Initial ARTs Results

Sarah P. Flanagan

03 July, 2018

The purpose of this model is to understand how genetic architectures of alternative reproductive tactics impact their maintenance in populations. I'm using an individual-based simulation model with different selection scenarios, types of alternative tactics, and genetic architectures (genome-wide additive genetic variance, supergenes, expression networks) To test the model and make sure that everything has been implemented correctly, I'm first testing to ensure that the model produces the expected results without the genetic architectures.

Overview of the model

Males can be courters or not-courters and parents or not-parents. When the model is run with both traits, this results in four possible morphs: courter/parent, courter/not-parent, not-courter/parent, and not-courter/not-parent. Generations are non-overlapping and there is one reproductive bout per generation. In each generation, the population follows the following timeline:

1. Females choose a nest
2. Males fertilize eggs
3. Nests survive or die
4. Viability selection on progeny
5. Stochastic survival to adulthood

1. Choosing a nest

A female samples 50 males and chooses a male to nest with based on his courtship trait. If there are no courtship traits in the model, she chooses based on the male's parental trait. If she does not encouter an acceptable male, she does not nest. If she encounters multiple equally-acceptable males, she randomly selects one of them.

2. Fertilization

Once a female decides to nest, up to three males can fertilize the nest. Courters and parental males can contribute more sperm than non-courter and non-parental males: $r_{courter} = r_{parent} = 8$ and $r_{non-courter} = r_{non-parent} = 4$. A courter/non-parent has $r_{non-parent}$ and a non-courter/parent has r_{parent}. The male with whom the female is nesting gets $r_{parent}/\Sigma n_{sperm}$ and additional non-parental males (up to 2) get $(r_{non-parent} * 0.5/\Sigma n_{sperm})$, where Σn_{sperm} is the total number of sperm contributed by all of the males, weighted by the sperm competition factor (0.5 is the default for all males except the nesting male). So, when a female mates with one courter and two non-parentals, $\Sigma n_{sperm} = r_{courter} + 2*(0.5*r_{sneaker})$, where $r_{courter} = 8$ and $r_{sneaker} = 4$, therefore $\Sigma n_{sperm} = 12$.

That being said, every time a male mates he uses his sperm, so after one mating where a courter fertilizes 50% of the female's 4 eggs, he only has 6 sperm for his next mating.

3. Nest Survival

Before the babies can survive, the nest has to survive. This step is only relevant when parental traits are in the model - if only the courtship trait is specified, then all progeny in the nest survive at this point. When

males have the parental trait, if the female has given eggs to a non-parental male (because she chose based on courtship traits), then the nest has a 10% chance of surviving. If the female has given eggs to a parental male, the nest has a 90% chance of surviving.

4. Viability selection and 5. Stochastic survival

Then the offspring experience viability selection. Courters and parental males are disfavored in viability selection, with a survival probability of 0.9950125. If an individual is both a courter and a parental male, the survival probability is 0.9900498. Non-courters and non-parental males have survival probabilities of 1. Once viability selection has been imposed, individuals die or survive randomly, and the next generation gets a chance to mate.

Evaluating equilibrium

After 10000 generations, I begin tracking the change in frequency of the courter and parent traits, and do so for 2000 additional generations. I calculate the variance in the change in frequency over those 2000 generations. I declare an equilibrium ('stasis') has been reached if the last change in frequency of both traits is less than the variance in changes in frequency.

Unlinked additive genetic variance

In these cases, the traits are encoded by a number (50) of loci, whose alleles contribute additively to determine the trait value. These alleles are all freely recombining and are not adhered to any physical genomic location (aka this is a classical quantitative genetics approach). The overall trait value is compared to a population-level threshold (which is static, in these cases), and if the trait value is above the threshold the male takes the parent or courter morph and if it is below he does not. Below, I'm showing the results from 10 replicates of each scenario.

Courter trait

Females choose nests based on whether the male is a courter or not, and they all prefer courters all of the time (the female preference does not have a genetic basis and does not evolve). The only way that non-courters produce offspring is through sneaking, but all males can be sneakers (both courters and non-courters). Because parental care is not incorporated in this model, all nests survive.
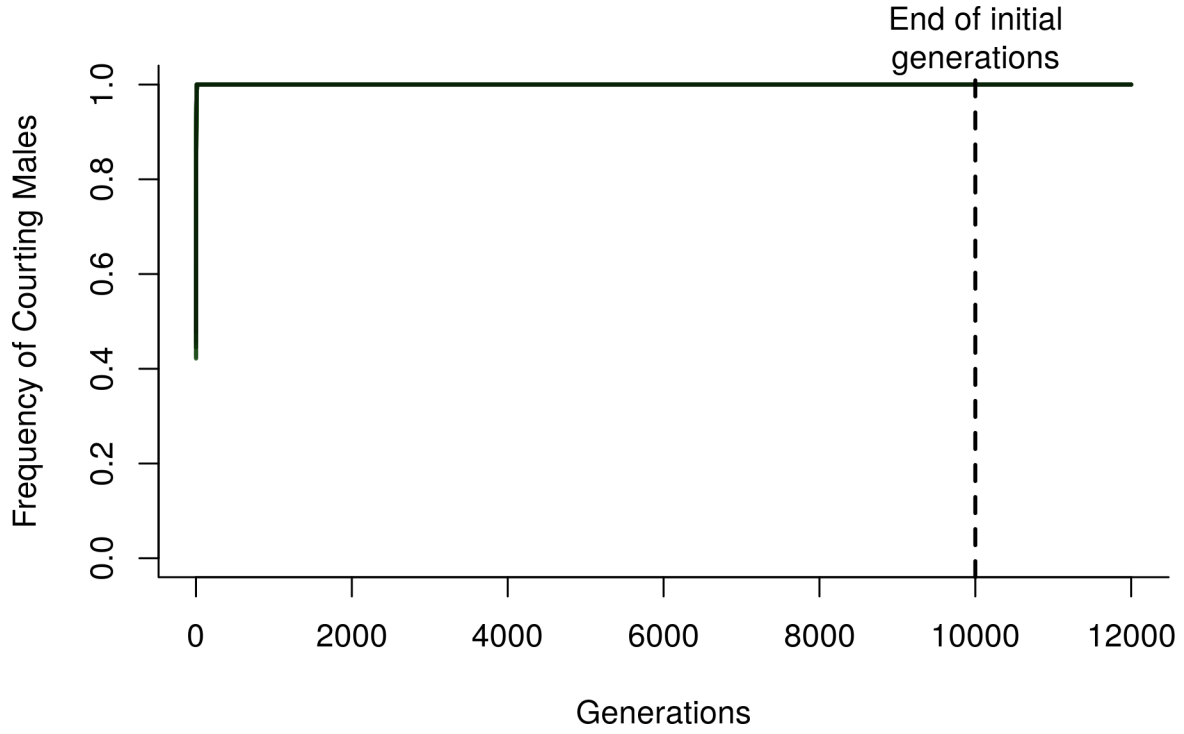
Figure 1: Frequency of the courter morph (each color represents a different replicate)

Of the 40 replicates, 0 reached an equilibrium by 10000 generations.

Table 1: Frequency of courters in final generation

	CourterFreq	CourterW	NonCourterW
courter-nogenetics_1_summary.txt_1	1	3.35270	0
courter-nogenetics_1_summary.txt_2	1	3.11905	0
courter-nogenetics_1_summary.txt_3	1	3.29774	0
courter-nogenetics_1_summary.txt_4	1	2.82286	0
courter-nogenetics_10_summary.txt_1	1	3.35270	0
courter-nogenetics_10_summary.txt_2	1	3.11905	0
courter-nogenetics_10_summary.txt_3	1	3.29774	0
courter-nogenetics_10_summary.txt_4	1	2.82286	0
courter-nogenetics_2_summary.txt_1	1	3.35270	0
courter-nogenetics_2_summary.txt_2	1	3.11905	0
courter-nogenetics_2_summary.txt_3	1	3.29774	0
courter-nogenetics_2_summary.txt_4	1	2.82286	0
courter-nogenetics_3_summary.txt_1	1	3.12475	0
courter-nogenetics_3_summary.txt_2	1	3.20968	0
courter-nogenetics_3_summary.txt_3	1	3.40756	0
courter-nogenetics_3_summary.txt_4	1	3.15832	0
courter-nogenetics_4_summary.txt_1	1	3.35270	0
courter-nogenetics_4_summary.txt_2	1	3.11905	0
courter-nogenetics_4_summary.txt_3	1	3.29774	0
courter-nogenetics_4_summary.txt_4	1	2.82286	0
courter-nogenetics_5_summary.txt_1	1	3.35270	0
courter-nogenetics_5_summary.txt_2	1	3.11905	0
courter-nogenetics_5_summary.txt_3	1	3.29774	0

