**Results**

Kin preference, average relatedness within groups, average group size and cooperation all evolved

within this model.

*Evolution of Group Size*

The size of groups was mainly affected by the group carrying capacity, 1/c (table x.) When the group carrying capacity was high however (c=0.02) the larger the intrinsic rate of growth, r, the larger the average group size observed. (table x). The cost of cooperation , β, only had an effect on the group size observed with C and r was small (C=0.02 and R<1.0), keeping groups below the stable group size. Otherwise the average group size stayed around the stable group size

*Evolution of cooperation*

When the group carrying capacity was small (C =0.1) average cooperation evolved to a high level regardless of the cost of cooperation or intrinsic rate of growth. However when the group carrying capacity is larger and the cost of cooperation is larger (C=0.02 and β 0.6, C=0.06 and β =0.8) lower levels of cooperation evolve.

*Evolution of relatedness*

90.7% of the variability in average relatedness is due to r, the intrinic rate of growth (table x). The intrinsic rate of growth, r, has a very large effect on the average relatedness within groups. The group carrying capacity, 1/c, and the cost of cooperation, β, have little effect (table x, figure 1)

*Evolution of kin preference*

The level of kin preference that evolves is most affected by the intrinsic rate of growth (r2=0.88 table x). The cost of cooperation, β, only has an effect when when R is small and the group carrying capacity, 1/c, is large (figure 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Kin Preference (asin transformed) | Relatedness (asin transformed) | Group size (log transformed) | Ave Coop (log transformed) |
| r (intrinsic rate of growth) | 88.4 | 90.7 | 15.8 | 11.1 |
| C (inverse of gp carrying capacity) | 0.10 | 0.53 | 63.3 | 6.4 |
| β (cost of cooperation) | 2.31 | 0.31 | 4.7 | 29.9 |
| Interactions | 2.49 | 0 | 10.6 | 36.9 |
| Total (r2) | 93.3 | 91.4 | 94.4 | 84.3 |

**Table x:** Percentage variance explained by each of the parameters of the model for the average kin preference, relatedness, group size and cooperation within each groups, for each run of the model after it had reached equilibrium.

*White noise test and within run correlations*

During each run cooperation, group size, relatedness and kin preference all oscillate. However significant values of the Fisher's κ statistic allow us to reject the null hypothesis that fluctuations observed in the series are due to white noise (table y).

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Fisher’s κ** | **P value** |
| Average cooperation | 672.3 | <<0.001 |
| Average group size | 1380.3 | <<0.001 |
| Relatedness | 730.1 | <<0.001 |
| Kin preference | 1757.4 | <<0.001 |

**Table y:** The Fisher’s κ value and corresponding p value for a randomly choose run.

During the runs the oscillating values of cooperation is correlated with group size and relatedness is correlated with kin preference. Kin preference and relatedness are counter-correlated with cooperation and group size (figure 2)

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**Fig 2:** Time series showing oscillations for R=0.1, c=0.06, β=0.2. Lines shown are cubic spline fits with flexibility parameter λ= 0.001 on the original data. The first 10000 records of the re run were removed to ensure that the cycle had reached equilibrium.