New approaches to zoology: Plenary 4

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Following the fourth session of the forum, we held a question and answer session facilitated by Paul Willis. The presentations covered by this plenary session were:

- What can we do with poo: genetic analysis of scat samples to inform the conversation Tasmanian Devil? (Catherine Grueber *et al.* University of Sydney)
- Probing the sex life of the dragon. (Arthur Georges, University of Canberra)
- Secrets from beyond extinction; unlocking the thylacine genome. (Andrew Pask, University of Melbourne)
- The Oz Mammals genomics initiative: developing resources for mammal conservation. (Mark Eldridge *et al.* Australian Museum)

The following is a transcript of the plenary proceedings, lightly edited for readability.

PAUL WILLIS: I'm torn for choice on my first question, and I know that I should be respectful and mature, but you wouldn't really think that I should be, so why don't we go straight to Arthur's glowing gonads? I mean, if sex is so complicated for dragons, what are the conservation and management issues that arise out of such a diverse and complicated set of reproductive strategies?

ARTHUR GEORGES (University of Canberra): Well, I guess the obvious one is a species with temperature-dependent sex determination would appear, superficially, to be extraordinarily vulnerable to climate change. It takes only a few degrees to shift the regime in a laboratory to 100 percent of one sex and zero of the other.

It's more complicated in the wild, and so understanding how they've coped with climate change in the past is a big area of inquiry, because only then can we see what we've done to compromise their ability to do that in the future. With the dragons we're studying, that sex reversal is something that occurs in the wild. So up in western Queensland they're actually sex reversing. That's the area where the climate has changed the most in the last 40 years.

So just looking at actual change, whether it's global climate change or not, it's changed. It's gotten hotter in the last 40 years and they're reversing, and we've done some modelling to show that it doesn't have to get much hotter and they will flip completely. They will lose the W chromosome and they will switch across to TSD, temperature dependent sex determination, altogether. So, they will trap their W chromosome and they will all be ZZs, and the females will be produced because they're reversed and the males will be produced because they're not reversed and it will become a TSD species. So, it does have implications.

We've got two PhD students up there at the moment, one is looking at the spatial ecology of sex-reversed animals in relation to the non sex-reversed animals. We found in the laboratory that the sex-reversed animals are bigger, they're bolder and they're much more fecund than the normal females, so dads make better mums. It's really quite interesting.

So, does that manifest in the field? One PhD student is looking at the nesting biology and the other one is looking at the spatial ecology to see whether sex reversal actually has an advantage that's going to accelerate their transition. It's not just something that happens in the lab and it's not just a curiosity. It's something that will really manifest in the field in the context of the changes we're bringing through habitat clearing and through climate change.

PAUL WILLIS: And to the papers around DNA and genomics, when we look at that work, what are the practical outcomes with respect to conservation and management of the species that you've been looking at? I'm throwing it open to the rest of the panel there.

ANDREW PASK (University of Melbourne): The genes that are involved in sex determination in the dragon are the same genes that are involved in our sex determination and so you get insights from very strange quarters in science. People studying the genes involved in the salivary glands in Gila Monsters discovered the best drug for treating diabetes. Now, who would know that was going to happen?

PAUL WILLIS: Yeah, and it's that pure serendipitous research. But with respect to Mark and Andrew, what you guys have been doing in DNA and de-extinction, are there implications for the management and conservation of species that arise out of your work?

MARK ELDRIDGE (Australian Museum): I think there is. As we learn more and more about this, we're realising just what a bad job we've done at classifying the Australian mammal fauna.

PAUL WILLIS: Did we need to look into the DNA to learn that?

MARK ELDRIDGE: I think so. We are actually realising a lot of widespread species are species complexes. Actually, there's a lot of species that have gone extinct before we even described them and now only exist in museums. So really, for a lot of groups we're starting back at the very beginning, working out how many species we've got, where are they found, what's their conservation status, but we're also learning about their basic biology and how we can better manage the ones that have survived our atrocious negligent.

PAUL WILLIS: Coming to your work with de-extinction, one criticism that's often levelled at the whole push around de-extinction is it kind of cheapens the lessons of extinction.

ANDREW PASK: Yeah. I think the key thing with de-extinction is you're never ever going to recreate exactly that animal. You'll have some sort of hybrid between that animal and a closely related species genome that you're editing the changes onto. We still can't bring that species back and, like I said, there are whole chunks of the genome we'll never be able to resolve from the DNA fragments that we've got, and that's all that's left. We can't ever fix those things, so we'll never have a pure thylacine running around.

So, I think that's a really key message from this. It's a really subpar way of trying to recapture something about that animal that you might be able to bring back, but you're never actually going to be able to bring that animal back.