	CourterFreq	CourterW	NonCourterW
courter-nogenetics_5__summary.txt_4	1	2.82286	0
courter-nogenetics_6__summary.txt_1	1	3.35270	0
courter-nogenetics_6__summary.txt_2	1	3.11905	0
courter-nogenetics_6__summary.txt_3	1	3.29774	0
courter-nogenetics_6__summary.txt_4	1	2.82286	0
courter-nogenetics_7__summary.txt_1	1	3.35270	0
courter-nogenetics_7__summary.txt_2	1	3.11905	0
courter-nogenetics_7__summary.txt_3	1	3.29774	0
courter-nogenetics_7__summary.txt_4	1	2.82286	0
courter-nogenetics_8__summary.txt_1	1	3.12475	0
courter-nogenetics_8__summary.txt_2	1	3.20968	0
courter-nogenetics_8__summary.txt_3	1	3.40756	0
courter-nogenetics_8__summary.txt_4	1	3.15832	0
courter-nogenetics_9__summary.txt_1	1	3.35270	0
courter-nogenetics_9__summary.txt_2	1	3.11905	0
courter-nogenetics_9__summary.txt_3	1	3.29774	0
courter-nogenetics_9__summary.txt_4	1	2.82286	0

Parental trait

All females nest with parental males, so the only way non-parental males reproduce is through sneaking. Parental males provide care that allows nests to have a 90% chance of survival. The female preference does not have a genetic basis and does not evolve.
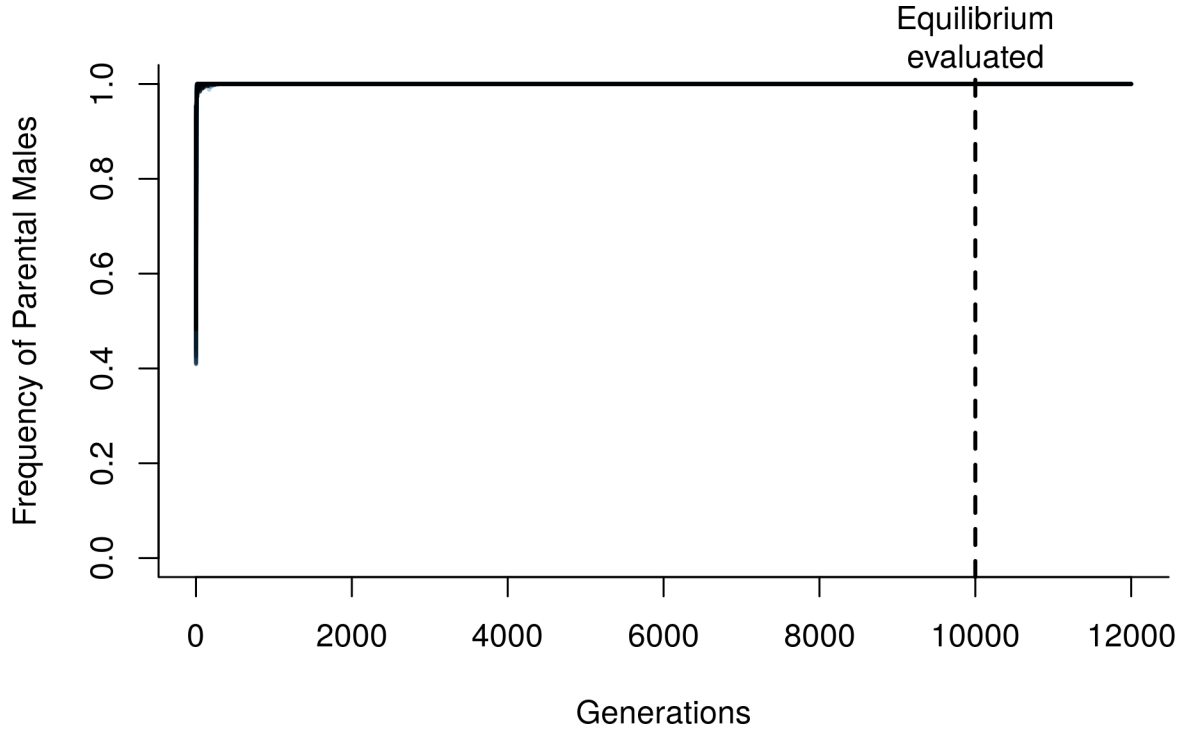

Figure 2: Frequency of parent morph (each color represents a different replicate)

Table 2: Frequency of parents in final generation

	ParentFreq	ParentW	NonParentW
parent-nogenetics_1_summary.txt_1	1	3.52295	0
parent-nogenetics_1_summary.txt_2	1	3.54757	0
parent-nogenetics_1_summary.txt_3	1	3.55221	0
parent-nogenetics_1_summary.txt_4	1	3.48611	0
parent-nogenetics_10_summary.txt_1	1	3.57531	0
parent-nogenetics_10_summary.txt_2	1	3.55000	0
parent-nogenetics_10_summary.txt_3	1	3.57085	0
parent-nogenetics_10_summary.txt_4	1	3.58996	0
parent-nogenetics_2_summary.txt_1	1	3.55689	0
parent-nogenetics_2_summary.txt_2	1	3.55439	0
parent-nogenetics_2_summary.txt_3	1	3.63235	0
parent-nogenetics_2_summary.txt_4	1	3.50100	0
parent-nogenetics_3_summary.txt_1	1	3.26996	0
parent-nogenetics_3_summary.txt_2	1	3.57551	0
parent-nogenetics_3_summary.txt_3	1	3.54582	0
parent-nogenetics_3_summary.txt_4	1	3.38791	0
parent-nogenetics_4_summary.txt_1	1	3.59465	0
parent-nogenetics_4_summary.txt_2	1	3.49304	0
parent-nogenetics_4_summary.txt_3	1	3.54455	0
parent-nogenetics_4_summary.txt_4	1	3.51297	0
parent-nogenetics_5_summary.txt_1	1	3.44336	0
parent-nogenetics_5_summary.txt_2	1	3.41942	0
parent-nogenetics_5_summary.txt_3	1	3.61443	0
parent-nogenetics_5_summary.txt_4	1	3.57114	0
parent-nogenetics_6_summary.txt_1	1	3.44336	0
parent-nogenetics_6_summary.txt_2	1	3.41942	0
parent-nogenetics_6_summary.txt_3	1	3.61443	0
parent-nogenetics_6_summary.txt_4	1	3.57114	0
parent-nogenetics_7_summary.txt_1	1	3.54491	0
parent-nogenetics_7_summary.txt_2	1	3.53719	0
parent-nogenetics_7_summary.txt_3	1	3.50895	0
parent-nogenetics_7_summary.txt_4	1	3.50100	0
parent-nogenetics_8_summary.txt_1	1	3.52295	0
parent-nogenetics_8_summary.txt_2	1	3.54757	0
parent-nogenetics_8_summary.txt_3	1	3.55221	0
parent-nogenetics_8_summary.txt_4	1	3.48611	0
parent-nogenetics_9_summary.txt_1	1	3.44336	0
parent-nogenetics_9_summary.txt_2	1	3.41942	0
parent-nogenetics_9_summary.txt_3	1	3.61443	0
parent-nogenetics_9_summary.txt_4	1	3.57114	0

Variation was maintained in 40 of the 40. 0 of the 40 populations crashed, though. Of the 40 replicates, 40 reached an equilibrium by 10000 generations.

Courtship and Parental Traits

Females choose nests based on males' courtship trait (they all only nest with courting males, and the female preference does not have a genetic basis and does not evolve), and then the survival of the nest depends on

