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Computational Tools in Predicting Earthworm Distribution: A Pilot Study

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Abstract: The study revealed that amongst all parameters, longitude, latitude, elevation and habitat revealed maximum correlation with distribution of earthworms. The methodology used is the first report of application of heatmap and correlation in ecological distribution of earthworms.

Keywords: Heatmap, Ecology, Distribution, Earthworms

Earthworms, belonging to phylum Annelida find importance as natural tillers of the soil. India being a country rich in its biodiversity and earthworms being of agricultural importance, their, ecology and distribution finds importance (Julka et al 2009). Since they are associated with soil and its quality control with a direct impact on agriculture, plant production, maintaining top soil quality, the study of the vast topic of ecological distribution of earthworm is complex but is of high importance. Earthworms mostly live in the soil, in different ecotypes of epi-endogeic, epigeic, endogeic, aneic forms, thriving on plant litter and soil (Ghosh 2019, Ghosh 2020-2021). Some aquatic forms of earthworms are also known residing in fresh water like lakes, ponds, soil adjoining fresh water areas etc. Like all life forms in the planet, earthworms are also being subjected to the impact of environmental stress factors like drought cold, soil salinity, famine, flood, exposed to pollutants from anthropogenic sources, pesticides, herbicides, pathogens from its habitat and food, subjected to harsh and harmful radiations and climate change. These agents have been reported to affect earthworm, health, distribution, reproduction and survival (Molnár et al 2012, Ghosh 2018, Singh et al 2019, Ghosh 2021). Ecological data about organisms is, heterogeneous, multidisciplinary of nature and voluminous and analysis by manual means is time and labour intensive process and is not only tedious but also challenging (Michener and Jones 2012, Arhami et al 2018). Therefore computational tools are gaining fast importance in data integration and analysis in the domain of ecology and recently computational tools algebra based applications has been used in ecological modelling (Jordán et al 2011) and attempts are being made to integrate the heterogeneous ecological data encompassing the genetic constitution of the organism and the biosphere (Jones et al 2006). A new domain of eco-informatics is developing that is helping researchers to collect, analyse, store, extract information, monitor and predicting trends from ecological data and aiding in solving various ecology related problems (Arhami et al 2018). In this study computational tools were used for generating a heat map and study of the correlation between datasets to understand and predict the correlation of an order of earthworms with its location, habitat, latitude, longitude.

MATERIAL AND METHODS

Data Collection: The earthworms of Haplotaxida, Moniligastrida, and Lumbricida, (Table 1) were collected from two major locations Golghat, Assam, India with latitude 26.52°N, longitude 93.97°E at elevation 98.46 meters and Dehradun, Uttarakhand, India with latitude 30º 18´ N, longitude 78º 01E at elevation 197.206 metres in Sept-Nov 2019. The taxonomic keys were used to identify the species.

Heatmaps: The data was analysed using Python language by using the Jupiter notebook by generating heat map. A heatmap is a two-dimensional data representation in which colours indicate values or data, enabling a quick visualisation of data, thus helping to comprehend difficult data sets and large volumes of data. To find correlation of the data, heat maps were taken into consideration, to find out the correlation in data sets. A positive correlation value indicated that is close to 1 or above 0. Whereas correlation that is negative, is considered as inverse correlation.

RESULTS AND DISCUSSION

Eutyphoeus kempi under Order Haplotaxida family Octochaetidae and *Metaphire posthuma* and *Lampito mauritii,* under Order Haplotaxida, family Megascolidae were common in distribution from NRC, Dehradun. From Golghat Assam. Order Haplotaxida including family Megascolecidae and species including *Amynthas diffringens, Perionyx excavatus , Perionyx pulvinatus* and Order Moniligastrida, family Moniligastridae, *Drawida nepalensis*, Order Lumbricida, family Lumbricidae, *Octolasion tyrtaeum* were exclusively collected while species under Order Haplitaxidae, family Megascolidae including *Amynthas hawayanus, Amynthas alexandri, Metaphire peguana,* were exclusively collected from NRC, Dehradun (Table 1). The strong positive correlations were observed between order and elevation (0.93), order and longitude (0.93),latitude (0.93), order and habitat (0.93) all four indicative of strong positive correlation (Fig. 2 A, B, C). The positive high correlation between genus and locality (0.7) and moderate positive correlation between genus and vegetation type (0.5) was observed (Fig. 2D-E). The results revealed positive correlation between latitude, longitude and genus and the rest scenarios like sex, earthworm family and state, revealed negative correlations. Availability of order of earthworms can be correlated strongly with elevation, longitude, latitude and habitat (Fig. 2A-C). Thus from the knowledge of the latitude longitude and habitat, one can predict the order of earthworm available in a locality. The positive high correlation between genus and locality description and moderate positive correlation between genus and vegetation type (indicated that the availability of a genus of earthworms can be predicted from its locality description and vegetation type Fig. 2D-E).

