	1	Weight 1975g with x6 pouch young

GROWTH MEASUREMENTS:

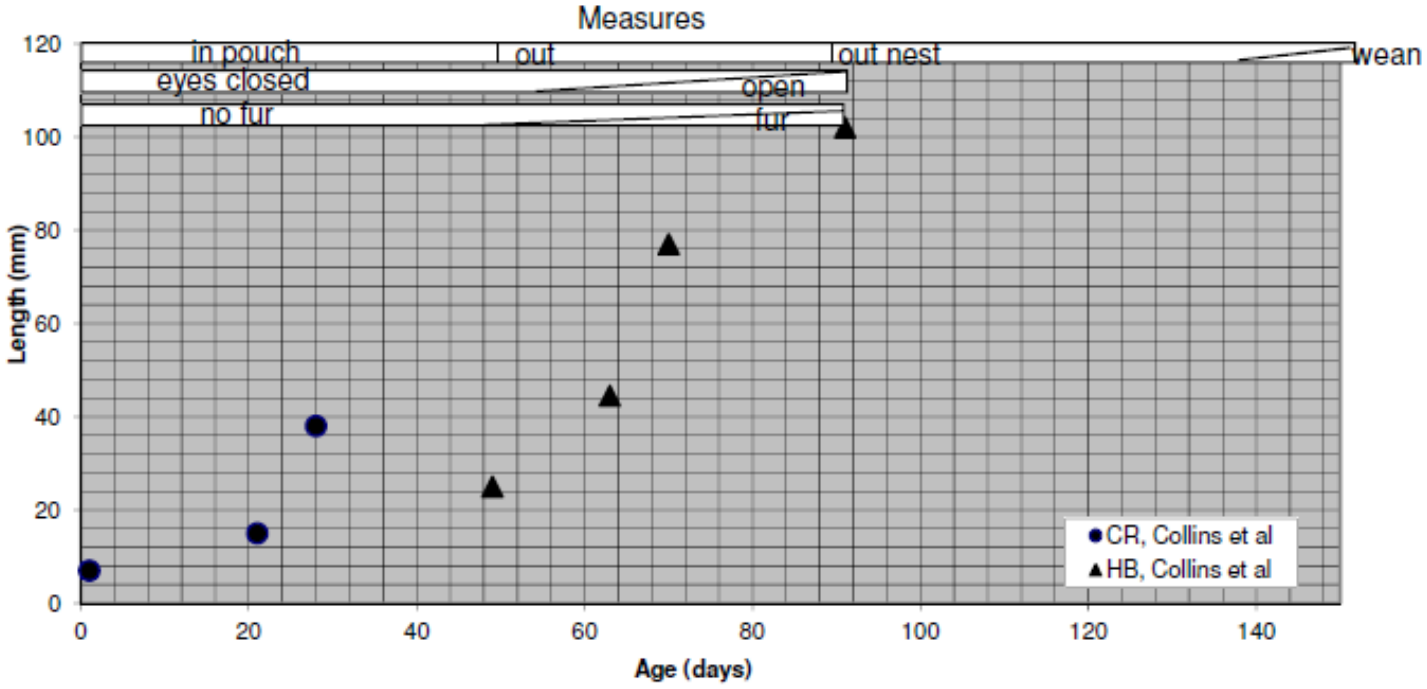
Growth rates and behaviour development chart of the Spotted-Tailed Quoll (below). Chart taken from "**Birth Date Determination in Australasian Marsupials**" 2nd Edition 2012. (Bach 2012)

TIGER QUOLL

Dasyurus maculatus

Size adults
males 380-759 mm HB
up to 7kg
females 350-450 mm HB
up to 4 kg

Gestation: 21 days



11 Artificial Rearing of Mammals

Hand rearing of spotted-tailed quolls is not a common practice. It is best to leave the pouch young with the mother to allow her to raise them in peace. If she is showing signs of stress or poor mothering, keepers should implement techniques to encourage her to keep and care for the young. This may include providing moving the female to a quieter area (away from the public, construction etc.), providing nesting boxes or other nesting areas, providing additional and varied nesting mediums or providing additional food.

Some zoos may remove juveniles early from their mothers to raise the young to be used to being housed in an enclosure or handling such as for educational purposes. Furless or juvenile spotted-tailed quolls may be rescued when the mother has be killed by humans or hit by cars, the juvenile is abandoned / ejected by its mother or juvenile has accidentally been trapped by humans.

Hand rearing of furless spotted-tailed quolls is unlikely to be successful. For additional information on rearing and care for marsupials refer to "The Care of Australian Wildlife" by Erna Walraven.

cfzaustralia@yahoo.com.au

Picture: Craig Borrow

Above (2 pictures): "Flare" was raised by Ballarat Wildlife Park

11.1 Housing

All aspects of caring and transporting young should be considered to minimse the levels of stress to the animal including:

- Preventing access by children and other animals
- Maintaining a high level of hygiene (refer 11.7 hygiene)
- Prevent escape of the joey / escape-proofing the area
- Ensure the animal is safe from dangers such as sharp edges or obstacles
- Shelter from weather and noise
- Providing a clean and comfortable environment

Furless / Smaller Furred Joeys:

Pouches: Small joeys should be kept in artificial pouches made from natural fibres such as cotton or wool; and be kept warm (see 11.2 for temperatures). Ideally the lining should be a soft cotton and then covered with wool for warmth. Pouches need to be kept clean. Ideally they should be changed and washed daily.

From pouch to weaning:

When Wild Life Sydney was rearing their litter of spotted-tailed quolls, they were placed in a quiet room away from public access and rarely entered by staff. The joeys were left in

Hot box at Wild Life Sydney Zoo like the one which a litter was housed during rearing. Photo: J.Marten

A litter raised by Wild Life Sydney Zoo
wildlifesydney.com

a pouch which was placed into a wooden box / cage (similar to a reptile cage) with glass doors, heat lamp and thermostat.

I think these hot boxes are the best option as the cage is kept at a constant temperature and monitored by a thermostat. As they begin to move they can move closer or further from the lamp as they desire.

When the joeys were increasing in size and beginning to emerge from the pouch, they were transferred to an aviary-like off-display enclosure. Their pouch was placed in a pet-pak with the door open and the joeys were allowed to explore their enclosure or return to their pouch whenever they wished.

When Brad Walker raised a litter of young quolls for Featherdale he housed them in a pet pack with synthetic grass as a floor covering. He also supplied a parrot breeding box that was lined with clean cotton clothing that was changed daily. (Walker)

11.2 Temperature Requirements

Furless joeys should be kept at 34-36oC. Temperatures can be reduced to 28-30oC as the joey develops fur. Temperatures may vary per individual and need to be adjusted accordingly. If the animal feels cold to touch (especially the feet) the animal is too cold.

Joeys should be placed in a controlled temperature environment. Temperatures can be monitored by placing a plastic coated minimum / maximum temperature gauge in the pouch with the young. Sources of heat can include:

- Keeping the pouch in a hot box similar to the one in 11.1 with heat lamp and thermostat.
- Keeping the pouch with a source such as animal heat pads or water bottles. Note that hot water bottles are not recommended as they lose heat quickly / temperatures vary and can scold skin if the animal comes in direct contact with an uncovered bottle. Ideally heat pads should be placed under 1/3 of the base of a box and the pouch not directly placed on this section of flooring, especially if it hasn't started emerging from the pouch.

11.3 Diet and Feeding Routine

The mother's milk is the most recommended milk to give to joey spotted-tailed quolls as they contain adequate levels of calcium, lipids, solids and protein. However commercial formulas may need to be used instead. For an excellent guide in rearing native animals refer to Wombaroo's "Milk Replacements and Supplements for Native Animals" at http://www.fmb.com.au/contents/en-us/milkbook.pdf

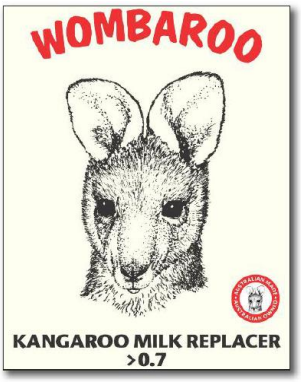
11.3.1 Milk Formulas

The formula carers / keepers give is artificial and different to its mother's natural milk. In the first 24 hours, instead of giving a commercial milk formula straight away, the joey should be given a water / glucose mixture. Mix 100ml boiled water into 1 teaspoon glucose. This prepares the joey for different milk.

Diet suggestions for rearing spotted-tailed quolls consist of low lactose milk formulas for furless and pre-wean joeys. DO NOT GIVE COW'S MILK – marsupials are lactose intolerant. Amounts vary per individual formula. It is recommended to not change formulas unless directed, as changing formulas can cause stomach upsets and diarrhea. Always use boiled water when preparing formula. For information on how to feed milk see 11.3.2 methods of feeding.

There is a range brands of milk formulas that can be used. I would use **Wombaroo** milk formulas.

Wombaroo have a large range of formulas for many groups / species of domestic and native animals, as well as a range of supplement diets that can be used in pre-adult and adult during and after weaning.



Wombaroo (Wombaroo Food Products / Passwell Pty Ltd) recommend that carnivorous marsupials, bilbies and bandicoots are fed the **Wombaroo 'Kangaroo Milk Replacer >0.7'**. Due to their short pouch life, this formula is used during the entire duration of feeding milk to the joey. I have provided the feed table in the appendices for quantities to feed per weight per day (25g powder per litre of water).

Some other brands of formulas that can be used include:

- **Biolac**: fed at 10-15% of their body weight per day. 3 formulas are available for different stages of growth including:
  1. Furless- M100
  2. Dense fur has developed – M150
  3. Starting to form solid (dark) pellet droppings – M200 (contain higher lipids in canola oil)

  It is suggested to mix formulas during transitions between formulas. Near to weaning age 2-5ml of canola oil should be added per 100ml of formula (S. Jackson 2003)
- **Digestelact** – successful for rearing quolls and Tasmanian Devils. High protein baby cereal should be added when fur is forming. Calcium powder, lean mince and Wombaroo carnivore mix should start to be introduced as teeth begin to appear.
- **Di-Vetelact** – low energy milk formula and is often supplemented with mono and polyunsaturated such as canola oil and Wombaroo diets. Given at a rate of 20% of body weight per day for joeys over 100g.

11.3.1 Methods of feeding

Milk formulas:

The joey should be warm when being fed or inhalation pneumonia can occur. Milk should be given warm at 35-36oC. Milk can be administered via:

A small Eastern Quoll young is being fed with a syringe and teat. Photo Courtesy of Bonorong Wildlife Park

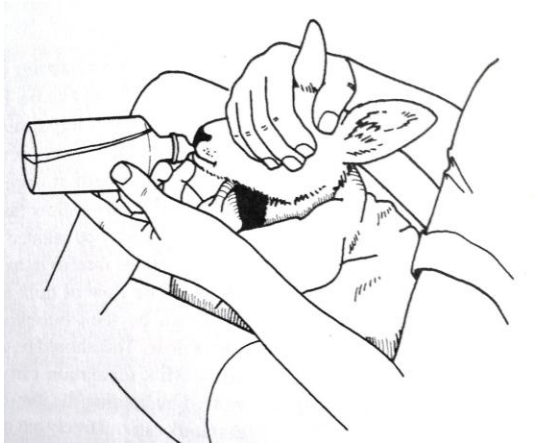
- Very tiny joeys – syringe fitted with an intravenous catheter or one inch infant gastric feeding tube or mini teat (see picture right)
- 50ml, 100ml or 120ml plastic feeder bottle fitted with special shaped latex teat. A very tiny hole is initially pierced into the end of the teat and gradually increased if adequate amounts of milk are not able to be accessed via suckling. Care must be taken that the hole is not too large and the joey is not receiving too much fluids at one time. This may result in the joey suddenly sneezing or coughing and aspirating (inhaling liquid into the airway and choking).

  Wombaroo supply both bottles and teats. The Wombaroo teat suitable for carnivorous marsupials is pictured above (code C).

C - Cats, rabbits, carnivorous marsupials

- Some joeys do not take to being bottle fed. Milk may be lapped from a small bowl. (B.Walker)

- Joeys are used to feeding in the dark pouch so joeys may drink better if feed with their eyes covered (see illustration right) and / or with their bodies still in the pouch. Keeping the joey in the pouch will also keep the joey warm during feeding.
- **Frequency** of feeds change as the joey grows and develops:
  - Unfurred – every 2-3 hours
  - Furred – approx. 5x a day (approx. every 4 hours)
  - Pre-weaning / emerged from pouch – 2-3x per day
- The joey should be encouraged / stimulated to urinate and defecate after every feed (see 11.4 Specific requirements)



Some marsupials prefer to feed with their eyes covered (picture R.Hale)

Solids: see weaning 11.10

11.4 Specific Requirements

- **Dehydration**: it is likely that the newly orphaned / rejected joey will be dehydrated on arrival. A mixture of:
  - 5g / one teaspoon of glucose added per 100ml of boiled water (not hot); or
  - 1g of electrolyte replacer (e.g. lectade); or
  - 20ml Vytrate to 250ml boiled hot

  can be given to replace hydration.

"Flare" bottle feeding. Picture: Craig Borrow

- **Warmth**: It is important that the joey is warm prior to feeding as joey may experience inhalation pneumonia. Additionally any fluids given orally or subcutaneously should not be cold (e.g. straight from refridgerator).
- **Skin**: Sorbelene cream should be applied to the skin of unfurred and slightly furred joeys to moisturise skin and prevent skin cracking and drying out as well as infection.
- **Stress**: joeys should be kept in areas that are low in noise, not over-handled and hygiene standards must be maintained (see 11.8 Behavioural considerations)
- **Toileting**: The joey should be encouraged /stimulated to urinate and defecate after every feed by rubbing its cloaca with cotton wool soaked in warm water. The joey should be dried after toileting and for unfurred joeys, have Sorbelene cream applied to their skin.

11.5 Data Recording

Records that need to be maintained include:

- At arrival
  - Date of arrival
  - Gender
  - Approximate age
  - Location found
- During rearing:

- Food consumption – type, size and regularity
- Date of all husbandry procedures
- Time of recording
- General demenour, activity and health
- Characteristists and frequency of urination and defecation
- Weights (to nearest gram)
- Veterinary examinations and treatments
- Physical changes – development stages / growth rates

Regular records will assist in recording growth curbs, background information if joey is transported or needs veterinary attention and as institutional and ISIS records.

