Slide 1.

MANGE, MORE TO ACHIEVE PART A

Abstract

The treatment of wombats with mange infestations and the prevention of the spread of infestations has progressed in the last few decades. More work and better methods for dealing with mange are needed and many are being used successfully in the field.

In a landmark registration one method using a proprietary product, Cydectin, was successfully approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA). This was based on a conservative, long term treatment protocol developed by the Wombat Protection Society of Australia Ltd, a National charity. This method was registered through the work of Mange Management Inc. in Victoria and remains the only veterinary medicine registered for use on any native animal.

Since then, real time field trials have demonstrated far better results for treating severely infested, free living wombats with up to 20x the registered dose rate for preventing and managing mild infestations using Cydectin. Other products and options exist depending on treatment circumstances.

Many groups and individuals registered to care for native animals now recognise the importance of being involved in mange treatment. This symposium will showcase

fieldwork, options and develop a consensus to assist change the current registration protocol based on observed outcomes of treating free living wombats.
Amanda Cox a founding Director of the Wombat Protection Society of Australia presents this opening summary of past work, introduces issues other presenters will explore in depth and poses questions for group discussions.

We meet today on Ngunnawal Country, homelands to the Ngambri, Ngambri-Guumaal and Ngunnawal people. To our North the Gundungurra, to our South the Ngarigu, inland the Wiradjuri and to the Coast the Yuin to which Nation the Budawang people from whom I descend belong. Budawangs call wombats Meringlees. I pay my respects to elders of all, past, present and future. Kwi:bien, where we meet means clear waters.

First of all, welcome to everyone, I know the next two days are going to help us move forward and onward in our shared quest to stop wombats suffering from mange. I have had the pleasure in meeting and working with many of you here over the years, others I have heard of and look forward to meeting and as equally great to see, there are folks here I haven't met and I am looking forward to meeting you and talking about your interest in our wonderful wombats.

I'd like to particularly thank Marie Wynan who you see in this photograph, Jenny Mattingly and Shirley Lack, my co-directors who have worked so hard to bring us together for this Symposium. I'd like to thank my other co-directors David Alder, Lyn O'Bern and Oma Rogers for their ongoing support of the Society's mange hub. You will be hearing from Jenny Mattingley next and Marie Wynan tomorrow.

Housekeeping

A little housekeeping to start.

Phones on vibrate rather than ring would be appreciated. If you are on call or likely to need to go outside if you could sit to the sides or back that would also be appreciate and if you then come back would you be kind enough to sit at the back until speakers change.

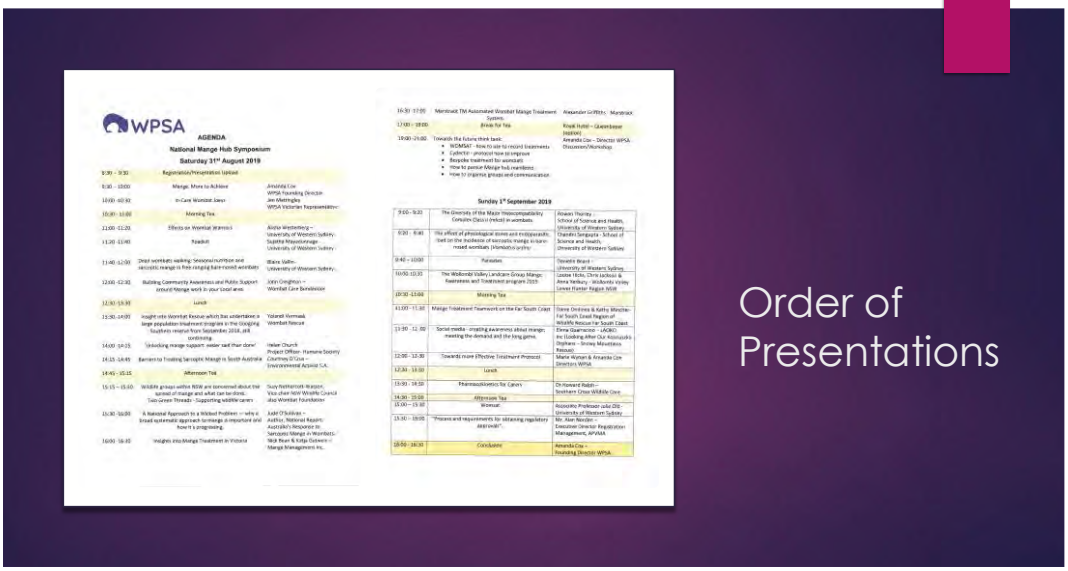
Questions
While we know there will be many questions and comments you will want to make our VERY tight schedule means we will need to deal with these in breaks, tonight and in our wrap up session. There are white boards and pens for you to write up your comments and questions, if someone has an answer, please also write that up there as well so the questioner and answerer might be able to get together informally.

Tonight we are heading to the Royal, a local hotel with food and the directors and Conference Conveners welcome anyone who wants to join us for a quick meal before tonight's group sessions.

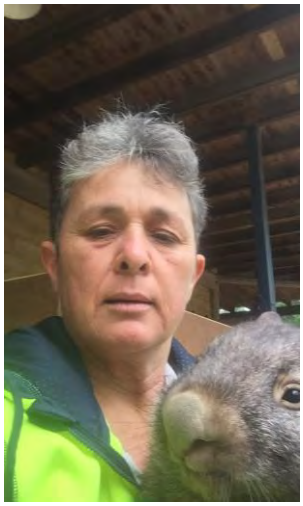
As you will know tonight we envisage five think tank groups to develop ideas and

objectives for the Mange Hub going forward. Please don't feel intimidated to join in any of these, we need and want your ideas and input.

We have a few changes to the Conference program……



We have some minor changes to the order of presentations. One of our University of Western Sydney students is unwell so the others have shuffled themselves around so that they cover the slot today and there will be time for another presenter to get here tomorrow, so all presentations will be covered.
Wombat Awareness Organisation of south Australia couldn't be here but sent a Video through late last night so for those of you who'd like to see that we will make arrangements. Correspondence with WAO prior to the symposium has also been included at the end of this opening presentation.



For those who don't know me, my name is Amanda Cox and I am passionate about wombats. My academic background is in science and psychology and social administration. My partner Jan and I bought a property on the far south coast of New South Wales some thirty years ago and found, with great delight, amongst the various wonders of eighty acres of bushland, that we had company.

Male wombat and joey playing

Wombats.

And then there were more

And, then, we went out of our way to invite more of them to live with us.

And more……

And more.

And more.

Responsibility and Compassion

WPSA

Along with the responsibility of caring for their land and raising and releasing wombats on that land came the responsibility of ensuring wombats released and in surrounding areas remained healthy and happy. That meant taking mange seriously and spending time and effort managing mange. And developing an organisation which could and would. And that is what brings us all here today. That responsibility. And our joint compassion.

Many threats to our three wombats

Lasiorhinus Krefftii

Northern Hairy Nosed Wombat
Critically Endangered and restricted to two protected areas in Queensland

Lasiorhinus Latrifons

Southern Hairy Nosed Wombat
Vulnerable and primarily in two areas in South Australia

Vombatus Ursinus

Bare Nosed Wombat

No protective listing and most vulnerable to mange

We have three species of wombats in Australia still surviving today.

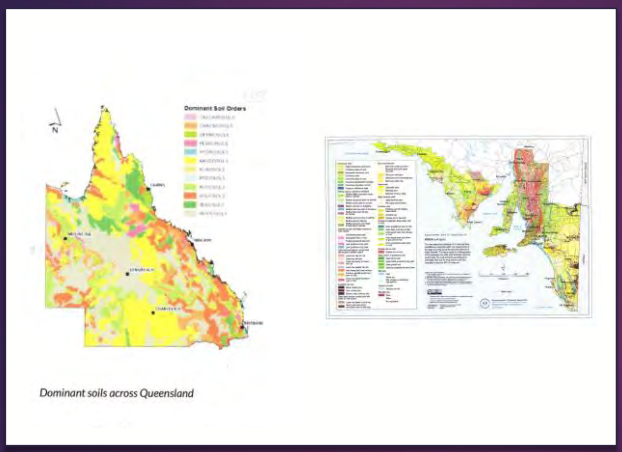
The Northern Hairy Nosed wombat is critically endangered and lives in two predator proofed, highly monitored areas in Queensland. There are approximately 250 (env.des.qld.gov.au) animals in total living. There has never been a report of mange in Northern Hairy Nosed wombats. This can't just be related to the heat in their two relatively small protected habitats in Queensland because *sarcoptes scabiei* is prevalent in places with similar temperatures, for example the Northern Territory.

There is some debate regarding the prevalence of mange in Southern Hairy Nosed wombats in South Australia and the smaller populations of Bare nosed wombats there as well. We will be hearing from Courtney D' Crus regarding her observations of South Australian wombats. Dr. David Taggart has conducted research on *Sarcoptes Scabiei* in SHN wombats and reported to us for this Symposium that he had found mange in Southern Hairy Nosed wombats. We will revisit some of his observations later when we discuss South Australia.

Of the three main species of wombat the Bare Nosed Wombat (*vombatus ursinus*) is most effected by mange across its' range which covers N.S.W., Victoria, South Australia and Tasmania. Threats include diminished or non- viable population numbers as with the Northern Hairy Nosed wombat, habitat destruction, legal and illegal culling and road kill . Most road killed wombats are healthy and male. (Old et

al.p.1, 2017). Sujatha Mayadunnage from Western Sydney University will be talking to us later this morning about this very issue.

The differences in mange between species is interesting. If correct, and certainly the NHN wombats are very well monitored so it seems very correct for them we should be asking WHY IS THIS SO?



Could soil types be a determinant of mange distribution… and diatomaceous earth an adjunct treatment?

The Northern and Southern Hairy Nosed wombats have silky hair, compared to bare nosed wombats, we wonder whether that is a factor. The Bare Nosed Wombats have in the past been called Coarse Haired Wombats so this observation of hair type has been noted for many decades.

Dr. Scott Carver from the university of Tasmania spoke to me about his research and belief that mange was being transmitted wombat to wombat by burrow sharing. If that is the case, we would think that Southern Hairy Nosed wombats, who often burrow communally would be at more risk than the Bare nosed wombats.

A further interesting factor is to consider soil types around wombats. Walker et al. (2007) from Monash University looked at whether soil types were a factor in the organization of Southern hairy- nosed wombats; as you may know many of these wombats live in a group of burrows often called warrens. Based on previous work showing rabbit burrowing and sharing of burrows was related to soil type, Walker et al. applied this to wombats.

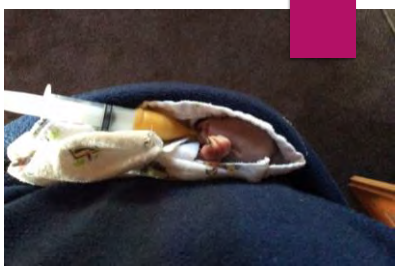
At a wombat training day a woman approached me to ask whether we had ever used the sand they use to remove mites in poultry farms. I'd not heard of this previously and did a bit of research into what is actually diatomaceous earth. Sand that is the crushed carapaces of diatoms, sea creatures. I was particularly interested to read in Walker et. al "the Nullabor Plain was a sea floor from the Lower Cretaceous

until the limestone rich plateau was uplifted in the late Miocene." (p.199). It is possible that soil types, particularly if burrow soils contain diatomaceous earth, may mean those wombats are mechanically ridding themselves of ectoparasites. There are so many interesting things to think about and discuss. Could we start using diatomaceous earth (easily purchased as a filter sand) in wombat scratching places and burrow entrances to assist reduce mite load?

From Little things big things grow

WPSA

- the idea that we should only react when a species is on the brink of extinction is anathema to people concerned with animal welfare and those concerned about species survival.



I recall when I put material together for the first Mange Symposium, a long, long, long time ago, it was relatively easy. There simply wasn't much information out there and what there was you found by going to a thing called a library and looking up potential material on a micro-fiche. The people involved with wombats as carers were few enough for me to have a handwritten notebook with their names and those actively involved in trying to treat wombat's with mange so few I didn't even need to write their contact details down. I called them on a telephone with a holey dial. The main fauna care group in NSW at that time had a belief that mange was untreatable and only contracted by immune deficient wombats and euthanasia was mandatory for members. (well, for mangey wombats!) Tasmania denied the existence of mange in wombats, no State government or any university was involved in mange monitoring or research.

