Interview about naked mole-rats with Dr Chris Faulkes, Queen Mary, University of London, November 2011

00:12 R. I'm with Dr Chris Faulkes who is a researcher at Queen Mary University in East London. Chris has got a rather interesting group of animals that he is studying; they are called Mole-rats. Where do these Animals live in the wild? Where do they come from?

00:32 C. The naked mole-rat comes from East Africa, so arid regions in Kenya, Ethiopia and Somalia. They are one of quite a large number of different species of African mole-rat that are distributed all the way through-out sub Saharan Africa , right through to the tip of Cape Town. The naked mole-rats are the only naked ones within the family, the rest look a bit more like guinea pigs and have fur.

01:01 A. Tell me about their lifestyle, what do they eat and what eats them?

C. Their lifestyle was really the first thing that intrigued Biologists going back to the late 70's, early 80's when it was realised that the naked mole-rat actually behaved like a social insect, and this kind of behaviour was unique at the time among mammals. That's really what sparked people's interest in them.

01:26 In this kind of system we have animals living together in very large groups, on average 80-100 in the wild, sometimes up to 300 though. Yet, within these enormous colonies there is just a single breeding female; the Queen. She mates with 1 or 2, maybe 3 reproductive males that she selects. The rest of the colony of both sexes, are reproductively suppressed and they help either by working and carrying out colony maintenance activity. Some of the bigger ones then may become non-workers and they adopt a defensive role within the group.

02:05 We think that they behave in this way because they are able to exploit the particular ecological niche that they are in by cooperating. They live completely underground, they are highly adapted to living underground and many interesting aspects of their biology relate to these adaptations. They feed on underground roots and tubers, and in order to be able to find these often quite widely dispersed food resources you need a whole gang of animals digging together. This reduces the energetic cost for individuals and it also decreases the risk of unsuccessful foraging. A single animal digging through really hard soil is unlikely to be able to find food on its own, enough to sustain it, so in these very harsh arid habitats cooperation is a really good adaptation.

03.03 R. Where did you get your mole-rats from?

C. The original founder stock came from Kenya, collected by someone who did a PhD in the wild on their ecology and behaviour and they brought some animals back to London to the Zoological Society of London. From those original founder colonies we have been, since the mid 80's maintaining breeding stocks and forming new groups, and breeding them in captivity.

03.36 R. So all of these animals are descended from that original group that was brought back?

C. Yes. I don't think that I have got any original wild core individuals left, although we now know that they can live an incredible long time in captivity. This has become one of the more

important research areas in recent years as labs like ourselves and others across the world have kept naked mole-rats for long enough in captivity to realise that they can live in excess of 30 years, which is incredible for a small mouse size rodent of average 35 grams body weight.

04:11 R. 30 years is extraordinary. I suppose they are smaller than a rat, bigger than a mouse so you would expect.., how long does rat live? 4 years perhaps? So up to 30 years, that's extraordinary!

04:26 C. The last time I asked a colleague in the States, she had some at about 32 years, so we probably don't know the upper limit just yet, it's quite remarkable. Among mammals it's comparable to the longevity we see in humans.

04:45 R. Are they very hard to keep? Could somebody set up their own colony in their garden shed?

C. Theoretically, but one of the main problems is because they are adapted to living underground and for various energetic reasons they can't thermo regulate very well so they are almost like a cold blooded mammal. Hence you can probably feel the temperature in the room we are now filming in, we have to maintain them at their body temperature of about 30 degrees. That's really important to keep them warm and in a very stable quiet stress free environment. If you get it right, they quite happily live for many, many years. Some of the animals that we can see here will be over 20 years old and going strong.

05.40 R. You said that they eat roots, now obviously it's probably a bit difficult to bring in tubers from Africa, so what do you feed them here?

05.49 C. In captivity we have to give them similar food as close as we can, so sweet potatoes and other root vegetables they like; sweet corn. We have experimented over the years to find a good balanced diet for them. In the wild they are often eating unusual plant roots and tubers that you wouldn't find commercially anywhere.

