ECOLOGY OF TROPICAL DESERTS WITH SPECIAL REFERENCE TO BIOGEOGRAPHY AND EVOLUTION OF DESERT ANIMALS

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Summary

Animals of tropical desert regions are surviving in harsh environment and developed adaptability to face all ecological conditions. Birds have mobility and fly to other regions to meet their food and water requirements while some migratory birds have seasonal visits. Large mammals have mobility to reach water points but other species have become accustomed to desert conditions. All animal species found in desert regions have made their own strategies to face the extreme hot and cold environment.

The main problems of tropical desert regions are significant human interface. Dense forests and plantation areas have been squeezed due to human encroachment by clearing plantation areas for cultivation requirements and large scale deforestation for meeting their fuel wood, fodder and timber requirements. Forests and plantation areas are necessary for hiding, hunting and reproduction of animals and animals are helpful for protection of trees, shrubs and vegetation by destructing harmful species. Plantation regions have remained a survival base of animal species and with continuous denudation of vegetative cover, many desert animal species are extinct and others are struggling for their survival in the absence of their habitat.

Unmanaged clearance of vegetated land created various problems for ecosystems of these regions and humans are also facing various problems like shortage of fuel wood, fodder and medicinal produce. Putting marginal lands under cultivation and uncontrolled drawl of water resources have further degraded lands as salinity, alkalinity, water logging, loss in natural fertility of soil are instant problems which caused serious impact over the earth's surface. Humans and their livestock have ruined plantation and animal species and the resultant problems being faced are irregularity in monsoon cycles, scattered rains, and dryness in the environment which have been further

aggravated by acute shortage of water resources. With regular loss of available resources, survival of life over the earth's surface is endangered.

In best interest of revival of ecosystems, destructive human acts need to be controlled by creating conditions of dense forests, sustenance of surviving animal species, and judicious use of water and land resources. These remedial and treatment measures need to be taken in the immediate future to save life on earth.

1. Introduction

Land covers only about 29 percent of the earth's surface and that too not symmetrically arranged about the equator. There is more than twice land surface north of the equator than in the south and twice as much in the eastern hemisphere as in the western hemisphere. If the Pacific Ocean is taken as the centre of a hemisphere most of the land is in the opposite hemisphere. In spite of small amount of land and its uneven distribution, most of the land forms single, more or less continuous system. All main continents are connected or linked by archipelagos. The main system of continents is so arranged that in the north of the tropics, there are large areas of land nearly connected within the tropics and the south of the tropics smaller areas are very widely separated from each other. Oceans are barriers in the distribution of land animals in several ways and modify land climates significantly. Ocean currents sometimes carry land animals to islands or from one continent to another and form process of dispersal.

Countries of the world having ten percent or more areas under tropical deserts are spread over in 43.30 million square kilometers and the total area falling under deserts is 31.53 million square kilometers which is 73 percent of their total geographical area comprising of 17 percent hyper arid, 35 percent arid and 21 percent semi-arid regions. Four countries of North and South American Continents viz. Argentina, Mexico, Peru and Chile are covered. Fifteen countries of Asia fall under tropical deserts, eighteen countries of the African Continent are part of tropical desert regions. Australian Continent has 69 percent desert. Country-wise position of geographical and intensity type of desert is given in Table 1. Out of total 38 countries, ten countries have total area under tropical deserts.

Climate is principally a matter of temperature and rainfall. Temperature of the earth's surface is determined almost entirely by the amount of heat received from the sun, earth's shape and motions primarily determine the distribution of temperature. Sunrays fall perpendicularly over the tropics and limits of zone are therefore northern most and southern most, the sun is directly overhead at extremes of the earth's annual cycle. The tropics have maximum temperature throughout the year, while wet tropics have comparatively lower temperatures in summers. Tropical heat is maintained within a few degrees in all seasons. North and south of the tropics, heat received from the sun diminishes approximately with the curvature of the earth and becomes increasingly seasonal. On mountains, temperature falls with latitude not because less heat is received from the sun but air becomes thinner and therefore colder. The effect of moving one degree north is different at varied places but the tropics have very small and insignificant variation. Dryness remains in most part of the year, which makes it difficult for the existence of plants and animals.

