An evolutionary game theory model for devaluing rhinos

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Abstract

Rhino poaching has escalated in recent years due the demand for rhino horn in Asian countries. Rhino horn is used in Traditional Chinese Medicine and as a status symbol of success and wealth. Wild life managers attempt to minimise the rhino casualties with approaches such as devaluation of the rhino horn. The most common strategy of devaluing horns includes dehorning. In [1] game theory modelling was used to examined the interaction of poachers and wild life managers. A manager can either 'dehorn' their rhinos or leave the horn attached. Poachers may chose to to behave 'selectively' or 'indiscriminately'. The approach described in this paper builds upon [1] and investigates the interactions between the poachers using evolutionary game theory. Evolutionary game theory, allows us to explore the evolutionary stabilities of the strategies available to a poacher. The purpose of this work is to discover the conditions which best encourages the poachers to behave selectively, that is, they only kill those rhinos with full horns. The results show that, poachers will never chose to behave selectively as long as there is even the slightest gain from a partial horn. Thus, we advice wild life managers to spend more of the their resources into security and not in dehorning rhinos.

1 Introduction

The illegal trade in rhino horn supports aggressive poaching syndicates and a black market (Nowell et al., 1992). This lucrative market entices people to invest their time and energy to gain a 'winfall' in the form of a rhino horn, through the poaching of rhinos. In recent years poaching has escalated to an unpresidented level resulting in concerns over their future existence (Smith et al., 2013). In response, rhino conservation has seen increased ilitarisation with 'boots on the ground' and 'eyes in the sky' (Duffy et al., 2015). An alternative method is to devalue the horn itself, one of the main methods being the removal so that only a stub is left. The first attempt at large-scale rhino dehorning as an anti-poaching measure was in Damordond, Namibia, in 1989 (Milner-Gulland and Leader-Williams, 1992). Other methods of devaluing the horn that have been suggested include the insertion of poisons, dyes or GPS trackers (Gill, 2010; Smith, 2013). However, like dehorning, they cannot remove all the potential gain from an intact horn (poison and dyes fade or GPS trackers can be removed). This paper builds on the work of [1] and considers the general strategy of devaluing horns, which includes dehorning.

Rhino populations now persist largely in protected areas or on private land, and require intensive protection (Ferreira et al., 2014). For wildlife managers law enforcement is often one of the main methods of deterring poaching, however rhino managers can remove the poaching incentive by devaluing their rhinos (Milner-Gulland, 1999). Milner-Gulland and Leader-Williams (1992) found the optimum proportion to dehorn using mean horn length as a measure of the proportion of rhinos dehorned. They showed, with realistic parameter values, that the optimal strategy is to dehorn as many rhinos as possible. A manager does not need to choose between law enforcement or devaluing, but perhaps adopt a combination of the two; especially given that devaluing rhinos comes at a cost to the manager, and the process comes with a risk to the rhinos.

A recent paper modelled the interaction between a rhino manager and poachers using game theory [1]. The authors consider a working year of a single rhino manager. A manager is assumed to have standard yearly resources which can be allocated on devaluing a proportion of their rhinos or spent on security. It is assumed that all rhinos initially have intact horns. Poachers may either only kill rhinos with full horns, 'selective poachers', or kill all rhinos they encounter, 'indiscriminate poachers'. If all rhinos are left by the rhino manager with their intact horns, it does not pay poachers to be selective so they will chose to be indiscriminate. Conversely, if all poachers are selective, it pays rhino managers to invest in devaluing their rhinos. This dynamic is represented in Fig. 1. Assuming poachers and managers will always behave so as to maximise their payoff, there are two equilibriums: either all devalued and all poachers selective; or all horns intact and all poachers indiscriminate. Essentially, either the managers win, the top left quadrant of Fig. 1, or the poachers win, the bottom right quadrant of Fig. 1. The paper concludes that poachers will always choose to behave indiscriminately, and thus the game settles to the top left quadrant, i.e., the poachers win.