whether the courting male is also a parental male. If the chosen male is a parental male, the nest has a 90% chance of survival. Otherwise, it only has a 10% chance. Non-courters only reproduce through sneaking.
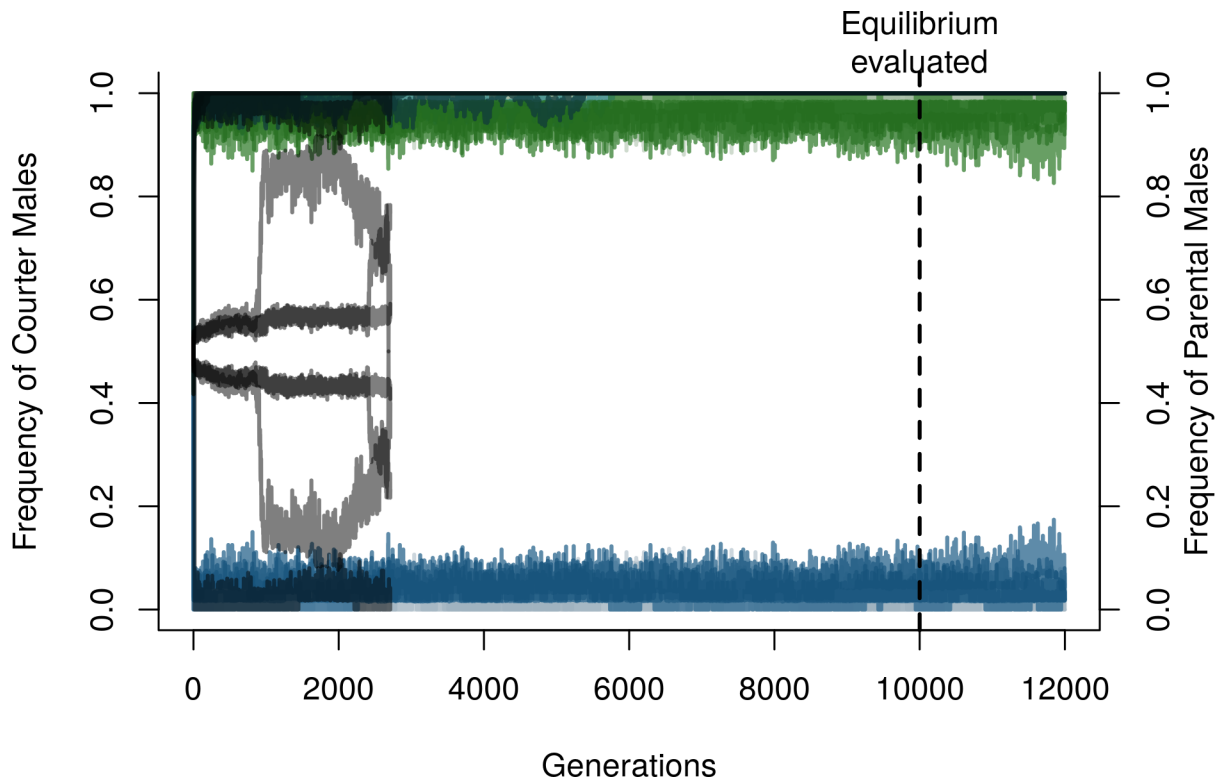
The different runs have different outcomes.
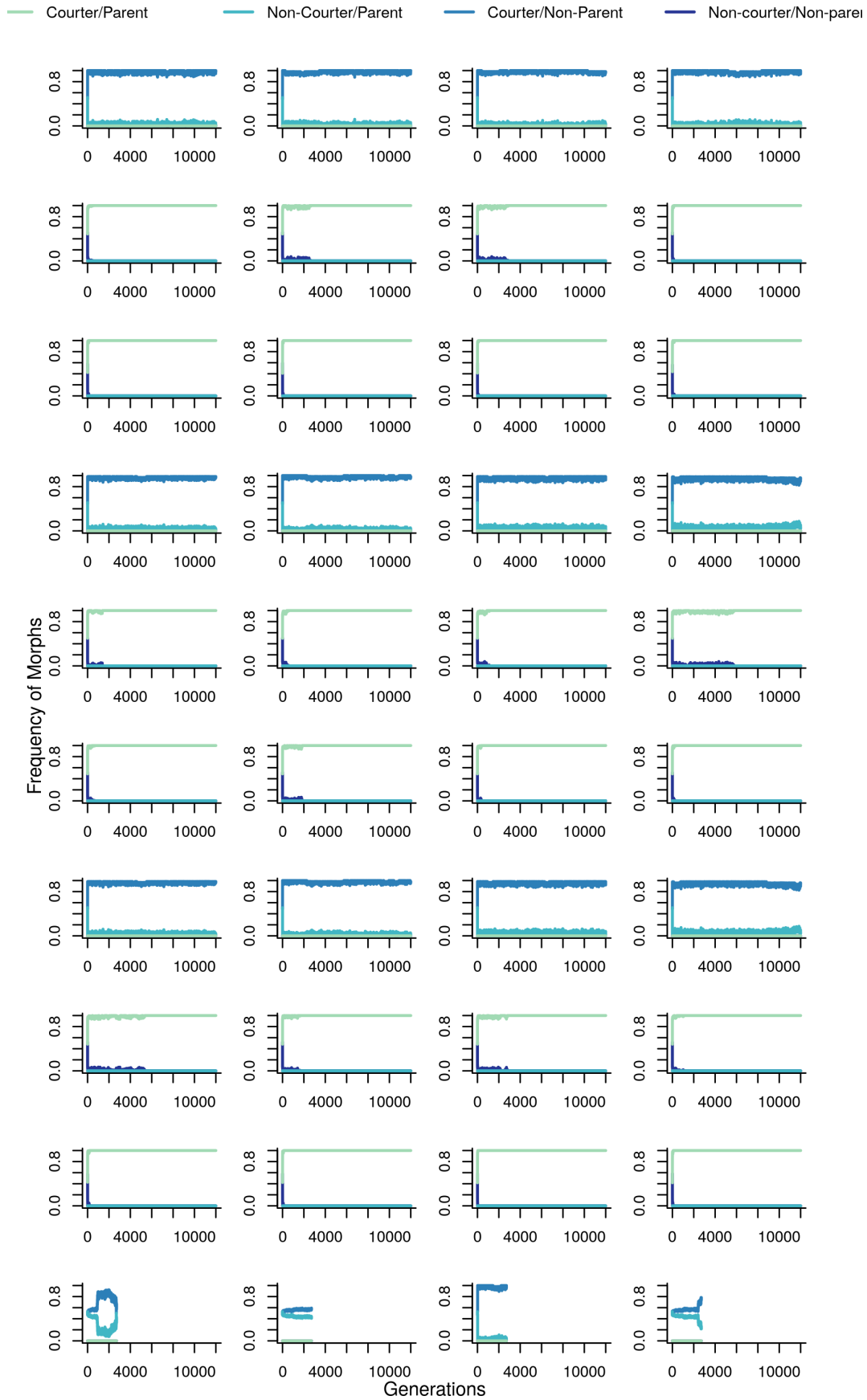
Let's look at the morph frequencies.

Figure 3: Frequency of the 4 morphs in each rep

In some of the runs the population crashed after few generations. This is obvious when looking at the the final frequencies in a table as well:

Table 3: Frequency of morphs in final generation

	Generation	FreqNcNp	FreqCNp	FreqNcP	FreqCP
parent-courter-nogenetics_1_summary.txt_1	11999	0	0.978261	0.0217391	0
parent-courter-nogenetics_1_summary.txt_2	11999	0	1.000000	0.0000000	0
parent-courter-nogenetics_1_summary.txt_3	11999	0	0.979592	0.0204082	0
parent-courter-nogenetics_1_summary.txt_4	11999	0	0.981132	0.0188679	0
parent-courter-nogenetics_10_summary.txt_1	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_10_summary.txt_2	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_10_summary.txt_3	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_10_summary.txt_4	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_2_summary.txt_1	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_2_summary.txt_2	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_2_summary.txt_3	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_2_summary.txt_4	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_3_summary.txt_1	11999	0	0.981481	0.0185185	0
parent-courter-nogenetics_3_summary.txt_2	11999	0	0.966667	0.0333333	0
parent-courter-nogenetics_3_summary.txt_3	11999	0	0.980392	0.0196078	0
parent-courter-nogenetics_3_summary.txt_4	11999	0	0.950000	0.0500000	0
parent-courter-nogenetics_4_summary.txt_1	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_4_summary.txt_2	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_4_summary.txt_3	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_4_summary.txt_4	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_5_summary.txt_1	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_5_summary.txt_2	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_5_summary.txt_3	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_5_summary.txt_4	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_6_summary.txt_1	11999	0	0.981481	0.0185185	0
parent-courter-nogenetics_6_summary.txt_2	11999	0	0.966667	0.0333333	0
parent-courter-nogenetics_6_summary.txt_3	11999	0	0.980392	0.0196078	0
parent-courter-nogenetics_6_summary.txt_4	11999	0	0.950000	0.0500000	0
parent-courter-nogenetics_7_summary.txt_1	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_7_summary.txt_2	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_7_summary.txt_3	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_7_summary.txt_4	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_8_summary.txt_1	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_8_summary.txt_2	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_8_summary.txt_3	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_8_summary.txt_4	11999	0	0.000000	0.0000000	1
parent-courter-nogenetics_9_summary.txt_1	2711	0	0.600000	0.4000000	0
parent-courter-nogenetics_9_summary.txt_2	2711	0	0.592157	0.4078430	0
parent-courter-nogenetics_9_summary.txt_3	2711	0	0.980392	0.0196078	0
parent-courter-nogenetics_9_summary.txt_4	2711	0	0.767857	0.2321430	0

Multiple morphs are maintained in 15 of the 40 replicates, and those morphs contain either a parent or a courter. However, 4 of those reps with variation actually crashed.

