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AN OBSERVATION OF FRACTAL PATTERN OF HEAD SCALE ARRANGEMENT OF DIFFERENT SNAKE SPECIES

Zoology

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ABSTRACT

The structural symmetry of dorsal head scales of different snake's species was analyzed based on the fractal dimension, using MatLab. Different snake species from India, have been examined for their structural symmetry. The results provide similarities of their FD value. The statistical data supports them and the study may provide a new approach in respective fields.

KEYWORDS

Fractal Dimension (FD), Fractal geometry, MatLab

INTRODUCTION

Snakes are elongated, legless, carnivorous reptiles of suborder Serpentes. The adaptation of snake with its respective habitat is performed by snake skin, which is covered with well-arranged scales. The scales on the back of snakes are either smooth or they are keeled (Whitaker and Captain, 2004; Proksch et al., 2008). Except head, snakes have imbricate scales, overlapping each other. Snakes have rows of scales along the whole or part of their length and also many other specialized scales, either singly or in pairs, occurring on the head and other regions of the body (Kaplan, 2000).Continuation of head to neck scales and their arrangement can be identified in dorsal view of head as shown in figure-1.Various types of scales are remarkable first for the identification of species and also to classify the snake whether it is poisonous or non-poisonous.

Organizations of Head Scale:

The shape of head and scale arrangement plays key role in identification of snakes. Different shapes of head like a broad arrow head, spade, and oval so on are the base for identification (Fig. 1) (Schmidt and Gorb, 2012). We found the arrangement of scales around eye, nostril, snout and around the neck are symmetric and repetitive patterns and follows the fractal property and measure the symmetry by counting fractal dimensions. The hypothesis has been proposed to express fractal symmetry of snake scale. Thus, fractal property of scale can be described and obtained, Fractal Dimension value gives an integral relationship of different species of snakes of India and also may provide tool to differentiate between venomous and non-venomous snakes.

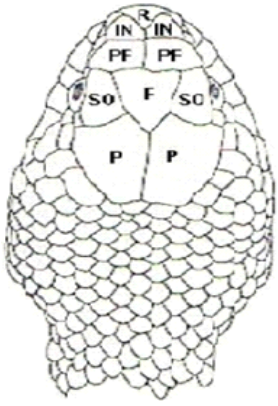

Fig.1: Detailed structure with dorsal view of Head Scale of family Colubridae

Table 1: Different families with their mean FD values

Snake Type	Family	Mean	Variance	Range
Venomous	Elapidae	1.837	0.004	0.2622
	Viperidae	1.8137	0.003	0.25
	Hydrophidae	1.8553	0.0020	0.17
	Colubridae	1.8298	0.001	0.11
Non-Venomous	Pythonidae	1.8048	0.005	0.13
	Typhlopidae	1.7372	0.04	-
	Boidae	1.8137	0.01	0.18

Fractals and Fractal Dimension

The word 'Fractal' was first coined by the mathematician B. B. Mandelbrot, (1975). The term derived from the Latin word 'Fractus' means franger, to break (Mandelbrot, 1982). Briefly, fractals are defined as a self-similar pattern. The fractals express the contracting similarities, whose small scaling exhibits the phenology of whole object. The skin structures or the scales of many living organisms also exhibit self-similarity in their arrangement viz. fractal property. This fractal property of any object can be measured by computing the fractal dimension using the box counting method.

$m = (1/r)D$

where, m is the function of scale factor r i.e. m(r), which denotes the number of scales down pieces, are needed to fill the original geometric shape. The D represents the dimension. The following algorithm can be used to measure the complexity of fractal structure and fractal dimension

METHODOLOGY

Total 36 species with 23 non-venomous and 13 venomous snakes of India from seven different families have been selected as per their availability from documentation and checklist of snakes of India from Zoological Society of India (ZSI). Only the head scale pattern has been considered from the dorsal and dorsolateral position of the snake. For calculation of FD high resolution captured photographs and also from authentic snake blogs (1-5) were selected. To maintain the equal image size the images were converted into web-large size image (640×800 px) and with resolution quality for each sample, head to neck part has been considered. For single species twenty photographic samples were selected. Then further modify for their calculation of FD value. The head scale pattern counter down in colorless image for exact consideration and a drawing diagram has been prepared. Further equal sized photographs were uploaded in MatLab version 2015Ra, FD was computed and graphs have been prepared to evaluate the value of FD value by using scale down factor.