The work of [1] did not take in to account the population dynamic effect of these strategies. In a population full of selective poachers would their be a benefit to a single poacher becoming indiscriminate or vice versa? This notion is

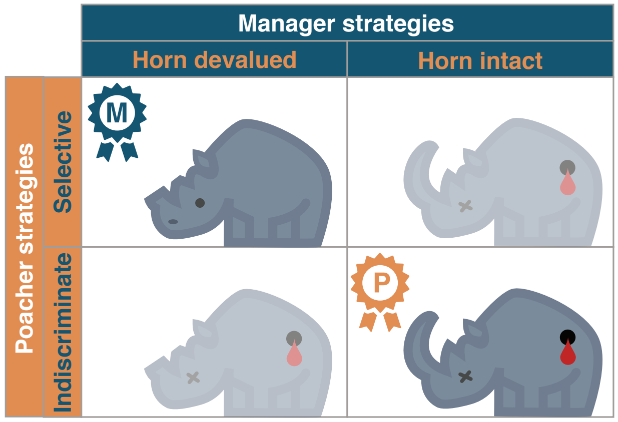


Figure 1: The game between rhino manager and rhino poachers. The system settles to one of two equilibriums, either devaluing is effective or not.

explored here using evolutionary game theory [3]. The game is not that of two players anymore (manager and poacher) but an infinite population of poachers is considered. This allows for interaction between poachers over multiple plays of the game to be explored with the rhino manager being the one that creates the conditions of the population.

In evolutionary game theory, we assume infinite populations and in our model this will be represented by $\chi = (x_1, x_2)$ with x_1 proportion of the population using a strategy of the first type and x_2 of the second, denoted by s_1, s_2 respectively. We assume there is a utility function u_1 and u_2 that maps the population to a fitness for each type,

$$u_1(\chi) \qquad u_2(\chi).$$

In evolutionary game theory these utilities are used to dictate the evolution of the population over time, according to the following differential equations,

$$\begin{cases} \dfrac{dx_1}{dt} = x_1(u_1(\chi) - \phi), \\ \\ \dfrac{dx_2}{dt} = x_2(u_2(\chi) - \phi). \end{cases} \tag{1}$$

The overall population is assumed to remain stable thus, $x_1 + x_2 = 1$ and

$$\frac{dx_1}{dt} + \frac{dx_2}{dt} = 0 \Rightarrow x_1(u_1(\chi) - \phi) + x_2(u_2(\chi) - \phi) = 0. \tag{2}$$

As follows the average fitness can be written as,

$$\phi = x_1 u_1(\chi) + x_2 u_2(\chi). \tag{3}$$

By substituting (3) and $x_2 = 1 - x_1$ in (1),

$$\frac{dx_1}{dt} = x_1(1 - x_1)(u_1(\chi) - u_2(\chi)). \tag{4}$$

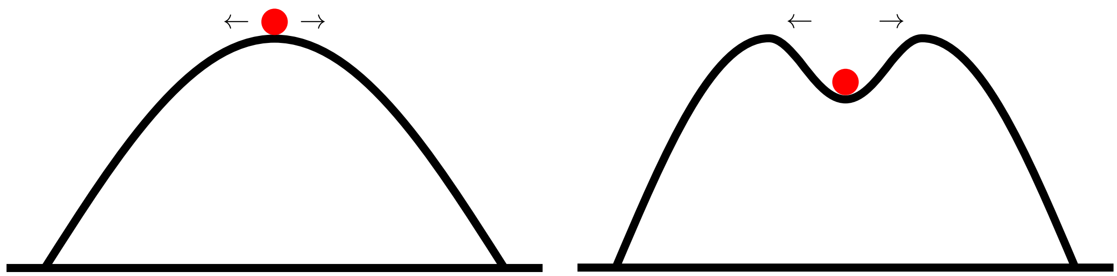
The equilibria of the differential equation (4) are given by,

- $x_1 = 0$,
- $x_1 = 1$,
- $x_1 \in (0, 1)$ for $u_1(\chi) = u_2(\chi)$.

Thereupon, two notions must be checked for the equilibria,

- stability. The notion of stability implies that the underlying differential equation does not move. A strategy is the best response in the population that it generated. Secondly,
- evolutionary stability. The notion of evolutionary stability implies that the differential equation ...