11.6 Identification Methods

Identification depends on facility and regularly not needed. Spotted-tailed quolls can be identified with visual markings (spot formations) or a PIT tag / microchip can be administered under the skin of the nape of the neck.

11.7 Hygiene

A high standard of hygiene MUST be maintained at all times of rearing young including:

- **Personal hygiene** – ensure hands are washed / disinfected (preferably using antibacterial solutions) regularly including before and after handling the animal, other animals and equipment.
- **Pouch** – the lining should be changed after every feed or if soiled by urine or faeces – minimum daily.
- **Joey** – wipe any faeces, urine or spilt milk from the joey's skin. The animal should also be kept dry to prevent hypothermia or skin infections.
- **Feeding equipment** – wash with warm soapy water before and after use. Prior to feeding equipment should be sterilised:
  - by boiling for 10minutes and allowed to cool; or
  - in an antibacterial solution such as Halasept or Milton; and then rinsed in cold water.

  Feeding equipment can be sterilised and then stored in the fridge.
- **Milk powders** – store milk powder in a cool dry place. Airtight containers prevent moisture that can cause microbial contamination. Do not store milk powder in the fridge.
- **Feeding**
  - When formula is initially made up it can be frozen in small quantities. When needed it should be thawed completely, remixed and warmed to the correct temperature for feeding.
  - DO NOT reheat milk a second time.
  - Do not refreeze milk
  - All left overs should be disposed of.
- **Contact with animals** – keep joey separate from other animals unless health status is clear of health issues.
- **Equipment** – other equipment should be cleaned thoroughly and sterilised daily.

11.8 Behavioural Considerations

Stress must be avoided as it can depress the immune system and leave the animal vulnerable to disease. Sources of stress can include handling, foreign human and animal smells and sounds, incorrect diet, changing temperatures and presence of other animals.

The decision should be made early to decide if the young being raised is to be returned to the wild or on display natural behaviour or be tamed for educational / encounter purposes. Those who will be used around the public should be handled regularly and trained from a young age.

Joeys to be released to the wild or to display natural behaviour on exhibit should be left with the mother so they can learn the natural behaviours of their species. If hand-rearing is necessary all attempts should be made to encourage natural behaviours. Contact should be minimal (especially if to be released) as quolls can become bonded to their rearer. To encourage natural behaviours they should be raised in a group (S. Jackson 2003). If possible raise a litter together or with other orphan Spotted-Tailed Quolls of similar age.

11.9 Use of Foster Species

I haven't found any information of cross fostering of Spotted-tailed quolls but as Tasmanian Devils and Spotted-tailed quolls are closest relatives it should be possible to cross foster a spotted-tailed quoll onto a tasmanian devil. The benefits of this would be that the diets are almost identical, milk composition would be similar and as they are growing they would learn behaviour such as devils show aggression to each other and they learn to avoid devils when they are older and travelling alone. Alternatively spotted-tailed quolls could possibly be surrogated to other quoll species.

"*Although not recommended due to the very different milk composition and the potential of predation, there is a record of three abandoned juvenile Tasmanian devils being fostered to a domestic cat that reared them successfully*" (S. Jackson 2003) If Tasmanian devils can possibly be reared by cats then it should be possible that cats can rear Spotted-tailed quolls as well. However, the behaviour is different (e.g. quolls are more solitary) and milk composition is different and should be avoided.

11.10 Weaning

Joeys are weaned around 18-20 weeks (5 months) of ages. Once the teeth begin to emerge (95-105 days of age) solids such as finely diced mince, beef or kangaroo should be introduced into the diet.

At Wild Life Sydney, when teeth began to develop they gradually introduced finely diced chicken mince to their milk formula. As the quoll grew the amounts of mince gradually increased and the amounts of formula decreased.

Calcium should also be supplemented into their diet at 1 teaspoon of calcium mixed into 500g of meat (5g: 500g / 1g: 100g).
Once emerging from the pouch, water should be supplied at all times but precautions should be made that younger quolls cannot drown in their drinking water.

Pre-wean / juvenile quolls
Picture: Jay Town/Newspix/Rex

At approx. 13 weeks of age, they may start catching prey for themselves. This should be encouraged by introducing small invertebrates such as mealworms, crickets, beetles and other insects.

Note: larval stage invertebrates are high in fat content and volumes given need to be controlled. Mealworms are low in calcium so calcium needs to be supplemented if not already supplemented with other meat provided.

As the joey grows in size and teeth develop, larger sized items can be introduced into their diets including thawed mice (pinkies, furred juveniles or adults – depends on size of juvenile quoll), day old chickens, meat mixes, rabbit, kangaroo or wallaby meat, chicken necks or wings, other raw bones to chew on, eggs, yabbies' and fish. For more information on diets see chapter 6. Additionally other supplements to the natural diet can include Wombaroo Small carnivore powder or Wombaroo insectivore mix.

Young quolls can easily imprint to their rearers. There should be little to no contact during rearing if the juvenile is to be released into the wild.

However training can be initiated with younger quolls pre-weaning to acclimatise zoo held quolls to:

- Transporting via pet packs and crates
- Handling for physical checks
- Wearing a harness (see picture right)
- Training for public demonstrations

Note: handling should be controlled to prevent the quoll becoming difficult to handle when older (due to a lack of fear for humans). It must be first determined whether the animal will be required for breeding when it matures before conducting handling acclimatisation.

Barney was raised and trained to walk on a harness at Wild Life Sydney Zoo

(Picture wildlifesydney.com)

11.11 Rehabilitation and Release Procedures

11.11.1 Rehabilitation of wild animals

Young and adult Spotted-Tailed Quolls may come into care from the wild for a variety of reasons including cat or dog attacks, hit by car, orphaned, human cruelty or disease. For care of pouch and other juvenile spotted-tailed quolls refer chapter 11.1 -11.10.

To care for wildlife you can apply for a NPWS 'License to rehabilitate and release sick, injured or orphaned native fauna' under the National Parks and Wildlife Act 1974.

Before rescuing or receiving a quoll from the member of the public you need to make sure you have all the details about the animal and where it was found so that the animal can be returned to the exact location (if possible). These details include:

- A description of the animal (estimated species, age etc.),
- Place where the animal is was found
- Time when the animal is was found
- The contact details (especially phone numbers) of the finder and anyone else who has handled the animal in between
- what possibly happened to the animal (hit by car),
- any visible injuries on the animal,
- if any treatments or food has been given,
- any other details that may be relevant.

Upon arrival the quoll should be given an initial examination for any signs of disease or injuries. Don't forget to check the weight, hydration and temperature of the animal as it may be in shock. Apply first aid if needed (e.g. bandage wounds, support / splint breaks, etc.) Even if it is appears ok the animal may have an underlying issue and may need to have an anaesthetic to examine it properly. Take care not to get bitten.

Keep the animal in a warm, quiet place such as a pet pack for at least an hour of arrival to allow the animal to calm down after being stressed from handling or transport; unless it needs urgent medical attention and then it should be sent to a veterinarian immediately.

11.11.2 Release Procedures

Wild adult spotted-tailed quolls rarely adapts to life in captivity and should be released back into the wild. For hand-reared quolls (either captivity bred or wild orphans) the first thing to do prior to weaning is decide if the animal will be:

- Released into the wild, or
- Stay in captivity and be:
  - Kept at the zoo or
  - Transferred to another zoo

This may be determined by:

- Animals need to be deemed suitable for release into the wild.
- Some animals may need to permanently be housed at a zoo (or similar institution) or euthanased if deemed unsuitable for release such as being imprinted to humans or sustaining a disability that could cause predation to the individual if released.
- Some animals should be released due to circumstances such as illegal or accidental capture, illegal trafficking, or the animal not adapting for being held at a zoological park.
- There is a shortage of wild individuals in the area of origin and numbers need to increase.

KEEP AT THE ZOO:

For hand-reared quolls (either captivity bred or wild orphans):

- Handling and contact depends on the institution or what purpose the quoll is being kept at the zoo, including:
  - kept to a minimum if kept on display to display natural behaviour
  - handled regularly if used for encounters or educational purposes (also see training below)
  - Training – some zoos may want the animal handled or trained when younger to acclimatise the animal to handling / restraint for purposes such as veterinary examination or treatments, transportation, cleaning enclosures.

  Note: "When an institution is deciding whether to raise a quoll for interaction it must be first determined whether the animal will be required for breeding when it matures. Long-term intensive training is required for a S.T. Quoll to be suitable for interaction and it is likely that the animal will become aggressive after breeding. A hand-raised animal with no fear of people will then become difficult to manage and require protected contact husbandry." (Per comm. K.Blout)
- Hunting should be encouraged by introducing invertebrates such as crickets; at weaning.
- Have a veterinary examination to clear for release. The veterinarian should be qualified to assess the health of native animals.
- The animals over all condition needs to be assessed and any issues corrected including:
  - If underweight (malnutrition) or overweight
  - Injuries or disabilities
  - Other health issues

- If kept at a zoo, how will the individual be housed – on display, with siblings of the same gender, off display to be used for breeding etc.?
- Time of release – depends on if kept in outdoor or indoor (nocturnal) enclosures. Release (into new enclosures) for quolls kept in nocturnal houses should be acclimatises to reverse lighting and released in the morning before light settings change to night settings when the quoll is still in its nesting box. This will also be before the public enters the zoo so the quoll has time to explore its enclosure in peace. This is also an ideal time for keepers can monitor the animal's progress and stress levels throughout the day.

  Similarly quolls kept in outdoor enclosures should be released at dusk or late afternoon after closing time, when it will become more active. A staff member should stay to monitor the animal's progress and stress levels. If released in the early morning it should be closer to dawn before the public arrive.

TRANSFER TO ANOTHER ZOO:

- Same rules apply as kept at the zoo, but it should be checked beforehand what role the quoll will have at the other zoo (kept on display showing natural behaviour, used for breeding or used for education or for public encounters). This will vary the amount of handling or training the animal receives.
- The correct transport containers need to be organised before transport (see Chapter 7).

RELEASE INTO THE WILD:

Wild Spotted-tailed quolls rarely adapt to life in captivity and should be released back into the wild. Generally wild animals that are rescued and rehabilited should be returned to the the same or surrounding location of where it was found. The wild animal will be familiar with the location including where to nest and find food. Hand reared individuals will not have this instinct so they can be released to a similar location as long as they do not impede on the exisiting populations in the area of release.

Prepare the animal for release:

Prior to release all quolls (especially hand-reared quolls) should be prepared for release including:

- Human contact should be kept to a minimum as quolls and Tasmanian devils can easily imprint to their rearer/s or carers.
- Hunting should be encouraged by introducing invertebrates such as crickets; especially for weaning quolls.Have a veterinary examination to clear for release. The veterinarian should be qualified to assess the health of native animals. The quoll should be in excellent condition at release. Each individual's over all condition needs to be assessed and any issues corrected including:
- If underweight (malnutrition) or overweight
- Injuries
- Other health issues are assessed. Will the animal survive with a current disability or disease?
- Predators - Ensure that the released quoll is not near other predators at time of release and that the animal has skills to avoid predation from others. This could be achieved by housing the individual in enclosures next to adult spotted-tailed quolls or devils who will show aggression toward the new and / or younger individual.

Eastern quolls are being trained not to eat cane toads and released with radio tracking collars to see if their work is paying off.
Picture
http://www.canetoadsinoz.com/savingpredators.html

- Start acclimatising the animal to outside conditions such as housing the adult or post weaning animal in an outside aviary-like enclosure.
- Quolls have started being trained to not eat cane toads by lacing dead one with minor doses of toxins. The toxins make the quolls temporarily ill and teach the quolls that cane toads are not good to eat.
- Worming - is it worth it (pre-release)?

Research release site:

Prior to release to a new area the release site must be assessed for suitability. The area should have suitable amounts of:

- **Food and Water**: Prey species to hunt and an adequate (quality and quantity) water source.
- **Habitat** - Shelter and nesting sites e.g. hollow logs, rocky crevices etc.
- **Hazards** - Have minimal hazards (roads, deforestation, pest species, fires etc.)
- **Competition / resident population** – are others quolls in the area? Do they pose a hazard to the quoll you are releasing?

Prepare the release site (prior to release):

If the animal is going to be released via soft release (see release methods below) noegal caging or fenced areas need to be set up at the release site (including furniture) and secured to keep other animals out.

- Pest control – foxes can be controlled with baiting programs using 1080 and removing any weeds of blackberry that foxes use for shelter. Rabbits are hard to reduce but if numbers of rabbits are high then foxes are attracted to the area.
- Nest boxes could be placed at the release site but it should not be necessary.
- Programs where volunteers remove road kill from roads.

Release methods:

- **Hard release** – Adults that have not been in care for longer periods of time can be released directly back into its original habitat.
- **Soft release** – an option is to house the quoll in a temporary cage at the release site to acclimatise the quoll to its new surroundings. I find this is especially important for hand reared from the wild or captive breed quolls that are not used to natural conditions and do not have an established home range.

Quolls in soft release enclosures have minimal human contact but food is provided. Eventually the enclosure is left open so that the quoll can exit in its own time but food is still provided after the door is opened. Provisions of food is gradually reduced and stopped.

Some sites have special fenced off areas to prevent predators and rabbits getting into the site and allows the released animal to investigate its new environment safely.

These have been successful for releasing Bilbies (*Macrotis lagotis*) in Currawinya National Park, Queensland (see fig.11.11) and the Western Quolls (*Dasyurus geoffroii*) in Wilpena Pound in the Flinders Ranges, South Australia (see fig.11.11a).

Fig.11.11 Currawinya's bilby fence
http://www.savethebilbyfund.com/our-work.php

Fig 11.11a Western quoll fenced off release area in Wilpena Pound SA. (":Helping hand" Landline ABC)

The bilby fence design is: (from http://www.savethebilbyfund.com/our-work.php)

- A 400mm wire netting "skirt" at the base of the fence on each side blocks invaders from burrowing in and Bilbies burrowing out under the fence.
- 4100 short "springy" wires pull the netting across to create a "floppy top" which stops foxes and cats climbing over.5000 volts of electricity pulse through six surrounding wires, preventing emus and kangaroos from crashing into and damaging the netting.