It wasn't until in 1998 R. Martin et al. published results of a survey they undertook and they concluded that mange was present in all wombat populations throughout their range, including Tasmania and Flinders Island. (p.411), yet when the Wombat Protection Society wrote to the Tasmanian Premier in 2006 we were told in no uncertain terms that whatever was happening with mainland wombats, theirs were safe.! And then along came the major epizootic in Narawantapu National Park wiping

out almost the entire population of wombats. See a different Martin, Alynn Martin et al (2019). R. Martin et al. also thought that epizootics were sporadic and had the potential to threaten long term survival of small remnant populations.(p.411) and we seem to hear this being quoted by others.

From little things big things grow

Do we only need to care and react if a species is likely to go extinct?

It is not only a welfare issue for wombats that we need to care and pay attention. The human element also needs care and support. You will hear from numerous wombat warriors this weekend of their work and the energy, cost and effort that goes into it. We need to care for one another and although wombat people seem to me to be as diverse and bolshey as their favourite animal, sometimes we forget to nurture one another. Alisha Westerberg from the University of Western Sydney will be speaking to us later this morning about the Effects on Wombat Warriors and later this afternoon, Suzy Nevercott – Watson will talk about Two Green Threads a site supporting carers and of the NSW Wildlife Council's concern for wombats with mange. Similarly later this afternoon we will hear from Jude O'Sullivan who has authored a report : Australia's Response to Sarcoptic Mange in Wombats.

The mighty mite ; *Sarcoptes Scabiei*

Back when we began we even had trouble finding a picture of a mite and did our best with a skin scrapping and a National Geographic microscope and an old thing called a camera!
I suspect we didn't even achieve the photo of the mite, rather a skin cell, but look what a few clicks of the computer can bring up today, thanks to Webmed.

WOMSAT a better way to collect data

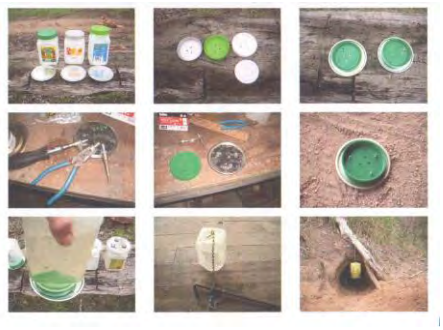
WomSAT.org.au

We mapped mange and wombat distribution with a map, literally.

And today we have WomSat technology a satellite system able to be used Australia wide. Associate Professor Julie Old from Western Sydney university has worked hard to develop this system and continues to direct the program. We believe it should be the “go to” place to record Mange treatment. To this end the Wombat Protection Society’s Mange Hub has a working group tonight to further that aim. We hope you will be able to join in and not only learn about WomSat if you haven’t already been using it,but help develop the system to allow the Mange Hub in partnership with the University of Western Sydney to make it easy for everyone to contribute. Associate Professor Julie Old will present formally on WomSat tomorrow afternoon and give us all a lot to think about as we wind up.

During this Symposium, the Society’s Mange-Hub will ask you to get on board and use this technology to record your work and observations . I’m sure you’ll feel confident to do so knowing your data will be protected and proactively used, not just collected for the sake of data collection. We’ll also ask you to sign on for Candice Skelton’s current research project, interviewing mange treaters, another Wombat Protection Society and University of Western Sydney collaboration.

Sulphur in oil to Cydectin in flaps



……So things change……So while mange was considered untreatable by many, Sulphur in oil was the one means used to treat mange in wombats. It was and is sometimes still used in treating scabies in humans at 8 - 10% medicinal sulphur in a carrier . (1) So although it sounds archaic, sulphur has been used as a miticide for centuries and still is today. We ran around with a bucket of sulphur and oil or a stick with a rag dripping with it trying to get it on free living wombats. A lovely bushy bloke by the name of Brian McCarthy, sadly no longer with us, invented a container and the idea of hanging it over a burrow to slurp the sulphur and oil mix onto the wombat. Brian's original device was made from a milo tin back in the days when milo tins were tins. When I asked him how much was needed to be on the wombat to work, he replied, "it's got enough on when your eyes slide off". The first picture shows our original instructions to help people make one of these sulphur and oil dispensers.

Lee Skerrat's ground-breaking thesis showing that mange in wombats could be treated successfully using injectable ivermectin was lodged with Melbourne University in 2001. By this time Cydectin was on the market as a pour on and seemed to me to be a suitable replacement for sulphur and oil. After a great deal of research into properties of the macrocyclic lactone class of chemicals of which ivermectin and moxidectin are members, Cydectin, containing moxidectin seemed to be a good proposition for treating free living wombats. I made the first burrow flap - a big

heavy plywood flap with a little bottle top attached to deliver Cydectin. I must say Brian was horrified when I suggested we honour his sulphur and oil device by calling the plywood flap a McCarthy flap. He hated the idea of using “chemicals” on wombats. I’d have to say the wombats weren’t too impressed by a big wooden thing in the front of their burrow precluding them from using that spot to sun themselves either.

A tiny top tip to a .....

So we moved onto Cydectin in tiny containers on gates and in flaps. The legs in the first picture belong to another wombat warrior no longer with us. Dr Phil Borchard shown here filling the tiny bottle cap we used from a syringe containing Cydectin. Phil, then a Phd student was studying how to limit wombat breaches through fences. He was doing his research on a Berry farm in Brooman State forest and offered to use his camera set up to help me test how much Cydectin landed on the wombat. This was back in the days where individuals couldn't dream of affording a MAC camera so I was very appreciative of his help with providing photos and discussions. Our first wombat treated shown in the second photograph didn't have mange and Phil and I had much discussion about whether there would be an issue if we treated non manged wombats! These days we are far more confident with the safety of moxidectin, the active ingredient in Cydectin for wombats, but not so back then. I was saddened when Phil, just awarded his Phd died, much too young. His work remains a seminal and instructional document on mitigating fence breaches by wombats.

Flaps and straps

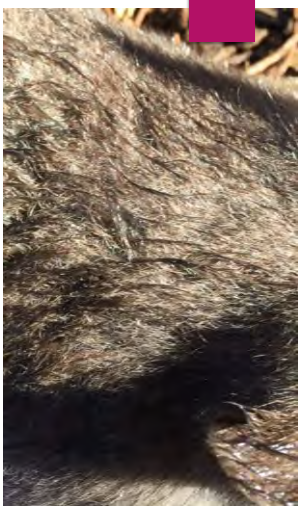
Over time, not only did the size of bottle tops diminish to the point where they weren't able to hold even the minimum amounts we used initially, but as the safety of Cydectin and its use over burrows became more established, larger quantities were being used with less concern so container sizes grew. Flaps were simplified using ice cream lids, later Perspex and corflute and more recently the Managing Mange in the Mullion group has made them out of chicken wire which allows sun in and stops wind disturbing the flap. My friend Lenore Taylor tends to just use a container and straps on sticks to connect it to the burrow and to allow the wombat to set it off.

Syringes on sticks to poles and scoops

The burrow flaps were originally hung over burrows where wombats seen with mange had run or on pathways or fence holes known to be used by them . We experimented with water pistols and other devices to try and squirt the Cydectin on those wombats we could get close to (with much loss of product) and an extendable stick with a syringe filled with Cydectin. This was a precursor to what is more commonly used today and known as the pole and scoop. Our last presentation today is with Alexander Griffiths on the Marstrack Automated Wombat Mange Treatment System. A far more up market, programmable delivery device. So, while there is more to achieve, much has been.

The ongoing quest for natural remedies

- Kritterkleen is a new product made from extracts of Flinders Island plants.
- While not fully tested for mange treatment and prevention the delivery system being used may be of benefit where product is needed regularly.



People continue to see whether less synthesised products can be used to prevent or treat mange. Mike Pickford developing Critterkleen was not able to attend but provided a sample bottle and these photographs.

Regarding Critterkleen he says "We are still unravelling the mystery ourselves but it works. The product is derived from natural oils distilled from plants on Flinders Island – its 100% organic which makes it pretty different from Cydectin!

We do know it actually rejuvenates skin and hair growth. Some of the laboratory tests we have done does show it can kill skin cells themselves, especially weakened ones. We suspect the infected wombat cells literally die and fall off.

We also know it is a strong insect barrier – whether it actually kills rather than repels mites we are still trying to understand. We are seeing the product have amazing results on companion animals with chronic rashes/flea bites/scratches so we are pretty excited about where it may end up.

Several animal refuges are using it and reporting impressive turn arounds within two weeks, especially on animals in care they can swab every day or two. "

Katja Gutwein from Mange Management Victoria will also give you an update on another non synthesised product and its delivery system, Red Healer, during the presentations.

An elder from the D'harawal people , botanist, Aunty Fran Bodkin has described

Mentha satureoides, native pennyroyal a plant wombats used to roll in to remove the mite. Aunty Fran says when cattle came they ate it all and this is why mange has spread throughout the wombat population. See Waraburranura.com. Wouldn't it be wonderful if we could get all our bush regen. folk planting out our riverbanks with this plant!!!

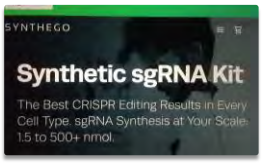
Towards the future – a think tank

Mechanical Tech.

Farmers are already using drones to monitor stock and animal recognition techniques to treat individual animals. Can our wombats benefit from new tech.?

Identity tech.

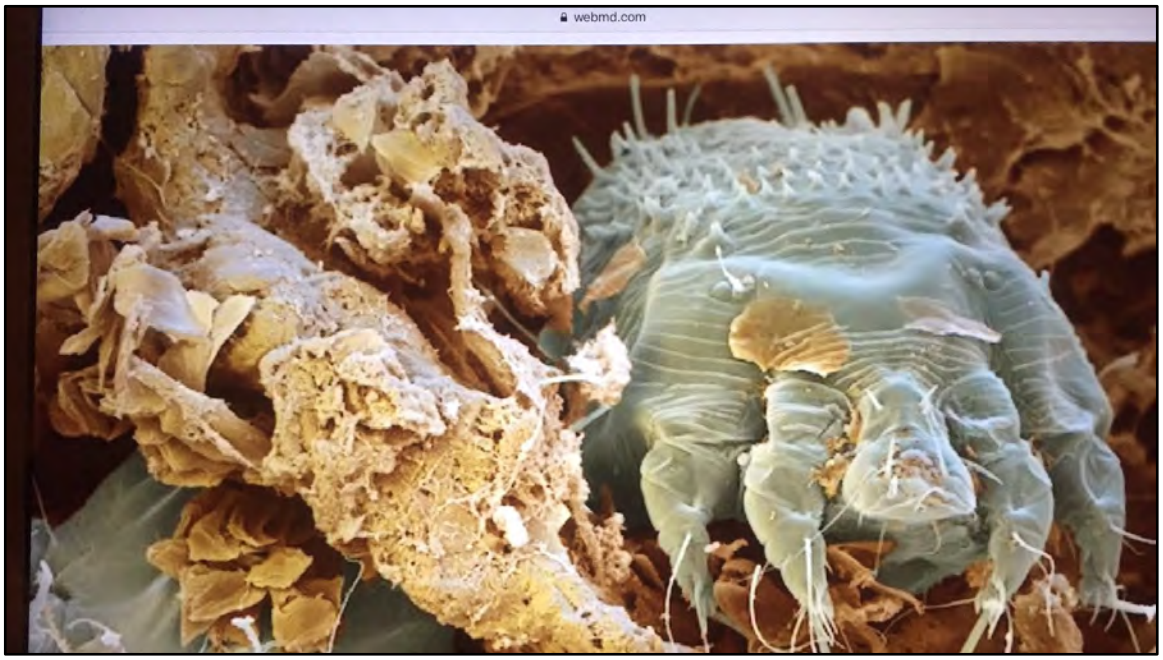
Pic. Cyberextruder Radio collar tracking and microchipping have been used- but will technology provide non invasive tracking and treatment?



Genetics

Would you genetically modify the wombat or the mite? The quest for a vaccine continues but is the answer modifying the mite?

