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An X-ray of the Competitive and Co-operative Habits of Wild-Life Animals Using Game Theoretic Approach in Ovu-Inland, Delta State, Nigeria

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ABSTRACT: *This paper will discuss game theoretic approach on the competitive and cooperative habits of wild-life animals in Ovu-Inland, Delta State. Focus was on how some wild-life animals in Ovu-Inland, Delta State used game theoretic approach to cooperate or compete for survival. This work will use the knowledge of both tree diagram and two-person non-zero sum games to explain the cooperative and competitive strategy of wild-life animals in Ovu-Inland, Delta State. The essence of survival of a given specie in wild-life is of paramount importance as it guarantees the existence while preventing extinction of a given specie. Data collection that aided this research work were source through interview from Delta State Ministry of Environment, Delta State Ministry of Health, Department of Veterinary Medicine as well website of previously existing works.*

This paper was developed to x-ray both the cooperative and competitive habits of wild-life animals in Ovu-Inland, Delta State using game theoretic approach.

KEY WORDS: *Game Theory, Cooperative Games, Non-cooperative games, Tree diagram, two-person non-zero sum games.*

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I. INTRODUCTION

Cooperative behavior in animals is when two or more animals interact socially to reduce competition and increase their chances of survival.

Cooperation – a widespread phenomenon that has fascinated biologists for centuries – refers to mutually beneficial interactions that occur among individuals of the same species or between different species [7].

A generalized conception of evolution that normalizes competition as a major mechanism casts cooperation as a paradox, a piece in a puzzle where survival is measured in terms of costs and benefits, following the market rule of self-maximization.

Cooperative behavior can take on many forms. It can be aggressive (e.g. when individuals coordinate territorial defense), sexual (e.g. trading in simultaneously hermaphroditic coral-reef fishes), associated with parental investment (food provisioning by parents), or even related to foraging (joint hunting) [11]. Most animals cooperate with each other for the purpose of joint hunting, mutual benefits, defensive mechanism and safety cooperative behaviours can be an evolutionary response to reduce competition between members of the same species.

Animals' social lives are both competitive and cooperative. For instance, animals may establish privileged relationships (couple bonds, friendships, alliances) with specific partners who are treated differently from others which contributes to generalized variation in behavior [8]. This is the case with the Indo-Pacific Cleaner Wrasse, often found in mixed-sex pairs. These fish remove ectoparasites, dead or damaged tissue from visiting reef fish from other species (known as clients) [5].

Interestingly, the quality of their 'cleaning service' is very much dependent on the quality of their 'marriage', as both fish need to restrain from conflict in order to attract and maintain the client in their territory (known as 'cleaning stations') [9].

Competition is most typically considered the interaction of individuals that vie for a common resource that is in limited supply, but more generally can be defined as the direct or indirect interaction of organisms that leads to a change in fitness when the organisms share the same resource. The outcome usually has negative effects on the weaker competitors. There are three major forms of competition. Two of them, interference competition, and exploitation competition, are categorized as real competition. A third form, apparent competition, is not. Interference competition occurs directly between individuals, while exploitation competition and apparent competition occur indirectly between individuals [4].

Competition is an interaction between organisms or species in which both require a resource that is in limited supply (such as food, water or territory) [1]. Competition lowers the fitness of both organisms involved, since the presence of one of the organisms always reduces the amount of the resource available to the other [6]. In the study of community ecology, competition within and between members of a species is an important biological interaction. Competition is one of many interacting biotic and abiotic factors that affect community structure, species diversity, and population dynamics (shifts in a population over time) [6].

Game theory on the other hand, is a bag of analytical tools designed to help us understand the phenomena that we observe when decision-makers interact. The basic assumptions that underlie the theory are that decision makers pursue their well-defined objectives and take into account their knowledge or expectations of other decision maker's behavior (they reason strategically) [3].

Games is concerned with interactive decision-making with more than one person. Outcomes are determined by whatever combination of actions resulting from the independent choice of several individual decision-makers [3].

The models of game theory are abstract representations of classes of real-life situations. Their abstractness allows them to be used to study oligopolistic and political competition, to understand why some animals cooperate with each other and why other compete.

A game is a description of strategic interaction that includes the constraints on the actions that the players can take and the players' interests, but does not specify the actions that players do take. A solution is a systematic description of the outcomes that may emerge in a family of games. Game theory suggests reasonable solutions for classes of games and examines their properties [3].