Courtship + Heritable Female Preferences

Here, the female preference has unlinked additive genetic variance that is inherited. The traits begin as uncorrelated and are not pleiotropic (i.e., they have different genes underlying them). A threshold is set in the first generation that determines the switch point for when females prefer courters or non-courters. This threshold does not change over the generations. All males can be sneakers, but the male who females choose to nest with get a first male advantage.
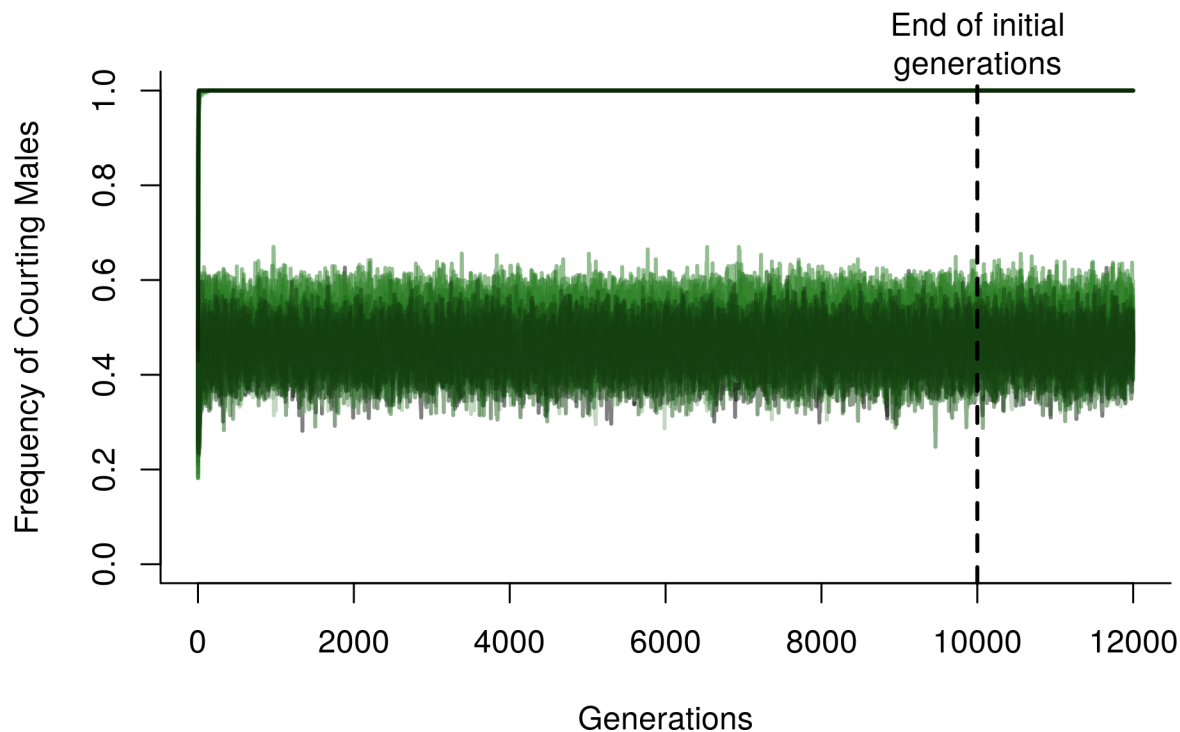

Figure 4: Courter frequencies

Table 4: Courter Frequncies with heritable female preferences

	Generation	CourterFreq	CourterW	NonCourterW
courter-pref-nogenetics__1__summary.txt__1	11999	1.000000	3.14172	0.00000
courter-pref-nogenetics__1__summary.txt__2	11999	1.000000	3.13828	0.00000
courter-pref-nogenetics__1__summary.txt__3	11999	1.000000	3.03529	0.00000
courter-pref-nogenetics__1__summary.txt__4	11999	1.000000	3.04554	0.00000
courter-pref-nogenetics__10__summary.txt__1	11999	0.533730	2.88104	3.09362
courter-pref-nogenetics__10__summary.txt__2	11999	0.464066	3.43363	3.18008
courter-pref-nogenetics__10__summary.txt__3	11999	0.510246	3.30924	3.26778
courter-pref-nogenetics__10__summary.txt__4	11999	0.491968	3.04898	3.09486
courter-pref-nogenetics__2__summary.txt__1	11999	0.439673	3.30233	3.15693
courter-pref-nogenetics__2__summary.txt__2	11999	0.541152	3.25475	3.24664
courter-pref-nogenetics__2__summary.txt__3	11999	0.460159	3.03896	2.99262
courter-pref-nogenetics__2__summary.txt__4	11999	0.482897	3.10833	3.17510
courter-pref-nogenetics__3__summary.txt__1	11999	1.000000	3.01179	0.00000
courter-pref-nogenetics__3__summary.txt__2	11999	1.000000	3.15895	0.00000
courter-pref-nogenetics__3__summary.txt__3	11999	1.000000	3.79642	0.00000
courter-pref-nogenetics__3__summary.txt__4	11999	1.000000	3.27105	0.00000

	Generation	CourterFreq	CourterW	NonCourterW
courter-pref-nogenetics_4_summary.txt_1	11999	1.000000	3.09163	0.00000
courter-pref-nogenetics_4_summary.txt_2	11999	1.000000	3.02778	0.00000
courter-pref-nogenetics_4_summary.txt_3	11999	1.000000	3.50858	0.00000
courter-pref-nogenetics_4_summary.txt_4	11999	1.000000	3.45474	0.00000
courter-pref-nogenetics_5_summary.txt_1	11999	1.000000	2.96471	0.00000
courter-pref-nogenetics_5_summary.txt_2	11999	1.000000	3.30913	0.00000
courter-pref-nogenetics_5_summary.txt_3	11999	1.000000	3.04941	0.00000
courter-pref-nogenetics_5_summary.txt_4	11999	1.000000	3.49682	0.00000
courter-pref-nogenetics_6_summary.txt_1	11999	0.596869	2.76721	2.96602
courter-pref-nogenetics_6_summary.txt_2	11999	0.458418	3.32301	3.07865
courter-pref-nogenetics_6_summary.txt_3	11999	0.563492	2.97183	2.94091
courter-pref-nogenetics_6_summary.txt_4	11999	0.533199	3.10566	3.18103
courter-pref-nogenetics_7_summary.txt_1	11999	0.435897	3.72549	3.35227
courter-pref-nogenetics_7_summary.txt_2	11999	0.490982	3.01633	3.08268
courter-pref-nogenetics_7_summary.txt_3	11999	0.420833	3.48020	3.19065
courter-pref-nogenetics_7_summary.txt_4	11999	0.492278	2.74902	3.02281
courter-pref-nogenetics_8_summary.txt_1	11999	0.503043	3.18952	3.07347
courter-pref-nogenetics_8_summary.txt_2	11999	0.479920	3.03766	3.17761
courter-pref-nogenetics_8_summary.txt_3	11999	0.438632	3.13761	3.10394
courter-pref-nogenetics_8_summary.txt_4	11999	0.490000	2.95102	3.13333
courter-pref-nogenetics_9_summary.txt_1	11999	1.000000	3.13972	0.00000
courter-pref-nogenetics_9_summary.txt_2	11999	1.000000	3.28542	0.00000
courter-pref-nogenetics_9_summary.txt_3	11999	1.000000	2.81190	0.00000
courter-pref-nogenetics_9_summary.txt_4	11999	1.000000	3.00588	0.00000

Evolving female preferences allow variation to be maintained in 20 of 40 replicates.
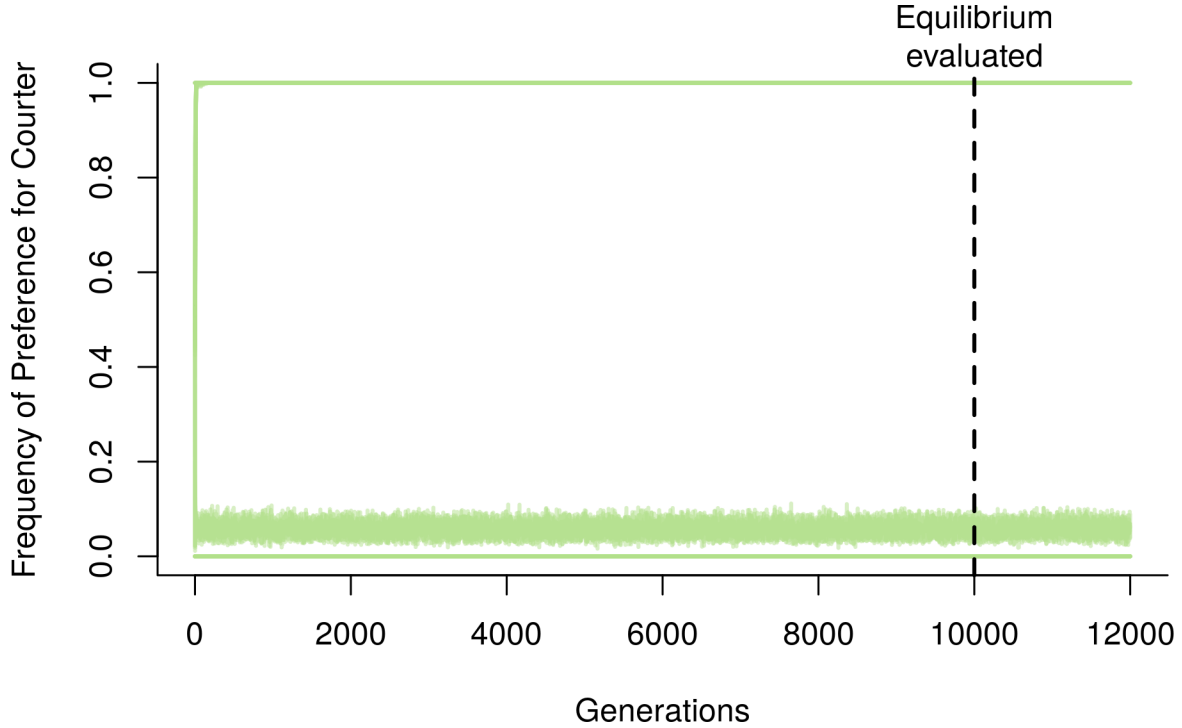