There are many new ideas, like Marstrack the programmable delivery device being developed. We hope tonight in the toward the future group some of you will enjoy brainstorming some of the possibilities for the future using application devices. Whether you think a drone might be able to deliver Cydectin or monitor wombats, whether facial recognition might be used to recognise an individual wombat and be connected to a treatment system or whether you think that genetically modifying the mite or the wombat might be a good idea, your opinion (and ideas) are wanted. And, if you don't get time to cover all you wanted to think and talk about tonight, there will be ongoing contact and discussion forums set up to support our work until we meet again.



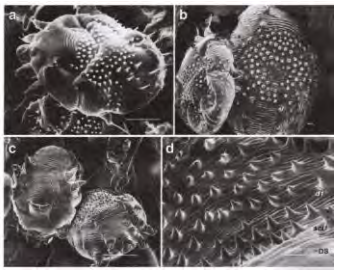
So here is our nemesis, the female mite thanks to Webmed.com and the electron microscope. She's an arthropod of the class Arachnida, the spiders being her relatives rather than the insects, her subclass is Acari and her family Sarcoptidae. She mates once and then begins to tunnel her small (0.2 – 0.4 mm)2. straw coloured oval body into the subcutaneous tissues of the wombat, or the human or other host.

She has no eyes, she has short thick legs and on her dorsal surface blunt short spines which help her keep place in her burrow.

A mated female needs only an hour to excavate a burrow in the skin and then she lays two to three eggs each day, burrowing a further 0.5mm – 5mm in a directionless serpentine manner using her mouth parts to clear the path and consume the skin and tissue fluids that ooze from her burrowing. Each burrow contains only one female, her eggs and her faeces. After two days the first eggs hatch (2) after three to four days (3) the larvae scrabble to the surface of the skin and make a moulting pouch or use a hair follicle to hide in until it moults to the next stage……causing itching.

(2) Medent.usyd/scabies
(3) Centre for Disease Control CDC-DPDx-Scabies

Classification



Super Oder – Acariformes
Order – Sarcoptiformes
Suborder – Oribatida
Infraorder – Desmonomata
Hypoorder – Astigmata
Family – Sarcoptidae
Subfamily – Sarcoptinae
Genera – Sarcoptes
Genus - Scabiei

The mite is considered one of the first known causes of disease in human medicine and recognition of the link between the mite and human scabies dates to 1687 in European medicine. The skin disease caused by mite infestation is believed to be described in Leviticus 1200 BCE. (Arlian, 2017, p. 1)

The mite has an oval tortoise like body, ventrally flat and dorsally convex. All eight legs of adult males and females are short and stout and are generally described as pairs 1,11,111 and 1V. Terminal segments of the legs have claws. Two spur like claws are on all pairs of the female and males may be distinguished by having only one spur on pair 1V. Males are smaller. (Arlian, 2017, p. 2). Mites are too small to be seen by eye.

Mite Life Cycle

Egg

Nymph

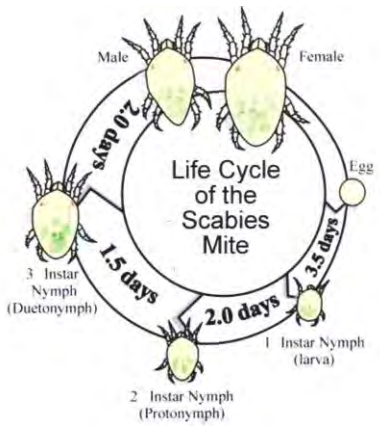
Protonymph

Tritonymph

Adult

Life cycle reports highly variable in the range 12-21 days.Female life span up to two months. In vivo studies suggest 10-15 days for canis and suis varieties.

Female produces 40-50 eggs over life span of 26-40 days.



The life cycle of the mite consists of egg, nymph, protonymph, tritonymph and adult. The nymph stage has six legs but each following stage eight. This is why the mite is more correctly related to the spider and placed in the Acariformes classification and why products like Cydectin are called acaricides.

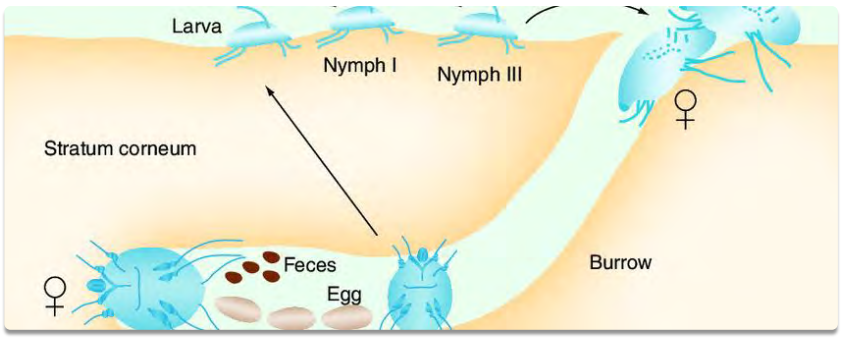
The mite life cycle is reported variously throughout the literature and has been so for decades. Larry Arlian recently reviewed thirty years of research and noted research indicating 12 to 17 days, 17 to 21 days, 7 to 10 days and 9 to 15 days. He noted that historical records suggest the female produces 40-50 eggs over her life span of 26-40 days. (Arlian, 2017, p.3). The longest potential life of the female mite I have seen in the literature is from the Centre for Disease Control CDC-DPDx-Scabies of one to two months. The later also says that only 10% of eggs develop to mature mites.

Further variations occur in the literature as to how many eggs are laid, how long each developmental stage of the mite is and how long the female mite lives.

Source differences in mite life cycle lead to significant variation in any predicted mite count. Lee Skerratt showed conclusively that Mite count = Clinical signs. If the female mite lives for a month and her first progeny are mature and fertile in 15 days, she produces two lines of mites before she dies, on day thirty there will be 15x15 (225) mites she has produced. If the time to maturity is 10 days and she lives for 30,

on day thirty there will be 10x10x10 mites (1000).

Danielle Beard from University of Western Sydney will be talking to us tomorrow about Parasites, the mite and others, and Chandi Sengupta also from the University of Western Sydney the effects of physiological stress and the endoparasitic load on wombats. Diagram from Pinterest



Mite development

The development of the mite infestation in wombats is a death sentence. There is no spontaneous recovery .

As the female mite burrows in, she lays eggs and leaves faeces in her tunnel. Her larvae move to the skin surface and make moulting burrows superficially in the skin. There they develop through three protonymph stages to adulthood. If female, she will mate the once and off into digging deeply into the skin she goes; if male, he'll remain on the skin surface along with the developing next generations.

Initial signs of mange are erythema (redness of the skin) parakeratosis (parakeratosis is a mode of keratinisation characterised by the retention of nuclei in the stratum corneum and keratinisation is the process in which the cytoplasm of the outermost cells of the mammalian epidermis is replaced by keratin – ie: the growth or production of hair, claws, nails- in birds feathers) alopecia (hair loss), excoriation and fissuring of parakeratotic crust and skin. (loss of and splitting/cracking or skin). (Skerratt 2003,p.179) for description, Cox 2002,2005 explanations in brackets.

Lee Skerratt found that previously uninfested wombats infested with mites showed erythema 14 days after exposure (DAE) or within 24 hours of re-exposure. Parakeratosis was visible 14-21 DAE and alopecia 35-77 DAE. Clinical signs increased in severity over time and lesions spread from the site of exposure (infestation). Wombats scratched excessively, lost weight and exhibited significant neutrophilia.

(high numbers of neutrophils in blood). The intense itching that occurs has been shown to be caused by T4 cell dominance and the pruritus (the intense sensation that creates the need to scratch) reduces as T8 cells increase.
Medscape.com/answers. This may explain why severely infested wombats don't do much scratching.
Diagram from Mumcuoglu et.al.

Sarcoptes infests many species

Wombats

Bare nosed and Southern Hairy nosed effected.

Dogs

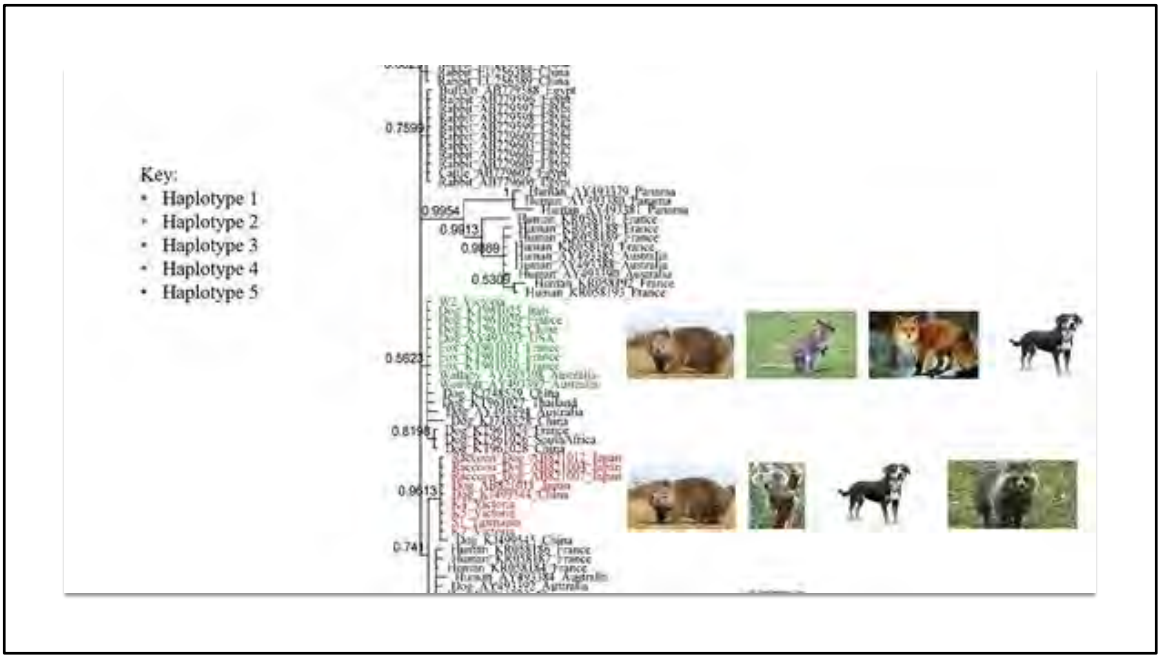
Dogs, Cattle, Deer, Racoons, Echnidas, Wallabies, Koalas, multiple animals outside Australia

People

Scabies remains a major issue of infestation for people. Very prevalent in indigenous communities in Australia.

'Sarcoptic mange is a globally distributed infectious disease that affects over 100 species in 10 different mammalian orders, including humans' (Simpson et. al. 2016) . Scabies mites have been found on virtually all animals and people world wide and while there is a tendency to designate the mite infestation by the animal it infests, for example *sarcoptes scabiei* var.wombati (Skerratt, 2003) current research (Fraser et.al. 2017) using mitochondrial genome sequencing is demonstrating the likelihood of multiple host origins and more similarities across mites between species (Koala/wombat) than within (wombat/wombat). Sarcoptic Mange in Wombats- a review and future research paper co-authored by Old, Sengupta, Narayan and Wolfenden (2017) provides an excellent discussion of this area.

In Australia many marsupials are reported or found to carry the mange mite including wombats, wallabies, koalas, bandicoots and dingos. (Frasier, 2017,p.2). I have seen echidnas with the typical crusting of mange on their rear legs.



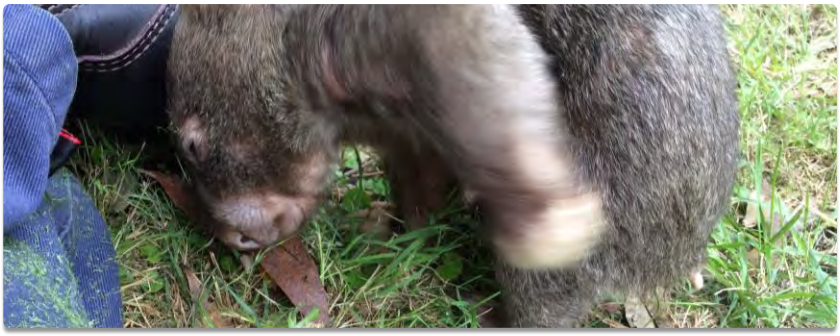
Many animals are able to be infested with the scabies mite, and the relationship of the mites to one another and to their originator is still being queried. There has been a tendency to call any mite infestation by the name of the animal it uses as its' host, hence var. *wombati* (as per Skerratt, 2003 and others). As research progresses the truth is yet to be known.