I think the fenced areas are the best option for released quolls as it has freedom to move, protected from most outside sources and are exposed to the natural environment.

Release day:

- Time of release – release is best done in the late afternoon / dusk for animals released into the wild. The quoll can be caught up while it is asleep in its nest box (block its exit from box and secure the box so the quoll cannot escape) and transported in the nest box. This will reduce the stress of having to try to catch a moving quoll and it will be familiar to the nest box. The nest box can be placed at the site of release and the quoll given access to escape in its own time. The nest box can be left at the site for a short time
  to provide additional housing / shelter post-release.
- Place of release – If it is a wild animal it is best to release the animal back to the same area it was found. This will increase the chances of success of survival as it has an established home range where it is familiar with the habitat to find food and compete with other quolls and similar predators. If introduced to a new area the area should be assesses for suitability (see research release site above).
- Prior to caring for an animal a person needs to acquire a permit to care for native fauna through NPWS.

This "LTL Acorn" scouting camera is a regularly used device to monitor animals in captivity and in the wild. It takes videos or motion sensored photos. Photo J.Marten

Monitoring and conservation work:

Additionally it should be decided if and how the animal should be monitored post-release e.g.

- Tagging e.g. microchips or ear tattoos
- Equipment - Radio tracking collars and wildlife monitoring systems / cameras (infrared, scouting cameras, Hyperfire Reconyx etc.) cameras have successfully monitored movements of animals

- Trapping – regular surveys by NPWS and research groups could conduct trapping and monitor details of released animals.
- Sniffer dog programs to sniff out quoll scats to survey populations.
- Some local governments have special quoll sighting programs where members of the public can report sighting of quolls in their area, especially in Queensland. Refer your local government.

For more information regarding the management of wild spotted-tailed quolls refer to the Australian "Action Plan for Australian Marsupials and Monotremes" (for both subspecies of Spotted-Tailed Quoll) found in the Appendix of this Husbandry Manual.

Or refer to chapter 1.5 Wild Population Management for details about other key actions taken to protect wild quolls. Other good groups managing wild quoll monitoring are the:

Quoll caught on an infrared camera
Picture Spotted Gold (Quoll Seekers).

- **Quoll Seekers network** (Wildlife Queensland)

  http://www.wildlife.org.au/projects/quolls/

  In 2009, the Quoll Seekers Network did:

  – 5 quoll discovery days – with 210 people attending
  – 49 quoll-proof poultry pen applications – with 23 successful applicants
  – 16 schools visited - with 1159 students attending
  – 46000 hours of camera surveillance
  – 45 new quoll records
  – 218 new QSN members
  – 35 radio, television and newspaper appearances (that we know of)
  – 5 Quoll Seekers Network newsletters
  – 1000 Quoll Info kits produced – distribution continues through online sales
  – 5000 Mary River quoll brochures distributed.

  They also:

  – plant native trees
  – undertake weed control
  – host Quoll Discovery Day and information sessions within the community
  – install infrared cameras to monitor fauna.

- **Conservation Ecology Centre** (Victoria) – website www.conservationecologycentre.org/ or video about their work at http://www.youtube.com/watch?v=Kfku3kzxGbk
  – breeding insurance populations of Spotted-Tailed Quolls
  – training sniffer dogs to detect Spotted-Tailed Quolls (scats) in the wild, with a view to identifying low density populations
  – partnerships with companies such as Prickly Moses selling a brand of ale "Spotted Ale" for fundraising to quoll research and breeding
  – public involvement programs including accommodation options; where funds contribute to their work

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15 Glossary

A

Abandoned: left behind usually by a parent/s

Abnormalities: varying from what is regular or usual

Abscess: A collection of pus in a cavity / Infection building up generally under the skin

Abundance: plenty

Acclimatise / acclimatisation: to make a person / animal familiar and unfazed to a situation, surroundings etc.

Acquisitions: the delivery and ownership of a new animal

Adjacent: next to

Aesthetic: looks / appearance

Aetiology: cause

Alopecia: a skin condition which results in patches of hair loss

Altricial: young are born in a relatively underdeveloped state; they are unable to feed or care for themselves or locomote independently for a period of time after birth/hatching.

Amputation: removal of a body part such as a limb.

Anaesthetics: loss of consciousness or feeling in a part of the body with the use of drugs.

Anthelmintics: prevention medicine again internal parasites (worms) / endoparasites

Animal liberationists: groups of people who fight for animal rights

Antibiotics: medications to fight infections

Arboreal: Referring to an animal that lives in trees; tree-climbing.

Aromatherapy oils: scented oils

Artificial: an action or object made or produced by human beings rather than occurring naturally, especially as a copy of something natural.

Axilla: an armpit

B

Basking: lie in the sun absorbing the sun's rays

Behaviour: the way an individual acts / conducts oneself

Benign tumours: a tumour that is not cancerous

Biopsies: collecting a sample of (bodily) tissue to conduct medical tests.

Blindness: inability to see – varies in degrees.

Bow-legged: often refers to a posture of an individual with a spinal or leg abnormality / injury. Causes the individual to walk unnaturally such as walking tiptoed with knees pointing out. Legs resemble an archer's bow.

Breed / Breeding: the process to produce offspring including copulation, pregnancy and rearing.

Bungee feeder: an elasticised cord which food is connected and is hung up or connected to another surface. The animal will experience tension when attempting to pull / take food away.

C

Captive: to be housed in an institution

Capture: to catch an animal

Carnivore: an animal that mainly eats meat

Carrier: Pet pack. A plastic cage with a handle on top to hold and transport animals, often used domestically for cats.

Carrion: flesh of dead animals.

Carcass: a whole (or part of a) dead body.

Cataracts: cloudiness forming in the lens in the eye that reduces the individual's vision / causes blindness.

Chemical: a distinct compound or substance, especially one which has been artificially prepared or purified. Generally refers to cleaning products used in a facility.

Chemical restraint: anaesthetics.

Cloaca: The common cavity into which the intestinal, genital, and urinary tracts open in vertebrates such as fish, reptiles, birds, and some primitive mammals.

Collapse: (of a structure) suddenly fall down or give way. (of a person) fall down and become unconscious or lose mobility as a result of illness or injury.

Colony: a group of the same type of individuals that live together

Construction: the action of building something

Controlled temperature: An enclosed cage layout (or pouch) where temperatures stay at a constant temperature often with a thermostat controlling a heat source such as a heat lamp.

Convulsions: a sudden, violent, irregular movement of the body caused by involuntary contraction of muscles and associated especially with brain disorders such as epilepsy, the presence of certain toxins or other agents in the blood, or fever in children.

Copulation: the act of sexual intercourse / having sex

Corneal reflex: also known as the blink reflex, is an involuntary blinking of the eyelids elicited by stimulation of the cornea, or bright light, though could result from any peripheral stimulus.

Crepuscular: time of day where light levels are low – dawn and dusk (twilight)

Cross fostering: placing a young animal from one species with a female from another species in hoping that animal raises that young animal as their own offspring.

Culturing (fungassays): maintain (tissue cells, bacteria, etc.) in conditions suitable for growth – testing for bacterias, fungus etc. by growing in a sample in specific medium

Curiousness / curious: taking interest in something. Eager to know or learn something.

D

Dasyurids: family of Australian carnivorous marsupial species

Defecation: the discharge of faeces (pooh) from the body.

Demenour: Behaviour / mood of an animal. Often refering to the depiction of the health of the animal by its behaviour.

Dentition – checking for levels of wearing of teeth

Depression: is often accompanied by a range of other physical and psychological symptoms that can interfere with the way an individual is able to function

Detergents: a water-soluble cleansing agent which combines with impurities and dirt to make them more soluble, and differs from soap in not forming a scum with the salts in hard water.

Development stages: the process of growth and change of the body from birth to adulthood

Device: a thing made or adapted for a particular purpose, especially a piece of mechanical or electronic equipment.

Devoured: ate / to consume enthusiastically

Diagnosis: determination of the nature of a disease

Diets: food types and sizes of meals consumed

Discharges: the emission of a liquid – varying in consistency – not usually present from a surface of the body. Usually refers to (infection) pus or blood from a bodily organ such as the nose, eyes, ears, mouth, skin or cloaca.

Disposition: transporting out of facility

Diurnal: during the day. Animal is active during the day

Dorsal: top of body e.g. back; top side of the head etc.

Drainage: cause the water or other liquid in (something) to run out, leaving it empty or dry.

Durable: strong, able to withstand pressure

E

EAPA: Exhibited Animals Protection Act 1986

Ectoparasites: parasites that live on the outside of the body e.g. fleas, ticks.

Educational: to teach others about something. In zoos this may mean demonstrations at the zoo, schools, public places or at events.

Ejected: A juvenile is rejected and pushed out of the pouch separating it from its mother's milk supply / food source.

Embryonic state: born undeveloped - similar to an embryo still developing in a placental female animal – that needs to drink milk and stay protected in its mothers pouch until fully formed and almost able to care for itself.

Emerge: to come out of the pouch

Enclosure / Exhibit: an area that an animal is securely housed. An enclosure represents its natural environment and must provide all physical and behavioural needs for the individual species housed within.

Endangered: (IUCN definition) ≥70% A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

Endoparasites: parasites that live on the inside of the body e.g. intestinal worms

Enrichment: various methods which improve the quality of life for an individual. Behavioural enrichment includes Feeding Strategies, Manipulative, Environment, Sensory and Social

Environment: 1. the surroundings or conditions in which a person, animal, or plant lives or operates. 2. the natural world, as a whole or in a particular geographical area, especially as affected by human activity.

Escape-proofing: securing an area to prevent an animal from escaping (getting away).

Euthanisation / euthanasia / euthanise: the deliberate and humane killing of an animal. The method varies per species of animal but is usually via a dose of a particular chemical.

Examination: a detailed inspection or study. Checking an animal or its environment for abnormalities.

Extinct / Extinction: the eradication of an entire species where there are no living specimens remaining. A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout

its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

F

Facial vibrissae: any of the bristle-like sensitive hairs on the face of many mammals; a whisker.

Faeces: waste matter from the digestion of food / excretions from the digestive tract.

Fighting: aggression between individuals that could result in harm to one or both individuals.

First Aid: initial emergency care and treatment of an injured person before complete medical and surgical care can be provided / secured.

First aid officer: person who applies first aid when a person if injured

Flaccid (pouch): soft, flabby

Foraging: (of a person or animal) search widely for food or provisions.

Fostering: the rear an animal from another mother.

Furless: to have not grown hair yet.

G

Gastric: of the stomach / digestive system

Gestation: length of time of pregnancy. The period of development of the young in mammals, from the time of fertilisation of the ovum to birth.

Gingivitis: inflammation of the gums

Glandular: pertaining to the glands. Glands are an organ composed of cells which secrete fluid prepared from blood for either use in the body or to assist excretion of waste

Gorging: eat a large amount greedily; fill oneself with food. Over eating.

H

Habitat: the natural home or environment of an animal, plant, or other organism.

Hand rearing: A person (human) rears an animal that cannot be reared by its mother or another of the same or similar species.

Hazard: a danger or risk.

Hazardous (criteria): an animal that has the ability to maim a person

Herbivore: an animal that has a diet of plant matter

Holding facilities: Alternate temporary caging

Home ranges: an area over which an animal or group of animals regularly travels in search of food or mates, and which may overlap with those of neighbouring animals or groups of the same species.

Horizontal: parallel to the plane of the horizon; at right angles to the vertical. Left to right / right to left.

Hot box: an enclosed cage similar to a reptile cage with heat lamp and thermostat

Hunched: raise (one's shoulders) and bend the top of one's body forward.

Hygiene: high levels of cleanliness.

Hypothermia: to get extremely cold, below a certain body temperature

I

IATA Container: animal transport box approved by The International Air Transportation Association (IATA) to transport a particular species of animal under specific guidelines.

Illegal: against the law

Imprint/ed: when a young animal gets attached to a carer / rearer and behaves like humans instead of its own species.

Inhalation pneumonia: Fluid is breathed into the lungs and results in a lung infection.

Inject / injectable: forcing a liquid under the skin (subcutaneously), into tissue (e.g. Intramuscular) or into the bloodstream (intravenously) via a needle and syringe.

Insecticidal sprays: aerosol to administer vaporous chemicals to kill insects.

Institution: an organisation founded for an educational, professional, or social purpose e.g. zoo.

Interchangeable: able to change parts of an item

Interspecific Compatibility: housing two or more different species together

Intraspecific Compatibility: housing two or more individuals of the same species together

Intra-sexual: referring to two or more individual of the same genders

Invertebrates: animals that lack a backbone such as an arthropod, mollusc, annelid, coelenterate, etc.

Irritability: having or showing a tendency to be easily annoyed. Reacting excessively to a stimulus.

Isolation / isolated: to house in solitary or away from other to prevent spread of disease.

IUCN: International Union for the Conservation of Nature

J / K

Juvenile: young animal. For or relating to young. Sub-adult.

Keeper: a person who cares for the health and wellbeing of animals in an institution such as a zoo.

Kibble: commercially produced dry animal (usually dog or cat) food

L

Lacerations: a deep cut or tear, especially in skin; a gash.

Lactating: the process where a female produces and secretes milk to feed to an offspring

Latrine: a communal area that various individuals use to defecate and urinate.

Legislation: a collection of laws.

Lesions: a region in an organ or tissue which has suffered damage through injury or disease, such as a wound, ulcer, abscess, or tumour.

Lethargy: a lack of energy and enthusiasm

Listlessness: lethargy. A feeling of lack of interest or energy

Locomotion: mobility / movement of limbs. Movement or the ability to move from one place to another.

M

Malignant: (of a disease) very virulent or infectious.

Manipulative: handle or control (a tool, mechanism, information, etc.) in a skilful manner

Marsupial: a mammal of an order whose members are born incompletely developed and are typically carried and suckled in a pouch on the mother's belly. Marsupials are found chiefly in Australia and New Guinea, and also in America.

Maximum: The most

Metabolic Bone disease: Metabolic bone diseases are disorders of bone strength, usually caused by abnormalities of minerals (such as calcium or phosphorus), vitamin D, bone mass or bone structure.

