Sociophysiology goes to work underground: the naked mole-rat Heterocephalus glaber

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The naked mole rat is a member of the family of African mole-rats, the Bathyergidae (the name comes from the Greek roots bath = deep and erg = work). Mole-rats are rodents who live underground and they are of interest because they have very varied social structures, ranging from a species which is completely solitary apart from mating and nursing the young, and the naked mole rat which lives in colonies of up to 300 members, and is the most eusocial of mammals (eusocial implies division of labour, overlap of generations and co-operative care of young – a system until recently thought to be limited to the social Hymenoptera). The naked mole-rat is small – a whole colony of 300 members may have a biomass of only 2 kilograms; it is the only mole rat to be devoid of fur and it has long sharp incisors {for digging) which are outside the mouth.

A recent monograph (1) describes the social life of these little animals, and compares them with other mole rats, especially the Damaraland mole rat, which also lives in large colonies. A colony typically consists of a mated pair and their offspring, although there may be up to three sexually active males. There is only one queen, and she keeps all the other females sexually suppressed, so that she is the only female to ovulate, the rest remaining in a prepubertal state as long as the queen and at least one mate survive, which may be for over 10 years. It is thought she does this by bullying – shoving the other females (and the males, who are also sexually suppressed) backwards along the burrows. She does not appear to secrete a sexually suppressing pheromone (as occurs in some voles). There is a social hierarchy among the non-breeders, which is partly determined by bouts of sparring with the incisors - lethal weapons which are not used as such on fellow colony members – in which two rats lock their incisors together and pull each other backwards. When two mole rats meet in a tunnel, the dominant one passes over the body of the other. The subordinate animals do most of the digging, and collecting of tubers, corms and roots, which are their main diet.

The naked mole-rat is unusual among mammals in lacking any mechanism to prevent inbreeding. If the queen dies, there is vicious fighting, with deaths, among the more dominant suppressed females, and the winner then becomes sexually active and suppresses the rest, breeding with the active male who is probably her father. This capacity for inbreeding means the colony can divide by fission or budding, in which case one female and at least one male in the bud become sexually active and mate together, in spite of being brother and sister.

Fission cannot occur in the Damaraland mole-rat, which has a prohibition on inbreeding. If the queen, or the sexually active male(s), are removed, the colony remins in an asexual state until it disperses (which could be for up to a year, waiting for the rains). In this mole-rat, the males are not physiologically suppressed, and their lack of sexual activity is due to the inbreeding prohibition. The females are not as suppressed as in the naked mole rat, their ovaries have unruptured luteinised follicles; they start ovulating when the queen dies and before they disperse, but do not attain queenlike hormone levels until they encounter a strange male.

In addition to fissioning, the naked mole rat also has a dispersal phenotype, characterised by much increased fat stores. It is thought that dispersal may occur above ground, but is usually done by burrowing away from the colony, and the dispersing animal drums with its feet on the earth to locate a partner.

It is an unusual life style – to be born into a group of a hundred or more siblings, a home which is about two kilometres of tunnels, never to see the light of day, to spend most of the day digging or transporting earth. Their life has led to some other adaptations:

- After weaning the pups solicit faecal pellets from their mother and eat them. This supplies them with the symbiotic bacteria which live in their guts and digest the cellulose in the diet, and it may also provide nourishment, if the mother refrains from absorbing all the nutrients herself.

- They have a teeth sharpening behaviour in which the incisors are sharpened by rubbing together. This may occur during breaks from digging, or in the toilet area.

- Since they do not see the sun, they have no Vitamin D to absorb calcium from the gut. They have another calcium absorbing mechanism which is so effective that they tend to suffer from ectopic calcification when fed high calcium diets.

- They are strongly xenophobic and attack strangers (but we do not know what happens if a suppressed female meets a strange male when she is on her own at the end of a long tunnel). If removed from the colony for 12 hours, a colony member is treated like a stranger.

It is thought that group living is an adaptation to arid environments, as the solitary mole rats live in areas of high rainfall. One solitary rat may weigh as much as a whole colony of naked mole-rats. Group living is facilitated by both sexual suppression and inbreeding capacity. William Hamilton pointed out that breeding by an unrelated pair of male and female, both inbred to the point ofhomozygosity, produces offspring that are genetically identical, all being the F1 generation. They are all heterozygotic at the loci in which their mother and father differed. The naked mole-rat does not quite achieve this degree of inbreeding, but the coefficient of relatedness between siblings is elevated from the average of 0.5 to 0.8. What more could a selfish genome do than to help its parents produce more individuals almost identical to itself?

The effect of social experience on our physiology and behaviour is the substance of sociophysiology. The naked mole-rat's experience of being shoved backwards along a tunnel represents the receipt of a class of signal which we have called catathetic (putting down). We think there may well be a central mechanism for integrating these signals which is common to all mammals and maybe all vertebrates. Each species has its own form of catathetic signal (ours is usually verbal!) and the output from the integrating mechanism varies from sexual suppression in the case of the mole-rat, inhibition of socially-induced sex change in certain fish, "stress-induced" ulcers and suppression of the immune system in many mammals, and, of course, changes in emotion and mood. Having a well-defined and easily measurable response, the mole rat may be a good experimental subject for investigating this central mechanism which seems so important for both mental and physical health. Also, the fact that the naked mole-rats are turned on sexually by their brothers and sisters, whereas the closely related Damaraland mole-rats are not, might be a good system for studying the neurobiology of sexual attraction and incest avoidance.

1. Bennett, N.C. & Faulkes, C.G. (2000) African Mole-Rats: Ecology and Eusociality. Cambridge University Press.