06:21 R. That sounds like a diet that is very high in starch and carbohydrates.

06:26 B… and cellulose as well.

06:28 R. How do they digest cellulose? That's pretty indigestible.

06:32 C. Their gut contains quite a potent mixture of microorganisms which helps them to ferment the high cellulose content of the food. Like all rodents they are hind gut fermenters, they have an enlarged Cecum where they do this digesting.

Also, it gives rise to one of the more unpleasant aspects of mole-rat behaviour which is Coprophagia**,** so when the young are being weaned they eat the faeces of the adults in order to infect their digestive tract with these all important microorganisms.

07:13 R. Do you think that your animals here in captivity which are the result of many years in captivity, behave in the same way as the animals in the wild?

07:23 C. That's a really good question and very relevant. With any laboratory species you wonder how typical they of the real world, and this applies to lots of model organisms even fruit flies for example. As far as we know and we have looked at this, we think that they more or less behave in the same way. So their characteristic worker type and defensive type behaviours

which have been studied in the wild do appear to occur in the same way in captivity. Their reproductive suppression is similar both in the wild and in captivity. We think the way colonies sought out the reproductive breeding female is the same.

08:16 The only thing that really differs is that they are not subjected to predation, so the extreme longevity we see in captivity probably does not occur in the wild. They can be preyed upon by a few species of snake that are adapted to eating mole-rats, they get down into the burrow and attack them. *Actually*, this is probably quite scary for the snake, when these larger soldier animals come and you see this wall of teeth coming after you. I would say that predation isn't a major issue even in this wild because they are in this habitat underground that helps.

08:53 R. How far underground are they?

08:55 C. Most of the burrow is composed of foraging tunnels which can extend for 3 or 4 km, massive labyrinths, but because those tunnels are dug searching for roots and tubers, their food resources, they tend to be at the level of the roots so within a level say .5 or 1 meter of the surface.

09:22 The more central core areas of the burrow where you find communal nesting chambers and communal toilet chambers can be deeper. Once in Kenya we dug down to a nest chamber and it was about 5 feet underground which is quite a lot of digging. Clearly that's difficult for predators to get at, even *for* the snakes that can get into burrows. It's also very thermo stable down at that level which is good for these cold blooded animals.

10.00 R. As they live so long, do you get to know them? Do you like them? Do you get attached to them?

10:08 C. They are very enigmatic animals, you can see some running round in the background. When I bring people to see the colonies they change their minds about them quickly, from thinking urgh these are ugly critters to wow these things are really amazing. They do all kinds of interesting behaviours all the time. As we are talking here they are running up and down and passing and you may hear the chewing noises in the background; that's some of the workers attempting to extend the burrow. They are always very busy and fascinating to look at, particularly they will go backwards and forwards in the tunnel rather like an animated train set. Often when you show children the animals that's the thing they really like the fact that they go backwards and forwards in these tunnels. They are pretty cute animals after you have been working with them for a few years.

11:10 R. They have an unusually long life span but they have also got this unusual society where you have got a Queen and just a few breeding males, and the rests' sexual activities are suppressed. How does that happen, what the biology behind that?

11:25 C. That's the very interesting area that first got me interested into mole-rats, this natural suppression of fertility or socially induced infertility. It is such an extreme scenario for a mammal to live for a long time and have its reproduction totally suppressed in both sexes, it's another unusual aspect, even the male reproductive physiology is suppressed.

11:54 Our initial research focused on that by looking at urinary hormone profiles in these non-breeding animals, collecting urine samples so that we could non-invasively understand what was going on physiologically. We found that the Queen does indeed suppress the

reproductive physiology of both the males and the females. The males are gonadally suppressed, the non-breeders have reduced testosterone, the gonads don't receive the stimulatory hormone from the pituitary gland from the brain, and likewise in females ovulation is supressed.