The notion of evolutionary stability can be checked only for the stable strategies. For a stable strategy to be an evolutionary stable strategy (ESS) it must remain the best response even an mutated population χ_{ϵ}. A mutated population is the post entry population, where a small proportion ϵ starts deviating and adopts a different strategy. The mutated population can be thought as a nudged. Assume Fig. 6, is illustrating two stable strategies. In Fig. 6a, though the population has reached a stable point once a nudge is applied the marble will lose it's position. In contrast, Fig. 6b illustrates a strategy that even when nudged the marble will bounce back to it's original position, making it ESS.



(a) A diagram of a stable strategy which is not ESS. (b) A diagram of a stable strategy which is ESS.

Figure 2: Diagrams of stable strategies.

In the following section 2, we determine expressions for u_1, u_2 that correspond to a population of wild rhino poachers and we explore the stability of the equilibria identified in [1]. The results contained in this paper are proven analytically, and more specifically it is shown that,

- all poachers behaving selectively is not a stable strategy,
- a mixed population where selective and indiscriminate poachers learn to co exist can not hold and
- finally all poachers adopting a indiscriminate strategy was proven to be stable and an evolutionary stable strategy.

2 The Model

A wild rhino poacher can adopt two strategies, to either behave selectively or indiscriminately. Calculating the utility for each strategy the gain and cost that poachers are exposed to must be taken into account. The poacher incurs a loss from seeking a rhino, and the risk involved. The gain depends upon the value of horn, the proportion of horn remaining after the manager has devalued the rhino horn and the number of rhinos (devalued and not).

Let us first consider the gain to the poacher, where θ is the amount of horn taken. We assume rhino horn value is determined by weight only, a reasonable assumption as rhino horn is sold in a grounded form [4]. Referring to Fig. 1, clearly if the horn is intact, the amount of horn gained is $\theta = 1$ for both the selective and the indiscriminate poacher. If the rhino horn has been devalued, and the poacher is selective, the amount of horn gained is $\theta = 0$ as the poacher does not kill. However, if the poacher is behaving indiscriminately, the amount of horn gained is $\theta = \theta_r$ (for some $0 < \theta_r < 1$). Therefore, the amount of horn gained in the general case is

$$\theta(r, s) = s(1 - r) + (1 - s)((\theta_r - 1)r + 1), \tag{5}$$

where r is the proportion of rhinos that have been devalued, and s is the proportion of selective poachers. Note that since $\theta_r, r, s \in [0, 1]$, then $\theta(r, s) > 0$. Standard supply and demand arguments imply that the value of rhino horn decreases as the quantity of horn increases. Thus at any given time the expected gain for a poacher is

$$H\theta(r, s)^{-\alpha}, \tag{6}$$

where H is a scaling factor associated with the value of a full horn, and $\alpha \geq 0$ is a constant that determines the precise relationship between the quantity and value of the horn. Fig. 3, verifies that the gain curve corresponds to a demand curve.

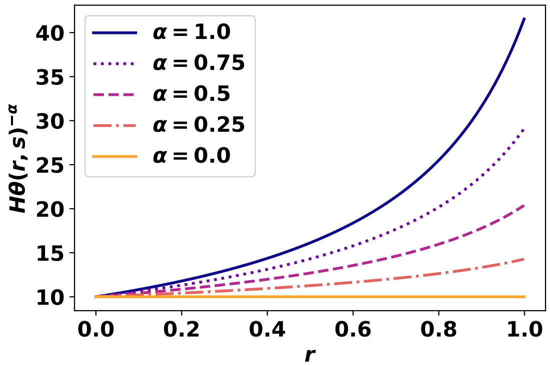


Figure 3: $H\theta(r,s)^{-\alpha}$ for values $H = 10, \theta_r = 0.3$ and $s = 0.2$..

An individual interacts with the population, denoted as $\chi = (x, 1-x)$. Thus, the gain is either

$$\begin{cases} \theta(r,1)H\theta(r,x)^{-\alpha} & \text{selective poacher} \\ \theta(r,0)H\theta(r,x)^{-\alpha} & \text{indiscriminate poacher} \end{cases} \tag{7}$$

depending on the chosen strategy of the individual, see Fig. 1.

