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Arising from an initial inquiry about the distribution of levels of inbreeding in Aboriginal Australian (Denham, 2012) societies and subsequent analysis of some small datasets with Dr Denham, I have come to read the paper "Alyawarra kinship, infant carrying, and alloparenting". It contains interesting observations about patterns of interaction within- and between-social and kinship groups studied by Dr Denham, which have prompted for me some questions and speculations. I should stress that my perspective on the material covered in the paper is a combination of quantitative genetic analysis, coupled with a broader interest in evolutionary processes, in this case as they may have applied in both the genetic and social or cultural senses of evolution. I share these questions and speculations simply to extend the discussion which I am sure will be prompted by the paper. And I stress in advance my extremely limited knowledge of the fields of research covered by this journal.

The paper covers a lot of territory in the sense of different sorts of observations about the groups studied/observed, but contains a core of data relating to carrying of infants by various categories of kin and non-kin. This data complements considerable detail and discussion on the mating structures or systems operating within the groups studied/observed.

The first observation for me in these data, is that carrying by remote or non-kin occurs at a much greater rate than would be predicted if it were determined solely by level of relatedness. In the data for the Alyawarra for example, we have data on the proportions of carries by full-sibs, half-sibs and cousins, and also for less related pairs. We can explore the pattern by asking "what would be the expected distribution of carries if carrying were completely according to relationship?" For example, if we have a community of 100 individuals older than self, with each child having 1.5 full-sibs, 6 cousins, and then 92.5 other co-locationals, and interaction was proportional to relationship, then the distribution of carries would be something like (r x 1.5 x 0.5), (r x 6 x .25), (r x …) for all the relationships, where r is a propensity to carry. If for the moment we ignore anything other than full-sibs and cousins, and assume 100 is the total community, and the basal relationship is 0.0025 – this is arbitrary, or simply a guess for the moment), we'd have

r x 1.5 x .5 = 0.75 r (for full-sibs)
r x 6 x 0.25 = 1.50 r (for cousins)
r x 92.5 x 0.0025 = 0.2315 r (for co-locationals)

Totaling these gives us 0.75r/(0.75r + 1.50r + 0.2315r) = 0.75r/2.4815r = 0.30r or 30%r, for full-sibs.

Accordingly, under this model the proportions of carries would be 30%, 60% and 9% respectively for full-sibs, cousins and co-locationals respectively, assuming constant r. In the data presented here, the proportion of carries by close relatives (full-sibs and cousins) is 22.13%, very much lower than the 90% my simple model would predict.

So, we have data in which carrying of non-close relatives occurs at a much higher rate, and carrying of close relatives occurs at a much lower rate, than would be predicted based on a simple relationship model alone.

This observation prompts for me the question of whether the observed pattern is typical of, or even found in, other groups?

If so, then the studied groups at least are doing something about which we can ask questions. Such as – is this a random behaviour ("just pick up kids sometimes and carry them")? This simple question in turn leads to several more (each of which could generate more in turn):

- If it's random, why do it?
- If it's not random, what explains the observed frequency distribution? If the behaviour provides some material benefit (which might be improved infant survival, and/or reduced maternal load, both leading to greater long-term maternal reproductive success), we would reasonably predict a distribution likely to be in some way proportional to level of relationship.
- Could it be that there is some other benefit being conferred – such as is suggested or implied by Dr Denham that reciprocal obligations are generated, which can be drawn on consciously or unconsciously later in life? And if this is the case, how did such a system of generating reciprocal obligations evolve? Such a system is non-trivial – it involves actions, recognition, and responses from several parties, and as such is more like (for example) the evolution of a complex organ such as the eye, rather than a simple thing such as eye colour (which is of course non-trivial too). And if the benefits being generated include some of this form, does that provide a basis for some predicted distribution of occurrence of the behaviour?

Another way of looking at this behaviour is to pose a nested set of questions:

- Does carrying have material benefit or not (yes or no)
    - If no:
        - why do it?
        - is the pattern or frequency distribution random?
    - If yes:
        - What form(s) does that benefit(s) take, or what benefits does it confer and on whom?
        - Did the behaviour and its pattern of distribution evolve? (yes or no)
            - If no, how did it come about?

There is no way of simply answering these questions within my limited knowledge of the field, but they point to a broader question to which I will return, after commenting on another aspect of the paper.

The second major focus of the paper is on the mating structure of the study population, and in particular on the age difference between males and females at mating, coupled with patterns of relatedness of mating pairs (in a simplistic and slightly inaccurate way, "girls marry (and mate

with) their father' sister's sons", for example). Two aspects are striking for me in these patterns. Firstly, as Dr. Denham discusses, it means that males have to pass some sorts of tests or hurdles before being allowed to marry (and mate). This is in a rather simplistic way not unlike males in some species of mammals where males essentially have zero mating success until they are strong enough to defeat male rivals in various forms of ritualistic and/or actual battles (such as elk, many types of seals, etc) This means that males do not start generating progeny until they are many years older than the average age of females. More generally, both males and females may have to prove or signal some form of value in order to attract mates – but what is interesting here are the consequences of the means by which this occurs in the observed society, including the differences in mean ages at progeny, and the resulting overlapping pattern of generations, and the pattern of alternating, or at least different "wavelength" pattern of expression of individuals' genes in their male and female descendants.