12:35 In a way it's almost like these non-breeders are prevented from going through puberty, Although they can be of adult body size their reproductive tract is held in a prepubertal state. The Queen appears to do this by behavioural means; maintaining her dominant position and asserting her dominant status by sometimes pushing and shoving the others around. This seems to be translated into this infertile state.

13.07 Remarkably, one of the most interesting things which we spend time studying is that you can reverse this blocked reproduction. So, in the non-breeders if you take a male and a female out of the supressing influence of the colony and pair them together away from the supressing influences of the Queen, they will quite rapidly become reproductively active.

13:29 R … in weeks or months?

C. Sometimes you can see evidence of reproductive activation in as little as 8 or 10 days. It's almost like they are going through puberty in that space of time and not surprisingly they quite often get aggressive during that period as their hormone levels start to come up. This is a remarkable model system to understand how fertility can be disrupted by environmental stress factors.

13:59 For example in humans, different forms of stress are known to create this kind of infertility at the level of the hypothalamus in the brain. So, the work has broad implications in understanding captive breeding and reproductive suppression in other species, and even maybe in humans. The mechanisms are likely to be very similar when you look at the physiology and the immunoendocrinology of it.

14:30 You mentioned adaptations to living underground. Can you take me through some of these adaptations, what makes them different to other small mammals?

14.43 There are many adaptations, we have mentioned about their inability to thermo-regulate, that's a little bit more difficult to understand and having the naked skin is possibly part of that. Again it's hard to understand why they are the only subterranean rodent that is naked, and every other subterranean mammal has fur. Although they are simple questions they are quite hard to answer.

15:12 The naked skin probably enables them to gain and lose heat very quickly behaviourally because if you can imagine 300 animals crammed into a small chamber underground they are in serious risk of overheating, and likewise if they cool down going into the peripheral burrow they need to be able to gain heat quickly. There will be an energetic saving as well having a low body temperature and a low metabolic rate which probably helps in this extreme habitat, where food may often be quite limiting.

15.49 You may be able to see the facial area, the eyes are there, they are vestigial; they do have small tiny eyes with functioning eye lids. There is no external ear which is similar to other subterranean mammals. The teeth are protruding outside where the lip seals behind, because these are rodents they dig their burrows with their teeth rather than with sharp claws like an insectivorous mole would do. This combination of naked skin, the teeth, large

ever growing incisors, very small eyes and no ears, gives them their rather characteristic appearance that people either love or hate.

16:56 Some other unusual features that help them to adapt to a life underground are their ability to tolerate very low oxygen levels and importantly high C02. There are various adaptations in their metabolism to help them with that. There is also this curious thing where they seem to be *invulnerable* to certain types of pain, they lack a substance P. That is another recent discovery that is maybe related to the kind of environment that they are living in but it's difficult to be sure of the functional significance of that.

17:39 R. Their Genome has been sequenced recently, what has that revealed?

20:39 C. Recently, there has been 2 separate naked mole-rat genome projects published because of their unusual biology, the genome enables us to get a genetic handle on what is going on. We can look at genes that are being over and under expressed, maybe at different ages if we are interested in looking at aging aspects of their biology. We can look for parts of the genome where there is positive selection, so adaptive evolution is occurring. So far the genome project has revealed that some of the genes that we would expect, so genes related to low oxygen, to cancer and genes that are implicated in aging, have been shown to be doing different things in naked mole-rats.

21:38 Now, there is lot of work to carry on with from this initial publication. Functional studies will enable other labs to look in more detail some of these genes that have been highlighted from the genome project. It's certainly already revealed many interesting lines of research that we can go forward with. It will have wide ranging for implications for human and animal health, and just general understanding of Biology.

22:18 R. In terms of using these animals to understand humans, what do you actually do to the animals? Do you take blood samples? What procedures do they undergo?