PAUL WILLIS: But does that really redress at least the popular image of, "Well, extinction doesn't really matter because we can bring them back"?

ANDREW PASK: Yes. I think that message has to always go out with "that we still can't actually bring those species back and this as close as we can come to ever being able to do that" but it's not the same, and I think that's got to be a clear message.

PAUL WILLIS: We've already got some questions, so let's come over here.

PHILLIPA BURTITTA: I've got a question in regard to what is impossible in terms of bringing the extinct animals back. We might not see that now but say that will be scientifically something that we strive for, say, in a hundred years. We don't see it right now, but anything is possible, I think. What's your view on that?

ANDREW PASK: I think that we know there are big chunks of the genome we cannot build from the thylacine DNA, but the more we sequence all these other marsupial genomes and we start to understand what that landscape looks like across maybe a hundred different marsupials, we can do a bloody good job of recreating exactly what we think that would have looked like in the thylacine.

We can also compare all these genomes from closely related marsupials and do ancestral state reconstruction, so we can figure out what it would have looked like back in time. So, we can get much better at it. A lot of the work where I showed that transgenic mouse, for example, is about trying to understand which regions of the genome were really important for driving the development that is unique in that species. We will get better at it, but it will still never ever be 100 per cent a thylacine.

JOHN KANOWKSI (Australian Wildlife Conservancy): Great to see this session, and we collaborate with, I think, three of the four people up the front there, so that's great. The question is around de-extinction, but more in the case of the fact that a lot of the extant mammal fauna has contracted to a very small part of its range.

A recent paper on the Woylie [*Bettongia penicillata*] showed that it's left with a few thousand individuals from something that was once in the millions. We are currently shifting that animal back to parts of the country it hasn't been for a hundred years. Is there ever a chance, or how far away is it until we can grab from museum specimens those parts of the genome, say, that were in New South Wales, and put them into the animal?

ANDREW PASK: Yeah. That's something where I'm hoping developing SSCs, the spermatogonial stem cells, this is the sort of technology that we're working towards, that you could do these more tractable questions. You can actually work on this stuff now. So certainly, with the mammoth de-extinction project, they're doing edits of the genome on the scale that you would need to do exactly that.

So, you take your living species. You look at the differences that you saw in the historical population in a particular distribution and edited those changes on. At the moment, you can edit thousands or 10s of thousands of differences in that DNA for a few million dollars, but this is like genome sequencing was 20 years ago. It's becoming so much more tractable and reproducible with CRISPR and they're developing ways of doing this really en masse. So I think that is something in the near future we'll be able to do, maybe in the next decade, start to really engineer in that diversity.

The sticking point at the moment for marsupials then is once you've engineered that diversity into your cell, we don't have the assistive reproductive technology to then create an embryo and transfer that embryo into a pseudopregnant female that can then give birth. So we're working on that using the dunnart which is like a lab mouse, as just a quick way of trying to develop all of those techniques, and then taking it to these more rare and endangered species to see if we can sort of carry that technology across to do exactly that sort of work.

PAUL WILLIS: Catherine, if we can bring it over to

you now. I mean, we're talking about what's possible in the future with DNA. What's possible in the future with poo? I mean, I was absolutely stunned at the amount of quality information that you can get out of a couple of quality jobbies, but how much further can you push that technology? What things would you like to be able to access in those turds?

CATHERINE GRUEBER (University of Sydney): Well, there are couple of things that I would like to add, and the first is the sample quality is a serious issue when studying faecal samples. They've got to be fresh; they've got to be stored properly. Because of all the bacteria that are in poo and the environmental sort of context of that sample, the DNA degrades very, very quickly. So, I guess one of the improvements that I would like to see is in our sequencing technologies and our ability to get more information out of those very poor-quality samples.

The second thing that I would like to add in this topic of de-extinction is the concept of the microbiome and the importance of the associated microflora that exists with species. What we've seen by studying the microbiome of captive versus wild devils, for example, is that the microbiome of the captive devils is much less diverse than in the wild. One of the reasons the Devil Program uses those large enclosures with multiple males and females is to encourage natural behaviours of the species, but also to try and preserve the associated flora of the animals, which undoubtedly contribute to their general health.

So, I just wanted to make a comment that thinking about those kinds of various organisms that are associated with these target species that we're really interested in is also quite important when trying to preserve threatened species.

PAUL WILLIS: How would it work if you brought back a mammoth and you didn't bring back its microbiome? Would that mammoth be able to survive on a surrogate microbiome from an elephant?

CATHERINE GRUEBER: Well, I can't really comment on that. Maybe Andy has something to add.

ANDREW PASK: No.