Game theory was mathematics to express its ideas formally. However, most game theoretical ideas are not inherently mathematical though a mathematical formation makes it easy to define concepts precisely, verify the consistency of ideas, and explore the implications of assumptions [10].

Game theory is the formal study of decision-making in which several players must make choices that potentially affect the interests of the players [12].

Game theory is an autonomous discipline that is used in applied mathematics, social sciences as well as in biology, engineering, political science, international relations, computer science and philosophy. Game theory is the mathematical study of strategy and conflict, in which an agent's success in making choices depends on the choice of others [2].

II. NOTATIONS

Pij is = pay-off of each player where i = index of the combination of decisions and j = the jth player.

P_{11} = Cooperate	P_{21} = Cooperate	P_{31} = Cooperate
P_{12} = Cooperate	P_{22} = Cooperate	P_{32} = Compete
P_{13} = Cooperate	P_{23} = Compete	P_{33} = Cooperate
P_{41} = Cooperate	P_{51} = Compete	P_{61} = Compete
P_{42} = Competition	P_{52} = Cooperate	P_{62} = Cooperate
P_{43} = Compete	P_{53} = Cooperate	P_{63} = Compete
P_{71} = Compete	P_{81} = Compete	
P_{72} = Compete	P_{82} = Compete	
P_{73} = Cooperate	P_{83} = Compete	

III. MATERIALS AND METHODS

This paper uses game tree approach to critically examine the competitive and cooperative habits of wild-life animals in Ovu-Inland, Delta State, Nigeria. It will also compare which of the Approach (i.e. cooperative and competitive approach) used by animals in Ovu-Inland, Delta State looking at the strategies joint hunting and mutual benefits as well as effective resource portioning with territoriality and competition of mates with reproductive success.

IV. TWO-PERSON ZERO-SUM AND GAME TREE

In zero-sum games, the total benefits to all players in the game, for every combination to strategies, always adds to zero (or more informally put, a player benefits only at the expense of others). Many games studied by game theorists (including the Prisoner's Dilemma) are non-zero-sum games, because some outcomes have no results or less than zero. Informally, in non-zero-sum games, a gain by one player does not necessarily correspond with a loss of another.

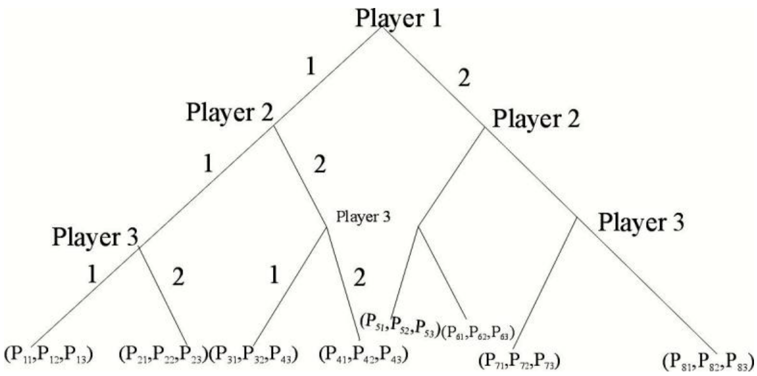
Table 1: Matrix of Payoffs

Player I/Player II	Y_1	Y_2	- - -	**Yn**
X_1	A_{11}	A_{12}	- - -	A_{1n}
X_2	A_{21}	A_{22}	- - -	A_{2n}
I	I			
I	I			
I	I			
X_n	A_{n1}	A_{n2}	- - -	A_{nn}

Table 1 gives the amount of aij won by player I from player II. If player I his ith pure strategy Xi then player II plays his jth pure strategy Yj. Thus, the matrix of pay-off (game) of player 1 are the positive entries while the matrix of the pay-offs (game) of player II are the negative entries of the above matrix.

A game tree lays out all possible moves from a given game state. The tree provides a good formalism to see the complexity of possible moves in an intuitive representation. In the context of combinatorial game theory, which typically studies sequential games with perfect information, a game tree is a graph representing all possible games states within such a game. For example chess checkers, go and tic-tac-toe. Data collection that aided this work, were source from through interview from Delta State Ministry of Environment, Delta State Ministry of Health, Department of Veterinary Medicine as well as Website of previously existing related works.