22:32 C. All of the procedures that we have been involved with here are mostly non-invasive because we want to look at the animals in their natural state. We can collect urine and blood samples. For example, to do hormone assays or DNA analysis you literally need just a few drops of blood. We also do a lot of behavioural work as well. Much work is done at post mortem, when we have animals that die we can do an extensive variety of tests and types of histology and so on. With modern genetics we can look at an awful lot non-invasively.

23:31 R. We have heard that mole-rats live an extraordinarily long time, but there are some other things about them that makes them interesting to study and one of the things is Cancer. Can you tell me something about that?

23:45 C. As a consequence of understanding their longevity as labs have kept them over the years, is that they appear not to get any of the usual age related problems including Cancer. That has excited many people in the past few years. What is going on there? Can we get a genetic handle on their apparent Cancer resistance? It may be tied in very much with the aging story as well. Certainly there has been some genes implicated in Cancer which are definitely shown to be behaving differently in naked mole-rats, work arising from the genome project. At the moment these are associations and interesting correlations, functional work will need to be done.

24:46 R. So we don't know yet whether they have got additional genes or less genes, or whether genes are switched off on or?

24:50 C. I think it's going to be a combination of all of the above as Cancer is a complex set of diseases that have multiple causes, multiple genes are implicated. I think that we can find common patterns and common genes which are known to be important in humans for example, maybe that are over or under expressed, or simply having a different sequence or under different kinds of selection. This is all work for the upcoming future.

25:35 R. Do they ever get out? Have you had any escape?

25:45 C. That is a really interesting question because animals escaping from the colonies led to serendipitous discovery of another particularly unusual aspect of their behaviour; the presence of a particular morphological type or a dispersal male. Often social insects for example have a dispersal phase and they may have a particular cast or morph that's adapted to dispersing.

26:21 R. When all the ants go flying…

26:24 C. That's rights so Alates and Termites and so on. It was noted some years ago now in Cape Town, in the lab of Jenny Jarvis who first discovered the sociality of naked mole-rats, she had particular animals that always escaped, they would stand up and push the lid off and get out, and she would find them on the floor the next day. She used to call them jokingly her Houdini's, after a while she realised that it was always the same individuals.

26:52 When we looked at that in more detail we found that if you do a soft tissue x-ray, these particular males are loaded with fat deposits, especially around the neck area. They also behave differently, so rather than being aggressive to foreign mole-rats they are much more submissive and passive. Also their reproductive hormones are more typical of a breeder male, although within the colony they don't attempt to breed.

27:26 These are phina atypically completely different, they are like a different cast within the colony. In the wild they have also been discovered, so these seem to be particularly adapted individuals to disperse, maybe get into new colonies or perhaps pair up and attempt to form a new colony which is a very risky strategy. All this helps to maintain genetic diversity in the wild. Another unusual feature of naked mole-rats is that they will inbreed if there is no one unrelated to mate and breed with, so called facultative inbreeding. This gives rise to high levels of relatedness within the colonies.

28:14 R. You would expect from that a high level of genetic disease?

28:19 C. Initially it's a risky strategy because harmful recessive traits can rapidly accumulate and often be lethal. We think with the naked mole-rats, that in their population they have gone through so many cycles of inbreeding in the past that most of those harmful recessives have been purge out of the gene pool.

28:43 Originally this high level of relatedness was thought to explain their highly social behaviour, so if 99% of the individuals within the colony never bred that doesn't make sense. In fact, Darwin in the origin of species worried about the evolution of sterile casts in insects. If you are very closely related, Kin selection theory can explain that, because although a particular non breeding mole-rat may never reproduce, by assisting the very closely related breeding

Queen and males to reproduce, a high proportion of genes are being carried on into the next generation.

29:24 R. Its genes are being passed on.

29:28 C. Exactly, we now know from other studies in other species of mole-rat that you don't have to be super related for that to work. Just normal family levels of relatedness of an average .5 relatedness is enough for this kind of social behaviour to become established if the ecological pressures are high enough, and it's difficult for individuals to set up and breed as a pair on their own.

