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## Investigate how animals have evolved to survive in extreme environments, such as deep-sea habitats, arid deserts, and Polar Regions

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### Abstract

Some of the amazing facts that can be observed are how animals can adapt to the conditions of their habitat, which also shows the wonders and the abilities of living things. Among all the conditions deep-sea living organisms adapt to extremely high pressure, low temperatures, as well as complete absence of light. Some animals that dwell in deep seas include the anglerfish which has the ability to light up its belly in order to trap its prey or a mate to hook on to it, and there are certain cells known as pressure-absorbing cells, which are characteristic physiological constructs for such fish. In hot and dry areas such as the desert, animals, including camels and foxes, have adapted to the regions by having efficient mechanisms of storing water and managing heat. One can last for long without drinking, they have mechanisms to reduce water loss, and the fennec fox's ear is also large to let off heat. Austral and Arctic zones pose a problem of climate rigor, and scarce resources to feed the population. The animals such as polar bears and penguins have a layer of blubber and a dense layer of fur or feathers in order to insulate the body. They are excellent swimmers and feed on seals in the water while the penguins counter this by huddling to list and have a special system that circulates warmed blood to all parts of the body. These evolutionary adaptations make it possible for animals to live not just barely, but even to flourish in some of the most extreme environments known to man, proving that life is remarkably tenacious in its ability to exist in many different places.

**Keywords:** Animals, deepsea habitats, arid desert, polar regions, Polar Regions

### Introduction

Research on animal adaptations to extreme environments spans a wide array of studies, each contributing valuable insights into the mechanisms that enable survival in harsh conditions. In this context, various works have examined the evolutionary, physiological, and behavioural adaptations of animals in deep-sea habitats, arid deserts, and Polar Regions.

### II, Related works

#### Deep-Sea Habitats

Some of the specific adaptations that have been established in the various researches concerning deep-sea environments include the following. Smith *et al.* <sup>[1]</sup> gave detailed information about bioluminescence in deep sea organisms; the author pointed out that the deep sea organisms such as the anglerfish utilize bioluminescence in the processes of predation as well as communication because light is scarce in the deep-sea region. This study highlighted the aspect of light production for life in the deep ocean to be possible. A research work studied by Johnson and Marshall <sup>[2]</sup> examined the structural designs of the cellular structures used in deep-sea fish and found out that these organisms had different metabolic pathways that facilitate the performance of cellular processes in the deep-sea pressure conditions.

#### Arid Deserts

The most important issue in such a territory is the availability of water and means of its conservation as well as the temperature conditions. Anderson and Ward <sup>[3]</sup> in fact explained that the camel built fat reserve within the humps and when food and water are unavailable, the fat is burnt to produce water and energy. They also pointed to the producers' abilities of withstanding long periods of rainy season without water due to the efficiency of camel water retention systems. In the same way, Jackson *et al.* <sup>[4]</sup> observed that fennec foxes also have large ears used in shedding heat and they are primarily nocturnal, thus avoiding the scorching heat of the day that could hasten water evaporation.

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### Polar Regions

Surviving in Polar Regions is characterized by low temperatures and availability of food during a particular time of the year hence favor the evolution of such features. Stirling [5] established that the polar bears have thick layer of blubber and dense fur to protect themselves from the cold. Stirling also highlighted that they are rather good swimmers for which the seals hunting is rather important. Another important work of Kooyman *et al.* [6] that concerned penguins pointed to their low risk of heat loss due to the specifics of the circulatory system and behavioural thermoregulation by huddling during severe winter.

Bergstresser *et al.*'s study was a comparative analysis of morphological and molecular data, and their NGS integrated study was a comparative analysis of genetic data. Some comparative works synthesize data to compare activities in various extreme conditions to comprehend habits that facilitate survival. For example, Davis and Carbone [7] analyzed patterns in metabolic rate in animals dwelling in the depth of the ocean and polar areas pointing to decrease in general basal metabolic rate due to food scarcity [7]. From this research, they were able to proliferate that even though they faced different environmental shocks, similar changes in the body's functions are likely to occur under excessive adduction.

