

# THE CAUSES AND SIGNIFICANCE OF STRIPES ON ZEBRAS

Dr. Deepak Rawal

Assistant Professor

Department of Zoology

Mohanlal Sukhadia University, Udaipur, India

**Abstract:** Stripes and spots on animal body always intrigue mankind. We also sometimes cross zebra crossing at road. As a human we know the importance of color pattern in the races of the world. Different tribes living in Africa, North America and Australia use striped body painting to deter biting flies. There are hundreds of animals with different pattern of stripes. Stripe riddle has puzzled mankind for over a century. Even Charles Darwin and Alfred Russell Wallace were unable to give plausible explanation for this. Dark color of skin or fur contains melanin which protects against ultraviolet radiation and helps to get more heat from sunlight. In general, there are four main reasons seems for evolution of these unique patterns amongst animals *viz.* camouflage, sexual selection, defense and aposematism. In this research I discuss and analyze various hypotheses of causes and significance of stripes on Zebra.

**Keywords-** Zebra, Stripes, Hypothesis, Melanocytes, Melanophores, Camouflage

## INTRODUCTION:

Stripes and spots on animal body always intrigue mankind. We also sometimes cross zebra crossing at road. As a human we know the importance of color pattern in the races of the world. Different tribes living in Africa, North America and Australia use striped body painting to deter biting flies. There are hundreds of animals with different and distinct pattern of stripes *viz.* Tiger, Chipmunks, Coral Snake, Honey Bee, Monarch Butterfly, Butterfly fish, Tasmanian devil, Okapi, Tiger salamander, Coral fish, Clownfish *etc.* Most interesting and unique case is of Zebra stripes. Some questions always puzzled us like what is cause and function of these stripes? Do they have any significance? What selective pressure causes their evolution? This stripe riddle has puzzled mankind for over a century. Even Charles Darwin and Alfred Russell Wallace were unable to give plausible explanation for this. Dark color of skin or fur contains melanin which protects against ultraviolet radiation and helps to get more heat from sunlight. In general, there are four main reasons seems for evolution of these unique patterns amongst animals *viz.* camouflage, sexual selection, defense and aposematism. Zebras are ungulates currently living in Africa including Savannah and Serengeti. They found in variety of habitats such as woodlands, mountains, scrublands, grasslands *etc.* Zebras evolved among the old world horses within the last four million years. There are three

living species of Zebra viz. *Equus quagga* (Plain Zebra/Common Zebra), *Equus zebra* (Mountain Zebra) and *Equus Grevyi* (Imperial Zebra). They are undomesticated because of their unpredictable and aggressive behavior. They forage with Antelope and Wildebeest. Lions, Leopards, Hyenas, Cheetahs, Foxes, Wild dogs and Crocodiles are their main predators. Stripes on them are typically vertical on the head, neck and body while horizontal on rear and legs. Sometimes spotted and albino Zebra are also reported.

## RESULTS AND DISCUSSION:

In vertebrates color patterns are composed of specialized pigment producing cells that show extensive cell-cell interaction and communication to form a final pattern. Pigment cells originate from the neural crest located at the dorsal neuroectodermal ridge from which progenitor cells migrate out into periphery to develop peripheral nervous system, glia and pigment cells [7]. Mammals have mainly one pigment cell type the melanocyte, producing the melanin pigment that is secreted into the skin and its derivatives like hairs and fur. Melanin is further of two types light pheomelanin and dark eumelanin. Birds show carotenoid based and structural colors [11]. In contrary lower vertebrates such as fishes, amphibians and reptiles develop several pigment cell types called chromatophores like xanthophores, melanophores, iridophores *etc* each producing different colors [2].

Color patterns of animals are genetically determined. Stripes may be colored or black and white. Stripes are due to pigments in skin or integumentary derivatives. Zebras have thin coats of hair in comparison to other furred mammals. The Zebra is naturally black in early embryonic stage and white stripes appear in later embryonic stages when the production of dark pigment is inhibited. In *Equus quagga* stripes are determined during third week, in *Equus zebra* the fourth week and in *Equus grevyi* the fifth week of embryonic development [9]. It means Zebras are black with white stripes. Each Zebra has somewhat different stripes like our fingerprints. Zebra like other ungulates are color blind but have good night vision but we have to keep in mind that their main predator lion is also colorblind.

Genes affecting the production of pigments and colors have been identified by mutations in many species [6]. A study on African striped mouse (*Rhabdomys pumilio*) revealed that *Alx3* is regulator gene in stripe development process. Pigment producing melanocytes did not develop fully where light stripes appears and gene *Alx3* was found more active where light stripes formed and acts as inhibitor of a protein that induces cells to produce pigment. A study on Japanese four lined snake (*Elaphe quadrivirgata*) showed that melanophores first appeared in myotomes and body cavity but not in skin surface during early embryonic development. Epidermal and dermal iridophores and melanophores appears later in embryonic development [1]. Another study on Zebra fish revealed that their skin patterns are made up of light xanthophores and dark melanophores that interact with each other. In this interaction xanthophores chase and melanophores run. This interaction leads to the initially disorganized pigment cells separating into the directed manner to form distinct stripes [5]. A further study revealed that agouti related peptide 2 facilitates convergent evolution of stripe patterns across Cichlid fish radiations. Some scientists suggests that different

orientation of stripes like horizontal, vertical and diagonal have evolved for different purposes. According to a computer model horizontal stripes are more visible than vertical stripes. Various hypotheses have been suggested to solve this stripe riddle. Let's look most plausible hypotheses one by one.

