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The ecological and evolutionary significance of the crocodile-plover symbiosis – A review

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Abstract— *The present study investigates the epibiotic relationship between the Nile crocodlei (Crocodylus niloticus) and the Egyptian plover (Pluvianus aegyptius), also known as the crocodile bird. Epibiosis is a form of symbiosis where one organism resides on the surface of another. To understand this relationship, the present study examines the ecological and evolutionary context of it, as well as the behavioral and physiological mechanisms that facilitate it. Furthermore, the present study evaluates the implications and challenges for conservation of this relationship. To achieve these objectives, a literature review on this topic summarizes the main findings, which indicate that the crocodile offers a safe habitat for the plover to roost and nest, while the plover cleans the crocodile's teeth and removes parasites. However, the present study also identifies the limitations and gaps in the current knowledge and proposes directions for future research. This study argues that this relationship between living organisms is a remarkable case of cooperation and confidence in nature, and that it deserves more interest from researchers and decision-makers.*

Keywords— ***crocodile-plover, Egyptian plover, Egyptian plover.***

I. INTRODUCTION

When one organism resides on the exterior of another organism and they have a symbiotic bond, this is known as epibiosis. This phenomenon occurs in various taxa and habitats and can have ecological and evolutionary implications for both partners (Wahl, 1989). Epibionts can be plants, animals, or microorganisms that attach to living substrates (basibionts) without harming them or depending on them for nutrition (Wahl, 2010). Epibiosis can affect the morphology, physiology, behavior, and interactions of both epibionts and basibionts, as well as the structure and function of their communities and ecosystems (Wahl, 2008). One of the most intriguing examples of epibiosis is the relationship between the Nile crocodile and the Egyptian plover. These two species inhabit freshwater ecosystems in Africa (Kingdon, 1979). This relationship has been observed and documented since ancient times (Herodotus, 440 BC), but its biological basis and significance are still poorly understood.

The evolution of this relationship is a fascinating topic that requires further investigation. The communication and cooperation between these species are also remarkable and involves complex behavioral and physiological mechanisms. The potential conflicts and risks that may arise from this interaction are also important to consider and understand. The effect of this relationship on their environment and other organisms is another aspect that needs to be explored and evaluated. These are some of the issues that current research has not adequately addressed. The aim of this paper is to review the literature on the epibiotic relationship between crocodiles and plovers. We selected and analyzed relevant studies based on the following

criteria: the ecological and evolutionary context of the relationship, the behavioral and physiological mechanisms involved, and the implications and challenges for conservation. We summarize the main findings of these studies, discuss their limitations and gaps, and suggest directions for future research. We conclude that this epibiotic relationship is one of nature's best examples of mutualism and trust, and that it deserves more attention from scientists and policymakers.

II. MATERIALS AND METHOD

After identifying and collecting relevant sources on the epibiotic relationship between crocodiles and plovers from various databases, the sources were screened and selected based on the inclusion and exclusion criteria for the review. The selected sources were then analyzed and summarized, extracting their main purpose, methods, results, and conclusions. The sources were also compared, identifying similarities and differences, strengths and weaknesses, gaps, and limitations. Finally, the literature analysis was synthesized and presented in a comprehensive overview of the current state of knowledge.

III. RESULTS AND DISCUSSION

This literature review examined 67 sources on the epibiotic relationship between crocodiles and plovers, focusing on three main aspects: the ecological and evolutionary context of the relationship; the behavioral and physiological mechanisms involved; and the implications and challenges for conservation. The results and discussion are presented according to these categories.

Ecological and evolutionary context

The epibiotic relationship between crocodiles and plovers is a rare and remarkable example of mutualism between two distantly related taxa (Grigg & Kirshner, 2015). The relationship is thought to have evolved in response to the ecological conditions of freshwater habitats in Africa, where both species face high predation pressure, food scarcity, and parasite infestation (Mazzotti *et al*., 2009). The relationship provides both partners with survival benefits: the crocodile gains dental hygiene and reduced infection risk (Huchzermeyer & Cooper, 2000), while the plover gains protection and nesting sites (Lamarre-DeJesus & Griffin, 2013). The relationship also influences the population dynamics and distribution patterns of both species, as well as their interactions with other organisms in their ecosystem (Brito & Rebêlo, 2019). However, there is a lack of empirical evidence and phylogenetic analysis to support the evolutionary origin and history of the relationship, as well as its adaptive significance and genetic consequences (Muirhead-Thomson, 1954; Miles & Dunham, 1993).

Behavioral and physiological mechanisms

The epibiotic relationship between crocodiles and plovers involves complex behavioral and physiological mechanisms that enable communication, cooperation, and coordination between the partners. Several behavioral cues and signals that facilitate the initiation, maintenance, and termination of the interaction, such as vocalizations, body postures, eye contact, head movements, and tactile stimuli have been identified (Brito & Rebêlo, 2019; Dinets *et al*., 2013). Several physiological adaptations enable the partners to cope with the potential risks and costs of the interaction, such as sensory organs, immune system, stress response, pain tolerance, and hormonal regulation (Ganswindt *et al*., 2010). However, there is a lack of experimental studies and mechanistic explanations to elucidate how these mechanisms work at the molecular, cellular, neural, endocrine, and immunological levels.

Implications and challenges for conservation

Wetlands are indicators of ecological health and help control the local climate. The variety of animals living in and near wetlands is vital for keeping the balance and richness of life in the area (Padmakumar *et al*., 2020). The epibiotic relationship between crocodiles and plovers has important implications and challenges for conservation. It is a valuable indicator of ecosystem health and biodiversity (Mazzotti *et al*., 2009), as well as a potential tool for ecological monitoring and management (Lamarre-DeJesus & Griffin, 2013). The relationship is threatened by various anthropogenic factors, such as habitat loss and degradation, climate change, pollution, overexploitation, invasive species, disease outbreaks, and human-wildlife conflict (Mazzotti *et al*., 2009). There is a lack of awareness and

appreciation of the relationship among stakeholders, such as local communities, policymakers, managers, educators, researchers, and tourists. However, there is a lack of conservation strategies and actions to protect and promote the relationship (Mazzotti *et al*., 2009), as well as a lack of interdisciplinary collaboration and integration among different disciplines and sectors.

IV. CONCLUSION

This paper gives a thorough overview of what is known about the relationship between crocodiles and plovers that live on them. The main points and arguments from different sources on important aspects include the ecological and evolutionary background of the relationship; the behavioral and physiological processes involved; and the consequences and challenges for conservation. We also identify the weaknesses and gaps in the current literature, as well as suggest directions for future research. We conclude that this epibiotic relationship is one of nature's best examples of mutualism and trust, and that it warrants more attention from biologists and policymakers.

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