30:16 The comparative studies of mole-rats, so not only looking at naked mole-rats but some of the other species within the family are revealing the neurobiology of social behaviour. I mentioned previously that within the family there are many species across sub- Saharan Africa. We have the most social naked mole-rat, we have another species called the Damaraland mole-rat which also has a similar social system. There are others that are more loosely social and then some that are strictly solitary and completely intolerant of one another. In those species they meet and the males and females pair up briefly for mating. The male goes off, the female rears the litter and as soon as the offspring have been weaned, they disperse. They are very intolerant and they are unable to act in any kind of social way and form affiliative bonds.

31.20 Some pioneering and now classic work on Voles has looked at the genetics that might underlay some of this pair bond performing behaviour, affiliative behaviours, and cooperative care as well. Two hormones that are implicated in that are Oxytocin and Vasopressin, these are fairly well known hormones especially Oxytocin. They act in many roles peripherally in the body but they also act centrally within the brain as a neurotransmitter. Some of the studies on Voles have shown that species differences in these kinds of mating behaviours, so whether or not you are promiscuous or monogamous, correlate with patterns of expression of Vasopressin receptors and Oxytocin receptors in the brain.

32:15 In a way, the brain is wired up differently in these different species, and underpinning those different patterns of expression are genetic differences in the genes for those receptors in the Oxytocin and Vasopressin gene. We are very interested in looking to see in the evolutionarily different group of mole-rats, if by comparing the solitary species and the social species, if we can see similar trends in these patterns of expression of these neurotransmitter receptors.

32:51 So you are trying to unearth the hormonal systems that allow animals to be social or force animals to be anti-social.

33:02 Exactly, these kinds of things could be fairly fundamental across mammals. For example, in humans some similar research is going on and there are associations with certain mutations in the Oxytocin receptor gene and autism. At the moment they are just associations, cause and effect can't be proven but it is very interesting, and it's giving us the same story in humans where acting in a socially appropriate way, reading emotions from facial expressions and so on are disrupted.

34:10 Some interesting studies on Vasopressin in humans have shown an association between certain mutations in the Vasopressin receptor gene and human males, and their perceived marital status and mate fidelity in humans. Again very much mirroring what was found in Voles, pointing to the fact that these kind of Oxytocin and Vasopressin systems may be fundamental in enabling pair bond formation, affiliative behaviours, and helping behaviours in across mammals. With our mole-rat system, because we have within one family this whole range of social behaviours we can also test the hypothesis; is Oxytocin expression in a particular part of the brain called the Nucleus Accumbens important?

35:07 With colleagues at Kings College in London we are finding that very thing, that these highly social naked mole-rats and Damaraland mole-rats have a pattern of expression of Oxytocin in the brain similar to what has been seen in social Voles as well.

35:33 Also, the various Genome projects are enabling us to look at the genetics that might be underpinning those different patterns of expression in our different mole-rat species. So again the naked mole-rat genome project can inform us on those social genes as well, and we are currently looking at the genetics of this in other species of mole-rat.

36:29 R. You work here in this university with your colleagues, how do you communicate with people like yourselves in the other universities in this country, and in other countries on our planet? How do you exchange information?

36:45 C. The world of science is a very small world, we travel overseas to conferences and present the work. We would hopefully be presenting new data on an annual basis. We write the work up for scientific journals, write reviews that are more widely read and try and hit popular science press like New Scientist and magazines like that. We do interviews for people that are making films, just try and get the message across as much as possible. Personally, I have been to schools to give lectures to 6th formers, give more general public seminars as well, just to communicate everything because if you don't publish or communicate then there is no point in doing the work at all.

37:38 Happily a lot of the work we have done over the years with the mole-rats is filtering through into textbooks now, into behavioural Ecology textbooks and animal behaviour and so on. It nice to see that we are advancing basic scientific knowledge apart from the more applied research which has implications in understanding human health behaviour and the behaviour of mammals in general.