Midline: a median line or plane of bilateral symmetry, especially that of the body. "The abdomen was opened by midline incision"

Minimise / Minimum: the least

Monitoring: observe and check the progress or quality of (something) over a period of time; keep under systematic review.

Morphometrics: the process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

MSDS: Material Safety Data Sheet. A Safety Data Sheet (SDS), previously called a Material Safety Data Sheet (MSDS), is a document that provides information on the properties of hazardous chemicals and how they affect health and safety in the workplace. For example an SDS includes information on the identity of the chemical, health and physicochemical hazards, safe handling and storage procedures, emergency procedures, and disposal considerations.

N

Native: (of a plant or animal) of indigenous origin or growth.

Natural fibres: materials made from natural sources such as cotton or wool; that are not artificially made.

Near Threatened: (IUCN definition): A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

Neonates: a newborn child (or other mammal)

Nest boxes: a box designed as a nesting place for birds and other animals to provide shelter, a place to rest and to encourage them to breed there.

Nocturnal: during the night. Animal is active during the night

Nomenclature: Categorised Taxonomic identification of fauna and flora as kingdom, phylum, class, order, family, genus and species names.

Non-parous: female has never had a litter / offspring.

Non-rebreathing circuit: tubing attached to an anaesthetic machine in which oxygen and vaporous anaesthetics are passed from anaesthetic machine, breathed in by the animal and scavenged (expelled to outside of the room) away from the animal in a one way system. Vapours are not filtered or reused.

O

Obesity: excess weight (fat) carried by an individual

Obstacles: Objects to fall over or blocks the way.

Occiput: the back of the head.

Occupational: relating to a job or profession

Oestrous: applies to nonhuman mammals: a state or period of heightened sexual arousal and activity

Off-display (Off-Exhibit): housed out of view of the public.

Offspring: children from a pair of individuals (male and female).

Omnivore: an animal that eats both meat and plant matter

Oral: of the mouth

Orientation training: information given to new staff or visitors to work in a safe manner in a working environment

Osteoarthritis: degeneration of joint cartilage and the underlying bone, most common from middle age onward. It causes pain and stiffness, especially in the hip, knee, and thumb joints.

P

Pacing: walk at a steady speed, especially without a particular destination and as an expression of anxiety or annoyance. In animals it is displayed as a stereotypic behaviour such as boredom or waiting for meals delivered at the same time daily.

Papillae: a small rounded protuberance on a part or organ of the body / a small (nipple-like) rounded protuberance on the body

Paralysed: usually refers to a sudden inability to walk / loss of mobility. a. Loss or impairment of the ability to move a body part, usually as a result of damage to its nerve supply. b. Loss of sensation over a region of the body.

Parous: female has previous had a litter.

Pathology: the science of the causes and effects of diseases, especially the branch of medicine that deals with the laboratory examination of samples of body tissue for diagnostic or forensic purposes.

Periodontal disease: a disease that attacks the gum and bone and around the teeth

Perpendicular: at an angle of 90° to a given line, plane, or surface or to the ground.

Pes: the foot

Pet-pack: see Carrier

Phantom pregnancy: an abnormal condition in which signs of pregnancy such as amenorrhoea, nausea, and abdominal swelling are present in a female who is not pregnant. False pregnancy – shows all signs of pregnancy but without an embryo being present.

Plaques: a small, distinct, typically raised patch or region on or within the body resulting from local damage or deposition of material.

Poison: a substance that when introduced into or absorbed by a living organism causes illness or death.

Polygynous: one female to several males for breeding

Polyoesterous: females can undergo a second oestrous if unmated or first litter is lost prematurely.

Population: 1. all the inhabitants of a particular place. 2 a community of animals, plants, or humans among whose members interbreeding occurs.

Post-mortem: conducting an autopsy (cutting a dead body open) to decide a cause of illness or death.

Posture: a particular position of the body. Usually refers to the way an animal sits, stands or moves.

Pouch/es: The pouch is a fold of skin with a single opening that covers the teats. Inside the pouch, the blind offspring attaches itself to one of the mother's teats and remains attached for as long as it takes to grow and develop to a juvenile stage. Artificial pouches (chapter 11) are pieces of material in the shape of a small sack that acts like a mother's natural pouch providing warmth and shelter. Feeding is usually done separately from the artificial pouch.

PPE / PPCE: Personal protective (clothing and) Equipment. Items of clothing or similar that are worn to protect the wearer from hazards in the workplace.

Pouch checks: the motion to view the inside of a mammal's pouch to check if there is a presence of young.

Predator: an animal that naturally preys (hunts) on others.

Predation: To be preyed upon

Pregnant: the development of an embryo / offspring in the uterus.

Prehensile: (chiefly of an animal's limb or tail) capable of grasping.

Pre-wean: the age on an animal where its diet gradually changes from its mother's milk to solid food.

Pre-weaning mortality: the amount of neonates that die while still developing in the pouch / while suckling milk from its mother.

Prey: an animal that is hunted and killed by another for food.

Preventative treatments: medications given in attempt to stop an animal from getting certain diseases e.g. vaccinations.

Psychological: of, affecting, or arising in the mind; related to the mental and emotional state of a person.

Pulse rate: heat beats per minute

Q / R

Quarantine: a state, period, or place of isolation in which people or animals that have arrived from elsewhere or been exposed to infectious or contagious disease are placed.

Rainforest: rainforests, both temperate and tropical, are dominated by trees often forming a closed canopy with little light reaching the ground. Epiphytes and climbing plants are also abundant. Precipitation is typically not limiting, but may be somewhat seasonal.

Receptive (breeding): time of oestrous when a female is able and willing to mate.

Reflexes: an action that is performed without conscious thought as a response to a stimulus.

Respiratory: breathing

Restrain / Restraint: prevent an animal from doing something; keep under control or within limits. Usually means to hold an animal in a way restrict movement especially to examine the animal, administer medicines or anaesthetics, transportation or prevent biting and scratching.

Reproduction: the production of offspring by a sexual or asexual process.

Reverse light cycles: daytime lighting that runs during night-time hours and night-time darkness operates during daytime hours.

Rodenticides: chemical products used to control (by killing) pest rodents such as rats and mice.

S

Scat: faeces

Scavenger: an animal that feeds on carrion, dead plant material, or refuse.

Scent marking: communicates by producing scents from special gland(s) and placing them on a surface whether others can smell or taste them

Scold: Burn

Seasonal breeding: breeding is confined to a particular season

Secretive nature: behaves in a way to prevent notice

Security: procedures / measures taken to protect people from harm.

Segments: each of the parts into which something is or may be divided.

Sexual dimorphism: distinct difference in size or appearance between the sexes of an animal in addition to the sexual organs themselves.

Sexual maturity: when an animal is old enough to start breeding

Shelter – hiding and resting places that are covered to protect the animal from the weather (including heat, rain and wind) including nest boxes and other furniture such as hollow hogs etc.

Singularly: lives alone

Sire: be the male parent of (an animal).

Solitary: lives alone

Spatial requirements: the legal requirement to house an animal / minimum legal enclosure size

Spores: a minute, typically one-celled, reproductive unit capable of giving rise to a new individual without sexual fusion, characteristic of lower plants, fungi, and protozoans.

Spot cleaning: removal of wastes and tidying of an area (enclosures) with thorough cleaning such as disinfection, cleaning windows etc. to ensure the area looks nice for public viewing and is clean enough that the animal is comfortable and free of disease.

Stereotypic behaviour: negative behaviour that has developed in an animal from poor husbandry (e.g. overcrowding, lack of training), lack of enrichment or disease. Examples include pacing, swaying, biting keepers, etc.

Sterile: aseptic, completely clean and free from microorganisms.

Sternal Gland: a gland on the chest that is mainly used to scent mark especially during the breeding season.

Stimulate: raise levels of physiological or nervous activity in (the body or any biological system).

Stress: a state of mental or emotional strain or tension resulting from adverse or demanding circumstances.

Subcutis: certain layers of tissue under the skin.

Subcutaneous: under the skin.

Subspecies: A taxonomic subdivision of a species consisting of an interbreeding, usually geographically isolated population of organisms.

Substrate: the substance that the ground is made out of or covers the ground e.g. dirt, mulch, sand etc.

Supplements: the addition of missing vitamins and minerals to an insufficient diet. Supplements are usually mixed into an animal's regular diet to assist with administration.

Surgical debridement: Debridement is the process of removing non-living tissue from pressure ulcers, burns, and other wounds; and assists in speeding the healing.

Surveys: examine and record information / features about (animals / an area of land) and consolidate information to gain conclusions and construct plans or descriptions.

T

Technique: a way of carrying out a particular task, especially the execution or performance of an artistic work or a scientific procedure.

Terrain: a stretch of land, especially with regard to its physical features.

Terrestrial: Living on the ground.

Territorial: defends an area within the home range, occupied by a single animals or group of animals of the same species and held through overt defence, display, or advertisement

Threatened: cause (someone or something) to be vulnerable or at risk; endanger. ~species:

Topical: applied on the skin

Transferred: move from one place to another

Transmissible: catching: (of disease) capable of being transmitted by infection

Trip hazards: Any situation where there is an increased likelihood of tripping or fall over (e.g. items on the ground, stairs that do not have a uniform tread or riser height all the way along the stairs).

U / V

Urban / urbanisation: living in cities and large towns, landscapes dominated by human structures and activity.

Urination: excreting waste fluids (urine) from the body

Vegetation: plants considered collectively, especially those found in a particular area or habitat.

Venepuncture: the insertion of a needle into a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous (drug) injection.

Ventilation: air flow

Vertebrates: an animal of a large group distinguished by the possession of a backbone or spinal column, including mammals, birds, reptiles, amphibians, and fishes.

Vertical: at right angles to a horizontal plane; in a direction, or having an alignment, such that the top is directly above the bottom. Up and down.

Visual: uses sight to communicate

Vocalisation: creating sound with the vocal cords as forms of communication e.g. stress.

Vulnerable: (IUCN definition) A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.

W

Wean / Weaning: the gradual refusing to feed an offspring from its mother's milk and accustom the young to other (solid) food

Weigh / Weight: how heavy an animal or object is

Welfare: the health, happiness, and fortunes of an individual or group.

Wild: (of an animal or plant) living or growing in the natural environment; not domesticated or cultivated. Not normally held in captivity.

Workcover: A government body that actively works to implement laws to ensure safe work practices. Workcover administer and oversee work health and safety, licensing and registration, workers compensation insurance, workers compensation benefits and sustainable return to employment for injured workers.

Y / Z

Zoonoses: diseases that can be transmitted from animals to humans.

Zygomatic arches: The bony arch in vertebrates that extends along the side or front of the skull beneath the eye socket and that is formed by the zygomatic bone and the zygomatic process of the temporal bone.

Definitions derived from:

- IUCN RED LIST CATEGORIES AND CRITERIA Version 3.1 Second edition http://jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf
- King Hawley Weller, "Australian Nurses' Dictionary" 4th Edition
- Google
- My own knowledge of definitions or wording

16 Appendix

(E.g. equipment details, suppliers and drug details)

Chapter 1:

Action Plan for Australian Marsupials and Monotremes

From:

Australian Government – Department of Environment

Dasyurus maculatus maculatus http://www.environment.gov.au/node/14782

Dasyurus maculatus gracilis http://www.environment.gov.au/node/14779

Wildlife Australia, December 1996

ISBN 0 6422 1395 X

Recovery Outline

Spotted-tailed Quoll (SE mainland+Tas)

1 Family: Dasyuridae

2 Scientific name: *Dasyurus maculatus maculatus* (Kerr, 1792)

3 Common name: Spotted-tailed Quoll, Spot-tailed Quoll, Tiger Quoll (SE mainland+Tas)

4 Conservation status: Vulnerable: C1,2a

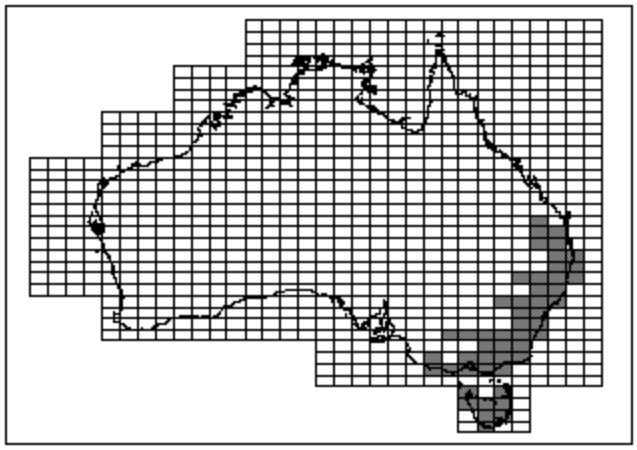
5 Intra-specific taxa:

Two subspecies have been described, *D. m. maculatus* from the south-eastern mainland and Tasmania, and *D. m. gracilis* from north-east tropical Queensland. *D. m. gracilis* is Endangered.

6 Former distribution:

South-eastern Queensland (as far north as Bundaberg and as far west as Chinchilla), eastern NSW, Victoria, South Australia, Tasmania (including some Bass Strait Islands).

7 Current distribution:



In south-east Queensland has undergone a range contraction indicated to be in excess of 30% over the last 25 years and is now rare in most areas. Remaining populations are concentrated in the Blackall/Conondale Ranges, southern Darling Downs (Stanthorpe to Wallangarra), Main Range (Goomburra to Spicers Gap), Lamington Plateau and McPherson/Border Ranges (Springbrook to Mt Lindsay).

Still extant in the ACT and eastern NSW, patchily distributed as far west as Warrumbungles NP with a number of localised areas where reasonably abundant, mostly in wet forests. Most abundant populations believed to be in north-eastern NSW, where most commonly encountered on the north coast and ranges from the Hunter Valley, Taree, Port Macquarie to Coffs Harbour and gorges and escarpments of the New England Tableland.

In Vic., now patchily distributed through the Eastern Highlands, East Gippsland, the Otway Range and the Mt Eccles - Lake Condah area. Records since 1970 are concentrated in the upper Snowy River valley, the Otway Range, Mt Eccles NP, the Rodger River - Errinundra Plateau area and around the Gippsland Lakes (Mansergh 1995). There is a recent

(1991) record from the Murray Mallee near Swan Hill; however, no population has been located.

