How might group selection explain the major evolutionary transitions?

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The central idea of group selection is that an individual will reduce its fitness so that the mean fitness of a group (of possibly non-related individuals) may increase. This is relevant to the major evolutionary transitions where an individual will cooperate by stopping reproduction on its own and reproduce instead as part of a group. Explaining the major evolutionary transitions should simply be a case of applying models of group selection. However, group selection may only work when there is a small difference between the fitness of a cooperator and a defector (Traulsen et al., 2006, Proc. Nat. Acad. Sci. U.S.A., 103, 10952).

A new approach (Bryden, 2008, PhD thesis, University of Leeds) sheds fresh light on this topic however. We must carefully look at what we mean by fitness and what we mean by group.

Recent perspectives on fitness (Metz et al., 1992, Trends Ecol. Evol., 7, p.198) argue that fitness should be calculated over a range of environments. This contrasts with the Hamiltonian perspective of fitness (Hamilton, 1964, J. Theor. Biol., 7, p.1) which is the number of adult offspring. By calculating over a range of environments, some traits which prosper in some environments decay in other environments. Tools are available (e.g., Tuljapurkar, 1990, Proc. Nat. Acad. Sci. U.S.A., 87, p.1139; Bryden 2008) for modelling long-run growth rates over varied environments.

To apply this long-run perspective on fitness to the major evolutionary transitions, resource allocation strategy modelling has been done by Bryden (2005, ECAL, p.551; 2007, ECAL, p.645;2008). The problem of the major evolutionary transitions is reformulated as a question as to whether an individual will invest resources in a higher reproductive process: a process of generating new offspring with two or more individuals having some genetic stake in, and contributing resources to, the new offspring. When an individual reproduces clonally, it will grow faster in favourable environments than those that contribute toward a higher reproductive process. However, reproduction can be risky and leave the fast reproducing lineage dangerously low on resources during unfavourable environments.

Analytic methods and computer simulations have shown how a strategy of collective reproduction (by sharing resources between several individuals and one offspring equally) can dominate a strategy of producing clonal offspring (Bryden 2007). When individuals are selfish and only contribute minimal resources, increases in the amplitude of environmental resource fluctuations becomes increasingly significant (Bryden 2008). The reason the shared strategy is successful is because the clonal strategy is very weak in harsh environments.

These results demonstrate that it is plausible that an individual may lower its Hamiltonian fitness (i.e., its reproductive output) to increase its long-run fitness by contributing to a higher reproductive process (such as those in the major evolutionary transitions). If I suggest a definition of a group as a lineage that is temporally spread out across several environmental eras, rather than all being present at the same time, we may then compare the long-run fitnesses of lineages to determine the most successful. In other words, the group that has the greatest long-run fitness is selected for. This theory calls for verification through scientific experiments and expansion through further modelling of the major evolutionary transitions.