Arlian (2017) only distinguishes three types morphologically (ie. by specific structural features) see slide 20 – human, dog and pig. (var.*hominis,* var.*canis* and var. *suis*) and although Skerratt et al. (2002) phylogenetically (evolutionary development and diversification) analysed sequence data for Australian wombats, humans and dog hosts and thought that the 12S ribosomal RNA gene would prove a good marker to follow the evolutionary trajectory of the mite, the methodology of Skerratt's model was quickly called into question by Morrison et. al. in 2003.

With the advent of new and better genetic sequences models and methods, we are discovering more. Fraser et. al. (2017) found that the *cox1* gene is the most informative gene for molecular epidemiological investigations and their work suggests multiple introductions of the mite and cross host transmission between different animal hosts. Tamika Fraser said "the evidence suggests the mite may have

been introduced to Australian wildlife by animals from overseas on multiple occasions since European settlement……this was surprising because previous research suggests the mange mite was introduced to Australia by European settlers. This research does not suggest this hypothesis is incorrect, but that the origins of scabies mites in Australia may be more complicated than originally thought." (My Sunshine Coast interview, 25th Jan, 2018).

Diagram showing relatedness of halotypes from Fraser et.al (2017), p.7.



Pruritis = intense sensation that creates the need to scratch

T4 cell dominance causes pruritis; pruritis decreases as T8 cells increase

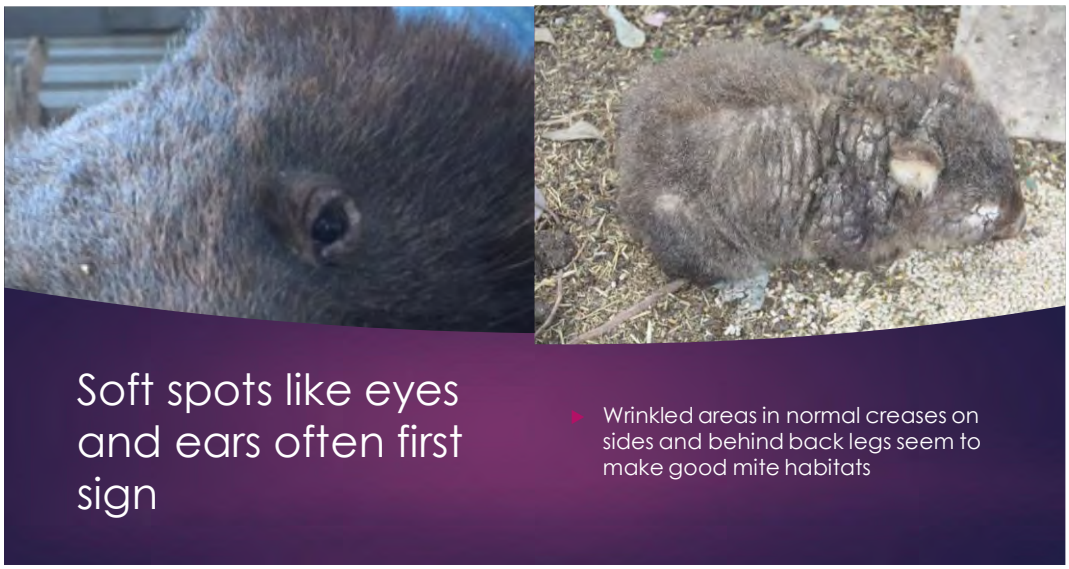
We will hear about the work Blair Vallin From University of Western Sydney is undertaking later this morning concerning nutrition- definitely a neglected adjunct area of treatment when we are treating wombats for mange. Given moxidectin is accrued in adipose tissue it makes sense that wombats will recover better is their fat reserves are maintained.

And I am sure when we hear Dr. Howard Ralph speak tomorrow afternoon on pharmokinetics for carers he will have more to say on this topic, Howard has been using a Blood Analysis Machine purchased for Southern Cross Wildlife by the Wombat Protection Society some years ago. To have someone of Howard's calibre speak to us on Sunday is a rare and precious privilege. Howard's combination of clinical understanding and experience and practise with wombats is second to none.

Rowan Thorley from the University of Western Sydney will talk to us about the diversity of the major histocompatibility complex class ii (mhcii) in wombats tomorrow.

Hair loss and loss of keratin early signs

Early signs in wombats include the persistent scratching and hair loss is sometimes seen around the face. Hair changes and hair loss are indicative of a well developed developed infestation.



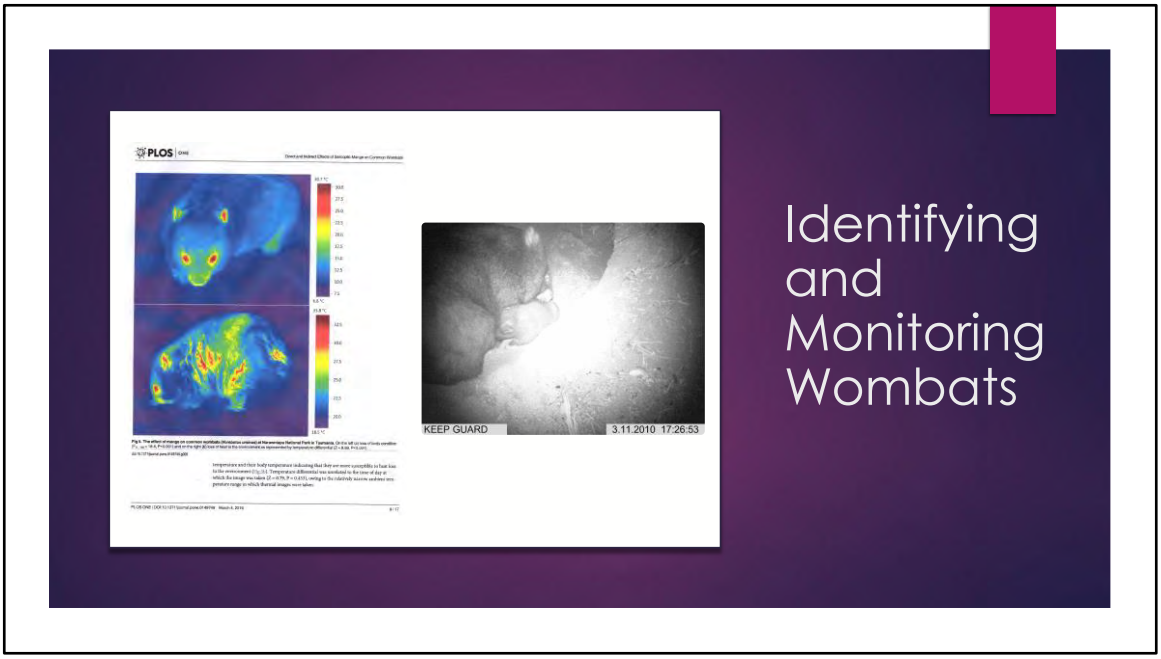
The keratinising process leads to scabbing, often formed around “soft spots”, eyes or in wrinkles on the sides and the back of legs. It is interesting that Skerratt (2001) found that when mites were placed on the wombat intentionally, the development of clinical signs began in the place infested.

Over time, the crusting develops often all over the wombat.

Over time the whole body shows keratinisation

Wombats often seen trying to sun themselves, a combination of heat loss and instinct? Recognising mite load decreasing in sunshine ?

Until the whole body is affected.



As technology improves so do our options for identifying and monitoring wombats we are treating. The male wombat in the second photo could be mistaken for having mange near his front right leg and on his battered left ear. The joey, caught in the flash looks quite bald. Neither had mange.

The thermal imagery in the Johnson and Carver paper is a great improvement on human assessment or basic MAC photography, but not everyone will have access to such technology.

Many options- circumstances dictate

Topical smothering

Sulphur in oil, neem oil, lotions and creams can smother superficial mites

Miticides

Oral pastes, injectables, tablets, spot on and pour ons

Adjunct therapies

Antibiotic therapies to treat and reduce bacterial infections.

Food and water

We know there are many, many ways to get rid of the mite. Small pinkies can be bathed and often just the normal greasing process to keep their skin supple will act as a mite removal process. Obviously, the females in the skin need to die and her eggs hatch, but once the various larvae and nymphs are out in their superficial moulting pouches on the skin, creams and oils, even without an active miticide will usually kill the infestation. Jenny Mattingley will be talking to us next about joey wombats and I'm sure we will hear many more options.

Just a reminder to carers that good husbandry is vital- clean bedding, pouches washed and dried in sunlight- husbandry is as important as whatever medicinal products get used. Similarly, for those poor wombats with mange that die or are euthanised, proper body disposal and quarantining until that can be arranged is VITAL. As the host's body cools, mites are desperate to colonise the next warm host that goes near them.

We next move into the various active miticides that can be used and once again there are many. Which to use is dependant on the state of the infestations, (mild, moderate, severe) the circumstances of the wombat (pinky, furred, in care, free living) and the additional clinical issues (fly strike likely or has happened, ticks present/ no ticks; other infections) and again, how to deal with those depends on the circumstances of the wombat and the people treating the wombat. Understanding

what you are dealing with and not having a “one method fits all” approach is also important. As an example, there is a misbelief that if the wombat smells it is so badly infested it must be euthanised. Sometimes the damaged skin allows for other wounds to develop into abscesses and frequently secondary bacterial infections exist. This happens with humans too but we don’t immediately euthanise them!.

Miticides

Multiple options exist and should be matched to clinical circumstances

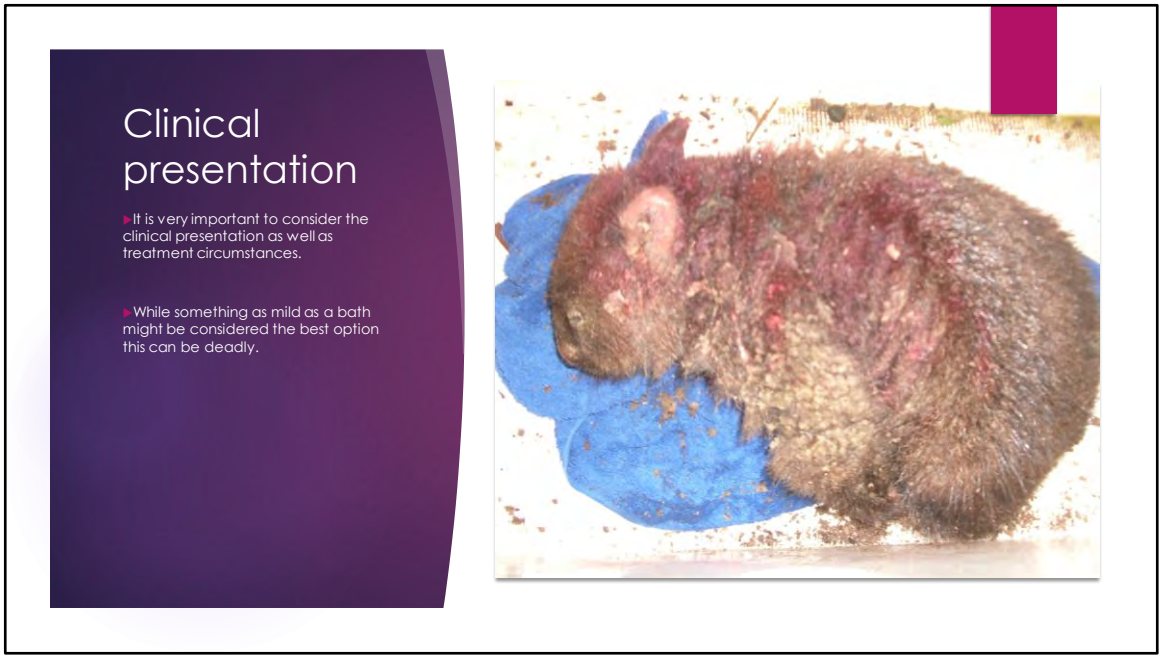
Once again, dependant on whether the wombat is in care or not there are different options. Topical antibiotics like terramyacin, available as both a powder and aerosol spray (often known as pink-eye powder/spray and available without script) can effectively assist where the wombat is not in a care situation and injectable antibiotics are not an option. (mind you, wombats, in general, dislike being sprayed with aerosols)…. And, although not necessarily registered as such, some of the miticides have antibacterial properties. Cetrigen an antibacterial spray is often used. It, like terraymacin spray have the added advantage of colouring the target wombat!