In Tasmania is absent from islands and absent or rare in the central midlands and parts of the central east coast cleared for agriculture. Records (339) during the past 30 years show it is more frequently recorded in wet forests or scrub in the north-east highlands and the west of the State (Rounsevell*et al.* 1991). There is no evidence of a decline in distribution or in numbers in remaining suitable habitat but the species is nowhere common (it may be naturally rare). Extinct in South Australia.

Overall, many populations are physically and genetically isolated. Total range reduction unknown, but could be as high as 50%.

8 Habitat:
Forests, woodlands, wet forest alliance, rainforest, coastal heaths and coastal wet scrub, estuarine areas and rocky headlands.

9 Reasons for decline:
Combination of habitat loss and fragmentation, possible disease at turn of century, competition with foxes and feral cats, predation by foxes and dogs and impact of widespread strychnine baiting for dingoes. Most recently non-target mortality from trapping and poisoning (use of 1080 poison without adequate protection of non-target species is of major concern in most States within range). Direct persecution is significant as they are attracted to caged birds and do not necessarily take flight when discovered.

Estimated forest loss as a result of clearing within its former range in south-east Queensland is over 70%, with the majority of loss occurring over the last 20 years.

The species uses a large number of den sites throughout the year and activities that impact on the number of den logs are likely to be significant. Spot-tailed Quolls are susceptible to 1080 poisoning and may be affected by fox control programs.

In Tas. this taxon is naturally rare, possibly as a result of competition with *D. viverrinus*, *Sarcophilus harrisii* and feral cats (Jones 1995). This renders it vulnerable to decline. Road mortality could be a significant factor where high speed roads and good habitat coincide, as quolls are attracted to feed on carcasses of road-killed animals.

10 Additional studies required for recovery objectives and actions to be defined:
10.1 Distribution survey, particularly in NSW. Cage trapping and hair tubing have proved fairly successful in detecting the species if more than one sampling period per site is undertaken. Studies in central and southern NSW are needed to complement forest surveys already undertaken in north-eastern areas. Determine population trends by repetitive density estimates in a range of habitats across its distribution.

10.2 Investigate effects of 1080 poison and baiting protocols on the species and effects of competition from other predators including feral cats, foxes and dingoes/wild dogs.

10.3 Study habitat and further study dietary requirements.

10.4 In Tas., monitoring of population densities particularly in relation to forestry practices.

11 Recovery objectives:
11.1 Monitor populations.
11.2 Prevent further habitat loss and fragmentation.
11.3 Minimise impact of 1080 baiting.
11.4 Undertake public education, especially of private land holders in rural areas, to reduce direct killing.

12 Management actions completed or under way:
Vic. - Action Statement prepared under *Flora and Fauna Guarantee Act 1988*. Study of diet and some home range estimates and bait take behaviour recently completed (Belcher 1995). Experimental baiting trials under way (commenced 1995 by DNRE Orbost).

NSW - None.
Qld - None.

Tas. - A three-year study of diet, fine-scale habitat use and competition with the two sympatric dasyurid carnivores *D. viverrinus* and *Sarcophilus harrisii* has recently been completed (Jones 1995, Jones and Rose 1996).
ACT - None.

13 Management actions required:
13.1 Determine the critical threatening processes and take remedial actions.

13.2 Minimise habitat loss, establish broad wildlife corridors between conservation areas and implement these in all land use plans.

13.3 Feral predator control in significant areas.

13.4 Minimise non-target kills from 1080 baiting in known habitat areas. Some recommendations already made by Belcher (1995); study proposed for the Orbost area (Vic.).

13.5 Ensure off-park habitat protection in State forests and on private land.

13.6 Establish a regular population monitoring program.

13.7 Community extension work to reduce the incidence of direct kills on farmland.

14 Organisation(s) responsible for conservation of species:
Vic. Department of Natural Resources and Environment, NSW National Parks and Wildlife Service, Qld Department of Environment, Tas. Department of Environment and Land Management.

15 Other organisations or individuals involved:
C. Belcher (Ecosystems Environmental Consultants), Healesville Sanctuary, Menna Jones (University of Tasmania).

16 Staff and financial resources required for recovery to be carried out:
Staff resources required - Tas. DELM 0.5 Technical Officer

Financial resources required - 1997-2001 -

Action agency ESP Total Cost
Research and monitoring in SE Qld $50 000 $250 000 $300 000
Tas. monitoring and research $50 000 $250 000 $300 000
Bairnsdale information and education seminars *$8 000 *$8 000
Orbost bait trials $*16 000 *$16 000
2-year radio-tracking study (Vic) $80 000 $80 000

Total $124 000 $580 000
* Annual costs, funded by Alps Liaison Committee

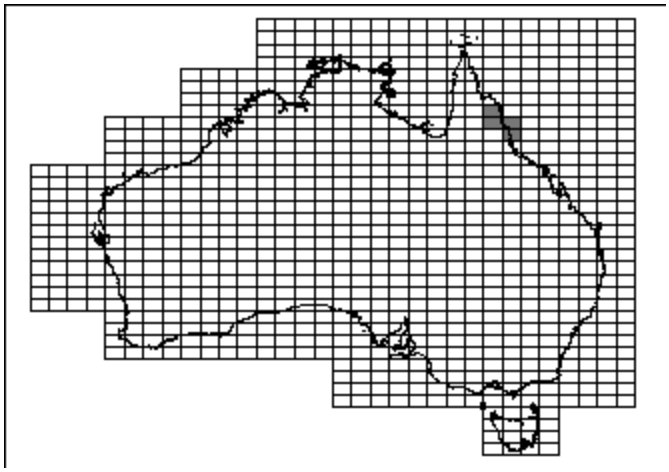
Total 1997-2001 $704 000

Recovery Outline

Spotted-tailed Quoll (N Qld)

1 Family: Dasyuridae
2 Scientific name: *Dasyurus maculatus gracilis* (Ramsay, 1888)
3 Common name: Spotted-tailed Quoll (N Qld), Yarri
4 Conservation status: Endangered: C2a
5 Other subspecies:
North Qld populations originally considered to consist of two species, *D. maculatus* and *D. gracilis* (Ramsay 1888, Tate 1947), but now considered to consist of a single subspecies *D. m. gracilis* (Troughton 1941). *D .m maculatus* occurs in south-eastern Qld and further southwards and is Vulnerable. The taxonomic status of *D. maculatus* sighted in the Mackay area (central Qld coast) and hinterland is unknown.
6 Former distribution:
Formerly occurred throughout the latitudinal range of the Wet Tropics World Heritage Area of north Qld.

7 Current distribution:



As per former distribution but now apparently extinct from the Atherton and Evelyn Tablelands. Few sightings south of 17o45'S. This represents a decline in extent of occurrence of approximately 20%.

8 Habitat:
Optimum habitat appears to be upland (>900 m ASL) notophyll vine forest. Occurs in lower abundances in progressively more marginal habitat in progressively lower altitude notophyll and mesophyll habitats. Occasionally occurs as a transient in wet sclerophyll forest and in modified habitats, eg. pastures.

9 Reasons for decline:
Life-history strategy (short maximum longevity), ecological constraints (natural rarity), and limited available habitat renders this taxon very susceptible to factors which increase juvenile and/or adult mortality, or which otherwise decrease breeding success. Such factors may include habitat clearance, logging, introduced species including Cane Toad, and direct killing at chicken pens, at houses and on roads.

10 Additional studies required for recovery objectives and actions to be defined:
10.1 Model the effects of the Greenhouse scenario on the Wet Tropics Area climatic regime.

10.2 Genetic study to evaluate the extent of isolation between populations.

11 Recovery objectives:
Identify current distribution, identify limiting factors and conserve remaining populations.

12 Management actions completed or under way:
Much of the habitat of this species is secure from large scale disturbances as it lies within the Wet Tropics World Heritage Area. A three-year field study of the life-history strategy, ranging behaviour, feeding ecology, distribution and abundance, and conservation status of the species in north Qld is in the report stage (Burnett, in prep.). A management profile for the species in State Forests in north Qld has been prepared (Burnett 1995) and a report on the conservation status of the species has been presented to QDE (Burnett 1993).

13 Management actions required:
13.1 Continued monitoring of quoll populations.

13.2 Additional survey work in order to locate other quoll populations and to test more rigorously for population distributional limits.

13.3 Experimental removal of Cane Toads from roads within the optimum habitat of *D. m. gracilis* and monitoring of effects if any on quoll populations.
13.4 Community extension work in areas where quolls have been displaced and continue to be so by high anthropogenic mortality.

14 Organisation(s) responsible for conservation of species:
Qld Department of Environment, Wet Tropics Management Authority.

15 Other organisations or individuals involved:

James Cook University of North Queensland, Qld Department of Primary Industries Forest Services, Australian National University, private landholders in relevant areas.

16 Staff and financial resources required for recovery to be carried out:
Staff resources required - QDE 0.5 extension officer
QDE/WTMA 1 research officer
1 research assistant
University postgraduate student
QDE consultant biologist

Financial resources required - 1996-2000

Action Total Cost
Greenhouse modelling $5 000
Genetic studies $20 000
Cane Toad management $40 000
Quoll monitoring $20 000
Distribution surveys $25 000
Community extension work $40 000
Total 1996-2000 $150 000

References:
Burnett S. in prep. The ecology of a suite of tropical Australia rainforest carnivores with particular reference to the Spotted-tailed Quoll, *Dasyurus maculatus gracilis*. Ph.D. thesis, James Cook University of North Queensland.
Burnett S. 1993. The ecology and conservation status of the Spotted-tailed Quoll, *Dasyurus maculatus gracilis* in north Queensland. Report to the QldDepartment of Environment and Heritage (unpublished).
Burnett S. 1995. Management profile for the Spotted-tailed Quoll, *Dasyurus maculatus gracilis* in Queensland's State Forests. Report to the QldDepartment of Primary Industries Forest Services (unpublished).

Program Outline: Northern quoll

1. General information

Taxon :		*Dasyurus hallucatus*
Common name:		Northern quoll
IUCN status:		LR/ N.T. 1996
CITES listing:		
Other relevant listings (e.g. VPC, DoC, EA):		EPBC: Endangered N.T (PWC) 2003: Critically endangered
TAG:		Monotreme and Marsupial TAG
Captive management unit (including taxonomic concerns if any):		Species level *(No subspecies are currently recognised, though this may change when the genetic analysis currently being undertaken by Karen Firestone is completed.)*
Scope of managed population:		• Captive population in ARAZPA institutions • Translocated island populations N.T.
Species contact:		Jenny Kirwan, Sarah Hirst
Contact details:	*Email:*	jenny.kirwan@nt.gov.au , sarah.hirst@nt.gov.au
	Fax:	08 89 887201
	Phone:	08 89 887200
Document prepared by:		Jenny Kirwan
Last updated:		May 2006

2. Rationale

The northern quoll (*Dasyurus hallucatus*) has recently been listed under the Federal Environmental Protection and Biodiversity Conservation (EPBC) Act as Endangered. The rapid advance of the cane toad (*Bufo marinus*) into tropical Northern Territory has been catastrophic for the northern quoll with studies revealing that some populations have been decimated and are unlikely to recover in the areas from which they have already disappeared. A viable captive population will act as an insurance for the (2003) translocated island populations. In the advent of cane toad control, a genetically sound captive population will have the capacity to re-stock decimated areas. It has been a TAG decision to prioritise the northern quoll and tiger quoll. The number of display/ breeding spaces available needs to be determined.

3. Aims of captive management

The aim of captive management is to ensure the persistence of a captive population that:

- can provide animals for release to the wild as part of a conservation reintroduction program if cane toad control methods are found
- can act as an insurance population in case of catastrophic declines in the wild
- conserves high levels of the genetic variability found in wild populations in conjunction with translocated island populations
- can provide animals for zoo-based research
- can support the development and documentation of husbandry techniques for the species
- provide support/ insurance for translocated island populations for the taxon
- achieve reliable breeding to ensure viable population persists

4. Additional program aims

In addition, the program aims to:

- support regional education and fundraising efforts by acting as a flagship animal for all species under threat from cane toad incursion
- Support in situ research through education

5. Program goals

Population management:	Retain 90% GD over 25 years and ensure persistence of population at planned size for 25 years. (to be reviewed 5yrly) Ensure captive display population
Husbandry:	Achieve reliable and consistent breeding; record circumstances and conditions under which successful breeding has occurred in captivity. Produce husbandry manual
Support for *in situ* projects:	Can provide genetics to ensure diversity of island populations and vice versa. Raise species profile.

6. Program type

Current: No regional program
Proposed: Population management program

7. Population management level

Current: 3
Proposed: 1b

8. Target population size

Target numbers: 30-40 pairs (preliminary PVA results to maintain for 25 years)

Immigration required: yes

Source of additional founders: Possible source from translocated island populations and mainland animals under threat from the cane toad

9. Current regional plans

(from ASMP Regional Census and Plan 2006 except Winnellie)

Institution	Current holdings	Planned holdings	Implementation Plan
Currumbin Wildlife Sanctuary	4.6	3.3	Maintain
Healesville Sanctuary	1.1	1.1	Maintain
Perth zoo	0.2	0.2	Maintain in 2006
Taronga Zoo	0.0	1.1	Acquire
Halls Gap	1.1	1.1	Maintain
Palm Grove	0.0	1.1	Acquire long term
Adelaide Zoo	0.0	1.2	Acquire in 2006
Winnellie (TWP)	12.11	30.30	Acquire locally
TOTAL	18.21.0	38.41.0	

10. Work plan

To be developed	Responsibility		Due date	Date completed
	Name	Institution		
Regional Studbook	Jenny Kirwan,	Territory Wildlife Park	30/8/2006	
Annual Report and Recommendations	Jenny Kirwan	Territory Wildlife Park	30/8/2006	
Husbandry Protocol: reproductive management	Jenny Kirwan	Territory Wildlife Park	30/8/2006	

11. Endorsements

This Annual Report has been reviewed and endorsed by the following bodies:	**Endorsement received (date)**
Monotreme and Marsupial TAG	
ASMP Committee	
This Annual Report has been reviewed and endorsed by nominated representatives of the following participating institutions:	**Endorsement received (date)**
Currumbin Wildlife Sanctuary	6/8/06
Healesville Sanctuary	3/8/06
Perth zoo	3/8/06
Taronga Zoo	3/8/06
Halls Gap	
Palm Grove	5/8/06
Adelaide Zoo	6/8/06
Winnellie (TWP)	

Chapter 4:

MATERIAL SAFETY DATA SHEET

F10SC VETERINARY DISINFECTANT

COMPANY DETAILS

UK Distributor:
Meadows Animal Healthcare Ltd
Unit 7, Windmill Industrial Estate
Windmill Road, Loughborough,
Leicestershire, LE11 1RA
ENGLAND
Tel 01509 2965557

Manufacturer:
Health and Hygiene (Pty) Ltd
P O Box 906 Florida Hills 1716,
South Africa.
Tel: +27 11 474-1668 Fax: +27 11 474-1670
E-mail: info@healthandhygiene.co.za
Emergency Telephone number: +27 11 474-1668

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **F10SC VETERINARY DISINFECTANT**
SYNONYMS: None
CHEMICAL FAMILY: Mixture

UN Number: None
D G Class: None
Hazchem code: None

USE: Biodegradable multi purpose disinfectant for hard surfaces, equipment and airspaces

SECTION 2. COMPOSITION

Quaternary ammonium and biguanidine compounds (5.8%), non-toxic ampholytic surfactants and sequesterants.