CATHERINE GRUEBER: But I would say though, that we know that the microbiome does contribute across many species. It does contribute substantially to our ability to digest different kinds of foods. It can modulate our behaviour. It can even modulate your emotions. There's some recent data coming out from humans to suggest that this is true. So I think it's really important to think about.

PAUL WILLIS: Wouldn't it be a crying shame if you did bring back a mammoth and it was gluten intolerant? Okay. Do we have any more questions, ladies and gentlemen?

PAUL MEEK: It's a question for you, Paul. You gave us some advice on selling ourselves on social media. One of the things that we still find, and it's an old chestnut that many of our elders in this room will support me on, is that we're still not getting the message of our science to the people that we're targeting.

In my particular area, we're still finding that we come up with great research outcomes but we're not getting it to the practitioners for their uptake. We've been trying to find novel ways of doing that. Social media doesn't work because most of them aren't on social media. We've tried Primefacts. We're still not getting to them on those issues. We've got a practitioners' conference that we're organising now to try and get our information to them. Any ideas on what we can do.

PAUL WILLIS: Who do you mean by your target audience?

PAUL MEEK: Well, in this case, it's the people who are involved in pest management and monitoring at the grassroots level, so rangers, foresters, local land services officers, farmers.

PAUL WILLIS: And they don't have their own social media groups?

PAUL MEEK: No, a lot of them aren't engaged in social media.

PAUL WILLIS: The analogy that I keep coming up with when dealing with this sort of question is the old joke about, "Why did Jesse James rob banks? Because that's where the money is." In other words, if you want to engage with those audiences, you have to go to where they're talking. They may not be talking on social media, but they've got to be talking somewhere. They might have a newsletter or something whereby they're communicating with each other and that's where you need to get into.

PAUL MEEK: That place is the pub, that's pretty much it. The problem is you've got to share yourself around and get drunk all the time.

PAUL WILLIS: Hey, you try and stop me from getting into the pub. If that's where they're meeting, if that's where they are, then that's where you need to go in order to be able to take your message to them.

PAUL MEEK: Agreed, but there's now been a big policy within our profession to get rid of the people who were there for that extension purpose. So short of us all going to every pub and trying every beer in a can around the countryside to get the message out, it's really challenging, and that's why we set up this practitioner's conference. That's a great opportunity for us to get 200 people who are constantly involved in this work to listen to what we've got to say and us listen to them, but that's only 200 out of a hundred thousand people, or whatever it might

be. Anyway, I'm just wondering if you had any novel idea.

PAUL WILLIS: Well, that's all I can recommend, is figure out where they are meeting up and - - -

PAUL MEEK: If you could let Minister Blair [Niall Blair, then NSW Minister for Land and Water] know that for me, that would be great.

PAUL WILLIS: I'm a palaeontologist, not a magician. But you do have to take the message to where it needs to be delivered.

PAUL MEEK: The other comment is that social media is great for some platforms and for some people and audiences, but if you're a government scientist and you want to get to a politician, you can't use social media, so we're sort of kept out of that area.

PAUL WILLIS: That is a problem. Whenever I talk to any group about getting into social media, mostly it's - I'm going to universities and one of the first slides I put up is that university's social media policy, "Be aware of your institutions specific social media policy." All of the universities have them and some government departments do also have a social media policy, and so you've got to play by the rules of your employer.

Most social media policies that I've seen, particularly in the universities, are actually quite enlightened these days. They're not a green light saying, "Just go berserk," and they're certainly not a red light. If you go back just five or six years, a lot of university social media policies were one page saying, "Don't do it."

But now most, in fact all of the social media policies that I've come across from universities are a very sensible amber light and they're saying, "There is great benefit in getting involved in social media, both for you as an individual researcher and for the university, but there are risks involved in getting into social media and you need to be aware of them," and each institution will outline what those specific problems are. So my advice, it doesn't matter who you're working for, you must hunt down the social media policy for your employer and play by those rules.

And if I can just put a little addendum on that, when it comes to the rules of engagement, there's a do and a don't. If you're to go into social media and you're going to talk shop, if you're going to talk about research, then you owe it to the audience to identify yourself as a researcher in that area and the institution that you work for, but the don't is, "Do not go onto social media and pretend or convey the impression that what you're saying is the policy or the position of the university or your employer." It's a very fine line to walk, but you should be cognisant of that line and make sure that you always come down to being identified but not necessarily - or not implying that what you're saying is the stated position of your employer.

PAUL MEEK: So, can I just suggest that in future you talk about mum, dad and the minister?

PAUL WILLIS: Yeah, not a bad idea. Okay. I'm just bringing to a close the plenary session, which involves everyone giving a huge round of applause, not just for our presenters but for all the presenters today. I think as always this forum has been enlightening in the quality and the breadth of presentations that we've had.