Figure 5: Frequencies of preferences for courters when parenting traits do not exist

Table 5: Frequncies of Preference for Courters

	Generation	PrefFreq	PrefThresh
courter-pref-nogenetics_1_summary.txt_1	11999	1.0000000	0.3584120
courter-pref-nogenetics_1_summary.txt_2	11999	1.0000000	0.3584120
courter-pref-nogenetics_1_summary.txt_3	11999	1.0000000	0.3584120
courter-pref-nogenetics_1_summary.txt_4	11999	1.0000000	0.3584120
courter-pref-nogenetics_10_summary.txt_1	11999	0.0000000	1.1455600
courter-pref-nogenetics_10_summary.txt_2	11999	0.0000000	1.1455600
courter-pref-nogenetics_10_summary.txt_3	11999	0.0000000	1.1455600
courter-pref-nogenetics_10_summary.txt_4	11999	0.0000000	1.1455600
courter-pref-nogenetics_2_summary.txt_1	11999	0.0000000	0.8400610
courter-pref-nogenetics_2_summary.txt_2	11999	0.0000000	0.8400610
courter-pref-nogenetics_2_summary.txt_3	11999	0.0000000	0.8400610
courter-pref-nogenetics_2_summary.txt_4	11999	0.0000000	0.8400610
courter-pref-nogenetics_3_summary.txt_1	11999	1.0000000	0.3851020
courter-pref-nogenetics_3_summary.txt_2	11999	1.0000000	0.3851020
courter-pref-nogenetics_3_summary.txt_3	11999	1.0000000	0.3851020
courter-pref-nogenetics_3_summary.txt_4	11999	1.0000000	0.3851020
courter-pref-nogenetics_4_summary.txt_1	11999	1.0000000	0.0386416
courter-pref-nogenetics_4_summary.txt_2	11999	1.0000000	0.0386416
courter-pref-nogenetics_4_summary.txt_3	11999	1.0000000	0.0386416
courter-pref-nogenetics_4_summary.txt_4	11999	1.0000000	0.0386416
courter-pref-nogenetics_5_summary.txt_1	11999	1.0000000	0.1233820
courter-pref-nogenetics_5_summary.txt_2	11999	1.0000000	0.1233820
courter-pref-nogenetics_5_summary.txt_3	11999	1.0000000	0.1233820
courter-pref-nogenetics_5_summary.txt_4	11999	1.0000000	0.1233820
courter-pref-nogenetics_6_summary.txt_1	11999	0.0633947	-0.0727359
courter-pref-nogenetics_6_summary.txt_2	11999	0.0887574	-0.0727359
courter-pref-nogenetics_6_summary.txt_3	11999	0.0685484	-0.0727359
courter-pref-nogenetics_6_summary.txt_4	11999	0.0397614	-0.0727359
courter-pref-nogenetics_7_summary.txt_1	11999	0.0000000	0.0247749
courter-pref-nogenetics_7_summary.txt_2	11999	0.0000000	0.0247749
courter-pref-nogenetics_7_summary.txt_3	11999	0.0000000	0.0247749
courter-pref-nogenetics_7_summary.txt_4	11999	0.0000000	0.0247749
courter-pref-nogenetics_8_summary.txt_1	11999	0.0000000	0.4192100
courter-pref-nogenetics_8_summary.txt_2	11999	0.0000000	0.4192100
courter-pref-nogenetics_8_summary.txt_3	11999	0.0000000	0.4192100
courter-pref-nogenetics_8_summary.txt_4	11999	0.0000000	0.4192100
courter-pref-nogenetics_9_summary.txt_1	11999	1.0000000	0.3851020
courter-pref-nogenetics_9_summary.txt_2	11999	1.0000000	0.3851020
courter-pref-nogenetics_9_summary.txt_3	11999	1.0000000	0.3851020
courter-pref-nogenetics_9_summary.txt_4	11999	1.0000000	0.3851020

Of the 40 populations that survived, 20 were fixed for a preference for courters and 16 were fixed for a preference against courters. 4 maintained variation in female preferences.

Parenting + Heritable Female Preferences

Here, the female preference has unlinked additive genetic variance that is inherited. The traits begin as uncorrelated and are not pleiotropic (i.e., they have different genes underlying them). A threshold is set in the first generation that determines the switch point for when females prefer parents or non-parents. This

threshold does not change over the generations. Only non-parental males can be sneakers, and when females choose to mate with non-parents, the nest has a 10% survival rate.
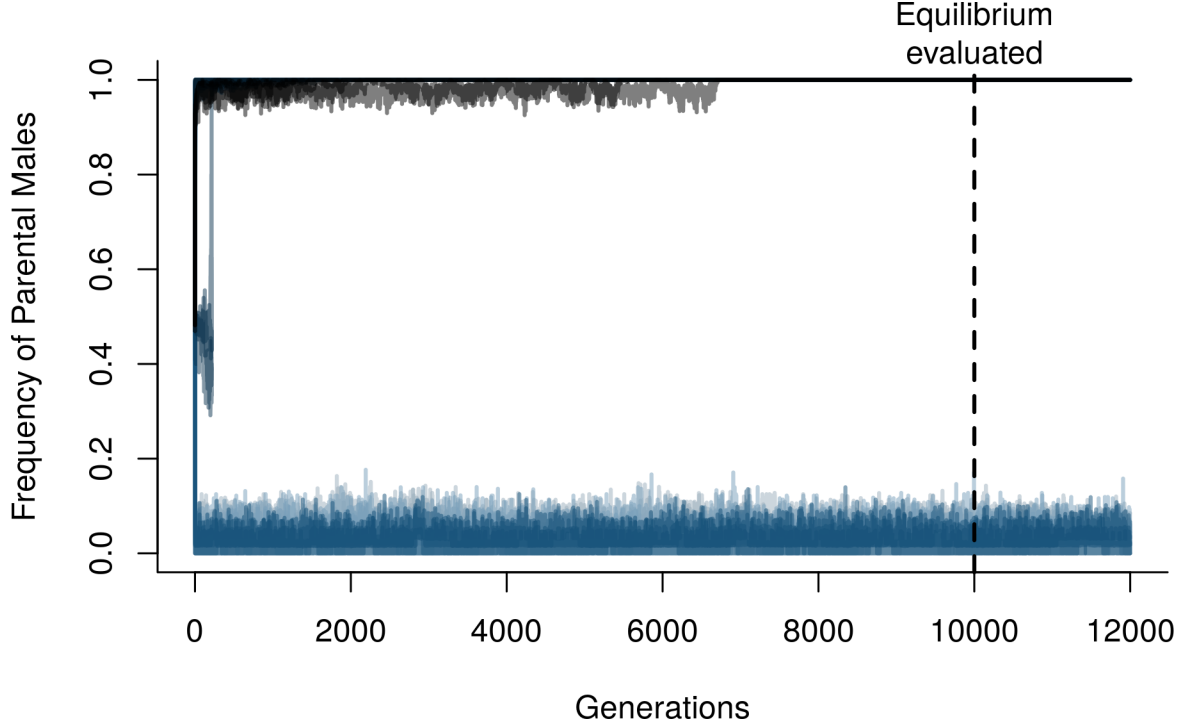

Figure 6: Parent frequencies

Table 6: Parent Frequncies with heritable female preferences

	Generation	ParentFreq	ParentW	NonParentW
parent-pref-nogenetics_1_summary.txt_1	11999	0.0847458	0.00000	0.2037040
parent-pref-nogenetics_1_summary.txt_2	11999	0.0208333	0.00000	0.2978720
parent-pref-nogenetics_1_summary.txt_3	11999	0.0612245	0.00000	0.3478260
parent-pref-nogenetics_1_summary.txt_4	11999	0.0217391	0.00000	0.3555560
parent-pref-nogenetics_10_summary.txt_1	11999	1.0000000	3.42710	0.0000000
parent-pref-nogenetics_10_summary.txt_2	11999	1.0000000	3.17426	0.0000000
parent-pref-nogenetics_10_summary.txt_3	11999	1.0000000	3.18235	0.0000000
parent-pref-nogenetics_10_summary.txt_4	11999	1.0000000	3.27888	0.0000000
parent-pref-nogenetics_2_summary.txt_1	11999	0.0338983	0.00000	0.1578950
parent-pref-nogenetics_2_summary.txt_2	11999	0.0434783	0.00000	0.3409090
parent-pref-nogenetics_2_summary.txt_3	11999	0.0454545	0.00000	0.2857140
parent-pref-nogenetics_2_summary.txt_4	11999	0.0000000	0.00000	0.2888890
parent-pref-nogenetics_3_summary.txt_1	11999	1.0000000	3.26761	0.0000000
parent-pref-nogenetics_3_summary.txt_2	11999	1.0000000	3.43763	0.0000000
parent-pref-nogenetics_3_summary.txt_3	11999	1.0000000	3.17349	0.0000000
parent-pref-nogenetics_3_summary.txt_4	11999	1.0000000	3.43149	0.0000000
parent-pref-nogenetics_4_summary.txt_1	11999	1.0000000	3.11845	0.0000000
parent-pref-nogenetics_4_summary.txt_2	11999	1.0000000	3.55042	0.0000000
parent-pref-nogenetics_4_summary.txt_3	11999	1.0000000	3.58562	0.0000000
parent-pref-nogenetics_4_summary.txt_4	11999	1.0000000	3.08108	0.0000000
parent-pref-nogenetics_5_summary.txt_1	11999	1.0000000	3.10385	0.0000000

