Philosophy 3334: Philosophy of Biology
Fall 2023
Homework 2

Answers should be uploaded into Blackboard before 11:59pm on Monday, Oct 9th.

1) Lets say that "siblings" refers to just any young animals raised together when they are still somewhat dependent on at least one adult to keep them alive. Some social behaviors between siblings we can call "sibling rivalry" where they one sibling harms another (sometimes even killing each other) and other behaviors are cooperative. Animal species exhibit a huge variety of types of family structures. Here are some possibilities: In species A children are born one at a time and raised by their mother. The species is like humans – many siblings have the same father but not all. Species B is like A except it is strictly monogamous. All siblings have the same father. Species C is like A except they aren't born one at a time but rather in litters like dogs. Remember that puppies in the same litter sometimes have the same father but do not always. It is the same way in species C. Species D is like A except they are raised in groups by multiple mothers who collectively take care of all of the groups' children. Which, if any, of these changes do you expect would increase sibling rivalry? Which would increase cooperation? Explain why. (So compare A to B, A to C, and A to D. Then if you can say anything about comparing B, C, and D do that too).

Answer:
Siblings in species B will cooperate more than A since they are more closely related to each other. Species A will cooperate more than C since in C, they have to compete for exactly the same resources. So in terms of cooperation, B > A > C. As for D, the 'siblings' here are not necessarily related at all and so for that reason, will cooperate less than A.

2) Across the animal kingdom (ignoring the social insects) do males or females tend to have more children on average? Why? Do males or females tend to have a higher variance in the number of offspring they have? (A higher variance means a wider "spread" so that they are more likely to have more or less than the average). Why?

Answer: Each offspring has one male parent and one female parent. Thus the number of children males have on average is #o/#m where #o is the total number of offspring and #m is the number of males in the population while #o/#f is the average number of offspring per female. Since the sex ratio is very close to 50:50 in almost all populations, the number of children on average is the same (if the sex ratio is not 50:50, then the minority sex will have more children on average).

While the mean is the same, males will typically have a higher variance in the number of offspring. Males are, by definition, the sex that has the smaller gametes. Thus they invest less per gamete than females do. Females are thus more limited in the number of eggs they can produce and since they stand to lose more from a failed offspring, they are often the sex that has more parental investment in offspring. If one sex has a much higher parental investment (on average) than the other, it limits the number of offspring that each individual of that sex can have. On the other hand, males can have a basically unlimited number of offspring. In humans for example, given pregnancy, there is an upper limit to the number of offspring that any one woman can have and basically no limit to the number of offspring that a man can have. This allows for high-risk high-reward strategies on the part of males who can have high numbers of offspring without much parental investment. As long as some males do this and woman can't do it, then there will automatically be a higher variance in the number of offspring of males vs. females.

3) Imagine a species of bird that gets parasites on its head that the individual with the parasite can't remove, but that other birds could remove. We will assume that each interaction follows the following payoff matrix.

	Groomer	Non-Groomer
Groomer	8,8	1,9
Non-Groomer	9,1	2,2

3 cont) Assume that players in the population meet at random and play this game one time. Which strategies are ESSs in this game? (the answer could be either one of them, both, or neither). Explain why.

Answer: Grooming (the altruistic strategy) is not stable. Imagine that everyone was a groomer. Then everyone would be getting 8. Now a mutant non-groomer coming in would get 9. This is more, so non-grooming would invade so grooming is not stable. On the other hand, not grooming IS stable. If everyone was playing 'non-groomer', everyone would be getting 2. A mutant groomer who came in would get 1. This is less than everyone else, so grooming can't invade so not grooming is stable.

Introductory text:
If you think about Dawkins' definition of altruism in terms of outcomes (ignoring motivations) you will see that "Groomer" counts as an altruistic strategy. So it would seem that it is impossible for grooming to evolve in a natural game like this. But it is possible in at least two different scenarios.

4) If the pairing of players is not random, then it is possible for grooming to evolve by kin selection. What would the average r (relatedness coefficient) between partners have to be in order for grooming to evolve by natural selection? Explain your answer. HINT: You can do this by calculating the inclusive fitness of each of the strategies (the payoff to you plus the payoff to your partner weighted by how closely related they are to you) or by using Hamilton's rule (the benefit is how much better off the recipient of the altruism is than they would otherwise be and the cost is how much worse off the altruistic actor is than they would otherwise be).

Answer:

For the sake of argument, assume your partner plays groomer. Then your inclusive fitness for playing groomer is 8 +8r while the inclusive fitness of non-groomer is 9+1r. 8+8r > 9+1r when 7r > 1 which is when r>1/7. [[Note the exact same thing happens if your partner plays non-groomer. IN(G) > IN(NG) when 1+9r > 2+2r which is true when r>1/7]].

Alternate answer: Hamilton's rule says that the altruistic strategy (grooming in this case) will evolve if r x b > c. In this case, the cost (how much worse off you are if you groom) is 1 (for example, if playing against a groomer, groomers get 8, NGs get 9 = 1 better). The benefit to the recipient of grooming is 7 (for example, if you are a groomer and you play a groomer you get 8 whereas if you play an NG you get 1. So recipients are better off by 8-1 = 7. So r x b > c when r x 7 > 1 which happens when r > 1/7.

5) Assume that the pairing stays random but that they play the game three times against the same partner before reproducing. Now there are numerous possible strategies including "conditional" strategies in the game. We will consider four of them: "Groomer" means you groom your partner on every round no matter what. "Non-Groomer" means you never groom your partner. "tit-for-tat" means you groom on the first round and then on every subsequent round do what your partner did on the previous round. "Odd" means you groom on the first and third rounds (the odd numbered rounds) and do not groom on the second round. Fill in the following 4x4 table that shows the payoffs for each of the sixteen possible pairings in this game. HINT: The total payoff is the sum of the payoffs on each of the three rounds of the game.

	Groomer	Non-Groomer	Tit for Tat	odd
Groomer	24,24	3,27	24,24	17,25
Non-Groomer	27,3	6,6	13,5	20,4
Tit for Tat	24,24	5,13	24,24	18,18
odd	25,17	4,20	18,18	18,18