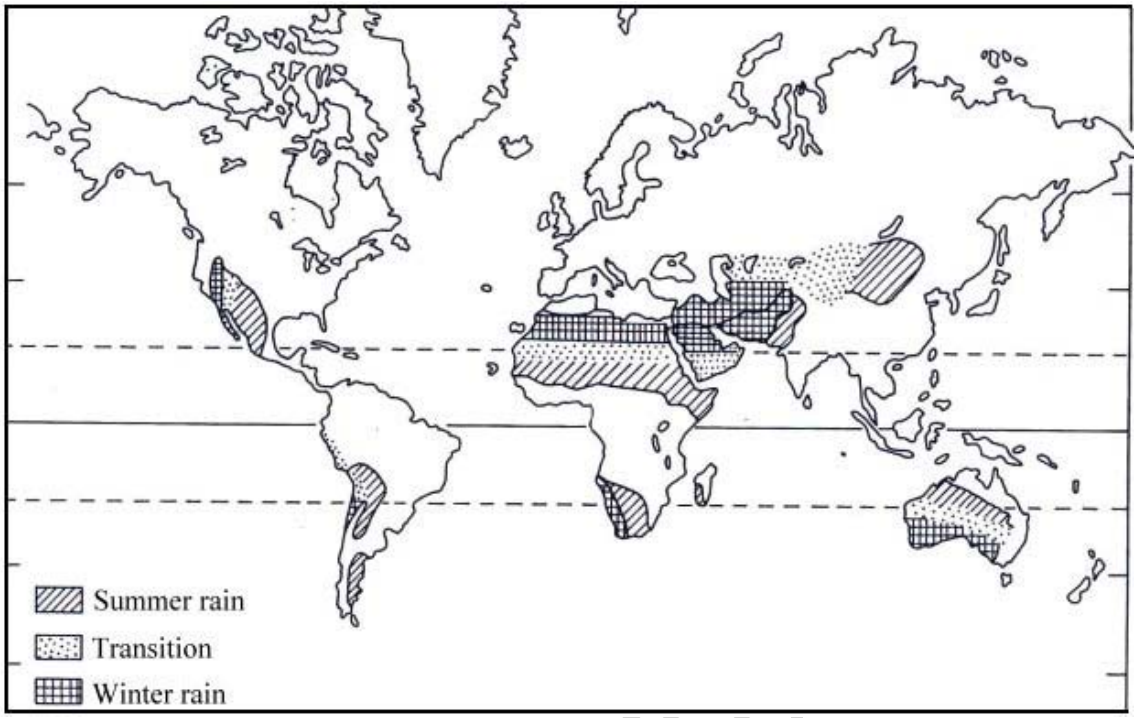

Figure 1. Tropical Desert Regions - Location

Rainfall tends to occur in zones, which depends on wind, which picks up water vapor from the oceans or other wet surfaces and carries it to other areas for rains. Basic zonation of rainfall is determined by the earth's pattern of atmospheric pressure and winds. There are zones of high pressure just outside the tropics in the northern and southern hemispheres; winds blow away from high pressure zones, carrying water with them and leave desert regions. Most of the great deserts in the north and south-west Africa, south-western Asia, North and South America and Australia lie in the high pressure zones near and across the edges of the tropics. In many places of the tropical regions, rainfall is seasonal and annual dry seasons are greatly pronounced to be difficult for survival.

The word 'Tropics' is evidently derived from the Tropics of Cancer and Capricorn, parallels of latitude of 23.5 degrees N and S, which indicate the outer limit of areas where the sun can never be in zenith. This area includes all regions of the earth where the sun reaches directly overhead at least once during the solar year in temperate zones north of the Tropic of Cancer and south of the Tropic of Capricorn. Tropic is a Greek word meaning turn because the apparent position of the sun oscillates between the two tropics with a period that defines the average length of a year. It is generally understood that tropical regions are mainly found between these two lines. They are, therefore, regions of low latitudes but the outer limits of these low latitudes are not easily determined as the Tropics of Cancer and Capricorn themselves are unsuitable as boundaries. They are too rigid and some areas with clear tropical characteristics are found at latitudes of more than 23.5 degrees while on the other hand some clearly non-tropical regions are found much closer to the Equator. Therefore, the best way to determine the outer limits of tropical desert areas is to use climatic characteristics,

which distinguish these regions from rest of the world. All geomorphic processes are directly and indirectly related to climatic features. Delimited in this way the tropics constitute a belt around the Equator varying in width from about 30 degrees south to 30 degrees north latitudes. Within the tropics lies approximately 30 percent of the earth's surface, more than half of which is covered with water. The Tropics receive over half of the world's total rainfall. Accordingly two-thirds of the total rainfall has been estimated to fall between 30 degrees north and 30 degrees south.