Secondly we consider the costs incurred by the poacher. Let us denote the number of rhinos that will be considered at risk given r and s as $\phi(r,s)$. The rhinos **not** at risk are the devalued ones that cross the paths of selective poachers. Thus:

$$\psi(r,s) = 1 - rs. \tag{8}$$

Additionally, the poachers are also exposed to a risk. The risk to the poacher is the opposite of the proportion of rhinos devalued r, since the rhino manager can spend more on security if the cost of devaluing is low.

$$(1-r)^{\beta}, \tag{9}$$

where $\beta \geq 0$ is a constant that determines the precise relationship between the proportion of rhinos not devalued and the security on the grounds. Therefore, at any given time the expected cost for a poacher is,

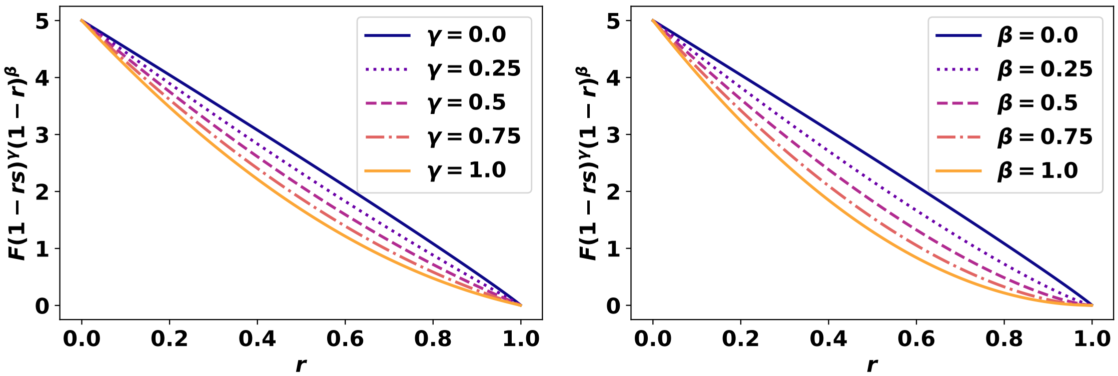
$$F\psi(r,s)^{\gamma}(1-r)^{\beta} = F(1-rs)^{\gamma}(1-r)^{\beta} \tag{10}$$

where F and $\gamma \geq 0$ are constants that determine the precise relationship between the proportion of vulnerable rhinos and the probability of finding a rhino, such that γ close to zero indicates very sparse rhinos. Fig. 4, verifies the decreasing relationship between r and the cost.

Note that for a indiscriminate poachers $s = 0$ the seeking cost (9) will always be 1, thus the cost of finding a rhino is greater than the same cost for a selective poacher. However, a selective poacher needs more time to secure an 'available' rhino, if they exist at all. Hence, an additional cost that tends to infinity as $r \to 1$ must be applied,

$$\begin{cases} \frac{1}{\psi(r,1)} = \frac{1}{1-r} & \text{selective poacher} \\ \frac{1}{\psi(r,0)} = 1 & \text{indiscriminate poacher} \end{cases} \tag{11}$$

To summarise, the cost incurred by a given individual when interacting with the population is given by



(a) For values, $s = 0.7, F = 5$ and $\beta = 0.95$.

(b) For values, $s = 1, F = 5$ and $\gamma = 0.95$.

Figure 4: $F(1-rs)^{\gamma}(1-r)^{\beta}$.

$$\begin{cases} \frac{1}{1-r} F(1-rx)^{\gamma}(1-r)^{\beta} & \text{selective poacher} \\ F(1-rx)^{\gamma}(1-r)^{\beta} & \text{indiscriminate poacher} \end{cases} \tag{12}$$

As a result, the utility of the poachers can now be defined. Let $\sigma = (s, 1-s)$ denote the strategy of an individual. Thus $\sigma = (1, 0)$ represent an individual poacher who is selective and $\sigma = (0, 1)$ represent an individual poacher who is indiscriminate. Combining (7) and (12) gives the utility function for the individual poacher σ in the population χ,

$$u(\sigma, \chi) = s u_1(\chi) + (1-s) u_2(\chi), \tag{13}$$

where

$$u_1(\chi) = \theta(r,1) H \theta(r,x)^{-\alpha} - \frac{1}{1-r} F \psi(r,x)^{\gamma}(1-r)^{\beta}, \tag{14}$$

$$u_2(\chi) = \theta(r,0) H \theta(r,x)^{-\alpha} - F \psi(r,x)^{\gamma}(1-r)^{\beta}. \tag{15}$$

Substituting (14) and (15) into (13) gives

$$u(\sigma, \chi) = H(\theta_r r(1-s) - r + 1)\theta(r,x)^{-\alpha} - F\left(1 - s + \frac{s}{1-r}\right)(1-rx)^{\gamma}(1-r)^{\beta}. \tag{16}$$

In section 3, the notions of stability and evolutionary stability of these two strategies as well as a potential mixed strategy will be investigated.