EEC Classification: Irritant: R phrases: R41/R38: May cause serious damage to the eyes. Irritating to the skin (Packed concentrate only) S2 Keep out of the reach of children. S7 Keep container tightly closed

SECTION 3. HAZARDS IDENTIFICATION		
HAZARD	**Packed Concentrate**	**Use Dilutions (1:100 and higher)**
MAIN HAZARD	**IRRITANT**	**NONE**
HEALTH EFFECTS		
SWALLOWED	Ingestion of the concentrate may cause irritation to mouth, throat and digestive tract.	None
EYE	Concentrate may cause serious damage to the eyes	None
SKIN	Concentrate may act as mild degreasant to sensitive skin.	None
INHALED	None	None

SECTION 4. FIRST AID MEASURES

SWALLOWED: DO NOT induce vomiting. Give milk or water to drink. Seek medical advice where necessary

EYE: Rinse thoroughly with clean water or buffered eye wash for 15 minutes. Seek medical advice where necessary.

SKIN: Wash affected area with soap and water.

INHALED: Not applicable

FIRST AID FACILITIES: Contact your medical practitioner or the emergency department of your local hospital.

ADVICE TO DOCTOR: Treat symptomatically

SECTION 5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA: Not flammable

SPECIAL HAZARDS: None

PROTECTIVE CLOTHING: Not required

SECTION 6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS: No special precautions required
ENVIRONMENTAL PRECAUTIONS

SMALL SPILLS: Flush with large amounts of water
LARGE SPILLS: Soak up on an inert material e.g. dry earth and dispose of in an area approved by local authority

7. HANDLING AND STORAGE

HANDLING/STORAGE PRECAUTIONS: Store below 30C in dry conditions

8. EXPOSURE CONTROL/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS: Not data found

ENGINEERING CONTROL MEASURES: None required

PERSONAL PROTECTION – RESPIRATORY: None required

PERSONAL PROTECTION – HAND: Wear waterproof gloves. Packed concentrate only

PERSONAL PROTECTION – EYE: Wear eye protection. Packed concentrate only

PERSONAL PROTECTION - SKIN: None required

OTHER PERSONAL PROTECTION: None required

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE:	Clear, colourless liquid.
ODOUR:	Slight natural odour
pH:	7.5
BOILING POINT:	110C
FLASH POINT:	Not flammable
FLAMMABILITY:	Not flammable
EXPLOSIVE PROPERTIES:	Not explosive
OXIDISING PROPERTIES:	None
VAPOUR PRESSURE:	Not known
DENSITY:	1.0
SOLUBILITY-WATER:	Soluble

10. STABILITY AND REACTIVITY

CONDITIONS TO AVOID: DO NOT mix with soaps and other chemicals

INCOMPATIBLE MATERIALS: Anionic detergents/chemicals

HAZARDOUS DECOMPOSITION PRODUCTS: Not known

11. TOXICOLOGICAL INFORMATION

Toxicity	Packed Concentrate	Use Dilutions (1:100 and higher)
Acute Oral Toxicity: (Rat)	>2000mg per kg	No toxicity (>200 000mg per kg)
Acute Dermal Toxicity: (Rat)	>5000mg per kg	No toxicity (>500 000mg per kg)
Acute Eye Irritation	May cause serious damage	None
Acute Dermal Irritation	Slight irritation	None
Acute Inhalation Toxicity	None	None
Skin Sensitization	Not a skin sensitizer	Not a skin sensitizer

12. ECOLOGICAL INFORMATION

Aquatic Toxicity – Fish: 16mg/l

Aquatic Toxicity – algae: not available

Aquatic Toxicity – daphnia: 0.9mg/

Biodegradability: Biodegradable

13. DISPOSAL CONSIDERATIONS

Disposal Methods: Soak up on an inert material e.g. dry earth and dispose of in an area approved by local by-laws. Flush small spills with copious amounts of water.

Disposal of Packaging: Rinse thoroughly before discarding.

14. TRANSPORT INFORMATION

ADR/RID Class: none
IMDG Class: None
IATA Class: None

15. REGULATORY INFORMATION

EEC hazard classification:  Irritant

Risk phrases: R41/R38: May cause serious damage to the eyes. Irritating to the skin (Packed concentrate only)
S2 Keep out of the reach of children. S7 Keep container tightly closed

Date issued: July 2012

Chapter 6: Diet:

Life Sciences & Environmental Education

Life Sciences Operations

DIV 3.6 Diet Sheet

SPECIES: Northern Quoll - *Dasyurus hallucatus*

ZOO DIVISION:
Australian Fauna Precinct

GROUP COMPOSITION:
0.1 housed in ANX004
1.0 housed in ANH003

NATURAL DIET:
Known to feed on mammals, reptiles, worms, ants, termites, grasshoppers, beetles (and larvae), moths, honey, figs and soft fruit (Strahan 1995).

BODY WEIGHT RANGE FOR WILD MALES AND FEMALES:
Males 400-900g; Females 300-500g (Strahan 1995).

TARONGA CONSERVATION SOCIETY AUSTRALIA DIET:

FOOD ITEM	MON	TUES	WED	THURS	FRI	SAT	SUN
Insects	30g		30g		30g		30g
Mouse (adult)							30g
Day Old Chick	20g			20g			
Whitebait/Prawn		15g					
Meatball		10g					
Supercoat Kibble					15g	15g	
Fruit				15g			
Mouse (pinkies)			15g			15g	

Diet preparation: Insects could include mealworms, crickets, grasshoppers or cockroaches. Fruit could include apple, pear, kiwi, grape, rockmelon, paw paw, banana and will vary depending on what is available in the daily food delivery. Vegetables are cut into chunks suitable to being held by this species. Fish and Prawns are thawed out and fed whole.

.

Recipe mixes or ingredients:
Carnivorous Marsupial Meatballs

Kangaroo or Beef Mince Meat	2kg
Shelled Hardboiled Eggs	250 g
Supercoat Kibble	300g

Mash eggs in blender then mix by hand into mince.
Crush kibble in blender then mix into egg/mince mix.
Roll into 25g balls. Store in Freezer.

Supercoat Kibble

Ingredients: wholegrain cereals and brans (wheat and/or sorghum), meat and meat by-products (chicken and/or beef), cereal and/or vegetable proteins, beet pulp, iodised salt, vitamins (A, D, E, K, B1, B6, niacin, riboflavin, folic acid, choline, biotin, B12) and trace minerals (iron, zinc, copper, manganese), mixed natural tocopherols (vitamin E), rosemary plant extract, lutein, garlic and kelp.
Composition: crude protein 17%, crude fat 7%, salt 1.3%, crude fibre 4%, Ca:P 1.3:1, sugar not added, linoleic acid 1.3%, metabolisable energy 300kcal/100g.
Manufacturer: Purina

Individual animal variations:
None

Feed method:
Food is scattered around the floor of the exhibit thus providing enrichment during the feeding.

Diet Updates:

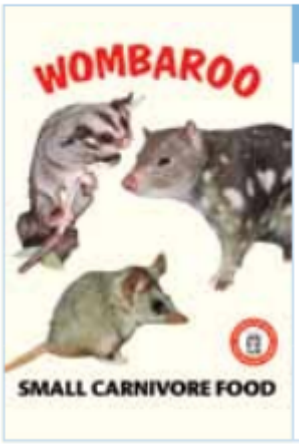
Date:	Diet change:	Approved by*:

* Precinct Manager or Unit Supervisor **and** a veterinarian

References:
Strahan, R (2005). The Australian Museum Complete Book of Australian Mammals. Reed Books, Chatswood.

Date of original diet submission:
16-4-2010

Small Carnivore Food



Small Carnivore Food	Analysis	
A nutritionally balanced substitute to live foods for carnivorous marsupials, rodents and other small mammals which include insects as a part of their diet. Fortified with essential amino acids, fatty acids, vitamins & minerals. **Pack size: 250g, 1kg, 5kg.**	Protein	34%
	Fat	10%
	Carbohydrate	32%
	Energy	15.2 MJ/kg

Using Small Carnivore Food

Preparing Food: Mix about 70% of Small Carnivore Food with about 30% of warm water. Add the water slowly while mixing to a moist, crumbly food. Do not make into a paste. Store prepared food refrigerated for 1 day or frozen for 1 week.

Kowaris, Dunnarts, Quolls and Antechinus: Prepared food can represent up to 80% of the total diet. Supplement with crickets, moths, grasshoppers, spiders and day old mice or chicks.

Gliders, Pigmy Possums and Bandicoots: Include up to 20% of prepared food in their diet. Also feed Wombaroo High Protein Supplement dispersed over fruit.

Hopping mice, Rats & Mice: Add 10% to 20% of prepared food to the diet of these animals.

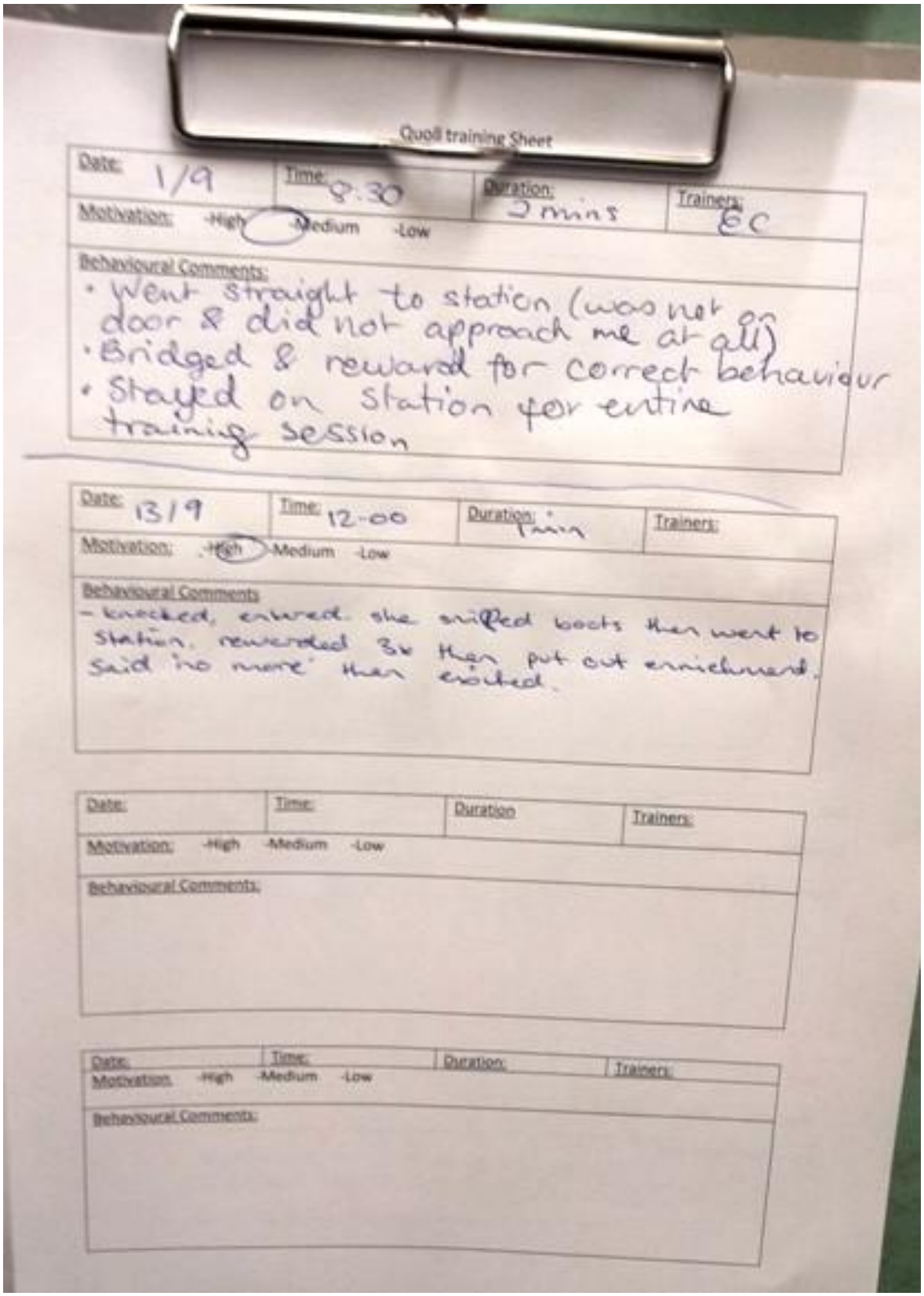
Echidna and Numbat: Mix prepared food with about 10% crushed termite mound and termites.

Insectivorous Bats: Have been successfully kept using this food as a maintenance diet while supplementing them with moths, beetles and a few fly pupae and mealworms.

