Survival of the luckiest

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Opposite dynamics are behind natural selection and sexual selection. While the fittest survives in natural selection, the survivor will most likely be the luckiest when both dynamics are combined. As a result, chance has a greater impact on evolution.

In episode 3 of Netflix's *Night on Earth*, it is a full-moon night in a Central American rainforest, and two male *Physalaemus pustulosus* frogs try to impress a demanding female. As their acoustic mating calls are not enough to impress her, the vocal sacs of one of the males begin to inflate and deflate like a pulsating balloon, creating ripples on the surface of the water [1]. He is on his way to winning the competition and mate. This contest exemplifies sexual selection in action. However, the propagating ripples unintentionally also serve as a target in the water echolocated by a *Trachops cirrhosus* bat. This circumstance is an example of natural selection in action. The impending winner of sexual selection has died as a result of natural selection, and the prospective runner-up frog is the one who survives and ends up reproducing. His success depended on chance.

Any organism that engages in costly signaling is susceptible to predation as a consequence of emitting the signal. This is true whether the signal is a warning signal, a courtship signal, or any other signal that may attract a predator or parasite's attention. However, I would like to draw attention to the fact that both sexual and natural selection act simultaneously in the preceding example. "The survival of the fittest" is a phrase coined by Herbert Spencer that is not part of standard evolutionary research but does influence public understanding of evolution. Taking it at its face value, I observe that "survival of the fittest" relates simply to natural selection and makes sense only when we ignore its connection with sexual selection. If we do not, the "survival of the luckiest" best reflects the condition of every living individual.

Charles Darwin did not develop his theory of natural selection simultaneously with sexual selection. The sight of a peacock used to make Darwin sick because his bright feathers did not appear to have any clear survival value. He could not explain it with his theory of evolution by natural selection. So, he felt compelled to further devise his theory of sexual selection to explain peacock plumage [2]. Darwin derived his concept of sexual selection from his general theory of descent with modification, which he established in *The Descent of Man* in 1871. *On the Origin of Species* was first published in 1859.

Consider another perennial drama on the theater stage of evolution. The antlers of the *Cervus canadensis* elk are primarily used as weapons in combat between males for access to females, not against predators. The use of antlers as a form of defense against predators is secondary. By means of runaway selection, the larger the antlers, the better. R.A. Fisher proposed runaway selection in the early twentieth century. He contended that the attractiveness of a male elk's antlers, for example, leads to a positive feedback loop in which individuals with the trait are favoured and so more likely to reproduce. This can result in the evolution of increasingly extreme variants of the trait over time. In other words, this situation results in an arms race. However, large antlers render an elk more vulnerable to the *Canis lupus* wolf attacks in areas with a high density of trees. In most cases, a trait that evolved to help an individual compete better in battles against conspecifics is a disadvantage to the species as a whole [3]. The species would benefit from smaller antlers on each individual. Regardless, having smaller antlers would not be in one's best interests. Individual and group interests clash. Economists refer to this as the collective action problem [4]. Therefore, I propose that we frame sexual selection as a collective action problem.

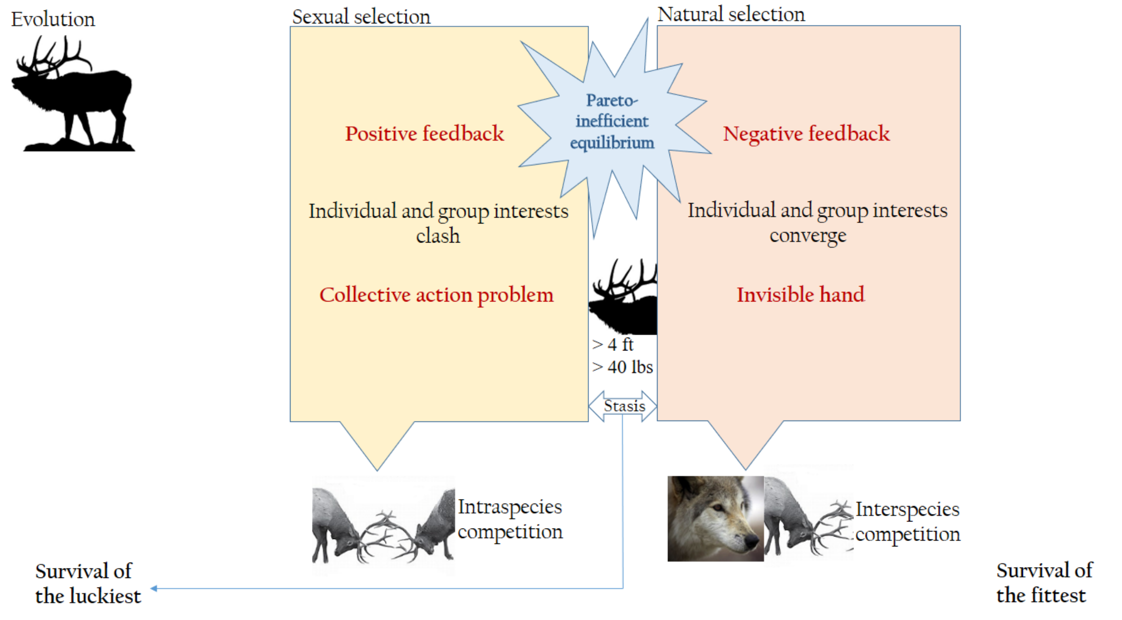
As previously stated, R.A. Fisher discovered that sexual selection has a positive feedback mechanism in terms of dynamics. As in an arms race, there is an amplification of an initial disturbance in the presence of positive feedback [5]. Natural selection, on the other hand, has a negative feedback mechanism in which a system responds in the opposite direction to a disturbance. A mutation that improves one hawk's eyesight, for example, is likely to spread through natural selection, making it suitable for the group of hawks as a species. The individual's and the group's interests are aligned. Obviously, negative feedback is not exclusive to natural selection, as a mutation that enhances a male's secondary sexual trait is also likely to spread through a population.