	Generation	ParentFreq	ParentW	NonParentW
parent-pref-nogenetics_5_summary.txt_2	11999	1.0000000	3.32114	0.0000000
parent-pref-nogenetics_5_summary.txt_3	11999	1.0000000	3.38809	0.0000000
parent-pref-nogenetics_5_summary.txt_4	11999	1.0000000	3.48133	0.0000000
parent-pref-nogenetics_6_summary.txt_1	11999	0.0000000	0.00000	0.4418600
parent-pref-nogenetics_6_summary.txt_2	11999	0.0322581	0.00000	0.2666670
parent-pref-nogenetics_6_summary.txt_3	11999	0.0227273	0.00000	0.3720930
parent-pref-nogenetics_6_summary.txt_4	11999	0.0178571	0.00000	0.4363640
parent-pref-nogenetics_7_summary.txt_1	217	0.4285710	0.00000	0.0000000
parent-pref-nogenetics_7_summary.txt_2	217	0.4307690	0.00000	0.4594590
parent-pref-nogenetics_7_summary.txt_3	217	0.3333330	0.00000	0.0714286
parent-pref-nogenetics_7_summary.txt_4	217	0.3870970	0.00000	0.2105260
parent-pref-nogenetics_8_summary.txt_1	11999	1.0000000	3.10588	0.0000000
parent-pref-nogenetics_8_summary.txt_2	11999	1.0000000	3.27000	0.0000000
parent-pref-nogenetics_8_summary.txt_3	11999	1.0000000	3.26148	0.0000000
parent-pref-nogenetics_8_summary.txt_4	11999	1.0000000	3.43532	0.0000000
parent-pref-nogenetics_9_summary.txt_1	11999	1.0000000	3.57474	0.0000000
parent-pref-nogenetics_9_summary.txt_2	11999	1.0000000	3.26441	0.0000000
parent-pref-nogenetics_9_summary.txt_3	11999	1.0000000	3.32460	0.0000000
parent-pref-nogenetics_9_summary.txt_4	11999	1.0000000	3.56632	0.0000000

Evolving female preferences maintain variation, although parental traits can lead to population crashes (in 4 of the 40 reps). In suriving populations, variation was maintained in 16 of 40 replicates.
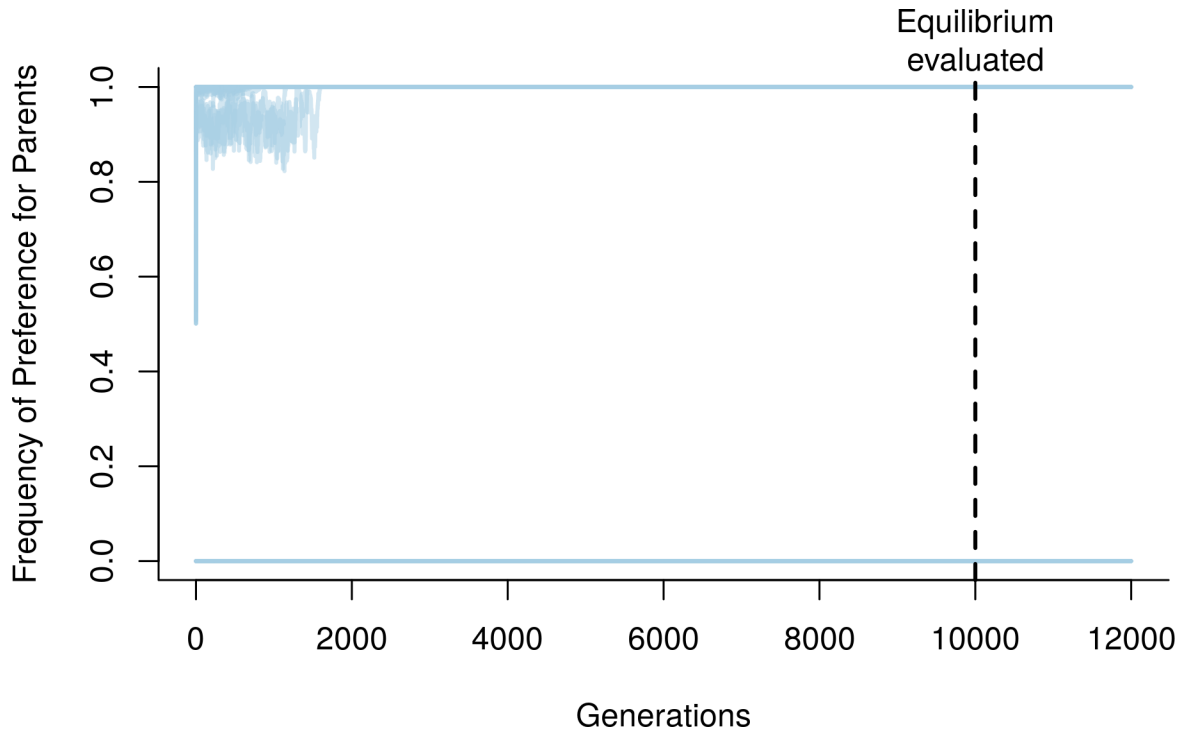

Figure 7: Frequencies of Preferences for Parents when no courtship traits exist

Table 7: Frequncies of Preference for Parents

	Generation	PrefFreq	PrefThresh
parent-pref-nogenetics_1_summary.txt_1	11999	0	1.1096700
parent-pref-nogenetics_1_summary.txt_2	11999	0	1.1096700
parent-pref-nogenetics_1_summary.txt_3	11999	0	1.1096700
parent-pref-nogenetics_1_summary.txt_4	11999	0	1.1096700
parent-pref-nogenetics_10_summary.txt_1	11999	1	-1.1258500
parent-pref-nogenetics_10_summary.txt_2	11999	1	-1.1258500
parent-pref-nogenetics_10_summary.txt_3	11999	1	-1.1258500
parent-pref-nogenetics_10_summary.txt_4	11999	1	-1.1258500
parent-pref-nogenetics_2_summary.txt_1	11999	0	0.6222860
parent-pref-nogenetics_2_summary.txt_2	11999	0	0.6222860
parent-pref-nogenetics_2_summary.txt_3	11999	0	0.6222860
parent-pref-nogenetics_2_summary.txt_4	11999	0	0.6222860
parent-pref-nogenetics_3_summary.txt_1	11999	1	0.4368050
parent-pref-nogenetics_3_summary.txt_2	11999	1	0.4368050
parent-pref-nogenetics_3_summary.txt_3	11999	1	0.4368050
parent-pref-nogenetics_3_summary.txt_4	11999	1	0.4368050
parent-pref-nogenetics_4_summary.txt_1	11999	1	-0.3575630
parent-pref-nogenetics_4_summary.txt_2	11999	1	-0.3575630
parent-pref-nogenetics_4_summary.txt_3	11999	1	-0.3575630
parent-pref-nogenetics_4_summary.txt_4	11999	1	-0.3575630
parent-pref-nogenetics_5_summary.txt_1	11999	1	-0.0435838
parent-pref-nogenetics_5_summary.txt_2	11999	1	-0.0435838
parent-pref-nogenetics_5_summary.txt_3	11999	1	-0.0435838
parent-pref-nogenetics_5_summary.txt_4	11999	1	-0.0435838
parent-pref-nogenetics_6_summary.txt_1	11999	0	0.6740810
parent-pref-nogenetics_6_summary.txt_2	11999	0	0.6740810
parent-pref-nogenetics_6_summary.txt_3	11999	0	0.6740810
parent-pref-nogenetics_6_summary.txt_4	11999	0	0.6740810
parent-pref-nogenetics_7_summary.txt_1	217	0	0.7532660
parent-pref-nogenetics_7_summary.txt_2	217	0	0.7532660
parent-pref-nogenetics_7_summary.txt_3	217	0	0.7532660
parent-pref-nogenetics_7_summary.txt_4	217	0	0.7532660
parent-pref-nogenetics_8_summary.txt_1	11999	1	0.8069470
parent-pref-nogenetics_8_summary.txt_2	11999	1	0.8069470
parent-pref-nogenetics_8_summary.txt_3	11999	1	0.8069470
parent-pref-nogenetics_8_summary.txt_4	11999	1	0.8069470
parent-pref-nogenetics_9_summary.txt_1	11999	1	-0.5381030
parent-pref-nogenetics_9_summary.txt_2	11999	1	-0.5381030
parent-pref-nogenetics_9_summary.txt_3	11999	1	-0.5381030
parent-pref-nogenetics_9_summary.txt_4	11999	1	-0.5381030

Of the 36 populations that survived, 24 were fixed for a preference for parents and 12 were fixed for a preference against parents. 0 maintained variation in female preferences.