Also, if a wombat is in care and has been given an oral worming paste, often the active ingredient is the same as the active ingredient in a pour on or spot on, or if not, can be used to cover for more issues. For example, if I worm a wombat using equimec, a horse paste, it contains ivermectin, so I'm not going to treat ectoparasites with more ivermectin. I would probably choose Advantix, the dog spot on product which contains permethrin as the active ingredient active against scabies mites. I would do this knowing ivermectin acts in one way on the parasite and permethrin another so I'm likely to have a far better clinical outcome for the wombat using these things together. I would further know that the ivermectin paste will also have a mild antibiotic effect so were I to believe the wombat had a secondary bacterial infection

that was ivermectin sensitive I wouldn't do any more about that than check whether the paste would cover long enough to be effective, or I'd use something like a terramyacin powder if bacteria was suspect in them and Cetrigen if I was further concerned about flystrike, whereas if I was concerned about flystrike and could see maggots in a wound, I would pour my Cydectin directly onto the maggots and put a great deal on the wombat.

But when it comes to our free living wombats, things are a bit more complex and options begin to narrow. The concern that an unwell wombat taken into care not only seems to fret for its country and not thrive, but loses its country if it survives and is returned. Perhaps this wouldn't happen to each and every wombat but unfortunately for each and every wombat that sort of option doesn't exist anyway. Mange outbreaks often receive multiple reports of manged wombats in a relatively small area so overall, treatment in situ is the best and in most cases only option.

Outbreaks often tax the resources of the few dedicated carers who try and look after wombats in areas. This is a nationwide problem in terms of a lack of resources that is a direct result of a lack of previous concern for wombats suffering from this infestation. A couple of attempts to use flaps to treat broader populations have been attempted by researchers now and they are aware of how much time and effort goes into this work, how difficult our target animal is to treat , burrow moving, nocturnal behaviour, pulling down treatment devices…and how environmental variants- wind blowing flaps, floods and terrain difficulty all impact this work. Quite a few people will talk to us about their work in bringing together concerned people to assist in this work. John Creighton from Wombat Care Bundanoon and Yolandi Vermaak from Wombat Rescue and Helen Church from the Humane Society will all talk today about their observations.



Irrespective of what method is chosen to help the wombat, there does need to be some level of clinical understanding. Their scabbed skin is not like the scabs on a wound in humans, it is often the congealed mess of mites, keratinised hair and exudations from leaking skin. Bathing such a wombat can be fatal, this little girl was doing well until bathed after which the dry scabs were able to be scratched off, opening up her skin beneath which was similar to a burns victim. She died of toxic shock within twelve hours of the bath, absolutely nothing to do with any type of treatment (other than the bath) so a far better option for her would have been a spot on or pour on and keeping her body dry and as much of her skin as possible intact.

Just because something- eg; a bath, seems like the “mildest” treatment, doesn’t necessarily mean it is the best.

Topical ointments too can sting and be highly irritant to the damage skin. Currie et al. (2004) report on the case of a man in the Northern Territory treated in hospital with benzo-benzoate and tea tree oil for a crusted scabies infestation after ivermectin failed . The topical treatment stung so much he needed nitrous oxide administered to assist cope with the pain.

When we consider how spot ons and pour ons are used on wombats we need to remember that both these types of products were made for above ground animals, like dogs, deer and cattle, with relatively clean back lines, the area usually suggested for the spot on to be distributed in spots, or the pour on to be delivered in a line. Wombats do not have clean hair, often it is full of burrow dirt and in addition they have a thicker epidermis which is also likely to impact the absorption of such products into the blood stream.

With any pour on or spot on product, like injections or tablets, the means by which mites are killed is by the product entering the blood system, they are NOT like topical products, whether sulphur and oil, lindane, benzo-benzoate, malathion; which work by smothering or direct contact. While the later (a localised kill effect) does happen – for example most pour - ons delivered directly onto maggots, kill them fairly quickly, this is not the action with the mite we are trying to achieve. We are trying to get sufficient product into the blood stream to work, not just using the product like an insecticidal rinse. We need to remember nothing kills the eggs buried in the skin, we are also trying to "beat" the mite life cycle…..whatever that may be.

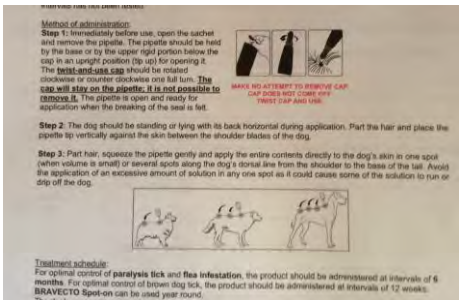
Our wombats are soil engineers, often healthily caked with mud and dirt let alone when they have keratinised plaquing from mange . These issues effect how much product can be absorbed through the skin. We will look at some commonly used

products next, but it is important to note that some of these give warnings which when working with wombats are particularly pertinent. Ivomec pour on product information specifically states "the anti-parasitic activity of ivermectin will be impaired if the formulation is applied to areas of skin with mange scab or lesions, or with dermatoses or adherent materials eg; caked mud or manure." The same general precaution is provided on the Ausmectin Cattle pour on product information.

Bravecto spot on product information includes “it is recommended not to use on skin lesions.”

Sometimes the discussion about mange treatment becomes academic and neglects the realities of what resources are on ground, available to treat wombats. Treating wombats with mange is to develop very critical skills of being able to make clinical decisions for the anima. To keep an area healthy often takes years of watching and monitoring, weeks of tramping back and forth, stalking the wombat, waiting for him or her to appear and really, really knowing an area of habitat to be able to do this. I’m sure you will feel the dedication and hours of expertise in presentations from those overworked and underfunded volunteers who have dedicated their time to this endeavour. It will be through their presentations that the Wombat Protection Society Mange Hub will develop, and publish as part of the symposium, an updated schedule of doses of Cydectin and we will also publish a summary of any alternative promising treatments that are discussed at this symposium. However I reiterate that wombats in care, zoos and sanctuaries are not the target of this endeavour. They, lucky ones, have many, many more options.

Spot on versus pour ons



Method of administration:
Step 1: Immediately before use, open the sachet and remove the pipette. The pipette should be held by the base or by the upper rigid portion below the cap in an upright position (tip up) for opening it. The **twist-and-use cap** should be rotated clockwise or counter clockwise one full turn. **The cap will stay on the pipette; it is not possible to remove it.** The pipette is open and ready for application when the breaking of the seal is felt.

MAKE NO ATTEMPT TO REMOVE CAP. CAP DOES NOT COME OFF. TWIST CAP AND USE.

Step 2: The dog should be standing or lying with its back horizontal during application. Part the hair and place the pipette tip vertically against the skin between the shoulder blades of the dog.

Step 3: Part hair, squeeze the pipette gently and apply the entire contents directly to the dog's skin in one spot (when volume is small) or several spots along the dog's dorsal line from the shoulder to the base of the tail. Avoid the application of an excessive amount of solution in any one spot as it could cause some of the solution to run or drip off the dog.

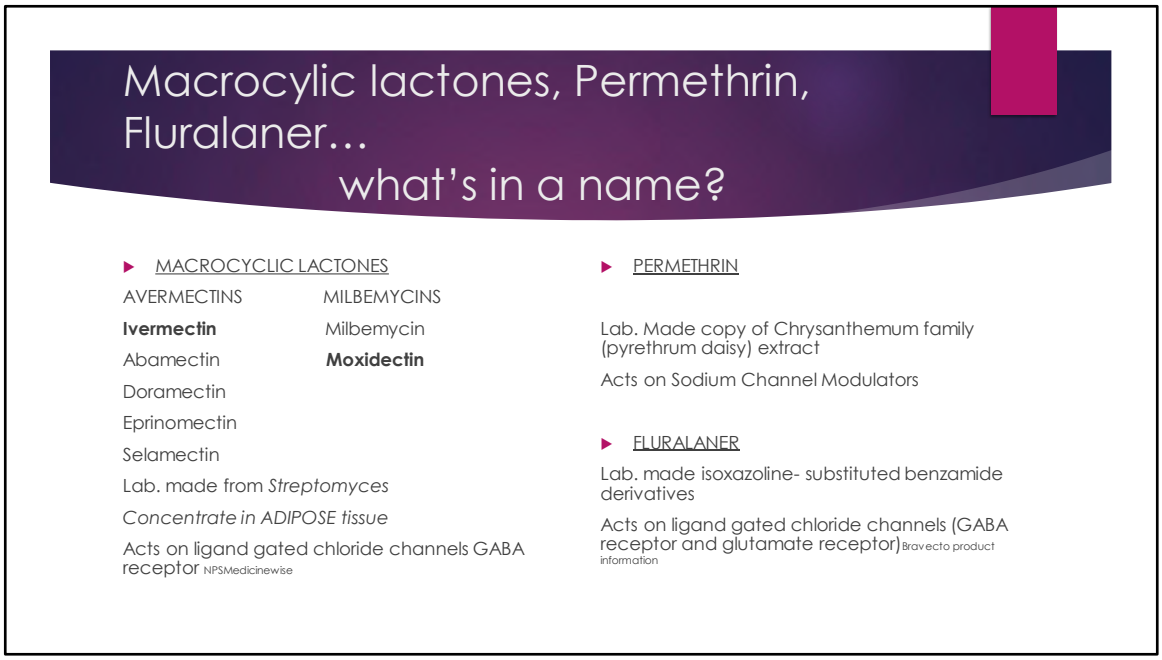
Treatment schedule:
For optimal control of **paralysis tick** and **flea infestation**, the product should be administered at intervals of **6 months**. For optimal control of brown dog tick, the product should be administered at intervals of 12 weeks. **BRAVECTO Spot-on** can be used year round.

Spot ons, are products developed to be directly to applied to the skin, specifically by parting the fur and placing a squirt of the product directly onto the skin. There are many products made to be used in this way,; Advocate, Revolution, Advantix, and the most recent one, Bravecto. All of these have been used for wombats…. BUT a spot on = captured wombat. The method of introducing a "spot on" into the bloodstream is to part the fur and squirt a proportion of the product onto the skin often in three or more places. The active ingredient is absorbed into the bloodsteam through the skin at those spotted on places. Pour-ons are different, mainly because their "carrier", the solution that distributes the chemical component "flows". Pour ons are most often used for herd animals, like Cattle and Red deer (Cydectin registered) . See parisitipedia.net for full descriptions of pipettes, squeeze ons, drop ons, pour-ons, backliners and spray ons.

Often the difference between these products is the carrier or solvent for the active ingredients. Spot ons generally have more viscous carriers, Advantix uses 484 g/l of N- Methylpyrrolidine to carry Imidachloprid and Premethrin; Bravecto uses Dimethylacetamide as a solvent to carry Fluralaner, a new class of isoxazoline - substituted benzamide derivates. Cydectin, to carry Moxidectin and Ausmectin , Noramectin and Ivomec pour- ons to carry Ivermectin are less open about what they are using but there are patents for water soluble ivermectin and others utilising

benzyl alcohol or oils.

There is a good body of work into carriers and solvents using zebra fish as test subjects (Maes et.al 2012) and it is possible that some of the newer products like fluralaner, the active ingredient in Bravecto and Afoxalaner in Nexguard, could be used in a more “flow” like carrier making them a possible future pour on solution for wombats. Chemical companies tend to present to the market their products in



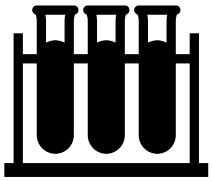
formulations likely to make profit, so spot- ons and chewables for dogs and cats and some other domesticated pets are the current market point for them. This does not mean, however, that their active constituent couldn't be placed in another type of solvent or carrier which could allow use with flaps or pole and scoop application methods. There is more to know and more to achieve. A "bespoke" product, specifically made for wombats may be the future. A vaccine would be terrific but as we haven't cracked one for humans with dust or scabies mites, it will be likely that option remains a hope for some time to come.