I am not suggesting that there is any form of inter-male conflict for mates in the societies studied by Dr Denham, rather there is a cultural hurdle imposed – the males have to know certain things before being allowed to become parents.

Dr Denham's material includes some discussion of inbreeding avoidance, or at least "management", with quite regular and cyclical patterns of relationships throughout the society and through time, and from some of the comment on other research, across space as well. This includes some culturally prescribed or at least guided exogamy – mating between individuals from quite different groups. If this is (or was) guided by broadly similar sets of rules across many groups, then it is hard not to conclude that the indigenous society had arrived at a system for not only limiting the upper level of inbreeding and co-ancestry, but possibly also maintaining levels of relationship within some possibly desirable range. Authors in evolutionary biology have speculated about the value of non-zero levels of inbreeding (e.g. Shields, 1982) and how they might be maintained.

My background is in animal breeding – a form of applied evolution – and there are models used for data analysis in that field which seem temptingly relevant to some of the observations in the paper. Two in particular are:

- Maternal models, in which genetic differences in the environment provided to their offspring by mothers, are analysed. In simplest form, these can be used to estimate genetic differences within a population in the quality of the uterine and lactational environment provided to the offspring. There is no reason to suppose that such models could not be applied to human data, and what brings them to mind here is the semi-regular structure of relationships through male and female offspring. Genetic effects from both fathers and mothers can contribute to such "maternal genetic effects", and mean that both male and female children contribute to future reproductive success, and so any society that has even guessed at such influences will value male and female children and further descendants equally. It may not be possible to estimate any maternal genetic effects in human populations, at least from datasets like those explored here, simply because very large numbers are required. However, this does not mean that such effects are not having an effect.

- Social effects models, in which genetic differences in what can simply be described as "getting on with others" are analysed, are also being used in animal breeding. These simply estimate genetic differences in the effects that individuals have on others they share time, space, resources etc with, and vice versa. Selection programs that explicitly use such genetic differences have been successfully employed in chickens for example, and lead to populations in which the chickens exhibit less negative interactions with their cage or shed-mates, leading to reduced stress, disease and other benefits. As with the maternal genetic effects models, the point here is not to suggest that these effects could be estimated in very small data sets such as those discussed here, but to note that such effects could quite likely be present, having effects in human societies, and likely to be selected for. And in a society where there was acute awareness of interactions between all its members, that fact and the prescriptions for what sorts of interactions are allowed and which are proscribed very much tempts one to suppose that the society is effectively aware of the possibility of positive genetic and cultural contributions to individual and group well-being and thriving. Which in turn, with perhaps a leap of conjecture, leads one to speculate on how the society under discussion came to structure and regulate itself in ways seemingly designed to maximize positive interactions and the evolution of more positive interaction.

The observations to this point essentially build on relatively simple quantitative data. More generally, the paper contains observations and discussion which prompt some broader and certainly more speculative comments.

The first is that it seems that the society under discussion "discovered" a set of relationships and/or ways of organizing social relations which a) are/were all-encompassing ie inclusive of genetic relationships and regulation of inbreeding and relationships, and b) are/were linked or overlain with ecological knowledge and management.

Which leads me to questions such as:

a) There is a strong suggestion in the discussion, and the references cited, that there is an apparently strong set of guidelines and parameters affecting relationship structures within and between population units (within the Alyawarra, between Alyawarra and others) and accordingly affecting inbreeding structures and levels, and also the flow of genes down through the generations. I have no real knowledge here, but it certainly seems that Dr Denham and others are hinting at some sort of continent-wide "mating wisdom". Is this a reasonable interpretation? Were such networks of wisdom developed by other societies?

b) How did they discover this complex of networks in several dimensions, given the apparent complexity of each one, and the absence of writing? (I am conscious that this question could be interpreted as rather patronizing – I have no knowledge of how such cultural evolution proceeds, and of what is presumably a rich literature on the topic – I am simply assuming that writing enables faster learning of at least some cultural innovations).

b) Are the networks of knowledge and relationship as rich as they appear to be, or is that some sort of sentimental projection?

c) Through what process was it discovered – was it evolutionary, and the failures died out, or was it in some way inevitable ie the only way humans could survive given ecological constraints?
d) Are all these aspects of the Dreaming? Is this a white fantasy or wish projection?