Annual rainfall varies from 0 to 10,000 mm in the tropics and this variation for geographic conditions caused large desert area within these limits. Desert regions exist outside the tropics but for limiting study of tropical deserts, the focus has been on the tropical area and deserts existing in between the identified area. Tropical regions are frost free, have only small variation in length of day, and have seasons defined by water availability rather than temperature. This poses some distinctive soil characteristics, more especially high levels of mineral accumulation in soil, combined with rapid leaching of nutrients. Temperature is relatively uniform and the monthly distribution of rainfall determines vegetation and geomorphic processes of each tropical region. The main characteristics of rainfall are intensity of storms, much of rain falling in few heavy downpours usually accompanied by strong winds. The intensity of storms is often in excess of infiltration capacity of the soil, much of the rain is lost by run-off, rather than by building up of soil reserves. Run-off flows over fertile topsoil causing flash flooding of streams and rivers. These effects are most marked where ground water is scanty. Occurrence of rain is scanty in desert regions and vegetation is very meager. Heavy rainfall areas have dense forests. Investigation in tropical regions indicates climatic changes especially during the quaternary period, giving rise to various morphogenic features. Deforestation is a general problem, which is due to the impact of various human factors like cutting trees for timber, fuel, and grazing animals, which disturbs the monsoon cycle. Such lands start deteriorating their fertility due to reduced occurrence of rains. Thus the present tropical deserts have emerged mainly due to disruption of monsoon system and large-scale deforestation.

The tropical ecosystem consists of rainforests, dry deciduous forests, spiny forests and other habitat types. There are often significant areas of biodiversity and species endemism particularly in rainforests and dry deciduous forests. Some examples of important biodiversity and high endemism ecosystems are Costa Rican rainforests, Madagascar dry deciduous forests, Water berg Biosphere of South Africa and eastern Madagascar rainforests. Soils of tropical forests are generally low in nutrient content vulnerable to slash-and-burn techniques, which are element of shifting cultivation agricultural systems. Biotic factors of desert ecology include interface of plant, animal and bacterial populations in the desert community. Some of the abiotic factors contain latitude and longitude, soil and climate. Each of these factors has caused adaptations to particular environment of any specific region. Deserts are most notable for their dry climates resulting from rain-blocking mountain ranges and remoteness from oceanic moisture. Deserts occupy one-fifth of the earth's surface and occur in two belts between 15 to 35 degree latitude in southern and northern hemispheres. Deserts support diverse communities of plants and animals and arid conditions and ecology is characterized by dry, alkaline soils, low net production and opportunistic feeding patterns by herbivores and carnivores, lichens and blue green algae are significant primary producers in

deserts. Detrital food chain is less important in desert ecology than ecology of other regions.

2 Animal Species

Special groups of animals, often rather specialized, are found in limited aquatic environments in deserts. Animal species are differentiated in view of body system, movement system, nature and frequency. Dietary systems of desert organisms are determined by the need to maintain water balance. Characteristics of various animal species found in tropical desert regions are as under:

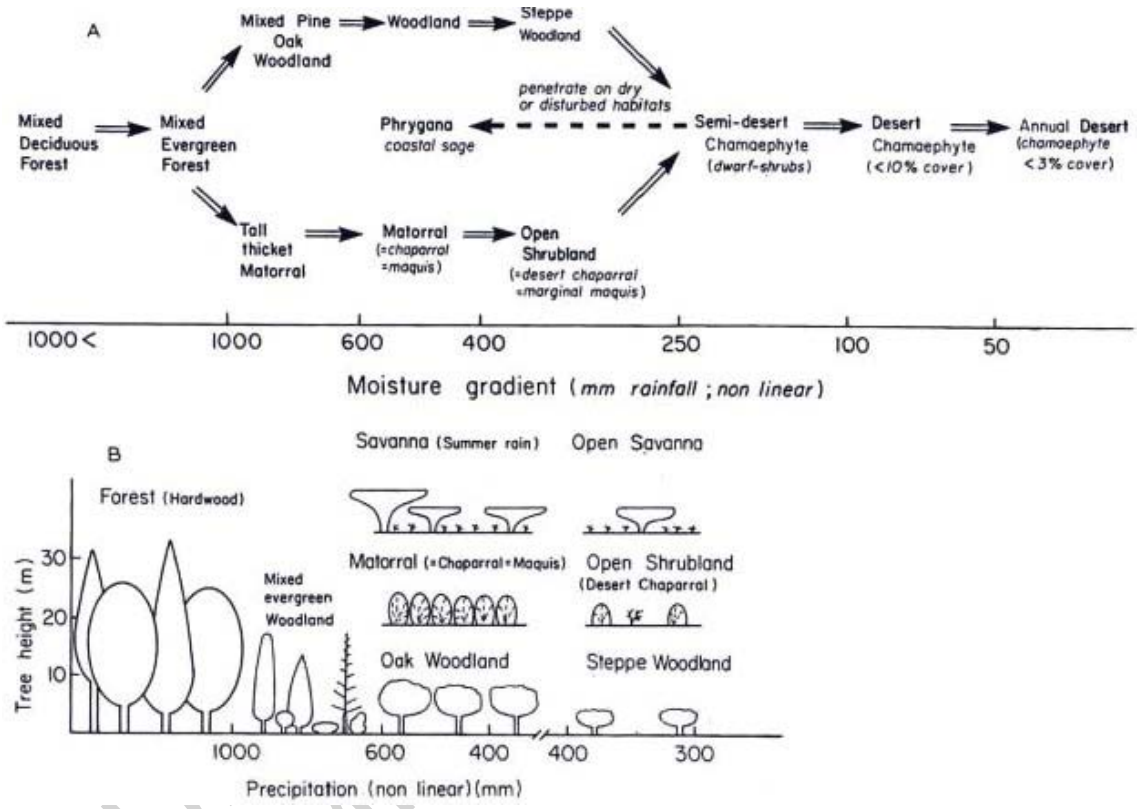

Figure 2. Moisture Gradient Precipitation

2.1. Mollusks

Mollusks are species of animals covering snails, sphincterochila zonata etc. Snails feed primarily on leaves of higher plants, feed on surface mud, which contains sufficient amount of detritus to maintain snails. Main adaptations of Mollusks are (1) heat balance (a) high heat tolerance of the body, (b) high radiation reflectance by white shell and (c) isolating air layer between the body in the upper part of shell and hot soil.(2) hctivity (activity) pattern (a) activity restricted to rainy days with wet soil and low temperatures, inactivity between rainfalls (b) capability to survive in crypto-biotic state during most of the year and (c) capability during short periods of activity to take up sufficiently large amount of water and food to enable survival during long anabiotic phenophase. (3) water balance (a) low evaporative water loss during cryptobiosis and (b) capability of maintaining continuous high hydration during anabiotic phenophase by formation of

metabolic water. (4) heproduction (a) Synchronization of reproduction with favorable environmental conditions and suppression of reproduction in drought years and (b) oviposition in localities protected against overheating and desiccation (5) relative longevity between eight to fifteen years as counter-balance against high mortality of young species. These desert snails can be compared with hyper-arid-passive plants where the activity rhythm is controlled most drastically by environment.

2.2. Arthropods

Arthropods comprise of Isopodan, ants, beetles etc. Mites eat termites while applying their pedipalps and chelicerae in preparation for sucking termites dry. They also eat fungi in active stage. Adaptations shown by these animals include (1) activity pattern (a) avoidance of dangerous heat load and water loss by staying in acclimatized burrows-low temperatures, high air humidity, during hot period of day e.g. hemilepistus, ants, (b) nocturnal animals are active only during nights with favorable environmental conditions and (c) activity of diurnal animals is restricted to favorable times of day- that is to early morning and late afternoon in hot summer and to most of day during cool winter. (2) water balance (a) conservation of body water by low rates of integumentary transpiration and spiracular control of water loss, (b) dew and condensed fog as water source, (c) capability to take up water vapor from unsaturated atmosphere, (d) prey as sole water source for carnivorous arthropods and (e) formation of metabolic water by digestion of dry, energy rich, plat material e.g. seeds (3) reproduction (a) reproduction initiated directly and/ or indirectly by rain and (b) eggs heat resistant(4) relatively low metabolic rates, low values for respiratory , reduced oxygen consumption(5). Long time of survival without water Coloration of desert arthropods poses interesting problem. Many are black, some white. White color reflects a large part of incoming radiation, decreasing heat load of animals and enabling it to be active during hot time of day. Black color causes absorption of radiation and therefore possibly permits animals, which are inactive during the hot time of day to prolong their early morning and late afternoon activity.