Most synthesised products we call chemicals, The Macrocyclic lactones are made in the laboratory. They are chemical derivatives of soil micro-organisms belonging to the genus *Streptomyces.*
There are two classes of macrocyclic lactones avermectins and milbemycins. The former include ivermectin, abamectin, doramectin, eprinomectin and selamectin. The later milbemycin oxime and moxidectin. (Vercruysse and Claerebout).

Many people who have treated wombats with mange will be aware of the pour-ons Ausmectin Cattle pour on (IAH), Ivomec for cattle (Merial) and Noramectin (Norbrook) all containing ivermectin, and Cydectin, containing Moxidectin. (see slide 32). Ivermectin is also used in Noramectin paste for horses and is the active

ingredient in Stromectol tablets for humans. Moxidectin is also used in the pet products Advantage and Advocate. The macrocyclic lactones concentrate if fat tissue which may be why the wombat, with relatively low levels of adipose tissue normally, and then when getting unwell losing weight, may use this class of chemicals differently.

Synthesised products



The permethrins are a class of chemicals made in the laboratory following the chemical structure of extracts from the naturally occurring Chyrsanthemum family (NPIC) . This includes the pyrethrum daisy. According to the APVMA Permethrin is formulated in Australia as powder, liquid, emulsifiable concentrate, wettable powder, dust, liquid concentrate, topical aerosol spray, shampoo, collar medallion, topical cream, ointment, paste, gel, lotion, ultra low volume liquid, suspension concentrate (flowable concentrate) topical pump spray, pressurised gas, ear tag and aerosol. Product poison Schedule listing depends on the concentration in product.

Advantix, a commonly used dog spot on product contains permethrin.
Y-Tex BRUTE, a cattle pour on uses Permethrin (25:75::CIS:TRANS) @ 87g/L. APVMA 56165. Demize, another permethrin based cattle pour on made by Elanco contains zeta-cypermethrin. Its' product information indicates that 'zeta- cypermethrin has a higher proportion of the biologically active "S-isomers" and a lower proportion of the relatively –inactive "R-isomers" than cypermethrin.' Deltamax, another cattle pour-on contains deltamethrin and is approved for use on horses for controlling Buffalo and Stable Fly and has a water base.

And the new kid on the block is Fluralaner, the active ingredient in Bravecto (a spot

on and tablet for cats and dogs) and a similar member of the isoxaline family Afoxalaner is in Nexguard (a chewable tablet) . Flurolaner and Afoxalaner are laboratory made from isoxazoline- substituted benzamide derivatives. They act on the parasite's ligand gated chloride channels, the GABA and glutamate receptors in much the same way as the macrocyclic lactones but have longer half lives according to their "hype".

Ivermectin Vs Moxidectin

- Ivermectin binds selectively and with high affinity to glutamate-gated chloride ion channels in invertebrate muscle and nerve cells of the microfilaria. This binding causes an increase in the permeability of the cell membrane to chloride ions and results in hyperpolarisation of the cell, leading to paralysis and death of the parasite. Ivermectin is also believed to act as an agonist of GABA. *Drugbank*

- Moxidectin selectively binds to the parasite's GABA-A and glutamate-gated chloride ion channels which are vital for the function of invertebrate nerve and muscle cells. It presents activity against the parasite but does not kill him. Once moxidectin is bound, there is an increased permeability leading to an influx of chloride ions and flaccid paralysis of the parasite. *Drugbank* Moxidectin differs from other macrocyclic lactones by being a poor substrate for P-glycoprotein. *Cayman chemicals*

According to NPS Medicinewise Ivermectin is an Avermectin acaricide that works by interrupting the functioning of a class of ligand- gated chloride ion channels in the scabies mite, causing persistent channel opening. It is postulated that ivermectin causes excessive release of the neurotransmitter gamma- aminobutyric acid (GABA) in the nervous system of the parasite, resulting in its death. Due to differences in life cycle stages and subsequent variability in ligand-gated chloride ion channel expression, ivermectin may not be effective against all stages of the mite. (NPS Medicinewise) As Moxidectin is not yet approved for use in humans in Australia similar information for it from Australian authorities is not available.

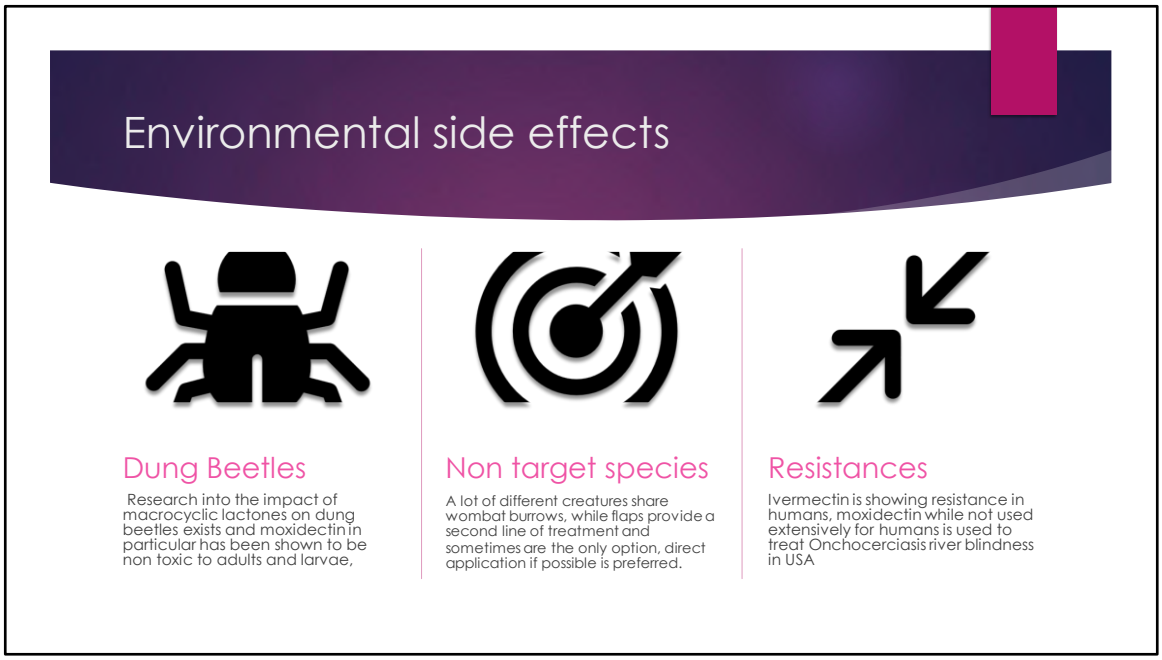
Cayman Chemicals produce commercial quantities of Moxidectin for laboratory work. They supply it as a crystalline solid which they indicate is soluble in organic solvents such as ethanol, DMSO and dimethyl formamide (DMF). It is produced from the fermentation of soil bacterium *S.hygroscopicus* subsp. *Aureolacrimosus.* Moxidectin is considered a second generation macrocylic lactone, it differs from other macrocyclic lactones by being a poor substrate for P- glycoprotein. 'P-glycoprotein, the most extensively studied ATP-binding cassette (ABC) transporter, functions as a biological barrier by extruding toxins and xenobiotics out of cells. In vitro and in vivo studies have demonstrated that P-glycoprotein plays a significant role in drug

absorption and disposition. Because of its localisation, P-glycoprotein appears to have a greater impact on limiting cellular uptake of drugs from blood circulation into brain and from intestinal lumen into epithelial cells than on enhancing the excretion of drugs out of hepatocytes and renal tubules into the adjacent luminal space“ Lin,2003.

Drugbank comparisons Ivermectin/Moxidectin
Toxicity :LD50 = 29.5mg/kg (mouse); 10mg/kg (rat) vs Moxidectin 70-131 micromol/kg (mouse)
Half Life: 16 hours vs Moxidectin 20.2 days
Metabolism: Primarily hepatic – excreted almost exclusively in faeces over 12 days , less than 1% in urine; Moxidectin 2% eliminated unchanged in faeces in 72 hours, renal elimination negligible
Protein binding 93% Moxidectin unknown in humans
Volume of distribution 3-3.5L/kg and it does not cross the blood- brain barrier, Moxidectin presents a larger volume of distribution and mean residence time when compared to ivermectin. The reported volume of distribution is of 1.2l/kg.

Permethrin in comparison, disrupts the sodium channel current which results in delayed repolarisation causing paralysis and death of the mite. As a result of this action, **permethrin is active against all stages of the life cycle of the mite**. (also Medicinewise, references quoted).

Dr Howard Ralph highlights the balancing act between achieving therapeutic levels and toxicity when he delivers Pharmakinetics for Carers tomorrow.



The Macrocylic Lactone Group of chemicals are the most frequently used ones to control external and internal parasites in stock. The APVMA (then NRA 1998) commissioned a study into the possible impact on dung beetles of excretions from stock. They reported that the excretion rate in cattle varied between products due to liphophilicity and rates of hepatic metabolism and clearance in the bile. They reported that following subcutaneous injections or application via topical dosing, ivermectin levels in cattle faeces peaked within 2-6 days and were found at negligible levels beyond 14 days. Doramectin was similar. Moxidectin residues were found to be excreted at a slower rate and persisted in the faeces for more than 28 days. (p.IX) The article also considered the impact of the various macrocylic lactones on dung beetles, moxidectin excreted in cattle dung was considered to be non-toxic to adult dung beetles and developing larvae, however residues in sheep dung after oral ingestion were high enough in the first two days after excretion to inhibit larval development in at least one dung beetle tested. (p.xi)

Non target species. Many animals and insects are seen to use wombat burrows. The burrow has its own ecosystem and at different times of the day you can see butterflies leaving, moths leaving and birds entering. Snakes, echidnas, wallabies, possums and foxes also occasionally enter burrows. The smaller creatures are unlikely

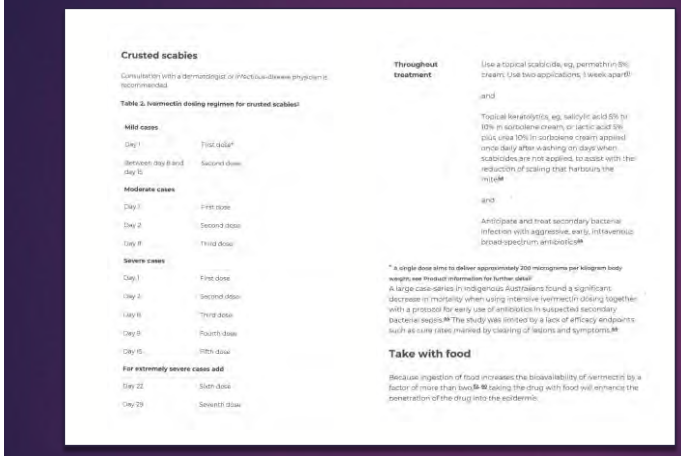
to set off flaps and to date there haven't been reports of mortality around burrows that have been flapped. Obviously, the ideal would be to have some mechanism that recognised the wombat and only ever allowed the target wombat to be treated.

Resistances

Moxidectin for treating wombats was and remains a good choice because it isn't widely used in humans. It is approved in the USA for treating Onchocerciasis, commonly called River Blindness, which is caused by the nematodes of the genus onchocerca. (Note 5)

Ivermectin which has been widely used for many decades in stock is used for humans (Stromectol) and is beginning to show resistances. Currie et. al. in 2004 published a paper concerning scabies mite resistance in human patients in the Northern Territory. Based on findings that some intestinal helminths in animals treated with Ivermectin for long periods had shown resistance they report on both clinical and in vitro evidence of resistance by scabies mites to ivermectin after intensive ivermectin use. One of their case reports concerned a 47 year old man from a N.T. top end community who had since 1996 received 58 doses of ivermectin for multiple episodes of recurrent crusted scabies. He received seven 18mg doses of ivermectin at 270ug/kg over thirty days and live mites were still present on days 12,19 and 26 despite the patient being in hospital and having six doses of ivermectin. He had to return home and three weeks after his last dose of ivermectin returned to the hospital with his crusted scabies clinically worse than at discharge three weeks

earlier. Interestingly, due to the resistance issue they ended up treating him with benzyl benzoate and 5% tea tree oil (though they needed to use nitrous oxide to help him deal with the pain). Radar, the NPS Medicinewise website for medical professionals recommend using permethrin cream 5% or benzyl benzoate 25% lotion as the first line for treatment warning ‘mite resistance through overuse of ivermectin may limit future treatment options’.