What I find extraordinary is that it looks very much as though Aboriginal Australia "discovered" all this – the long-term value of both the "fine-grained and huge-distance in both time and space encompassing" networks of culture and relationship which seem to have been their "raison-d'etre", and that they integrated this with an ecological world-view, which as Dr Denham says in his summation of the Dreamtime, was designed to maintain the entire world in a state of exquisite poise and fruitfulness – which if one thinks about it, is the most extraordinary benefit-cost analysis anyone has ever even conceived – all future and past costs and benefits are simultaneously captured or dealt with in the present, and in a sense, the ripples that flow out from every action or even thought, are all fully accounted for.

Included in the system of rules are prescriptions and proscriptions about where individuals and groups spend time during the year and during their lives. If in fact this fluidity or complexity of location was both true and widespread, then this seems to me to be potentially a cultural innovation of extraordinary importance – most social species have well-defined territories for "kinship" groups (I'm thinking of wolves, dolphins, orcas) with permeable but nevertheless definable and semi-permanent boundaries. If the Alyawarra and potentially others have a dimension of life which is that you might spend time periods of extreme variation in length with other groups, with a range of relationships between you and them, and engage in a range of behaviours across those "visits" and "stays", then that is another almost infinitely complex dimension of what is already a highly dimensioned social and cultural existence – and one with structure and connection always inherent and known. Presumably it comes with learnings, with acts that nurture the Dreaming and hence one's own world, and with the sort of constant enlivening of multiple networks of mutual obligation and reciprocity which generate infinite survival and cognitive richness. Which is an interesting contrast to our discovery (e.g. Castells, 2009) of what it means to exist in a "network society" – it seems to me that Aboriginal Australians have been immersed in, and managing, and co-creating and nurturing, network society, for tens of thousands of years.

One can envisage a multi-dimensional matrix of interactions between/amongst all extant and ancestor individuals – genetic relationship, moiety, shared location, direct contact such as via being carried or being a carrier … it is very appealing to imagine that this multi-dimensional matrix would have a much more even distribution of coefficients than would be expected by chance or by the workings of social power laws – and if it did, this would have to reflect some sort of shared consciousness or collective wisdom. Most social interaction systems tend towards power law distributions, highly skewed and (increasingly in our current political perspective) inequitable, It appears that the distribution of almost everything in Aboriginal societies was more even (in genetic relationships, in time, space, stage of life etc), than could possibly exist under the workings of power laws, which adds another dimension to the apparent societal wisdom).

Finally, it seems that it would be possible to allocate all individuals in Dr Denham's study group to their respective consanguineal, affinal and other "classifications", and so I wonder whether the usual situation is that no two individuals in a "band" actually fall into the same n-dimensional classification cell, and hence, everyone is usually expected to be unique – which would have the effect of saying that everyone was essential for some Dreamtime purpose ie no-one was redundant. This would be a very thin but extremely wide network, which presumably could be considered to be optimal in an extremely resource-limited environment, and one which had been so for a very long time. This point again highlights the question – "how on earth did they learn all this?" Is such a complex and powerful system some sort of strange attractor[1] in socio-genetic evolutionary space? Is the learning simply the outcome of selection by death of the ones who didn't learn it? And is such a system inherently both very rich and very fragile, or at least susceptible to certain sorts of "invasion" – which is pretty much exactly what happened in Australia.

This paper covers considerable ground, and is very rich in generating further questions. I enjoyed reading it, and I hope my observations and speculations add to the reading experience of others.

References:

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Denham, Woodrow W. 2012. Kinship, marriage and age in Aboriginal Australia. *Mathematical Anthropology and Cultural Theory*, 4(1):1 - 79. In http://mathematicalanthropology.org/Pdf/MACT_Denham_0512.pdf

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[1] "Strange attractor is a term used in the study of the mathematics of chaotic or complex systems, to describe points or regions to which a system tends to move, or return periodically – in the sense of it being attractive for the system as a whole to move towards, or be in, that state or region. Here "state" or "region" implies a set of parameters of the system – which could for example in some ecological study be a combination of settings of numbers of species and the proportions of different species, or in a study of human population behaviour be the settings of the numbers of interactions between members of the population, and the balance of cooperative and competitive behaviours. In a rather simple way, we can think of "strange attractors" as being the solution to some problem or set of problems inherent in a complex system.

I use strange attractor here to ask the question whether the set of knowledge and the rules implied by or developed from that knowledge, held by a particular population or set of linked populations, could be or be close to, the set of knowledge and resulting rules that "solve" the problems – in this case of sustainable existence – facing those populations. And whether perhaps human societies may exist as possible solutions in a problem space where complex, embedded, shared, multi-dimensional knowledge ("the Dreaming") is very close to, or is the solution. The point of raising the idea of strange attractors is that they imply that the system will find the solution represented by the strange attractor, more rapidly or readily than would be anticipated by chance alone (ie the blind trial and error process of simply trying all possible combinations of knowledge and rules).