2.3. Reptiles

Reptiles e.g. lizards, snakes etc show various types of adaptations to desert environments. Lizards are feed on termites, beetles, saw-flies, moths, butterflies, while snakes feed on warm blooded animals using their heat sensing pits to detect prey and some species eat lizards which are easy to swallow. (1) Activity pattern: (a) through high mobility and use of stress protected microhabitats, diurnal reptiles are exposed to heat and water stress only for short periods and (b) nocturnal reptiles avoid environmental stress by remaining in deep burrows or in shady micro niches like geckos below stones.(2) Heat balance; (a) temperature control by counter-current heat exchange and cutaneous vasodilation with heating and vasocontraction with cooling and (b) color change from dark to light may occur by contraction of melanophores. (3) Water balance (a) prey constitute water source of carnivorous reptiles of herbivorous reptiles, (b) excess electrolytes taken up perforce from halophytes eater are eliminated through salt-gland excretion enabling animal to balance its hydrature and osmotic potential and (c) body water is conserved by excreting semi-solid urine (4) Reproduction Some lizards abandon social behavior and reproductive activity altogether during drought years.

2.4. Birds

Most birds associated with deserts are insectivorous, while there other modes are dry seeds, green vegetation. Adaptations of birds to desert environment include:

(1) Heat balance (a) constitutionally high body temperatures (2-4 degree C higher than in mammals), (b) facultative hyperthermia, (c) protection against overheating by air enclosed in plumage, (d) cooling by soaring at high altitudes and by special posture of wings when resting, (e) evaporative cooling by panting and gular fluttering, (f) water conserved by low glomerular filtration rate (GFR) reduced urine flow (UFR) and excretion of almost solid uric acid and (g) dietary intake in water source for carnivorous and omnivorous birds.

(2) Activity patterns (a) during hot season main activity of day-active birds in early morning and evening, resting in shady itches during hottest hours, (b) some species exclusively nocturnal, (c) herbivorous birds especially seed eaters can fly large distances to few sources of drinking water and transport water in their plumage to their young and (d) nesting sites are selected or constructed to avoid stress (nests in rock fissures or on soil below protecting roof or rock open to north-western ventilation, or stone walls at entrance of nest.

(3) Reproduction: (a) breeding synchronized with rainy season, triggered by rain in regions with summer and winter rain sometimes bimodal breeding and (b) clutch size varies in accordance with rainfall.

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Biographical Sketches

Dr. T.S.Chouhan is a Senior Geographer in the Department of Geography, University of Rajasthan, Jaipur, India. He is engaged in teaching and research primarily in the fields of environmental geography, remote sensing and its applications, geography of arid lands, agricultural geography, cartography and GIS and GPS and Integrated Area Development. Dr. Chouhan has worked in reputed institutions of learning and research like the Central Arid Zone Research Institute, Jodhpur, Department of Geography, University of Jodhpur and National Remote Sensing Agency, Hyderabad. He was also awarded post-doctoral fellowship and research Associateship by the University Grants Commission, New Delhi. He has to his credit more than 70 research papers published in reputed journals in India and abroad and is author of more than two dozens of well acclaimed books. He has been guiding research work for more than two decades and supervised more than three dozens of doctoral theses. Dr. Chouhan is a recognized consultancy expert to the Government of Rajasthan, Planning Department in various fields of Watershed Development, Forestry, Land Management, Water Conservation, Remote Sensing and Digital Cartography. He is also trained in GIS Application from National Institute of Rural Development, Hyderabad and using it for current projects. Dr. Chouhan visited Brazil, Morocco and Saudi Arabia in connection with the United Nations Workshops on Combating Desertification through Space Technology.

Mr. Uma Kant Sharma is an Economist and presently working as National Level Monitor in the Ministry of Rural Development, Government of India. He remained associated with the preparation and implementation of the World Bank assisted project on Poverty and also worked in World Bank assisted Watershed Development Project. Mr. Sharma visited Bangladesh for impact assessment of poverty eradication program. He has to his credit various activities related to treatment of degraded lands, implementation and evaluation of rural development programs of Rajasthan state of India. He had prepared multi-sectoral Geographical Information System of Rajasthan on area and distance approach.