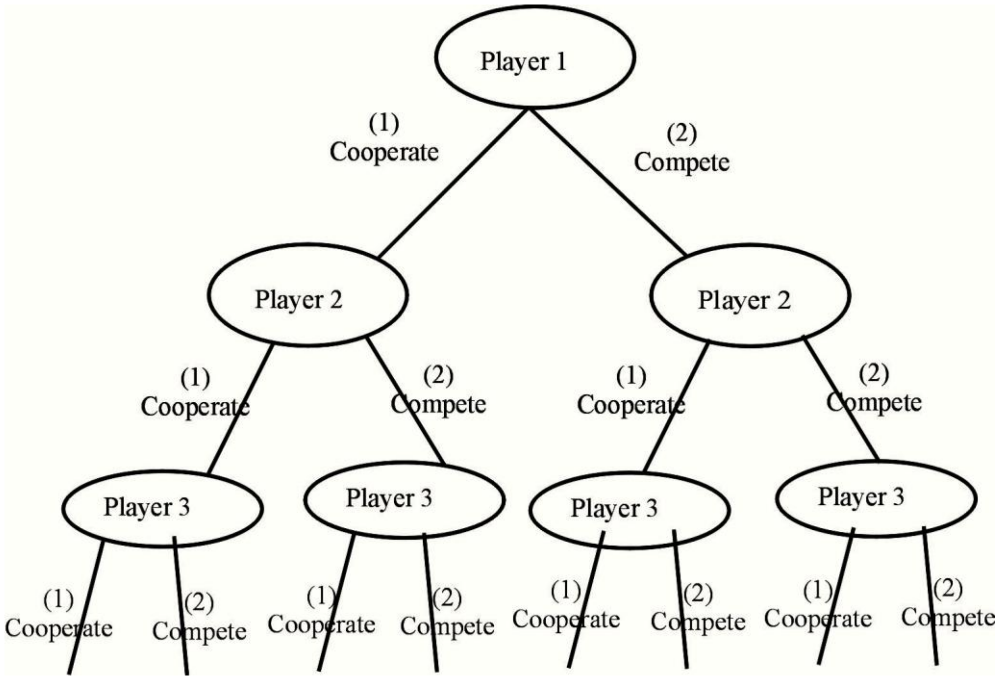
Fig. 1: Showing an extensive game with 3-players 2-decisions.



In Fig. 1, Pij is the pay-off of each player. Subscript i is the index of the combination of decisions while the subscript j refers to the jth player. For example, P_{11} is the payoff for the first combination of decisions for player 1, P_{12} is the payoff for the first combination of decisions for player 2, and so on. This game can be either be with perfect information, when the player who has to make a decision knows the choice of the previous player (s), or with imperfect information otherwise.

Next, this paper will examine how wild-life animals in Ovu-Inland, Delta State uses their respective strategies to either co-operate or compete using a game tree – more specifically 3-players, 2-decision approach. After which, it examine the result obtained from either case and thereafter draw conclusion.

V. CO-OPERATIVE AND COMPETITIVE EXTENSIVE GAME TREE WITH 3-PLAYER 2-DECISIONS



(P_{11},P_{12},P_{13}) (P_{21},P_{22},P_{23}) (P_{31},P_{32},P_{43}) (P_{41},P_{42},P_{43}) (P_{51},P_{52},P_{53}) (P_{61},P_{62},P_{63}) (P_{71},P_{72},P_{73}) (P_{81},P_{82},P_{83})

Table 1: Analysis Showing the Results of Cooperative and Competitive Habits of Animals.

Player 1	**Player 2**	**Player 3**
Cooperative = 4	Cooperative = 4	Cooperative = 4
Compete = 4	Compete = 4	Compete = 4

Table 2: Outcome after Using the Strategies for Cooperation and Competition

		Compete	
Cooperate		B_1	B_2
	A_1	4	4
	A_2	4	4
	A_3	4	4

Table 3: Pay-Off Matrix

		Compete			
Cooperate		B_1	B_2	Row Minima	Maximia
	A_1	4	4	4	
	A_2	4	4	4	4
	A_3	4	4	4	
	Column Maxima	4	4		

Saddle Point => Maximin = Minimax = 4

Taking Inequalities across column, we have
$4x_1 + 4x_2 + 4x_3 \leq g$
$4x_1 + 4x_2 + 4x_3 \leq g$
Recall that $x_1 + x_2 = 1$ (expectation of two-person non-zero sum)
Taking Inequalities across row, we have
$4y_1 + 4y_2 \geq g$
$4y_1 + 4y_2 \geq g$

$4y_1 + 4y_2 \geq g$
Also, recall that $y_1 + y_2 = 1$ (expectation of two-person non-zero sum)
=> $y_2 = 1 - y_1$
$4y_1 + 4y_2 \geq g$
$4y_1 + 4(1 - y) \geq g$
$4y_1 + 4 - 4y_1 \geq g$
$4y_1 - 4y + 4 \geq g$
$4 \geq g$
Similar results occurs for both 2nd and 3rd row respectively.