Crusted scabies

Consultation with a dermatologist or infectious diseases physician is recommended.

Table 2. Ivermectin dosing regimen for crusted scabies[1]

Mild cases	
Day 1	First dose*
Between day 8 and day 15	Second dose
Moderate cases	
Day 1	First dose
Day 2	Second dose
Day 8	Third dose
Severe cases	
Day 1	First dose
Day 2	Second dose
Day 8	Third dose
Day 9	Fourth dose
Day 15	Fifth dose
For extremely severe cases add	
Day 22	Sixth dose
Day 29	Seventh dose

Throughout treatment

Use a topical scabicide, eg, permethrin 5% cream. Use two applications, 1 week apart[1]

and

Topical keratolytics, eg, salicylic acid 5% to 10% in sorbolene cream, or lactic acid 5% plus urea 10% in sorbolene cream applied once daily after washing on days when scabicides are not applied, to assist with the reduction of scaling that harbours the mite[1,4]

and

Anticipate and treat secondary bacterial infection with aggressive, early, intravenous broad-spectrum antibiotics[1,5]

* A single dose aims to deliver approximately 200 micrograms per kilogram body weight; see Product information for further detail[1]

A large case-series in Indigenous Australians found a significant decrease in mortality when using intensive ivermectin dosing together with a protocol for early use of antibiotics in suspected secondary bacterial sepsis.[6] The study was limited by a lack of efficacy endpoints such as cure rates marred by clearing of lesions and symptoms.[6]

Take with food

Because ingestion of food increases the bioavailability of ivermectin by a factor of more than two,[5,6] taking the drug with food will enhance the penetration of the drug into the epidermis.

Treatment Protocols need to be clinically relevant

This treatment protocol is part of an overarching treatment protocol for humans recommended to Doctors in Australia who are treating scabies. It actually begins with a whole section on using creams and lotions prior to beginning Ivermectin therapy.

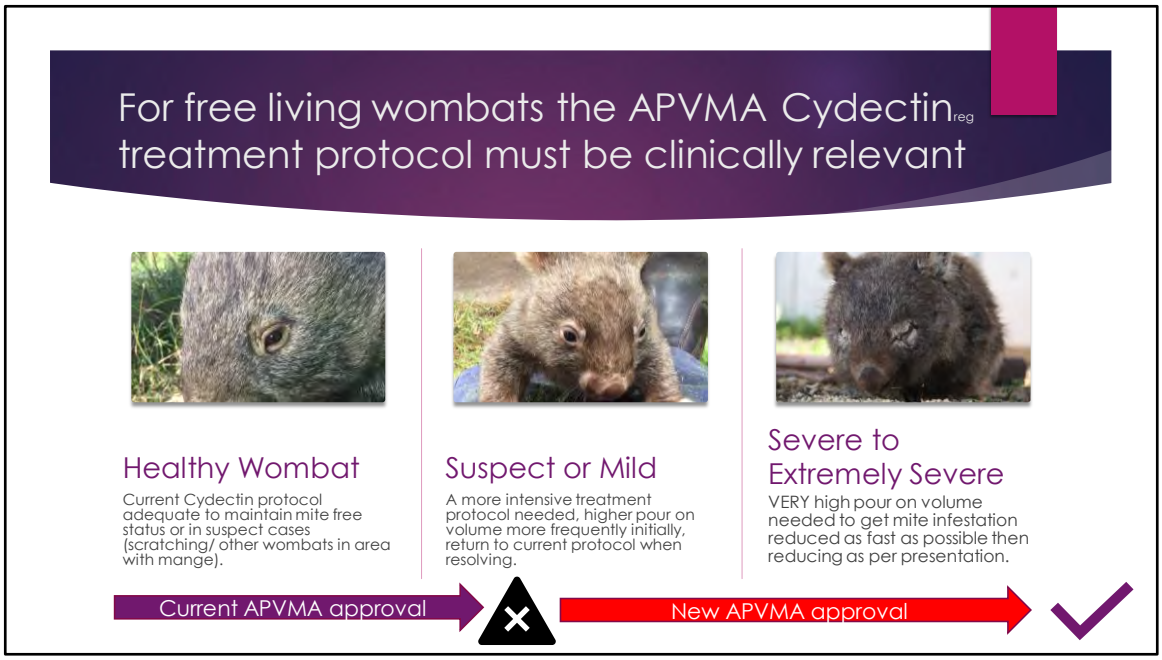
So if treating humans can have a tiered treatment protocol we should be able to develop one for wombats, which provides a range of options.

A few points to note in this treatment protocol a “Mild Case” is one where the humans haven’t responded to creams/ lotions to get rid of scabies. So a step before for wombats may be Itching- pre mild and the step before that prophylaxis. (prevention).

In this manner using clinical descriptions prophylaxis, indicated (eg: itching, other wombats in the area with mange), mild, moderate, severe and extremely severe we probably need to vary the recommendations currently used for applying Cydectin to wombats because one size does not fit all when it comes to treating rather than preventing infestations.

We also need to add in the same type of clinical variations a good clinician does- will

this person be going home to a family who may also now be infested and if so what additional measures should be taken to protect the whole family. Translated into Wombat – will this wombat be visiting other burrows so should we treat him/ her and flap any local burrows as part of our treatment protocol.?



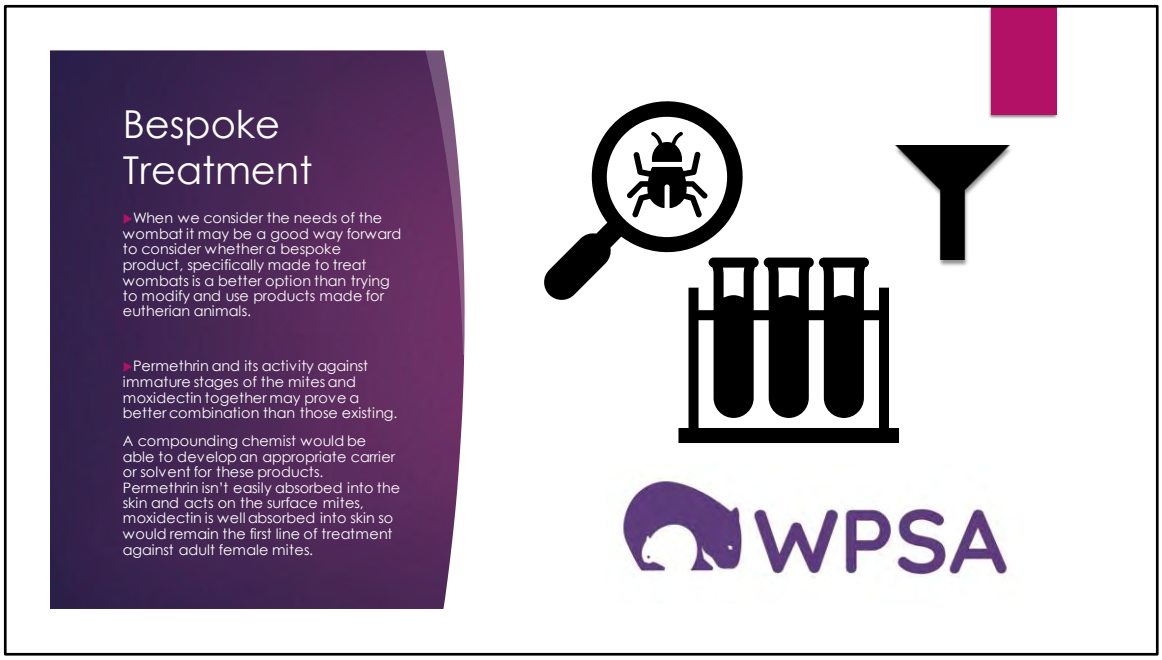
While it was a major success to have Cydectin registered for use on wombats by the APVMA at the time of registration Cydectin was trademarked and moxidectin was not available in any other pour on product. Now Moxidectin is available in a number of products the APVMA approval needs to be changed to the active ingredient, moxidectin so people don't feel restricted to using Cydectin. We are very pleased to have Alan Norden Executive director of APVMA Registration here to present tomorrow.

Next, field work has shown that significantly larger amounts of moxidectin work best when treating mange rather than preventing mange. The registered protocol is primarily preventative and needs revisiting to create a treatment protocol. Dr. Howard Ralph will explore with us some of the issues related to maintaining therapeutic doses and avoiding toxicity.

The Macrocyclic lactone group, in general, are demonstrated to be relatively harmless and frequently have very wide ranges recommended for their use. Noramectin (an ivermectin pour on) advises on its' product label to use 10mls for animals weighing 50-100 kilos. The lethal dose rates mentioned previously also indicate a wide safety margin and those issues specific to wombats with mange also previously discussed

need to be taken into account.

The name of Blair Villon's presentation "Dead Wombats Walking" is a very good description of any wombat with any level of mange. Untreated IT WILL DIE, there is no "spontaneous recovery" from mange infestations.



A number of options exist for developing a treatment suitable for and specific to wombats. The issues with pursuing such work are fairly major, however many of the active ingredients like moxidectin and permethrin or fluralaner are already registered for certain uses so this work would be easier than developing a totally new or untrialed product.

Permethrin is available like moxidectin as a pour on is more able to kill superficial mite populations, the males and nymphal stages where moxidectin, working via entry into the blood stream more targets the females buried within the skin. A simple and immediate potential treatment program could involve simultaneous dosing with a permethrin based pour on and a moxidectin based pour on or alternating these as treatment progresses.

If, as appears to be the case wombats metabolise Moxidectin quite differently to eutherian animals, a product with higher concentrations of moxidectin may be better. Moxidectin and Fluralaner together may work better.

There are also herb based miticides being tried and developed so keeping up with outcomes and communicating with one another is key.

It is vital that we all try and pool our information and outcomes, not to prevent or dictate how people treat wombats but to inform and assist everyone make the best decisions.

What we now ALL know and agree upon is mange, any amount of mange is a DEATH sentence for wombats. They don't "get over it", there aren't "immune deficient wombats that get it" - all and every wombat with mange will eventually die from mange unless treated.

Groups and organisations

CAN BE CO-OPERATIVE AND SUPPORTIVE OR CAN BE A BIT ROUGH ON ONE ANOTHER –

THE MANGE HUB OF THE SOCIETY WANTS TO IMPROVE OUTCOMES FOR WOMBATS BY

- BY DESIGNING AND SUPPORTING A STRUCTURE WHICH BRINGS TOGETHER EXISTING GROUPS AND INDIVIDUALS TREATING WOMBATS
- AND WHICH WILL DEVELOP AND MENTOR NEW GROUPS AND INDIVIDUALS TO DO SO
- AND PROVIDE ACCESS TO AND SUPPORT RESEARCH
- AND MAINTAIN POLITICAL AND BEST PRACTICE MOMENTUM.

We are not going to defeat mange without one another. In Australia we have very different legislation in different States and that in itself creates a major problem for managing mange. In NSW people are forced to belong to area based wildlife groups and those wildlife groups cover all native animals, no species specific group for wombats is licensed. This means resources are fragmented away from what has been and continues to be a major animal welfare issue. While groups struggle to maintain their own viability and membership, each repeating the wheel with multiple replications of the varying corporate governances needed to maintain them we waste time and resources. Merging with other groups and sharing resources is critical, as is training up members of the public on whose land wombats often reside. John Creighton of Wombat Care Bundanoon will tell us today how he brought a community on board by picking grass and the Wollombi Valley Landcare Group will present one collaborative solution from NSW to us tomorrow. Danie Ondinea from Wildlife Rescue South Coast NSW presents another strategy involving property owners.