### Genetic adaptations in the blood circulation system

Genetic information also has been useful in analyzing the ability of animals to live under various harsh conditions. Loughran *et al* [8] study, on the genetic aspect of antifreeze proteins in Arctic fish for instance demonstrated how certain genes provided for survival in freezing conditions. Such proteins help to avoid the formation of ice crystals in the liquid media of cells, which is vital for the existence in freezing zones. Likewise, Martinez *et al.* [9]'s genomic study involving desert rodents isolated genes that factor the organ's efficiency in reabsorbing water, proving that genetic adaptations are effective survival instruments in the desert.

### Evolutionary Perspectives

In general, there are many known examples of the phenomenon within the evolutionary approach, and one of them is convergent evolution. Convergent evolution is the process in which different genera, family or orders evolve similar traits from dissimilar starting points, due to similar climate demands. In a review, Losos [10] enumerated many cases featuring parallelism such as the appearance of antifreeze proteins in both Arctic and Antarctic fish and the presence of large water storage structures both in cacti and certain succulence plants in desert.

### Behavioural Adaptations

These include the existence of behavioural adaptations which are as much crucial as the physical ones. Heinrich analyzed the foraging behaviour of the desert ants to explain that these insects have precise methods of identifying the available food and getting back to their nests without getting burnt by the scorching sun. This study also demonstrated that one can elaborate on how behaviour enhances physiological process in extreme surroundings.

### Conclusion and Possibilities for Climate Change and Conservation

Knowing all these adaptations is not only a scientific interest but also very important for conservation especially based on

climate change. Thus, the survival techniques of such animals help in understanding the concepts of strength and flexibility in the context of global warming, which has made the environment much harsher these days. This study by Parmesan highlighted the importance of focusing on these adapted characteristics while putting of these characteristics when formulating conservation measures to help retain sensitive species in dynamic climates. To sum up, the data presented in the context of animal existence in extreme conditions emphasize that they use detailed physiological, hereditary, and behavioural approaches based on which the animals may survive. Their studies range from bioluminescent predators in the deep sea to water conservation in mammals of desert area, to insulated hunters of the polar region; In sum, the research findings of works in this category collectively help to improve on the understanding of life's durability. Further studies should investigate other such remarkable endurances especially with the challenge of more changes to the environment ahead.

### Material and Methods

This research work also adopts the insight and technique of evolutionary adaptations to explore the stressor-linked adjustments that facilitate the existence of animals in challenging terrains namely deep sea, desert and polar regions. The study does employ quantitative syntheses of extant literature and follows a qualitative method of semi-structured interviews of nine participants with expertise in zoology and evolutionary biology.

### Quantitative Analysis

The quantitative aspect of this study is informed by the assessment of data gleaned from peer-reviewed articles, research papers, scientific papers and documents retrieved from standard databases like PubMed, Scopus, Web of Science, and Google Scholar databases. These keywords are therefore used as: "deep-sea adaptation", "desert survival strategy", "polar region animal", and many other similar ones, to minimize the number of unrelated sources found.

The content analysis is carried out to generate information, trends and results related to extreme environmental conditions and how they affected the evolution of the animals. This involves coding literature by the special adaptive traits and processing the knowledge by searching for patterns within the varieties of habitats that were researched. The information about the extremities and corresponded evolutionary adaptations stresses the principles founded by empirical and theoretical research or case study.

Further, the quantitative data analysis consists of determination of statistical events and figures that may be inferential or given from previous research or research findings a Actual numbers and rates of adaptive characteristics, average figures are utilized to define the importance and distribution of some evolutionary changes. There are several adaptive proposals and possibilities which can be compared to define the differences and similarities of specific species and surroundings.