VI. DISCUSSION OF RESULTS

Using Table 3, notice that the pay-off matrix possesses a saddle point at (Minimax = Maximin = 4) on either strategies chosen (ie from A_1 to A_3). Animals with competitive strategies will try to minimize its greatest loss while trying to exact dominance in the habitat, it can only do this by choosing between strategies $A_1 - A_3$. Similarly, animals with cooperative strategies will equally try to co-habitat while trying to resist predators. The biggest that can befall co-operative animals if it chooses A_1 is 4, which occurs when competitive animals chooses B_1. If co-operative animals chooses A_2, the greatest loss will be 4, which occurs when co-operative animals chooses B_2.

Observe that to minimize loss in wild-life, both competitive and cooperative animals will choose from either strategies from either cases, their greatest loss is limited to 4, which is the saddle point which implies that employing co-operative strategy A_1 (Joint hunting with mutual benefits and Defensive Mechanism with Safety) and A_2 (Resource Partitioning with territoriality and competition of Mates with reproductive success), we notice there is no predictable outcome with an equilibrium situation. (Minimax = Maximin = 4) which implies that all animals from either situation act in their own rational best interest.

VII. CONCLUSION

Notice, there is no geometric increase in either cooperative or competitive habits in wild-life animals in Ovu-Inland which accounts for a saddle point situation (Maximin = Minimax = 4) from either cases. This implies the game has no value as there is no predictable outcome with all wild-life animals acting in their own-rational best interest.

Finally, based on the findings and circumstantial evidence provided from prior conclusion, we conclude that the lack of a game value makes it difficult to predict the outcome of the game and to make advise on best strategies to adopt.

REFERENCES

[1]. Begon, M., Harper, J.L. & Townsend, C.R. (1996). Ecology: Individuals, Populations and Communities. Blackwell Science.
[2]. Bellal A. Bhuiyan (2016). An Overview of Game Theory and Some Applications. Philosophy and Progress: Vols. LIX – LX, ISSN 1607-2278 (Print).
[3]. Chikwendu, C.R. (2009). Elementary Operations Research with Applications. God's Time Publishing Concept, Nnewi.
[4]. Holomuzki, J.R., Ferminella, J.W. & Power, M.E. (2010). Biotic Interactions in Freshwater Benthic Habitats. Journal of the North American Benthological Society 29, 220-244.
[5]. Isabelle M. Côte (2000). "Evolution and Ecology of Cleaning Symbiosis in the Sea Oceanography and Marine Biology" 38:311-355.
[6]. Lang, J.M., & Benbow, M.E. (2013). Species Interactions and Competition. Nature Education, 4(4), pp. 8.
[7]. Lee Alan Dugatkin (1997). Cooperation Among Animals: An Evolutionary Perspective. Oxford University Press.
[8]. Marta C. Soares, Redouan B., Leonida F., Wolfgang G., Michaela H., Katharina H., Rui F.O. (2010). "Hormonal Mechanism of Cooperative Behaviour", Philosophical Transactions of the Royal Society: Biological Sciences 365, no. 1553:2737-50. https://doi.org/10.1098/rstb.2010.0151
[9]. Marta C. Soares, "The Neurobiology of Mutualistic Behaviour": The Cleanerfish swims into the Spotlight. Frontier in Behavioural Neuroscience 11 (2017): 191.
[10]. Osborne and Rubinstein (1994). A Course in Game Theory (The MIT Press).
[11]. Robert Axelrod and William D. Hamilton (1981). "The Evolution of Cooperation". Science 211:1390-139. https://www.science.org/doi/10:1126/science.7466396
[12]. Theodore L. Turocy and Stengel B. Von (2002). Analysis of Dynamics of Voting System for Small Number of Candidates. Journal of Information Technology & Software Engineering 07(04).