In Victoria, individuals are licensed to care for native animals and Nick Bean and Katja Gutwein from Mange Management there will give us a Victorian perspective this afternoon. In South Australia a wombat taken into care may not be released where in NSW they must be. In Victoria 193 parishes offer minimal protection to wombats and no State holds an exemplary record for following through on what little

protection is offered under the law.

While the “enemy” is outside the gates, those of us who care for wombats, need to ensure each and every one of us is appreciated for what we can do and not expected to do more than we can. Yolandi Vermaak from wombat Rescue in the Googong Southern Reserve will speak of some of the limitations and tough decisions she has had to make to preserve and protect one population of wombats.

We, as a group of people who care for wombats need to be careful that our concerns aren't manipulated- in Victoria "disease" is a criteria upon which licenses to harm can be given, purposely allowing animals to be manged infested to meet that standard can be a real threat to wombats.

Working together and trying to support one another is always going to be a challenge. Finding funds to carry on our work another. Helen Church, project officer for the Humane Society will talk to us about "Unlocking mange support- easier said than done" later today. The WPSA auspices grants and donations for specific projects where groups do not meet the requirements for independent acceptance. WPSA tries to support small groups or individuals doing great work meet the corporate governance issues that allow them to receive money for their work. WPSA has in the past "seeded" many groups that have gone onto be independent .Groups form and storm and priorities change depending on their membership and how those individuals feel embraced or otherwise. Often an individual's great idea doesn't mesh with the current objectives of the group or issues pertaining to corporate governance make some ideas impossible to implement. As we highlight the issue of mange, more people want to be involved and "do something". Social media is a great tool, and certainly not one that previously existed as a means of getting the word out there. With that though comes the need to be able to answer the public's concerns, one of

the criteria all charities in Australia have to address “for the common good”. We will hear from Elena Guarracino from LAOKA on Sunday about using social media to create awareness and tonight we hope the brains will be twitching when we try and think tank better ways of bringing the various threads together. While it is wonderful that much has changed we now need to be careful that we don’t loose the momentum by fragmenting efforts or failing to have an ongoing response.

Addendum - Southern Hairy Nosed Wombats

Lasiorhinus Latrifons

Courtney de Crus will speak to us about the plight of the Southern Hairy Nosed Wombat. In addition we reached out to some others involved with the Bare Nosed wombats' silkier brethren.

Dr. David Taggart, who, as many of you will know conducted research on *Sarcoptes Scabiei* in SHN wombats reported to us for this Symposium that he had found mange in Southern Hairy Nosed wombats. He commented " it appears to me that animals might become infected (sic) in winter/ spring, but then die as conditions dry and food availability declines. Populations only seem to have mange in some animals for short periods and then become mange free again. …I assume this is because the mange infected (sic) animals don't live long as opposed to CW (sic) in temperate environments) and also because the mites don't seem to survive the dry summers we have in semi-arid SA. Hope this helps".

Communication with the Wombat Awareness Organisations based in the Murraylands of S.A. also suggests they don't see much mange. Briggitte Stevens of that organisation was unable to attend but sent through these comments and a video. " There has been a great change in the Southern Hairy-nosed Wombats in the Murraylands over the past decade. From floods, fires, Sarcoptic mange to toxic emaciation, mass culls and starvation, the future of the wombats is being shaped far quicker than I could have ever imagined.

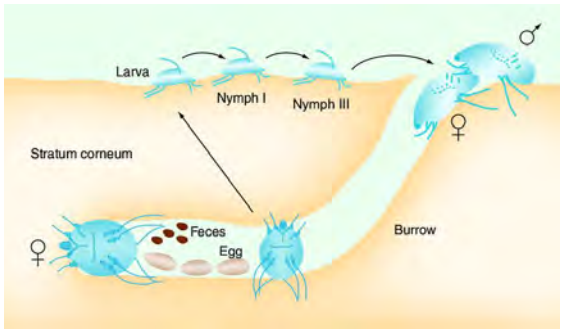
WAO undertook the Murraylands Mange Management program back in 2009. As Southern Hairy-nosed wombats inhabit semi arid to arid environments, Mange has historically only effected certain populations close to creeks or the Murray River. As the wombat population has died out for all the above- mentioned reasons, fewer and more severe cases of mange were being seen. Mange used to be quite commonly seen along the Murray River, until four years ago when the sightings became far less

frequent. Instead, only very severe cases were being reported and the wombats requiring rehabilitation at our sanctuary. These wombats showed us the true sensitivity this species has to antiparasitics and we found a base line for the use of these products. Wombats with less than 30% coverage generally responded well however anyone over 30% showed symptoms of poisoning via the mass death of the mites. This required veterinary treatment and a lot of around the clock nursing and medication and left us with no choice but to find natural alternatives. Cases of Sarcoptic mange have reduced so greatly in the past two years largely due to the Murraylands being in two years of the worst drought on record. We can only but assume the drought has made either the soil too dry for the mite or the wombats are succumbing to starvation instead.In 2010-11, thousands of wombats were seen with fur loss, it took quite a bit of persistence to convince the Department and University that this was not mange and after research, these wombats were diagnosed with toxic emaciation as their habitat no longer had any grass available and the wombats were forced to eat toxic weeds.

With the drought, we are seeing the volume of wombats in similar conditions only the blood indicate this is purely starvation. People unfortunately are panicking and wanting to help and these animals are being misdiagnosed as having Mange. As these wombats are so compromised, the anti-parasitics used are having reverse effects and

killing the wombats. Due to the sheer size of the area where wombats inhabit, the fact that 90% of wombats inhabit private properties which are generally farming properties plus the inability to source Oaten or meadow hay, the only food sources readily accepted by Southern Hairy-nosed wombats, we are forced to watch the unimaginable. A joint collaboration from everyone is required if we have any chance of saving these animals.

References and notes 1



ADVANTIX Bayer product information
APVMA Australian Pesticides and Veterinary Medicines Authority Permethrin
AUSMECTIN Cattle Pour on by IAH product information
Borchard,P. Wright,IA. Bulldozers and blueberries: managing fence damage by bare-nosed wombats at the agricultural-riparian interface. J.Human-Wildlife Interactions 4(2):247-256, Fall 2010
Bravecto product information and use documents. MSD Animal Health Information
Brute Y-tex Pour on for cattle by Farmcraft product information
Cayman Chemicals Product Information Moxidectin
Cox,A. First Mange Report to the Wombat Protection Society. Previously published on site www.wombatprotection.org.au 2002
Cox,A. Second Mange Reort to the Wombat Protection Society. Previously published on site
www.wombatprotection.org.au
Currie,B.J., Haramul,P., McKinnon,M. and Walton,S.F. First Documentation of In Vivo and In Vitro Ivermectin Resistance in *Sarcoptes Scabiei*
Clinical Infectious Diseases, Vol. 39,1. July 2004. pp.e8-e12
DELTAMAX quick dose pour on cattle lice and fly treatment. Product information. Hunter River company. APVMA 65322

DEMIZE Y cattle pour on by Elanco product information
DRUGBANK drugbank.ca

References and notes cont.2

Fraser,TA, Shao,R, Fountain-Jones,NM, Charleston,M.,Martin,A.,Whitely,P.,Holme,R.,Carver,S. and Polinghorne,A. Mitochondrial genome sequencing reveals potential origin of the scabies mite *Sarcoptes Scabiei* infesting two iconic Australia marsupials. BMC Evolutionary biology (2017) 17: 233 pp.1-9.

Fraser,TA. Research sheds light on mite causing wombat mange. My Sunshine coast Interview January 25th 2018.

IVOMEC Pour on for Cattle. Product information. Merial.

Johnson,C. and Carver,S. Sarcoptes scabiei: The Mange Mite with Mighty Effects on the common wombat (*vombatus ursinus*) Article in PLOS one DOI: 10.1371/journal.pone. 0149749 Research Gate. March 2016

Lin JH , Yamazaki M. Role of P-glycoprotein in pharmacokinetics: clinical implications. Clin Pharmacokinet. 2003;42(1):59-98.

Maes, J., Verlooy, L., Buenafe, OE., de Witte, PAM., Esguerra, C.V. and Crawford, AD. Evaluation of 14 Organic Solvents and Carriers for Screening Applications in Zebrafish Embryos and Larvae. Laboratory for Molecular Discovery, University of Leuven. Belgium. PLOS one, open access.

Martin RW, Handasyde KA and Skerratt LF. Current distribution of sarcoptic mange in wombats. Aus Vet/ Vol 76, No 6, June 1998

Martin, AM., Richards, SA., Fraser, TA., Polkinghorne, A., Burridge, C. P. and Carver,S. Population-scale treatment informs solutions for control of environmentally transmitted wildlife disease. Journal of Applied Ecology. 2019. pp1-13.
Medscape https://www.Medscape.com/answers/ 1109204 Barry,M. (Ed) Which type of cells are responsible for persistent itching in scabies, and which type of cells reduces (sic) pruritis? Thursday, July 18, 2019.

References and notes cont. 3

Morrison,D.A.,Erland,L.L.,Mattson,J.G. The origin of *Sarcoptes scabiei* in wombats. Parasitology Research (2003) 91 : 497 -499

Mumcuoglu, Kosta & Gilead, Leon & Ingber, Arieh. (2009). New insights in pediculosis and scabies. Expert Review of Dermatology. 4. 285-302. 10.1586/edm.09.18.

National Pesticide Information Centre NPIC.orst.edu (USA)

NEXGUARD product information. Merial.

NORAMECTIN Pour on for cattle product information Norbrook.

NORAMECTIN Paste for horses product information Norbrook.

NRA Special Review of MACROCYCLIC LACTONES by the Chemical Review Section of the National Registration Authority. May 1998. Australia.

Old,J.M., Sengupta,C.,Narayan,E. and Wolfenden,J. Sarcoptic mange in wombats – A review and further research directions. Journal of Transbound and Emerging diseases. Pp1-9. 2017.

Queensland Soil Types. Common Soil types. Queensland Government.

Simpson,K.,Johnson,N.,Carver,S..Sarcoptes scabiei: The Mange mite with Mighty Effects on the Common Wombat (*vombatus ursinus*). PLOS ONE/ DOI:10.1371/ Journal.pone.0149749. March 4. 2016

Skerratt, L.F. Sarcoptic Mange in the Common Wombat *Vombatus Ursinus* (SHAW,1800) Submitted in total fulfilment of the requirements of the degree of

Doctor of Philosophy, Department of veterinary Science, The University of Melbourne. June 2001.
Skerratt, L.F., Campbell, N.J.H.,Murrell,A.,Walton,S.,Kemp,D.,Barker,S.C.. The mitochondrial 12S gene is a suitable marler of populations of *Sarcoptes scabiei* from wombats, dogs and humans in Australia. Journal of Paristolology Research, 88, pp 376 -379. 2002.

References and notes cont. 4

Skerratt, LF. Clinical responses of captive wombats (*vombatus ursinus)* infected with *sarcoptes scabiei var. wombat.* Journal of Wildlife Diseases 39(1) 2003 pp.179-192
South Australian Soil Types. Government of South Australia. Department for Environment and Water.
Vercruysse,J. and Claerebout,E. Macrocyclic Lactones. MSD Veterinary Manual.
Walker,FM.,Taylor,A.C. and Sunnucks,P. Does soil type drive social organisation in southern hairy- nosed wombats?. Molecular Ecolology (2007) 16, 199- 208.
Notes
1. https://www.ncbi.nim.nih.gov PubMed. Sharkuie KE, Al-Rawl JR, Noaimi AA, Al-Hassany HM. Treatment of scabies using 8% and 10% topical sulfur ointment in different regimens of application. Journal of Drugs and Dermatology. 2012 March, 11(3) 357-64.
2. medent.usyd.edu.au/fact/scabies.html Department of Medical Entomology University of
   Sydney. Scabies. P.1.
3. Centre for Disease Control CDC-DPDx-Scabies p.1-2
4. Parisitipedia.net
5. Drugs.com Medications for Onchocerciasis, River Blindness

Pictures and Diagrams

Slide 11 mite Webmed
Slide 20 Mite Life Cycle diagram from Pinterest
Slide 21 Mite stages in skin from Mumcuogla see references
Slide 22 First Wombat AC personal collection; Second Petra (stoneface) dog from Greece via dogtime.com and human hand via Webmed.
Slide 33 Bravecto Spot on instruction diagram