3 Evolutionary Stability

Using an evolutionary model to study the devaluation of wild rhinos allows us to gain insight on the evolutionary stability of the strategies and their conditions. An evolutionarily stable strategy (ESS) is a strategy which, if adopted by the population, cannot be invaded by any alternative strategy [2].

3.1 Stable Strategies

By definition, for a strategy to be an ESS it must first be stable. In our model there are three possible stable distributions based on the equilibria of equation (4),

- All poachers are selective $s = 1$;
- All poachers are indiscriminate $s = 0$;
- Mixed population of selective and indiscriminate poachers.

3.1.1 All poachers are selective $s = 1$

For a strategy $\sigma = (s, 1-s)$ to be stable, it must be a best response in the population it generates. So if the utility for a poacher behaving **selectively** in a population of selective poachers

$$u((1,0),(1,0)) = H(1-r)^{1-\alpha} - F(1-r)^{\beta+\gamma-1}, \tag{17}$$

is greater than the utility for a poacher behaving indiscriminately in a population of selective poachers,

$$u((0,1),(1,0)) = H(\theta_r r + 1 - r)(1-r)^{-\alpha} - F(1-r)^{\beta+\gamma}, \tag{18}$$

then $\sigma = (1,0)$ is stable. Setting (17) to be greater than (18) gives

$$H\theta_r r < F[1-(1-r)^{-1}](1-r)^{\gamma+\beta+\alpha} \tag{19}$$

This inequality states that the gain from partial horn available needs to be less than a given amount for selectiveness to be a stable strategy, and thus devaluing would be an effective strategy to deter poachers. However, the left-hand size of (19) will always be negative since $1-(1-r)^{-1} \leq 0$ for any r, see Fig. 5. **Thus, being selective is never a stable strategy.** Whilst, in [1], it was identified as an equilibrium for the corresponding stage game, we here have shown that it will never be selected in a population of poachers.

3.1.2 All poachers are indiscriminate $s = 0$

Similarly, if the utility for a poacher behaving **indiscriminately** in a population of indiscriminate poachers

$$u((0,1),(0,1)) = H(\theta_r r + 1 - r)(\theta_r r + 1 - r)^{-\alpha} - F(1-r)^{\beta}, \tag{20}$$

is greater than the utility for a poacher behaving selectively in a population of indiscriminate poachers,

$$u((1,0),(0,1)) = H(1-r)(\theta_r r + 1 - r)^{-\alpha} - F(1-r)^{\beta-1}, \tag{21}$$

then $\sigma = (0,1)$ is stable. Setting (20) to be greater than (21) gives

$$H\theta_r r > F[1-(1-r)^{-1}](1-r)^{\beta}(\theta_r r - r + 1)^{\alpha}. \tag{22}$$

This inequality states that for indiscriminate behaviour to be stable, the value of a partial rhino horn available needs to be greater than a given amount. Since $1-(1-r)^{-1} \leq 0$, the inequality holds for any r, see Fig. 5.