Courthip and Parenting + Heritable Female Preferences

Here, the female preference has unlinked additive genetic variance that is inherited. The traits begin as uncorrelated and are not pleiotropic (i.e., they have different genes underlying them). A threshold is set in the first generation that determines the switch point for when females prefer courters or non-courters. This

threshold does not change over the generations. Only non-parental males are sneakers, and when females choose to mate with non-parents, the nest has a 10% survival rate.
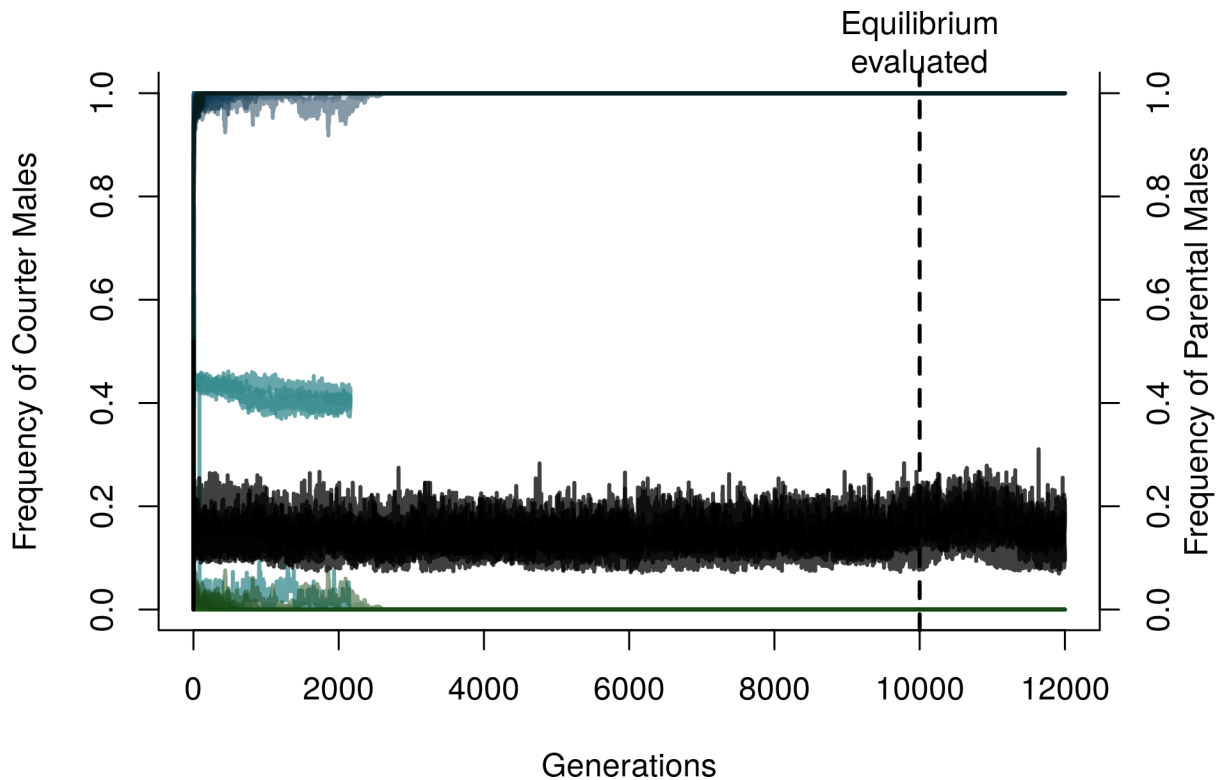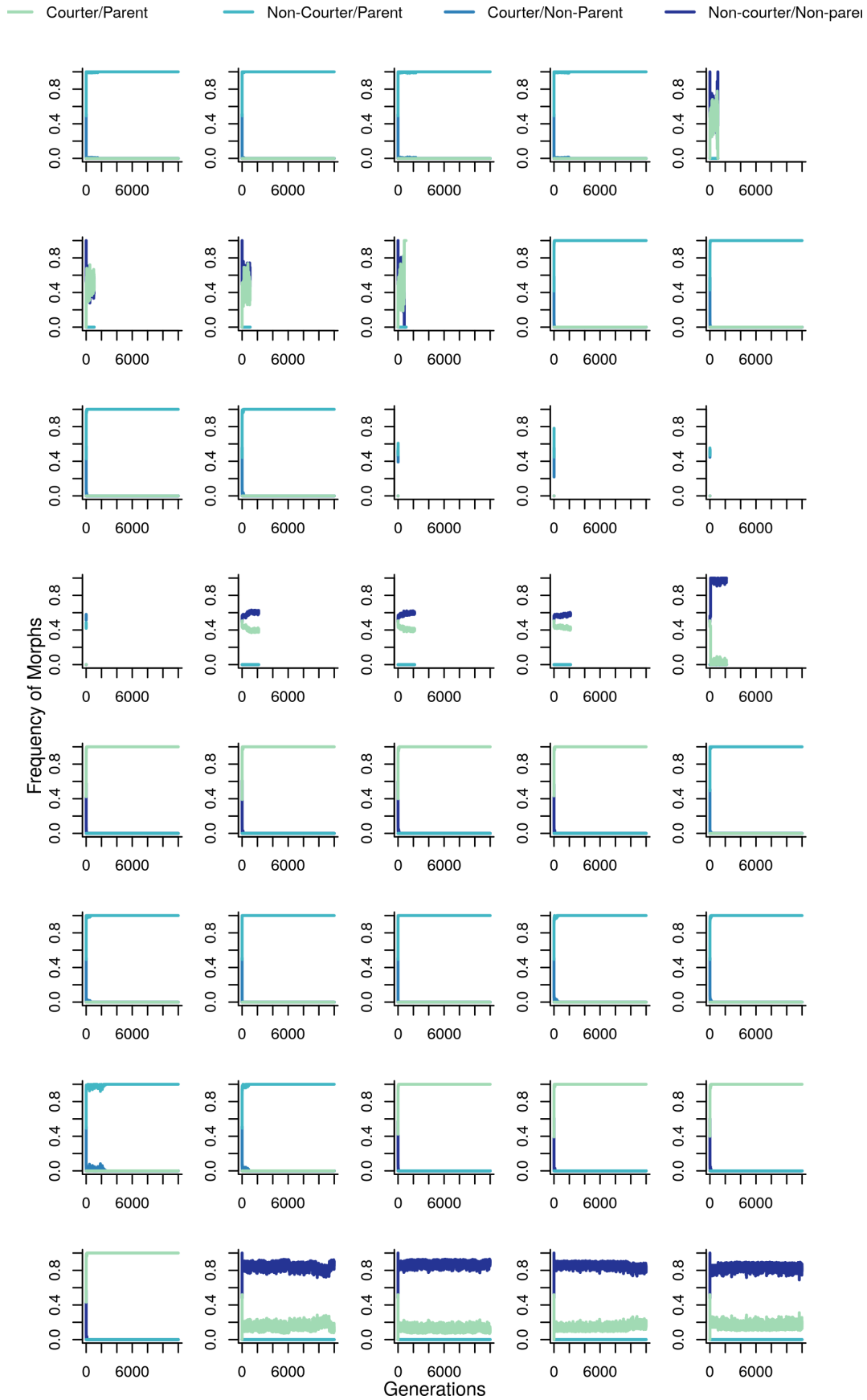
Figure 8: Frequency of four morphs per rep