In their metaphor of the "invisible hand," economists preferentially prioritize negative feedback [5]. They exploit this property to demonstrate that markets function well, extending to all forms of collective behavior [4]. Goods and services markets have negative feedback, whereas financial markets may have positive feedback. For example, when the price of an iPhone rises, the number of people who want one decreases. However, if the price of Apple stocks rises, the demand for them may rise as well!

I argue that positive feedback occurs in *intra*species competition and negative feedback occurs in *inter*species competition. For example, a typical *Cervus canadensis* antler is more than 4 feet in diameter and weighs slightly over 40 pounds. In interspecies competition, one elk with antlers larger than this equilibrium value has become or will become wolf food. In intraspecies competition, an elk with smaller antlers is less likely to mate. This equilibrium is called stasis or steady state. It is Pareto-inefficient, which means that trimming every elk's antlers in the same proportion will improve the position of all elk. Therefore, surviving individuals' antler size is not optimal in this sense. Of course, evolutionary processes do not generally produce optimum conditions, despite the fact that biologists frequently employ optimality models. (See the infographic.)

In arms races, individual incentives lead to waste. Peacocks with exaggerated tails result from competition for females with positive feedback. Peahens prefer a flamboyant tail because this signals a healthy immune system and progeny. However, peacocks with oversize tails are more visible to predators. To see that those overly large tails mean waste to the group, imagine we chop off 2 inches of the tail from all group members. Every male's relative position remains unchanged as a result of this procedure. The experiment reveals a collective action problem, in which the invisible hand fails. It also reveals that one individual's interest in the intraspecies competition clashes with the group's interest.

In human affairs, collective action problems abound. For example, a hockey player prefers to play without a helmet because they gain a competitive advantage by seeing, hearing, and speaking more clearly. However, this increases their chances of being hurt. If players had the option of wearing helmets or not, they all choose not to. If they vote, however, they choose the mandatory helmet for everyone [4].



The collective action problem is ubiquitous and extends to any goal dependent on relative income. Many objectives in life are dependent on relative purchasing power. When you earn more money, you improve your ability to achieve your goals while decreasing the ability of others to achieve the same goals. This may not be the case if the economy as a whole is expanding, but current activities that increase an individual's income impose what economists call negative externalities on others [3]. This fact justifies market intervention because, as John Stuart Mill observed, the only legitimate reason to limit one's freedom is to prevent harm to others.

While we should encourage negative feedback competition in the economy, we should discourage positive feedback competition. We should free the invisible hand under negative feedback dynamics, limiting the market power of monopolies and oligopolies. However, there is a need for regulation in positive feedback dynamics to tame the collective action problem and protect us from the consequences of excessive competition among ourselves. After all, rewards based on relative performance create collective action problems, which leads to market failure. Because rewards are based on rankings, there is no way to assume that individual and collective interests are aligned. In an arms race, no more than half of the contestants can be in the top half [3].

The existing literature on success weights the role of talent and luck in human affairs and boils down to two formulas: 1) success = talent + luck, and 2) great success = a little bit more talent + a lot of luck [6]. However, disentangling talent from luck is a difficult task. Despite this fair reward problem [7], one point has been established: skill alone cannot explain the top rewards [3] [8].

Returning to nature, what role does the lucky one play in evolution? Darwin gave chance a lot of thought, and modern biologists are still thinking along same lines. It has been established that evolution involves 1) adaptations, 2) by-products, and 3) randomness [2]. However, an adaptation reponds to a mutation, or randomness that occurs in a single individual. It may give the individual an advantage (or disadvantage) in terms of survival and reproduction. If the mutation is beneficial, it will spread throughout the group and become a species adaptation. However, one implication of what I am showing is that evolution is ultimately just randomness, namely 1) the adaptations that result from successful mutations (randomness), 2) its by-products (second-degree randomness), and 3) mutations (randomness) that do not translate into adaptations. The runner-up frog fits this third scenario: despite being less fit, he took the trophy by sheer luck.