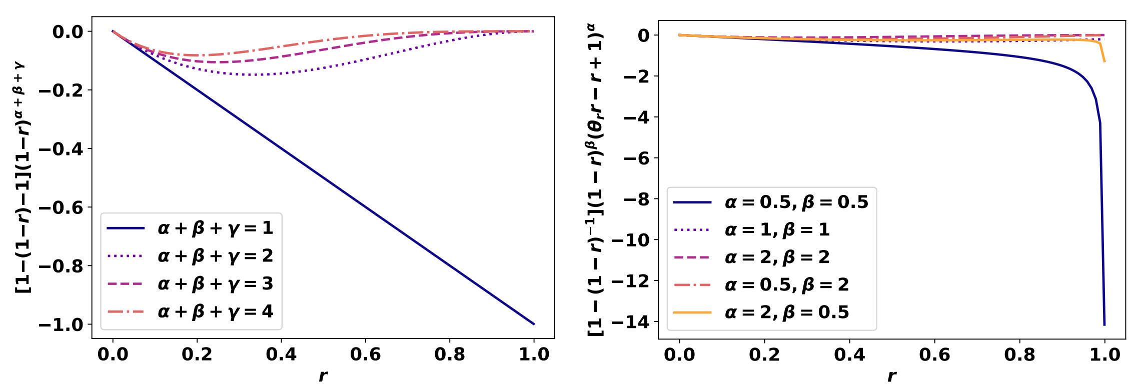


Figure 5: Left: $\frac{H\theta_r r}{F}$ needs to be less than this for selectiveness to be a stable strategy. Right: $\frac{H\theta_r r}{F}$ needs to be greater than this for indiscriminate behaviour to be stable (shown with $\theta_r = 0.2$).

3.1.3 Mixed population of selective and indiscriminate poachers

The third potential stable solution is that of a **mixed population**, $\sigma = (s^*, 1-s^*)$, where s^* is the solution to

$$u((1,0),(s^*,1-s^*)) = u((0,1),(s^*,1-s^*)). \tag{23}$$

The left-hand side is

$$u((1,0),(s^*,1-s^*)) = H(1-r)\theta(r,s^*)^{-\alpha} - F(1-r)(1-rs^*)^{\gamma}(1-r)^{\beta}.$$

The right-hand side is

$$u((0,1),(s^*,1-s^*)) = H(\theta_r + 1 - r)\theta(r,s^*)^{-\alpha} - F(1-rs^*)^{\gamma}(1-r)^{\beta}.$$

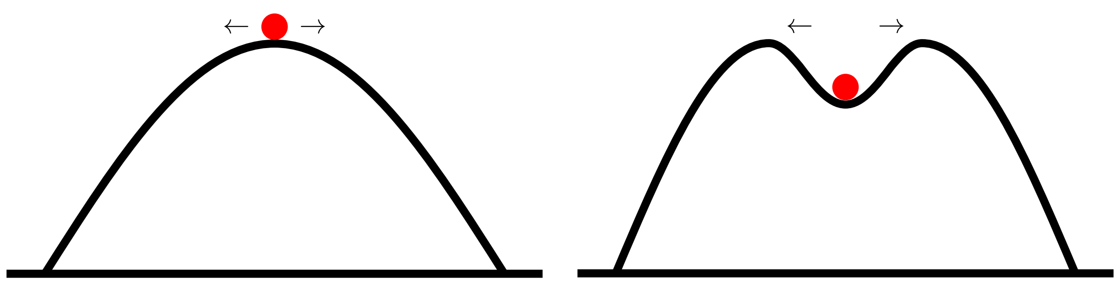
Substituting these into (23) gives an expression to solve for s^*,

$$-H\theta_r r\theta(r,s^*)^{-\alpha} + Fr(1-rs^*)^{\gamma}(1-r)^{\beta} = 0. \tag{24}$$

However, this is not possible to solve analytically, in section 4 we consider numerical solutions.

3.2 Evolutionary Stable Strategies

The notion of evolutionary stability is now checked for the stable strategies. For a stable strategy to be ESS it must remain the best response even an mutated population χ_ϵ. A mutated population is the post entry population, where a small proportion ϵ starts deviating and adopts a different strategy. The mutated population can be thought as a nudged. Assume Fig. 6, is illustrating two stable strategies. In Fig. 6a, though the population has reached a stable point once a nudge is applied the marble will lose it's position. In contrast, Fig. 6b illustrates a strategy that even when nudged the marble will bounce back to it's original position.



(a) A diagram of a stable strategy which is not ESS. (b) A diagram of a stable strategy which is ESS.

Figure 6: Diagrams of stable strategies.