38:07 R. How do you make sure that the work you do here isn't just copying something that somebody else has done or replicating something that you have done?

38:16 C. Sometimes things by mistake get replicated if 2 labs aren't in touch with each other and could be doing similar things. Usually is not exactly the same and some replication in science is good. On the whole, everybody knows what's going on through keeping up with the literature, reading papers that are published and just having a general awareness, and talking to other people around the world. The world is such a small place, it's very easy to keep in touch with colleagues in Tanzania, for example I can e-mail them easily. The general state of communication is so good now that within a few seconds you know what someone on the other side of the world is up to. We hope not to replicate things too much, a little bit of independent replication is a good thing but of course a lot of time and effort goes into

what eventually become published, so you don't necessarily want to have your thunder stolen by another lab that publishes the same thing a week earlier as an awful lot of effort goes into scientific research.

39:28 R. Specifically what sort of things has your team found in the last year of two?

39:35 C. Some exciting things we have found on the neurobiology of social behaviour has been looking at the patterns of expression of the Oxytocin and Vasopressin receptor in the brain and finding correlations with the social system. Again in parallel to some of the studies done in voles, so that was a very exciting finding because it's in a whole new group of mammals.

40:06 We've also been looking at aspects of their immune system evolution to understand what potential disadvantages living in groups has in terms of parasites and infectious disease. On a broader level, we have been looking at the biodiversity of mole-rats across sub-Saharan Africa, just to understand what species richness there is out there, how they have adaptively radiated through-out sub-Saharan Africa, and become either social or solitary as a result of the particular habitat they're in.

40:47 We have been using molecular genetic techniques to build evolutionary trees based on DNA sequence differences and then map that on to the known geology of that part of Africa. We have found that the formation of the African rift valley has had a major influence in the adaptive radiation, biodiversity, and speciation of the mole-rats as a group.

41:33 R. Looking at evolution of immune systems, are you looking at profiles of immunoglobulin or how does it work?

41:45 C. We can look at the biochemistry of it but as we tend to focus on genetic aspects, we have been looking at a particular set of genes involved in the immune system called the MHC genes. (Major Histocompatibility Complex) We can look to see what kind of variation there is in those genes within different populations. We can also look more closely at the DNA sequence level to see if there is evidence for positive selection, in order words, selection for different functional forms of the molecule derived from the gene which you would predict would be a good adaptation to fight new antigens. We can look at it at a number of different levels, in fact right down to the DNA sequence level.

42:37 R. Although they live a long time and they don't get Cancer, I guess they do get disease though?

42:44 C. Not a lot is known about that in the wild sadly, or maybe that's good. There are no apparent disease problems that we have particularly pin pointed in the wild or in captivity.

43.00 R. What about parasites in the wild, do mole-rats have fleas?

43:04 C. Some have fleas, but not commonly. It's more common to see Mites and Endoparasites like round worms and tape worms.

43:22 R. Do your colonies still have worms or have you de-wormed them?

43:26 C. No, they don't appear to have any parasites, just an interesting mixture of microorganisms that you hope find in their gut. Sometimes when you catch them in their wild you will find some colonies infested with mites and other colonies completely free of

parasites, we are interested in understanding how transmission within and between groups could occur.

47:12 C. Although they are called naked mole-rats, they are not in fact completely naked because they have sensory whiskers scattered along the body which gives them an important tactile sense given that they living in total darkness. The sense of touch is very important for them.

47:37 You can see the teeth that protrude outside the mouth, those front incisors which is what they use to dig the burrows. The mouth seals behind them so that they don't swallow soil as they are digging away. You may just see that little black pin pricks of eyes there, their visual sense is very poor but they can probably perceive the extremes of light and dark. The external ear is absent, it gives them a more streamlined body to get down the tunnels with.

48:16 R. Is that one a male or a female?

