**Results**

*Evolution of Group Size*

The size of groups formed was primarily affected by the group carrying capacity, 1/c, with 63.3% of the variation attributable to C (table x.) However intrinsic rate of growth, R, had an effect. When the group carrying capacity was high, (c=0.02) the larger the intrinsic rate of growth, R, the larger the average group size evolved. The cost of cooperation, β, only had an effect on the group size when C and r was small (C=0.02 and R<1.0), keeping groups below the stable group size (figure 1). Otherwise the average group size remained around the stable group size

*Evolution of cooperation*

The level of cooperation that evolved depended on the cost of cooperation, β, with 29.9% of the variation explained by the cost of cooperation. 36.9% of the variation was explained by interaction terms in the ANOVA model (table x). From figure 1 it can been seen that 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 both the group carrying capacity and the cost of cooperation is large (C=0.02 and β 0.6, C=0.06 and β =0.8) lower levels of cooperation evolve.

*Evolution of average relatedness within groups*

90.7% of the variability in average relatedness within groups is due to r, the intrinsic rate of growth (table x, figure 1). The intrinsic rate of growth, r, has a very large effect on the average relatedness within groups, with the average relatedness increasing as the intrinsic rate of growth increases. The group carrying capacity, 1/c, and the cost of cooperation, β, have little effect, with β only explaining 2.31% of the variation (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) with higher levels of kin preference evolving as the R increases, with it apparently leveling off as R approaches 1.5 (figure 1). Cost of cooperation, β, only has an effect on kin preference when both R is small (< 1.0) and the group carrying capacity, 1/c, is large (C=0.02) (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.

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*White noise test and within run correlations*

During each run each output parameter oscillates (figure 2). However significant values of the Fisher's κ statistic carried out on a randomly chosen runs, allow us to reject the null hypothesis that the 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). Leticia: I have potentially found a way to test/measure correlations within time series, using a function I found in R. If you agree I think it might be good to test for the amount of correlation within all runs and get the average result, as the magnitude of correlation seems to differ a bit between runs, but not necessarily the direction. (see table z below for an example of cross-correlation tested for one run)

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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 run were removed to ensure that the cycle had reached equilibrium.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Cooperation | Kin Preference | Group size | Relatedness |
| Cooperation | NA |  |  |  |
| Kin Preference | -0.052 # not such a strong correlation | NA |  |  |
| Group size | 0.256 | -0.845 | NA |  |
| Relatedness | -0.185 | 0.646 | -0.862 | NA |

Table z: Cross correlations for sample time series same as in graph