I conceptualize selection as a dynamic of positive and negative feedback. The concept of selection as dynamics is not foreign to Darwin, who uses the example of domestication (artificial selection) to show how evolution by natural selection is plausible. Domestication dynamics illustrate how a population can be transformed through differential reproduction of its component individuals, and this dynamic can be extended to nature. While a breeder selects among a population of domesticated animals in artificial selection, and thus intentionality is compatible with teleology, natural selection explains adaptation without recourse to teleology. Natural selection was not well received by Darwin's contemporaries because of its rejection of teleology [9]. Darwin himself acknowledges that natural and sexual selection have distinct dynamics. Historically, Darwin added sexual selection later after originally proposing only natural selection, as observed. However, logically and developmentally natural selection comes before sexual selection. This can be demonstrated in species that reproduce only once in their lifetime and then die. This is because the primary objective of these species is to survive long enough to reproduce successfully, as opposed to attracting mates and reproducing repeatedly. Notwithstanding, sexual selection is solely based on individual efforts to monopolize the gene pool, and the results may be detrimental to the species as a whole. It may even result in extinction. This is an additional route to extinction, as natural selection can also lead to extinction. Thus, teleology is unnecessary, and maladaptation is possible. While natural selection explains adaptation, sexual selection is compatible with maladaptation [9]. This allows for attitudes like Alfred Russel Wallace's, who rejected sexual selection while accepting natural selection.

According to textbook wisdom, evolution is based on constraints of physical and chemical laws, the two principles of descent and modification (selection), and chance. The synthetic theory of evolution considers evolution as changes in gene frequencies in a population caused by mutation, migration, drift (sampling error in finite populations), and selection. As sexual selection interacts with natural selection, I contend that chance is the most fundamental factor. The luckiest survive while the other factors remain in play. The Netflix example at the beginning shows a sequence of sexual followed by natural selection, but when the males pulsate rather than call, that change is not just a random innovation, but they do it to attract females. Thus, the workings of sexual selection are in place, despite the fact that the victim of predation is naturally selected against, and the runner-up frog's success is based on chance. Although my case does not rule out the other factors, it appears heretical because chance is the ultimate destroyer of any teleological ideas. When operating in automatic mode, our minds are prone to type I errors, detecting patterns where none exist. People seek patterns and refuse to accept randomness [6]. This explains the widespread skepticism among Darwin's teleologically inclined contemporaries that chance plays a significant role in evolution. However, subsequent debate acknowledged the role of chance in evolution, culminating in John Herschel's description of evolution as "the law of the higgledy-piggledy," implying that chance could influence the design of organisms. Beginning in the 1970s, paleobiologists such as David Raup, Stephen Jay Gould, and Thomas Schopf [10, 11] argued that evolution is predominantly stochastic, emphasizing the role of chance events, such as genetic drift or random mutations, in determining the course of evolution. They argued that randomness played a crucial role in evolutionary history, especially during periods of rapid diversification or mass extinctions. Due to the influence of stochastic events, Gould famously argued [12] that if we "replayed the tape of life" from the beginning, we would not necessarily observe the same outcomes each time. This does not imply, however, that natural and sexual selection do not also play a role.

Intraspecies competition in sexual selection causes a collective action problem because the species would benefit if, for example, each peacock's tail were smaller. The peacock's tail is analogous to human positional goods, where satisfaction with consumption is determined by signal ranking rather than absolute quality [3]. Because rewards are based on rankings, there is no way to reconcile individual and group interests. The effects of an individual's position in a hierarchy on others, even if there is no direct interaction or exchange between them, are referred to as positional externalities [3]. Externalities are costs or benefits that accrue to individuals who are not directly involved in a transaction. The fact that externalities are associated with sexual selection has been perceived in the literature because what is advantageous to certain individuals is not always advantageous to the wholes of which they are parts in sexual selection. Sexual conflict is also an example of the tragedy of the commons [13], which occurs when the depletion of a shared resource has a negative impact on individuals who are not involved in the decision-making process or do not benefit from the resource's exploitation. Sexual selection in evolutionary theory is similar to rent-seeking in economic theory [9], in which individuals seek wealth by capturing a larger share of the existing economic pie rather than creating new wealth. While sex seeks "profit," sexual selection seeks rent [9]. Rent-seeking is associated with externalities because it distorts resource allocation and reduces incentives for individuals to internalize the costs of their activities. This can result in inefficient outcomes because resources are diverted to rent-seeking rather than productive activities that generate new wealth. Because sexual selection is ultimately a collective action problem, externalities, whether positional or those resulting from rent-seeking and the tragedy of the commons, should be involved.

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