48:21 C. This one is a male, it's quite a large male. It might be one of the breeders from that colony although it's quite hard to tell externally. Their testes are within the abdomen, they don't have external testes so they are quite hard to sex. The abdominal testes is related to their low body temperature, so they don't need to be held outside the body to keep them cool, their body temperature of around 30 degrees is fine.

49:06 The skin is also very loose, it helps them if they're in a tight spot in the burrow. They can almost turn around within their skin, it helps them get stuck in small tunnels.

49:20 I'm not sure if you can hear any of the vocalization sounds in the background, they sound like little birds twittering away. They have about 17 or 18 different vocalizations, the majority of which are context specific so they do have their own vocal repertoire.

49:44 R. So they would have a warning call for a snake for example.

49:47 C. Yes the louder chirping noises are given off in aggressive encounters and the Queen has an aggressive chirp. Sound communication is important within their social context and odours as well are probably very important in individual recognition in the darkness of the burrow. They have a very acute sense of who is who within the colony and they can be a very aggressive to foreign mole-rats from other colonies.

50:27 R. If you want to breed members from 2 different colonies, how would you go about doing that?

50:35 C. If we wanted to pair together 2 unrelated individuals from different colonies we can do that. We do it rather carefully and keep an eye on the animals to begin with because they can often be aggressive towards one another. If they are happy after about half an hour then they will accept each other and then they will be fine. Often in the wild if colonies meet they will fight, they can be quite xenophobic in fact.

51:09 R. How often does the female reproduce?

51:11 C. In a good colony she can have an inter-berth interval of about 100 days or so. The gestation and pregnancy is about 72 days which is quite long.

51:26 R. Are the workers bringing her food all the time?

51:30 C. Certainly, towards the end when the Queen is very large and pregnant as they can have 27 offspring in one litter. She would have great difficulty in getting down the smaller tunnels in the wild and would be dependent on the work-force bringing food back.

51:50 R. Is she fed all the time or will she go foraging as well?

51:53 C. Not all the time, the Queen will go foraging as well. She will tend to do little in the way of colony maintenance kind of behaviours which included digging and foraging. The smaller animals tend to do more of that kind of activity. We don't have distinctive casts apart from the reproductives, what we have is a gradual change in behavioural role as animals increase in body size and more or less as well as they age. The small ones do more work and the bigger ones laze around and maybe soldiers.

52:27 R. Do you have any idea how the female chooses the male?

52:33 C. It's normally a higher ranking male or males and it's the case that the queen solicits mating, and also has in fact control over the breeding male and his reproductive physiology. We can say that the breeding Queen is the one who is in command and her breeding males or kings are subservient, although they will be amongst the larger more dominant individuals within the colony as a whole.

53:33: C. She looks early pregnant so she has got that nice plump look about her. It's a pity that we haven't got any really pregnant ones because it's just mind boggling to see, they get so huge it's really reminiscent of a Queen termite, you know the little head and the massive abdomen full of babies, like a baby producing machine.

54:10 C. The Queen generally has an elongated body, after having the first few litters the vertebrae get longer to help accommodate these large litters. She will have well developed teats and also her external genitalia will be mature looking. So we can usually work out who is the Queen fairly quickly. She is also the one that normally tramples over the top of everyone else when they meet in the tunnels or face to face encounters. The Queen always passes on top of the others.

55:01 R. So she is the boss.

55:32 R. So do you give the Queens a name?

55:33 C. No, sadly they have a number but not usually a name. Actually we should maybe go through the British monarchy through the ages. That will be fun.

55:50 C. You can see she looks as though she might be in the early stages of pregnancy, that slight plump appearance is typical. She will become really big as the gestational period advances.

56:04 R. How pregnant is she? How many weeks would you guess?

56:08 C. She is probably in the first 20 or 30 days of pregnancy I would say, maybe half way through the 72 days. The pregnancy is quite long for a rodent as well.