First hypothesis is that it provides camouflage by disruptive coloration during foraging [3] and [13]. Some suggests it provide camouflage in the dawn and dusk but we know that Zebras and their predators both are diurnal and forage during day time. There are many flaws in it such as grasses of Africa are not tall enough to hide them and also brownish but zebra are with white and dark stripes are even more conspicuous by it so with present perspective we must deny this hypothesis.

Second hypothesis is of aposematism it means they are warning their predators that they are unpalatable [4]. They more conspicuous than other cohabitants like Wildebeests and it may be to generate clear distinction from other palatable preys. This is also seems not true because predators are frequently hunting them.

Third hypothesis is that, stripes confuse predators while they move individually or in herd and break up animal outline so predator can't focus on them and try to avoid them [12] but field results is not in concordance with it.

Fourth hypothesis is that, stripes helps in thermoregulation. As we know that dark colors absorbs more heat than light colors. Some suggested that differential heating on body produce a counter cooling which keeps the Zebras cool to some degrees. [3] This conclusion was drawn on the data collected from various populations of Zebras in which more stripes were found on warmer areas. When this hypothesis was tested practically by means to put striped water containers in the field and no difference in temperature of controlled and striped water containers was found so this hypothesis is also not true.

Fifth hypothesis is that, stripes are unique and used in individual recognition in herd. According to this hypothesis, as a gregarious animal Zebras live in a herd so they identify each other by these unique stripes on them [4]. I don't think this may be true because we don't identify each other by our fingerprints and nervous system of any mammal is not so developed to detect this sharp and complicated detail. There are many other methods of individual recognition like scent, sound *etc* like other equines.

Sixth hypothesis is that, stripes helps to choose partners and helps in sexual selection. This is also not looks true because there is no sexual dimorphism in stripes of stallion and mare and even foal for parental care.

Seventh hypothesis is they deter tsetse fly and horse fly which cause sleeping sickness, anemia and influenza in them and protects them from disease transmission. Stripes may create a dazzling effect when Zebra is in close proximity [8] and stripes may disrupt the vision of flies [10]. As we know that stripes reduce polarized light. Flies preferred to land on dark surface because it reminds them of mud or water in which they breed. Flies can detect motion, shapes and even colors. Flies eyes are stationary and mosaic so can't focus so they are unable to see pattern so it is speculated that flies either misinterprets the stripes as

different individuals or it creates a depth perception issue where flies miss the Zebra as to feast on it. This hypothesis seems true on function of stripes but does not explain the cause of stripes.

Eighth hypothesis is that their ancestors were habitants of dense forest and stripes provided camouflage through obliterated shadowing by pattern mixing [9]. By means of natural selection theory this hypothesis seems to be most feasible. According to this hypothesis ancestors of Zebras were inhabitants of dense forests and migrate to grasslands and mountains later but their stripes remains with them but there is also a flaw, if we see stripes of other animals like tiger they seems to mix well in forest but white and dark stripes are very strange and unique. It seems that it might beneficial in tundra like ecosystem.

Ninth personal hypothesis of mine is that, these stripes protect them from large predator birds earlier and after extinction of large predatory birds, these stripes became redundant today. When see from above Zebras does not look like living entity and also unpalatable, so predator birds might avoid them as their prey.

Tenth hypothesis is that it is just a redundant genetic anomaly generated by mutation in some genes that have nothing to do with any benefit or loss and we are potentially concluding its cause and significance by various means. If it is true, then question arise that, why environment does not change this redundant trait in millions of years?

## CONCLUSIONS:

All hypotheses seem to be function of stripes but no one explains origin and evolution of stripes. It is also possible that albino genes are partially activated and produce these stripes. It is also possible that they are descendent of fertile hybrid of a black and an albino Zebra. I think we are missing something and we must look from different perspective. I think it is not a case of chance mutation and stripes evolve slowly over generations from less to more as we see in lineage of Zebras. It means there a definite connection of stripe to natural selection and environment. It is a unique case like origin of life on earth. If we want to solve this mystery, we have to guess exact environment at the time of origin of these animals because only environment can originate and evolve a trait. I think that striping is a best example of timed and tuned cellular communication and show their fitness as they have better cellular communication and due to metabolic gradient of cells and their by products during early development. Animals with stripes show their superiority of genes and fitness by these stripes like we do show in some traits like facial symmetry.

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