Feeding Live Food

Carnivorous and omnivorous animals need to catch live food. Feeding live food is not only important nutritionally it also helps maintain a healthy attitude in captive animals. If insects are offered as live food ensure they represent the insect stage eaten by the animal in the wild. There are considerable differences in composition between mature and immature (larval stage) of insects. Animals that prey on mature insects such as moths, beetles and crickets should not be fed large numbers of larval stage insects. Captive animals are commonly fed mealworms and fly pupae which are larval stage insects. These can be poor food substitutes for many animals because of their high fat content. Fat contains twice as much energy as other nutrients and increased quantities in the diet can significantly dilute the intake of essential nutrients.

Training sheet for Lisa, the Spotted-Tailed Quoll at Wild Life Sydney



Quoll training Sheet

Date: 1/9	Time: 8:30	Duration: 2 mins	Trainers: EC

Motivation: -High -Medium -Low

Behavioural Comments:
- Went straight to station (was not on door & did not approach me at all)
- Bridged & reward for correct behaviour
- Stayed on station for entire training session

Date: 13/9	Time: 12-00	Duration: 1 min	Trainers:

Motivation: -High -Medium -Low

Behavioural Comments
- knocked, entered. she sniffed boots then went to station. rewarded 3x then put out enrichment. said 'no more' then exited.

Date:	Time:	Duration	Trainers:

Motivation: -High -Medium -Low

Behavioural Comments:

Date:	Time:	Duration:	Trainers:

Motivation: -High -Medium -Low

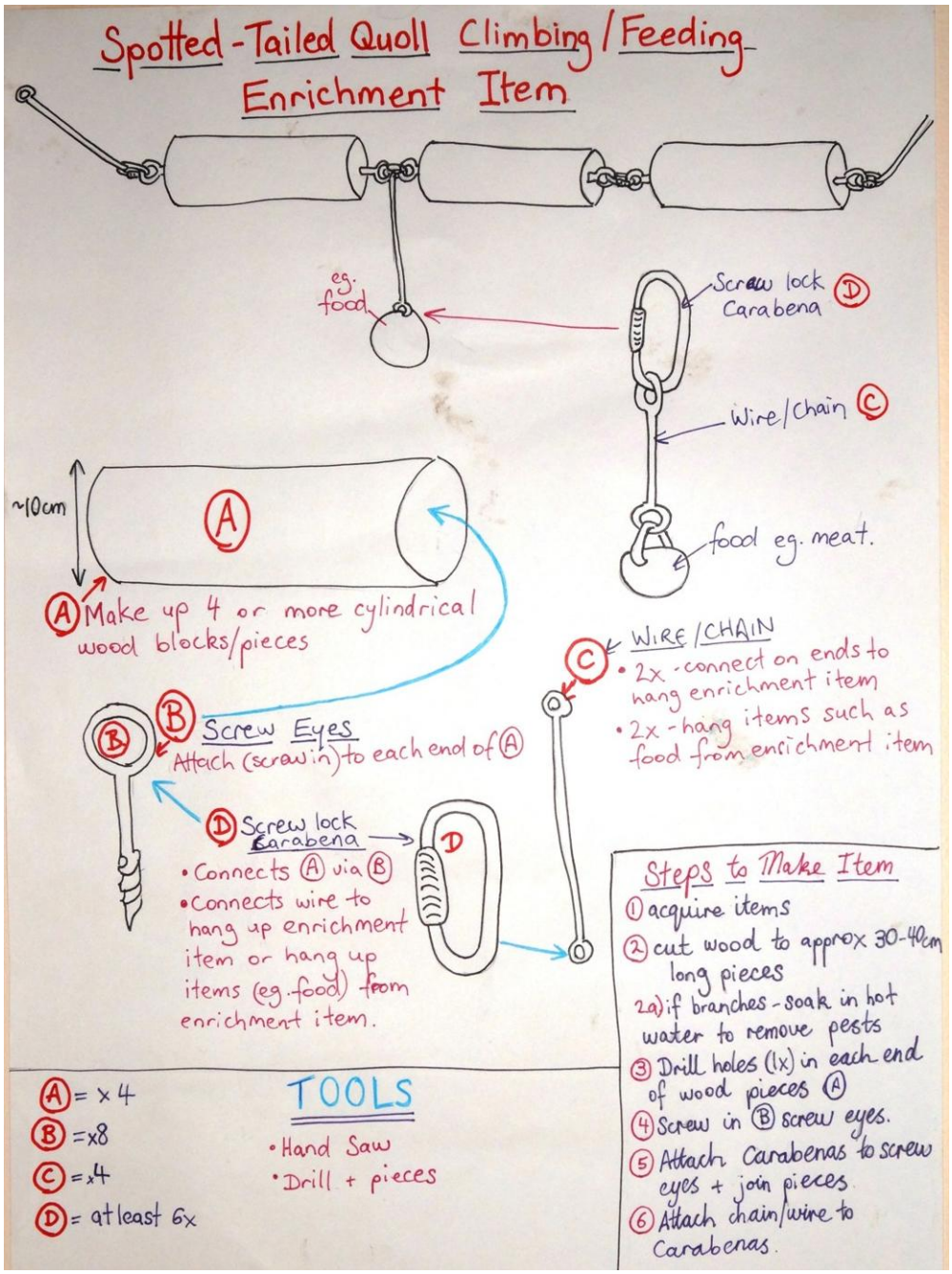
Behavioural Comments:

Example ENRICHMENT ITEM by Julie Marten

Supplies to make enrichment item. Photo J. Marten

Below is an example of an enrichment item I created at Tafe. A simple device consisting of lengths of wood / branch pieces that have rings on each end. Each piece is **interchangeable** and connected together by a screw lock carabiner clips / connecters and / or chains etc. connected to hang from the device via the carabiners.

1-4 pieces can be used at a time and hung up in various ways. One wooden piece or a piece of chain is connected to the connecting carabiner and have food attached to it or simply used as a more mobile climbing device.



STEPS AND EXAMPLES HOW TO USE FINAL PRODUCT (Photos J. Marten)

Step 1.
Clamp pieces to a bench-top to hold securely in place and cut branch/es to desired lengths. I cut pieces to approx. 300mm long.

Step 2.
Drill holes in each end of each piece to the width of the screw eyes.

Step 3. Screw in screw eyes into each hole.

(step 2)

(step 3)

Above: after Step 3

An example of a finished product

Above: pieces can be connected together or wire; OR **Picture right**: chain can be connected to carabiners to hang device up or hung food etc. from.

Carnivorous Marsupials, Michael Archer – breeding strategies of dasyurids

Figure 1. Key factors in the classification of dasyurid life histories.

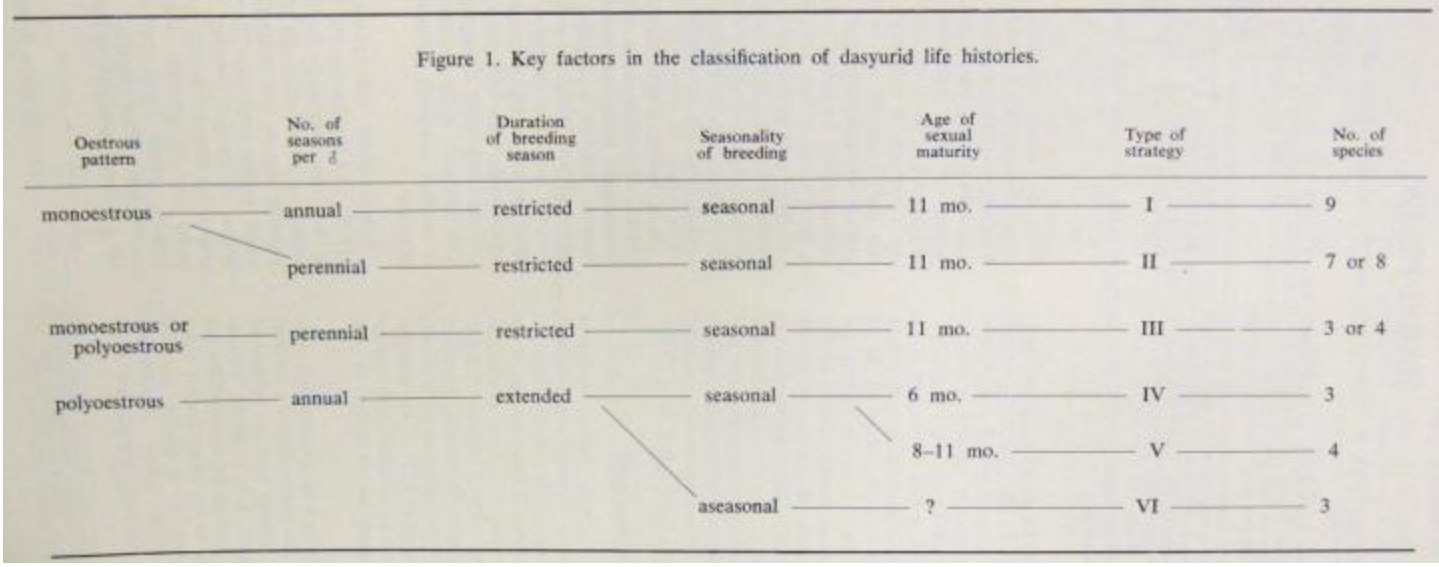


Table 1. Some life history correlates of dasyurid marsupials. Field weight have been used wherever possible. * Dimorphic ratio = ratio of maximum male to maximum female body weight. See text for full names of species.

Strategy	Species	Adult body weight (g) ♂♂	♀♀	Dimorphic ratio*	Month of births	Usual litter size	Teat number	Source
I	*A. bellus*	55-70			Sept.			8,44
	A. flavipes	35-55	20-35	1.6	July-Sept.	8-12	10-12	15,39
	A. godmani	90-105			Aug.-Sept.		6	35,46
	A. leo	75					10	34
	A. minimus	46-100	30-58	1.7	July-Aug.			28,36,37
	A. rosamondae	25-40	20-30	1.3	Oct.-Nov.	6-8	8	45,46
	A. stuartii	28-40	19-30	1.4	Sept.-Oct.	6-10	6-10	28,38,39
	A. swainsonii	50-90	40-60	1.5	July-Aug.	6-8	6-10	28,42,46
	P. tapoatafa	180-240	120-200	1.2	Aug.	7-8	8	9,12
II	*A. apicalis*	60-100	40-75	1.3	April	8	8	40
	A. bilarni	20-36	22-28	1.1	Aug.-Sept.	5	4-6	6,8,45
	A. macdonnellensis	25-45	20-40	1.1	Aug.-Sept.	6	6	42,46
	S. leucopus	15-25	15-25	1.0	Aug.-Sept.	10	10	47
	Ninbing Antechinus	20-25	15-20		July	1-4	4	46
	D. hallucatus	600-800	400-450	1.8	July-Aug.	6-8	6,7,8	17
	D. geoffroii				May-June	6		1,3
III	*D. cristicauda*	75-130	60-95	1.4	June-July	5-7	4,6,8	16,27,30,41
	D. viverrinus	1010-1800	700-1225	1.5	May-Aug.	6	6	19,24,25
	D. maculatus	7000	4000	1.8	July-Aug.	5	6	14,32
II or III?	*S. harrisii*	9000	6500	1.4	April-Sept.	2-4	4	7,13,23

Extract D.Andrew 2005 - Below are some plates (photos) and **measurements** taken by Deborah Andrew during her research of Spotted-Tail Quoll Ecology (including breeding) conducted at Featherdale Wildlife Park, over 4 breeding cycles between 1991-1994 (1991 = litters 1-3; 1992 = litters 4-6; 1993 = litters 7-8; and 1994 litters 9-12). See plates 3.6 - 3.25. Note: measurements taken from different litters.

Andrew, D Plates 3.6 - 3.25

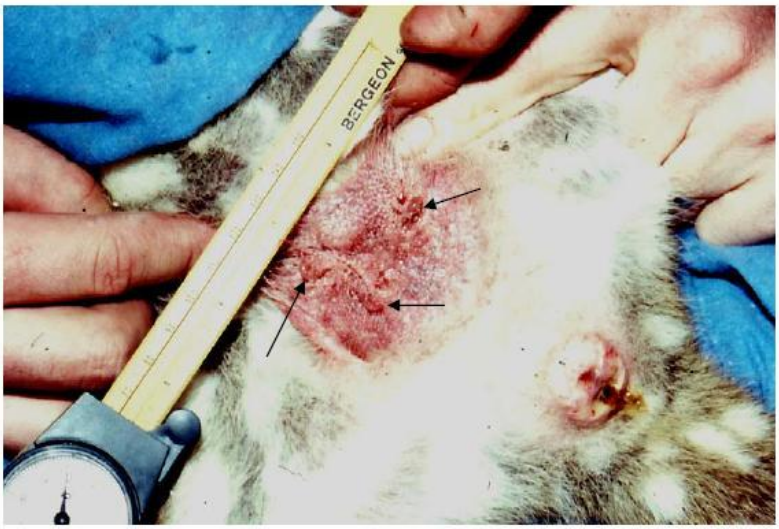


Plate 3.6: Three newborn Tiger Quoll young of Litter 10 observed within hours of birth on the 10.6.94 appear like tiny pink jelly beans. The crown-rump length of two young measured was 6.5 and 6.7 mm.

Plate 3.7: Tiger Quoll young from Litter 4 aged 6 days old. For litter mates crown-rump length measured 10.6-11.3 mm on the 22.6.92.

Plate 3.8: Tiger Quoll young from Litter 2 at 20 days old. Measurements for litter mates are crown-rump length 16.4-21.7 mm. Pinnae forming.

Plate 3.9: Tiger Quoll young from Litter 5 at 26 days old. Crown-rump length 21.3 mm. Eyes and pinnae forming.

Plate 3.10: Tiger Quoll young from Litter 2 at 39 days old on the 10.7.91. Measurements for litter mates are crown-rump length 32.3-33.5 mm and head width 13.2-14.3 mm. Pinnae now free from the head.

Plate 3.11: Tiger Quoll young from Litter 4 at 49 days old on the 31.7.91. Measurements for litter mates are crown-rump length 40-44.5 mm and head width 16.4-17.2 mm. Spots appearing on the head and body and the tail is well formed but not yet spotted.