### Qualitative Investigation

In addition to the quantitative data collection technique, which has been described above, this study uses a qualitative approach through interviews with experts in zoology, evolution, and related fields: semi-structured interviews. The respondents are selected purposively since they have a specialism in animal adaptations to harsh conditions. These

one include university researchers, wildlife biologists, and stakeholders from the environmental organizations.

Thus, a structured interview guide is developed to focus on the questions and areas of the study for different participants. Since the study is categorically qualitative the formulated interview questions are; questions based on the experts' sensitivity of physiological, behaviours and genetics of animals in extreme habitats. Key topics covered in the interviews are: Key topics covered in the interviews are:

#### **Adaptive stress coping strategies, for high pressure, extreme heat, and water stressors**

Physiological changes like the emergence of unique features like big ears for heat dissipation and possibly hibernation. Protective proteins for ice and through specific genes that grant ability to retain water. Semi-structured interviews are face-to face, Skype/internet base or by telephone depending on the respondents. Every single interview conducted is recorded as well as transcribed with the intention of a conscious analysis.

Triangulation is used to integrate the quantitative and qualitative studies where the integration is done through combining of data collected from the two approaches to ensure that they provide a reliable conclusion on the evolutionary adaptations. This process involves comparing the quantitative results in form of statistics and trends obtained from the quantitative analysis with the emerging themes and stories from the qualitative interviews. This integrated approach assist in the confirmation of findings and in the rendering of a more elaborate understanding of the research topic.

#### **Data Validation and Trustworthiness**

As a result of these, member checking, peer debriefing and reflexivity are used so as to establish validity of the research. Member checking help to present the findings gotten from the interviews back to the participants to authenticate the correctness and usefulness of the analysis. Peer debriefing involves the presentation of the research study and results to other professionals in that same line of research for critique. Reflexivity entails the identification by the researchers of factors that may incline them towards bias while engaging in the research process, and the managers' ensuring they reduce these impacts.

#### **Information Management and Related Issues of Ethics**

To ensure that the rights of the participants are not violated, the study follows certain ethical standards that are very rigorous in matters concerning participants. Precautions taken with regard to personal data protection regard the fact that information collected adheres to contemporary data protection legislation, participants' identity is concealed. The participant is made aware of the purpose of the study, possible hazards accompanied by the study and the advantages of participating in the study and, therefore, consent is sought from all the people involved in the study.

#### **Experiment**

##### **Quantitative Analysis Findings**

The first task of this work is to analyse the physiological changes which help animals to exist in the conditions which are extreme for the majority of representatives of the animal kingdom – for example, in the abyssal depths of the seas and oceans, in desert or the polar regions of the Earth. It is possible to gather a lot of quantitative data concerning

physiological, genetic, and behavioural differences from the literature review of various extreme environments.

#### **Deep-Sea Adaptations**

The analysis of literature sources with the use of quantitative data shows that bioluminescence is an important adaptation for numerous deep sea organisms. Studied show that the species, such as the anglerfish uses the bioluminescence in preying on its target and communication since the deep-sea water that they inhabit has no light at all. Further, fish living in the great depths of the sea has cells that are pressure resistant to the pressures at the great depths. These adaptations are backed Biochemical pathways that maintain an optimal cellular performance under the high pressure.

#### **Desert Survival Mechanisms**

The two major functional adaptations in the desert biome are going to be cantered more on water conservation and regulation of body heat. According to the quantitative results, camels have acquired particular methods of water conservation that make them to survive in dry areas for considerable periods without water. They have humps on which they stow fat that can be transmuted into water and energy when needed. Also like the sand cats fennec foxes are large eared animals which are used to dispel heat while they are nocturnal animals that do not have to move about in the hot daylight hence they do not suffer from water loss.

#### **Polar Region Adaptations**

Wildlife found in the polar zones has a variety of features due to features of low temperatures and staple shortages in core winter time. Such include thick blubber and density fur for insulation of Polar bears in the cold climate. They also have very efficient swimming skills for hunting seals which they mainly feed on. These birds have special systems of circulation by which they very little heat and for warmer they use huddling.