Table 8: Morph Frequencies with heritable preferences

	Generation	FreqNcNp	FreqCNp	FreqNcP	FreqCP
parent-courter-pref-nogenetics_1_summary.txt_1	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_1_summary.txt_2	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_1_summary.txt_3	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_1_summary.txt_4	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_10_summary.txt_1	1039	1.000000	0.000000	0.000000	0.0000000
parent-courter-pref-nogenetics_10_summary.txt_2	1039	0.446429	0.000000	0.000000	0.5535710
parent-courter-pref-nogenetics_10_summary.txt_3	1039	0.584615	0.000000	0.000000	0.4153850
parent-courter-pref-nogenetics_10_summary.txt_4	1039	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_2_summary.txt_1	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_2_summary.txt_2	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_2_summary.txt_3	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_2_summary.txt_4	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_3_summary.txt_1	14	0.000000	0.391304	0.608696	0.0000000
parent-courter-pref-nogenetics_3_summary.txt_2	13	0.000000	0.294118	0.705882	0.0000000
parent-courter-pref-nogenetics_3_summary.txt_3	13	0.000000	0.489362	0.510638	0.0000000
parent-courter-pref-nogenetics_3_summary.txt_4	13	0.000000	0.561404	0.438596	0.0000000
parent-courter-pref-nogenetics_4_summary.txt_1	2161	0.606383	0.000000	0.000000	0.3936170
parent-courter-pref-nogenetics_4_summary.txt_2	2161	0.600000	0.000000	0.000000	0.4000000
parent-courter-pref-nogenetics_4_summary.txt_3	2161	0.572519	0.000000	0.000000	0.4274810
parent-courter-pref-nogenetics_4_summary.txt_4	2160	1.000000	0.000000	0.000000	0.0000000
parent-courter-pref-nogenetics_5_summary.txt_1	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_5_summary.txt_2	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_5_summary.txt_3	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_5_summary.txt_4	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_6_summary.txt_1	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_6_summary.txt_2	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_6_summary.txt_3	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_6_summary.txt_4	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_7_summary.txt_1	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_7_summary.txt_2	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_7_summary.txt_3	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_7_summary.txt_4	11999	0.000000	0.000000	1.000000	0.0000000
parent-courter-pref-nogenetics_8_summary.txt_1	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_8_summary.txt_2	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_8_summary.txt_3	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_8_summary.txt_4	11999	0.000000	0.000000	0.000000	1.0000000
parent-courter-pref-nogenetics_9_summary.txt_1	11999	0.904762	0.000000	0.000000	0.0952381
parent-courter-pref-nogenetics_9_summary.txt_2	11999	0.895349	0.000000	0.000000	0.1046510
parent-courter-pref-nogenetics_9_summary.txt_3	11999	0.840000	0.000000	0.000000	0.1600000
parent-courter-pref-nogenetics_9_summary.txt_4	11999	0.811321	0.000000	0.000000	0.1886790

Again, evolving preferences maintain variation in 13 of the 40. 12 of the 40 populations crashed, though.
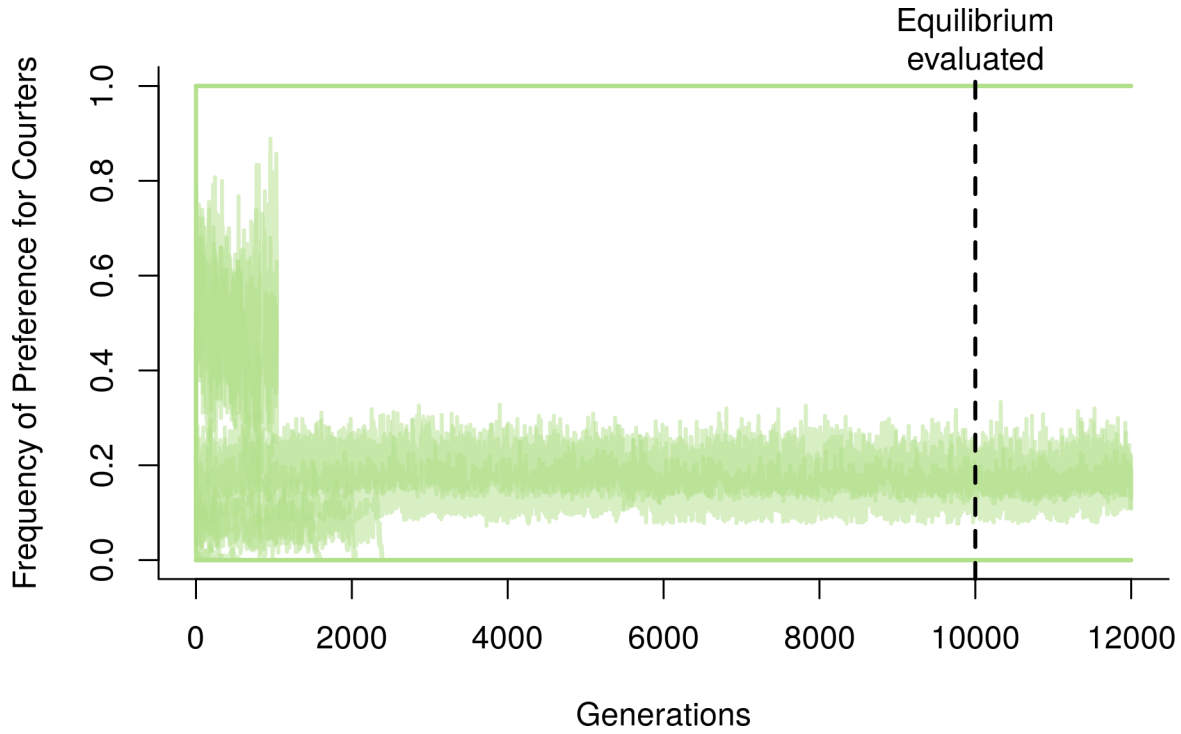
Figure 9: Frequency of Preference of Courters with both parents and courters in the population

Table 9: Frequncies of Preference for Courters

	Generation	PrefFreq	PrefThresh
parent-courter-pref-nogenetics_1_summary.txt_1	11999	0.000000	-0.192267
parent-courter-pref-nogenetics_1_summary.txt_2	11999	0.000000	-0.192267
parent-courter-pref-nogenetics_1_summary.txt_3	11999	0.000000	-0.192267
parent-courter-pref-nogenetics_1_summary.txt_4	11999	0.000000	-0.192267
parent-courter-pref-nogenetics_10_summary.txt_1	1039	0.250000	0.510057
parent-courter-pref-nogenetics_10_summary.txt_2	1039	0.434783	0.510057
parent-courter-pref-nogenetics_10_summary.txt_3	1039	0.562500	0.510057
parent-courter-pref-nogenetics_10_summary.txt_4	1039	0.000000	0.510057
parent-courter-pref-nogenetics_2_summary.txt_1	11999	0.000000	0.776179
parent-courter-pref-nogenetics_2_summary.txt_2	11999	0.000000	0.776179
parent-courter-pref-nogenetics_2_summary.txt_3	11999	0.000000	0.776179
parent-courter-pref-nogenetics_2_summary.txt_4	11999	0.000000	0.776179
parent-courter-pref-nogenetics_3_summary.txt_1	14	1.000000	-0.351398
parent-courter-pref-nogenetics_3_summary.txt_2	13	1.000000	-0.351398
parent-courter-pref-nogenetics_3_summary.txt_3	13	1.000000	-0.351398
parent-courter-pref-nogenetics_3_summary.txt_4	13	1.000000	-0.351398
parent-courter-pref-nogenetics_4_summary.txt_1	2161	0.000000	0.157242
parent-courter-pref-nogenetics_4_summary.txt_2	2161	0.000000	0.157242
parent-courter-pref-nogenetics_4_summary.txt_3	2161	0.000000	0.157242
parent-courter-pref-nogenetics_4_summary.txt_4	2160	0.000000	0.157242
parent-courter-pref-nogenetics_5_summary.txt_1	11999	1.000000	-0.408489
parent-courter-pref-nogenetics_5_summary.txt_2	11999	1.000000	-0.408489
parent-courter-pref-nogenetics_5_summary.txt_3	11999	1.000000	-0.408489
parent-courter-pref-nogenetics_5_summary.txt_4	11999	1.000000	-0.408489

	Generation	PrefFreq	PrefThresh
parent-courter-pref-nogenetics_6_summary.txt_1	11999	0.000000	-0.156515
parent-courter-pref-nogenetics_6_summary.txt_2	11999	0.000000	-0.156515
parent-courter-pref-nogenetics_6_summary.txt_3	11999	0.000000	-0.156515
parent-courter-pref-nogenetics_6_summary.txt_4	11999	0.000000	-0.156515
parent-courter-pref-nogenetics_7_summary.txt_1	11999	0.000000	0.461824
parent-courter-pref-nogenetics_7_summary.txt_2	11999	0.000000	0.461824
parent-courter-pref-nogenetics_7_summary.txt_3	11999	0.000000	0.461824
parent-courter-pref-nogenetics_7_summary.txt_4	11999	0.000000	0.461824
parent-courter-pref-nogenetics_8_summary.txt_1	11999	1.000000	-0.408489
parent-courter-pref-nogenetics_8_summary.txt_2	11999	1.000000	-0.408489
parent-courter-pref-nogenetics_8_summary.txt_3	11999	1.000000	-0.408489
parent-courter-pref-nogenetics_8_summary.txt_4	11999	1.000000	-0.408489
parent-courter-pref-nogenetics_9_summary.txt_1	11999	0.189655	0.215129
parent-courter-pref-nogenetics_9_summary.txt_2	11999	0.175439	0.215129
parent-courter-pref-nogenetics_9_summary.txt_3	11999	0.145833	0.215129
parent-courter-pref-nogenetics_9_summary.txt_4	11999	0.216667	0.215129

Of the 28 populations that survived, 8 were fixed for a preference for courters and 16 were fixed for a preference against courters. 4 maintained variation in female preferences.