All poachers behaving selectively was proven to be a non stable strategy, thus it will not be considered in this section. In order for the stable strategy all indiscriminate $\sigma = (0,1)$, described in section 3.1, to be evolutionary ESS,

$$u((0,1),\chi_\epsilon) > u(\chi_\epsilon,\chi_\epsilon). \tag{25}$$

where,

$$\begin{aligned} u((0,1),\chi_\epsilon) &= H(\theta_r r - r + 1)\theta(r,\chi_\epsilon)^{-\alpha} - F(1-\chi_\epsilon)^{\gamma}(1-r)^{\beta}, & (26)\\ u(\chi_\epsilon,\chi_\epsilon) &= H(\theta_r r - r(1-x_\epsilon)) + 1)\theta(r,\chi_\epsilon)^{-\alpha} - F(1-x_\epsilon)^{\gamma}(1-r)^{\beta}(1 - x_\epsilon + \frac{x_\epsilon}{1-r}). & (27)\end{aligned}$$

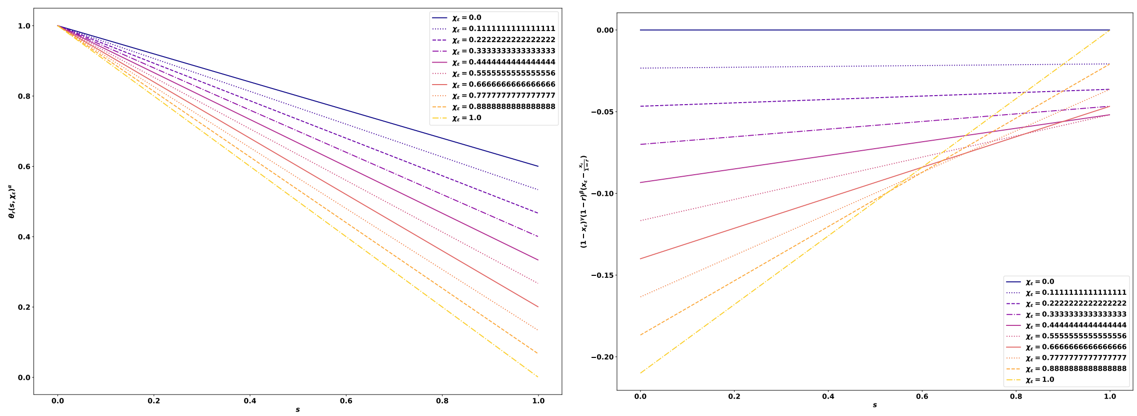
Let the difference be denoted as,

$$\delta = u((0,1), \chi_\epsilon) - u(\chi_\epsilon, \chi_\epsilon), \tag{28}$$

$$\delta = H\theta(r, \chi_\epsilon)^{-\alpha}\theta_r r x_\epsilon - F(1-x_\epsilon)^\gamma (1-r)^\beta (x_\epsilon - \frac{x_\epsilon}{1-r}) \tag{29}$$

all indiscriminate will be an ESS if and only if $\delta > 0$ for any small value of ϵ. Thus,

$$\frac{H\theta(r, \chi_\epsilon)^{-\alpha}\theta_r r x_\epsilon}{F} > (1-x_\epsilon)^\gamma (1-r)^\beta (x_\epsilon - \frac{x_\epsilon}{1-r}) \tag{30}$$



The evolutionary stability can not be examined analytically any further. In the following section some numerical experiments are preformed.

4 Numerical experiments

In this section several analytical experiments are performed to gain some insight on the different possible scenarios. The following values have been chosen as appropriate for our model parameters. Note from that r can not be 1, because the denominator of (13) can not be nullified. Likewise, θ_r never reaches 1 for the partial horn is being considered in the gain only when $r > 0$ (7).

- $0 \leq r < 1$
- $0 \leq \theta_r < 1$
- $1 \leq H \leq 500$
- $1 \leq F \leq 50$
- $0 \leq \alpha \leq 2$
- $0 \leq \beta \leq 2$
- $1 \leq \gamma \leq 3$

The data set used in the following analysis have been generated using the computational facilities of the Advanced Research Computing @ Cardiff (ARCCA) Division, Cardiff University. The source code for the purpose of this research was produced using the programming language python. Best software practices have been taken into account. The source code is available on line, accompanied by documentation and automatic tests that ensure the correctness of our results.

In total 82825 different scenarios of our problem have been simulated, including all the edge values of each parameter. Table 1 shows the descriptive statistics of the data set.