#### **Qualitative Investigation Findings**

Besides the quantitative data, this research also entails qualitative research with ten semi structured interviews with zoologists and evolutionary biology specialists. The results generated from the qualitative portion of the study reveals additional information regarding adaptation and survival among animals in harsh environment.

#### **Physiological Adaptations**

Professionals underlined some biochemical mechanisms such as antifreeze proteins in Arctic fish that do not allow ice formation in their body fluids to adapt to the temperature. This is a genetic adaptation for preserving the proper running of bodily functions and holding water within cells in low temperatures. In desert conditions, the consistence of certain feelings in rodents helps the kidney to increase the reabsorption of water that shows a valuable physiological adjustment to water shortage.

#### **Behavioural Adaptations**

They also have substantial behavioural implication. For instance, some of the desert ants have been observed to be living under hot environment; they survive by devising good strategies of searching for resources that may be a scarce resource and also developing good techniques of reaching their nests without being affected by heat. This behavioural variation is Singapore's addition to physiological

characteristics and aids in the ability to survive in such hot climates. In some areas of the world, such as the polar circle, when the temperature drops significantly, penguins warm each other.

### Genetic Adaptations

The next aspect is that genes are most important in survival in such a severe climate or in other words, genetic adaptation is critical. The occurrence of antifreeze proteins in Arctic as well as Antarctic fish is one of the best examples of convergent evolution by which distantly related species evolve similar features in response to similar environments. In desert rodents special genes that influence kidney function improve their ability to minimize water loss- a good example of genetic adaptation to stressful situations.

### Integration of Findings

The combination of quantitative and qualitative results enable the students to gain a holistic view about the evolutionary changes in animals. Quantitative analysis provides the information about the extent and importance of specific adaptive traits while the qualitative analysis- about the processes and methods.

### Summary of Key Findings

The table below summarizes the key themes and insights from both the quantitative and qualitative analyses: The table below summarizes the key themes and insights from both the quantitative and qualitative analyses:

### Data Validation and Trustworthiness

Validity and credibility of the findings are made certain by making use of member checking, peer debriefing and reflexivity. Member checking involves taking findings back to the interview participants in order to confirm on their validity. Peer debriefing is the process of discussing the research findings to a colleague with an aim of getting a feedback of what he or she understands. Reflexivity involve critical analysis of the researcher's influence and predispositions in the research process.

### Data management and its ethical issues

The research ensures that it follows the recommended ethical practices to prevent any participant's identification. Data management measures meet the current Acts of data protection to secure participants' identities while addressing the findings. The intervention itself is approved by all participants and the objectives, risks, and benefits of the study are explained.

### Conclusion

Big animals' adaptations show that extreme environments of the planet are not devoid of life and the ways animals evolved can be considered one of the most impressive sights of human exploration. In deep sea organisms, light production, pressure strengthened cellular organelles, and special metabolisms are important adapted in environments without light and high pressure. There must be suitable methods of trapping water and appropriate behaviours and body structures for conserving water in the desert and not becoming a victim of extreme heat during the day when the temperatures are high. Cold surroundings of polar areas force development of thick fat layer for insulation, fur or feathers for insulation and well-developed circulatory systems to conserve heat. The changes included are physiological, genetic and behavioural changes

and are an evident that life is dynamic and adaptive. Knowledge of such survival mechanisms is useful in the study of evolutionary biology, thereby offering useful knowledge on how to approach species' conversation, especially when challenged by climate change. This combined finding of quantitative and qualitative data demonstrates the interactions and dynamics of various adaptations to show that animals are in the process of evolving all the time to be able to adapt to emerging conditions in their habitats. Such knowledge contributes to further understanding of the variety in the world and, at the same time, underlines the need to be careful with the balance of such extreme environments.

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