RESULTS

The obtained FD value of different venomous species are found to be around 1.8 and seems to be change at the third decimal place. Among all the venomous species; the Bamboo Pit Viper has lowest mean FD value (1.79492), whereas the Yellow Sea Snake has the highest mean FD value (1.8766). This reflects the simple scale arrangement of Viper's head. The scales on Viper's head are small and more or less equal, which exhibits the fractality with more symmetry and less complexity. Total 23 species of non-venomous snakes have been considered from which the Common Worm Snake from Typhlopidae possess lowest mean FD value (1.73728), whereas Red Sand Boa from Boidae family possess highest FD value, is 1.90866. The comparative account of mean FD value for different families i.e., four from venomous and three from non-venomous snakes have been also considered and is found to be around 1.8, except family Typhlopidae

from which only one member has been considered is Common Worm Snake having mean FD value of 1.73728. Thus, from this obtained FD value, the simple scale structure can be observed. Moreover, Worm Snakes are smaller with cylindrical worm like structure and smooth scales arranged transversally. The mean FD values of different families with variances and range is shown in table 1. Further the data were put for the statistical tests as shown in table 2. Thus, statistical values suggested to favor the null hypothesis that mean FD values are found to be similar for different snake individual, which have habitat in different geographical regions. They might be committed for different scaling pattern which lead for their adjustment in surrounding environment.

Table 2: Statistical data

Name		Statistical Tests	Statistical Value			Results
			F value/ t Value	F crit/ t crit	P Value	
Between Families	Venomous Snakes	One-way ANOVA Single Factor	0.68	2.12	0.71	H0= H1
	Non-Venomous Snakes	”	1.62	1.71	0.07	H0 = H1
Within Families	Elapidae	”	0.71	2.86	0.59	H0 = H1
	Viperidae	”	0.47	3.23	0.7	H0 = H1
	Hydrophidae	”	1.1	3.23	0.37	H0 = H1
	Colubridae	”	1.59	1.79	0.09	H0 = H1
	Pythonidae	”	0.62	3.88	0.55	H0 = H1
	Boidae	”	2.37	1.85	0.02	H0 = H1
Within Genus	Lycodon ″	Un-paired t-Test	1.44	1.85	0.09	H0≠ H1
	Spalerosophis		0.82	1.85	0.21	H0 = H1
	Bungarus		-0.27	1.85	0.39	H0 = H1
	Hydrophis		1.78	1.85	0.05	H0 = H1

CONCLUSION AND DISCUSSION

The FD value of snake skin i.e., scale, provides interlinking with phylogeny, which are taxonomically classified depending on their pigmentation, scale type, pattern and arrangement with their evolved traits and habitats. Different snake species which are found at different geographical regions of India, for example, Rock Python found throughout India whereas Burenes Python is restricted to north and Reticulated Python is only found in Nicobar Island. These species which are distinct for their habitat and with that scales may modified but show unique similarities in their fractal arrangement. In the present study scale arrangements of both venomous and non-venomous show the dramatic similarities for their fractal properties and related Fractal Dimension, which also express the similarity in their ultimate arrangement. Thus, the study concluded the geometrical symmetry of scale pattern of different snakes which are classified as a distinct species. The results of study also support the previous findings of development and evolution of different taxas of snakes; from primitive snakes like Boa, Python to the modern snakes like Green Vine Snake and others with advanced arrangement of scales (Reeder et al., 2015). FD data provides strong efficiency to support the concept of interlinks and development of snake species. With that it can be also marked as a one of the important useful tools to support the theory of Biology like evolution and natural selection. Thus, FD value of snake head scale gives the complexity and similarity of head structure, the same FD value can also be obtained for dorsal scales, tail scales and for the scales of the whole body also. Thus, the present obtained data provide an understanding of taxonomy of snake species along with scales complexity can be observed and also be considered as a supportive tool to describe Animal Biometry.

Abbreviations:
F- Frontal
IN- Internasal
P-Parietal
PF- Prefrontal
R- Rostral
SO- Supraocular

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