Plate 3.12: Tiger Quoll young of Litter 1 at 58 days old on the 7.8.91. Measurements for litter mates are crown-rump length 49.1-56.9 mm and head width 19.3-20.6 mm. Fine fur over the body with spots now on the tail. Pinnae becoming pigmented and lie flat against the head.

Plate 3.13: Tiger Quoll young of Litter 2 at 60 days old on the 31.7.91. Tail finely furred and spotted and rudimentary pouch visible.

Plate 3.14: Adult female Tiger Quoll with 60 day old young of Litter 2 on the 31.7.91 hanging onto teats. Young were first observed to voluntarily release from teats at 56 days.

Plate 3.15: Tiger Quoll young of Litter 1 at 65 days old on the 16.8.91. Measurements for litter mates are crown-rump length 70.8-75.5 mm and head width 21.4-22.9 mm. Coarse ginger fur is now appearing on the head. Pinnae held against the head.

Plate 3.16: Tiger Quoll young of Litter 2 at 76 days old on the 16.8.91. Measurements for litter mates are crown-rump length 111.1-114.5 mm and head width 25-26.6 mm. Coarse ginger fur extending down the back and pinnae are standing out from the head.

Plate 3.17: Tiger Quoll young of Litter 1 at 84 days old on the 4.9.91. Measurements for litter mates are head width 28.3-37.8 mm, nose-vent length 150-175 mm and weight 136-152 g. Eyes are now open and coarse ginger fur extends to the top of the tail (Photo: B. Walker).

Plate 3.18: Tiger Quoll young of Litter 1 at 84 days old climbing on their mothers back.

Plate 3.19: Tiger Quoll young of Litter 1 at 91 days old on the 11.9.91. Measurements for litter mates are head width 32-33.4 mm, nose-vent length 163-175 mm and weight 179-197 g.

Plate 3.20: Tiger Quoll young of Litter 1 at 105 days old on the 25.9.91. Measurements for litter mates are head width 33.1-37 mm, nose-vent length 220-230mm and weight 256-298 g.

Plate 3.21: Tiger Quoll young of Litter 2 at 116 days old on the 25.9.91. Measurements for litter mates are head width 36.8-40.1 mm, nose-vent 260-275 mm and weight 388-434 g.

Plate 3.22: Tiger Quoll female young of Litter 1 at 147 days old on the 6.11.91. Measurements for this individual are head width 44.4 mm, nose-vent 320 mm and weight 750 g.

Plate 3.23b: Male Tiger Quoll young from Litter 4 at 177 days on the 10.12.92. Measurements for this individual are head width 42.7 mm, nose-vent 300 mm and weight 900 g.

Plate 3.24: Tiger Quoll male young from Litter 1 at 218 days old on the 16.1.92. Measurements of two male litter mates were head width 51.7, 54.8 mm, nose-vent 360, 400 mm, and weight 1575, 1725 g.

Plate 3.25: Adult female from Litter 1 at age 376 days on the 22.6.92 in her first breeding season carrying six-day-old pouch young. Her measurements are head width 59.3 mm and weight 1975 g.

Table 3.3: Morphological development of young Tiger Quolls with comparison to other studies. Age given in days unless otherwise stated and is the age the feature was first observed.

	Age from this study			Age from Conway (1988)	Age from Settle (1978)	Age from Troughton (1954)	Age from Fleay (1940)
Feature	Mean Age (days)	Range (days)	N (litters)	weeks (estimated days) (N = 5 litters)	(days) (N = 2 decreasing to 1 young)	weeks (days estimated) (N = 5 decreasing to 1 young)	weeks (days estimated) (N = 5 young)
Eye dots	6	6	2				
Line of fused eyelids	40.5	36 - 42	6				
Front feet and non-deciduous claws well developed	40.8	37 - 46	5				
Hind feet and claws well developed	47.5	46 - 49	2				
Pinnae free from head	40.8	37 - 46	5				
Pinnae pigmented - beginning	59	54 - 65	6				
Pinnae pigmented - fully	67.3	63 - 72	3				
Pinnae well formed, pointing upwards	59.8	56 - 67	9				
Pinnae standing out from head	79.8	75 - 87	6				
Pouch, scrotum readily discernable	51.2	41 - 56	6	10-12 (70-84)			
Pelage, fine fur on head	44.8	41- 48	9	7 (49)			7 (49)
Pelage, fine fur on rump	51.8	49 - 62	9				
Pelage, fine fur on underbelly	66.5	60 - 72	4				
Pelage, spots 1st appear -head	47.6	46 - 49	3	9 (63)	40 (subcutaneous hair)		7 (49)
Pelage, spots - body	53.4	48 - 59	8				
Pelage, spots - tail	61.1	58 - 67	9				
Pelage, adult fur (coarse)-head	69.2	65 - 72	6	9 (63)			
Pelage, adult fur (coarse)-body	76.5	75 - 79	4				
Pelage, adult fur (coarse)-tail	89.5	87 - 92	2	13 (91)			
Vibrissae, mystical	58.2	49 - 76	5				
Vibrissae, wrist		95	1				
Jaw slit	37	33 - 41	4				
Jaw separation	64.2	52 - 76	6				
Vocalisations	72.2	59 - 87	6	10 (70)	61-63		
Free of the teat	70.63	56 - 79	8	11 (77)	47-50	8 (56)	7 (49)
Left in nest					50-60		7 (49)
Eyes open	85.4	82 - 87	7	12 (84)	61-63	9 (63)	7(49) beginning to open
Teeth, incisors (first observed)	100.7	95 - 105	7				
Teeth, incisors (all out)	142	142	2				
Teeth, molars (first)	103.5	102 - 135	2				
Teeth, molars (second)	123.5	115 - 128	3				
Teeth, molars (third)	134.3	133 - 135	3				
Teeth, molars (fourth)							

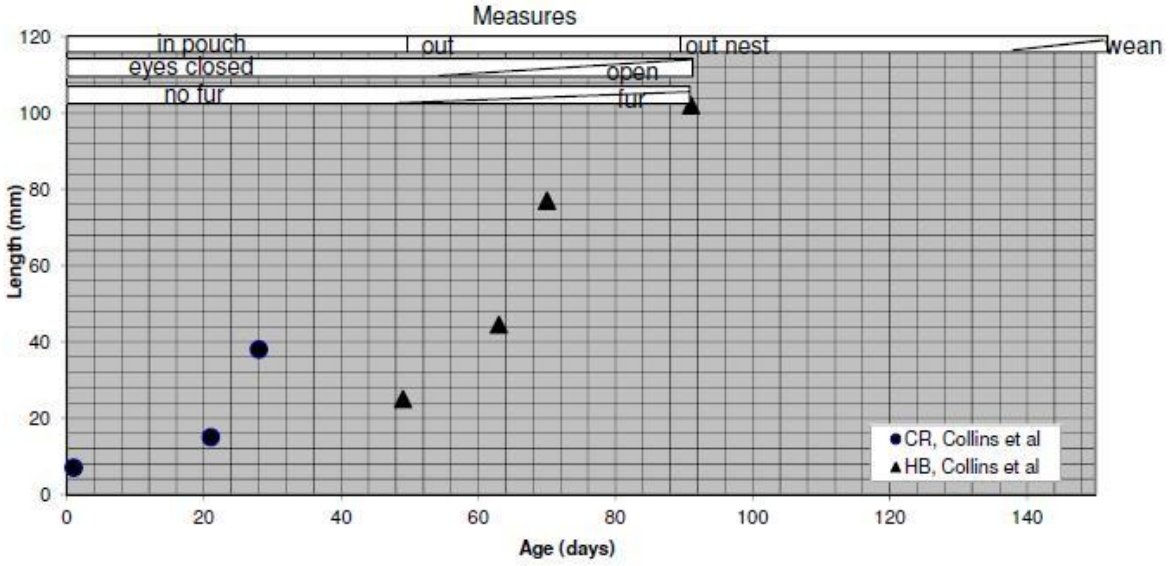
Teeth, canines	103	102 - 104	2				
Taking solid food (solid droppings)	107.6	87 - 124	3	17 (119)	100		14 (98)
Kill live prey				17-19 (119-133)	95	8 months (240)	
Climbing on mothers back	111.7	84 - 132	4	12-13 (84-91)	not observed	9 weeks ? (63)	12 (84)
Independent excursion	103.5	102 - 105	2	12-13 (84-91)	71?		
Weaned					120-150	5 months (150)	18 (126)
Sexually mature (first mating observed)	347	344 - 352	5	52 (364)			within 12 months
Full adult size		2 years or >		2 years			2 years

Growth rates and behaviour development chart of the Spotted-Tailed Quoll (below). Chart taken from "**Birth Date Determination in Australasian Marsupials**" 2nd Edition 2012.

TIGER QUOLL
Dasyurus maculatus

Size adults
males 380-759 mm HB
up to 7kg
females 350-450 mm HB
up to 4 kg

Gestation: 21 days



Below are some other measurements taken by **varied** Spotted-Tailed Quoll (Tiger Quoll) researchers. Taken from the ZAA "**Birth Date Determination in Australasian Marsupials**" 2nd Edition 2012.

TIGER QUOLL *Dasyurus maculatus*

Body **Edgar and Belcher(1995),** N=? HB len. Adults males: 380-759mm, females: 350-450mm **Strahan(1992),** N=? HB len. adults=35-76mm **Nowak(1991),** N=? HB len. adults=400-760mm **Conway(1988),** N=? HB 3 weeks=12.5-19mm, 7 weeks(49d)= 25mm, 9 weeks(63d)=38-51mm(44.5)mm, 10 weeks(70d)=77mm, 13wks(91d)=102mm **Fleay(1948)** N=5, At birth=7mm, curled position; 4 wks=38mm, 18 weeks=1/3 of adult size, 2 years=full adult size is reached

Weight **Edgar and Belcher(1995),** N=? Adults males: up to 7 kg; females: up to 4 kg **Nowak(1991),** N=? adults=2-3 kg

Tail **Edgar and Belcher(1995),** N=? Adults males: 370-550mm, females: 340-420mm **Strahan(1992),** N=? adults=34-55mm **Nowak(1991),** N=? adults=350-560mm

Eyes **Conway(1988),** N=? 13 weeks=eyes open **Troughton(1954),** N=? 9 weeks=eyes open **Fleay(1948)** 7 weeks (49d)=eyes beginning to open, N=5

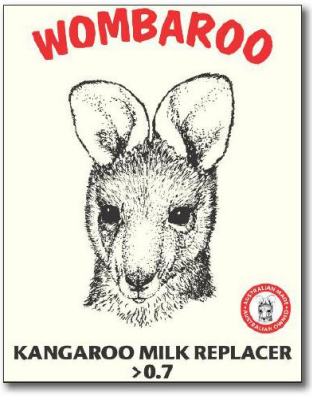
Pouch life **Edgar and Belcher(1995),** N=? 7 weeks (49d)=becomes free of teat 18 weeks (126d)=independent **Collins et al.(1993),** N=? 26 weeks (182d)=still observed nursing. **Strahan(1992),** =? 7 weeks (49d)= young leave the pouch and are suckled for a further 6 weeks **Conway(1988**), N=? 11 weeks=off teat and left in nest, 25-30 weeks=independent **Troughton(1954),** N=?, 8 weeks=detach from teat, 5 months=weaned **Fleay(1948)** N=5, 4 weeks (28d)=one or more young would hang outside the pouch, 7 weeks (49d)=no longer constantly attached to teat, 18 weeks (126d)= completely independent

Other **Edgar and Belcher(1995),** N=? Sexual maturity=1 year Gestation=21d; 13 weeks=social play well developed **Strahan(1992),** N=? Sexual maturity=1 year **Collins et al.(1993)** Gestation=21d (Ride 1970, Settle 1978, Edgar 1983, Nowak 1991 and own obs.) 3 weeks=pink and hairless; 6 weeks=Spotted pattern begins to appear (Settle 1978), 7 weeks=Brown pelage well developed (Fleay 1940, 1948), 8 weeks= first vocalisation heard (Present study), Respond to dam's vocalisation, play first observed, self-grooming begins (Settle 1978), 10 weeks=aggression appears in play, climbing back on siblings (Settle 1978), 13 weeks=social play well developed (Settle 1978, Edgar 1983), able to kill adult mice alone (Settle 1978), 14 weeks=eating solid food (Fleay 1940, 1948, Settle 1978), 32 weeks=able to kill adult rabbits (Troughton 1954), 104 weeks=adult size attained (Fleay 940, 1948, Nowak 1991, Conway 1988) **Conway(1988),** N=? 9 weeks=fine fur; 13 weeks=young is fully furred **Fleay(1948)** Gestation=3 weeks, N=1; 4 weeks (28d)=show considerable limb movement; 7 weeks=dark brown fur well developed, N=5; 4 weeks (28d)=show considerable limb movement; 12 weeks (84d)=white pelage takes on 'pinkish' tinge (gradually fades); 18 weeks (126d)=size differentiation between sexes becomes evident; Sexual maturity=12 months, N=5

Chapter 11:

Carnivorous Marsupials, Bandicoots & Bilby

The milk of carnivorous marsupials, bandicoots and bilby undergoes similar quantitative and qualitative changes as in other marsupials. This involves a progressive increase in total solids, fat and protein from early to late lactation while carbohydrate increases to about mid lactation and then declines to low levels during late lactation.



It is impracticable to produce a multi-stage milk replacer for these animals as most have short pouch lives and rescued animals tend to be at late lactation stage. We recommended feeding them **Kangaroo Milk Replacer >0.7**. This is a suitable high energy formula which many carers will have on hand or find readily available. Depending upon age, young Tasmanian Devil joeys may be started on either **Kangaroo 0.4 or 0.6**.

Feed Table Using Kangaroo >0.7

Body Weight (g)	Feed Volume (ml/day)	Body Weight (g)	Feed Volume (ml/day)	Body Weight (g)	Feed Volume (ml/day)
5	1.3	60	8	200	20
10	2.2	70	9	250	24
15	2.9	80	10	300	27
20	3.6	90	11	350	29
25	4.3	100	12	400	32
30	4.9	110	13	450	35
35	5.5	120	14	500	38
40	6.1	130	15	550	42
45	6.7	140	16	600	44
50	7.3	150	16	650	46

Wombaroo –small carnivore mix – see appendix chapter 6 Diet.