The stability of the strategies has been explored using numerical experiments. Mixed strategies, were proven to be stable for 0.014 percentage of our experiments. The scenarios where a mixed strategy is stable, as shown in Table 1, is for values s^* close to zero. Thus, we conclude that in the parameter area that we have covered the only stable strategy seem to be all indiscriminate.

	r	θ_r	H	F	γ	α	β	mixed stable (s^*)
count	82825	82825	82825	82825	82825	82825	82825	1.333000e+03
mean	0.486	0.101	208.082	24.666	1.795	0.871	0.965	8.446770e-13
std	0.299	0.188	187.728	18.698	0.795	0.740	0.762	8.556157e-13
min	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.000000e+00
25%	0.232	0.00	1.00	1.00	1.00	0.00	0.00	0.000000e+00
50%	0.475	0.00	250.50	25.50	2.00	1.00	1.00	0.000000e+00
75%	0.747	0.167	333.667	41.833	2.50	1.333	2.00	1.818989e-12
max	1.00	0.50	500.00	50.00	3.00	2.00	2.00	1.818989e-12

Table 1: Descriptive statistics.

Secondly, the evolutionary stability was explored. This was done following the condition that (**??**) must be greater than a values t for all $\epsilon \in \bar{\epsilon}$. The following values were chosen, $t = 0.0000001$ and $\epsilon = 0.0001$. It was shown that, for our experiments only, all indiscriminate is not an ESS. Not being an ESS it's an advantage to the wild life manager. Let a population where all individuals chose to behave indiscriminate, the manager could nudge the system enough that mutated strategies, more selective individuals, can be introduced to the population. Minimizing the number of rhinos that are killed.

5 Discussion and Conclusions

Wild life managers are faced with the increased demand for rhino horns endangering the life of the rhinos. On an attempt to rescue wild rhinos, devaluating their horn is a commonly used in recent year. More specifically, one of the approaches includes removing the rhino horn permanently. A poacher can either ignore the dehorned rhino, for the reason that the gain from a partial horn does not exceed the cost, or behave indiscriminate attach the animal securing even the slightest proportion of horn. On the contrary, a wild life manager can chose how to distributed their annual resources. Either on devaluation of the rhino horns or on ground security. The interactions between manager and poachers can be represented using game theory. This was done by [1] and their work the identified the possible solutions to the game.

Evolutionary game theory, does not examine the interaction of players but the interactions of strategies, such as the strategies of the poachers. More detailed, if a given population is consists of a number of selective and a number of indiscriminate poachers is it possible for these strategies to co-exist? or is a strategy more dominant than the other? The model described in this work captures this behaviour. Several parameters are introduced. Some of the parameters are controlled by the manager, percentage of dehorned rhinos, the risk of being caught due to security. The gain of full and partial horn are introduce, as well as the costs of seeking a rhino and the risk of securing a horn. Demand and supply arguments have also been taken into account.

The main goal of this works is to explore stability. A stable strategy is a strategy which is the best strategy to adopt in a population of players of that strategy. A mixed population can be also be stable, a mixed population consists of a proportion of selective and indiscriminate poachers that learned to co-exist. Though stability is important, a far more interesting concept is that of an evolutionary stability. An ESS is a population that did not only achieved stability but if a strategy was to be introduced it would fast be rejected by the population.

In this work it was proven analytically that a selective strategy is never stable. On the other hand being indiscriminate is. There have been conditions that could not be studied analytically, such as the stability of a mixed population and the evolutionary stability. In search of answers several numerical experiments were simulated using modern software best practices. In the data set that has been explored though this work no stable mixed strategies were identified. Furthermore, the only stable strategy, failed to satisfy the evolutionary conditions.

All rhinos behaving indiscriminate is undesirable case. Because the manager can not secure the life of the rhinos even if they were to dehorn them. Due the fact that the indiscriminate strategy is stable we disagree with Milner-Gulland and Leader-Williams (1992). We believe that dehorning in not the solution to the problem and the manager would be better off assigning more security to the ground or use modern methods such as using drones (`https://www.savetherhino.`

org/rhino_info/thorny_issues/the_use_of_drones_in_rhino_conservation). This is applied to real life because poachers do not always think of the danger and the risk of getting caught. They are more interested in the horn even if that means that a full horn will not be secured but only a partial. The fact that the indiscriminate is not an non ESS strategy will not manage to reject the invasion leaving room to introduce more desired strategies. Thus the manger could shake the system. This could introduced enough mutant strategies and the manger would hope to minimize the causalities.

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