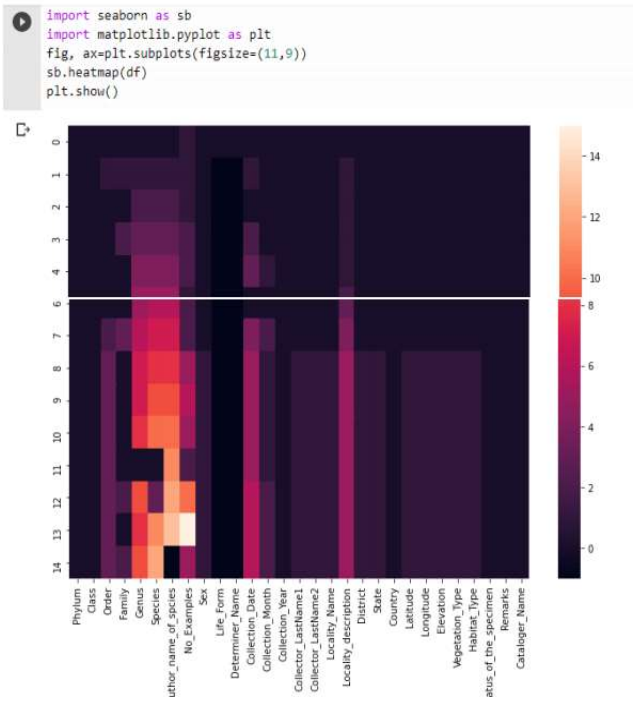

Fig. 2. Heatmaps

Photo Courtesy: Director, Zoological Survey of India with permission.

Fig. 1. Earthworms in the study

Table 1. Earthworm collection data (Phylum – Annelida, Class- Clitellata)

Order	Family	Scientific name		Number	Month	Locality
Haplotaxida	Megascolecidae	*Lampito mauritii*	Kinberg 1866. 1ex.	1	November	Golaghat, Assam
Moniligastrida	Moniligastridae	*Drawida nepalensis*	Michaelsen 1907. 1ex.	1		
Haplotaxida	Megascolecidae	*Amynthas diffringens*	Baird 1869 1ex.	1		
Haplotaxida	Octochaetidae	*Eutyphoeus kempi*	Stephenson 1914. 2ex.	2		
Haplotaxida	Megascolecidae	*Metaphire posthuma*	Vaillant 1868 2ex.	2	September	
Haplotaxida	Megascolecidae	*Perionyx excavatus*	Perrier 1872 1ex.	1	November	
Haplotaxida	Megascolecidae	*Perionyx pulvinatus*	Stephenson 1916. 2ex.	2		
Lumbricida	Lumbricidae	*Octolasion tyrtaeum*	Savigny 1826. 2ex.	2	October	
Haplitaxida	Megascolecidae	*Amynthas hawayanus*	Rosa 1891	5	September	ZSI, NRC Dehradun
Haplitaxida	Megascolecidae	*Amynthas alexandri*	Beddard 1900	6		
Haplitaxida	Megascolecidae	*Metaphire peguana*	Rosa 1891	5		
Haplitaxida	Megascolecidae	*Lampito mauritii*	Kinberg 1867	2		
Haplitaxida	Octochaetidae	*Eutyphoeus kempi*	Stephenson 1914	10	October	
Haplitaxida	Megascolecidae	*Metaphire posthuma*	Sims and Easton 1972	15		
Haplitaxida	Octochaetidae	*Eutyphoeus* sp.		5		

1. Year of collection and study: 2019, 2. Sex: Hermaphrodite, 3. Life form: mature for all specimens, 4. Latitude of sample collection zone of Golghat Assam and ZSI, NRC Dehradun: 26.52°N and 30º 18´ N respectively, 5. Longitude of sample collection zone of Golghat Assam and ZSI, NRC Dehradun: 93.97°E and 78º 01E respectively, 6. Elevation(m) of sample collection zone of Golghat Assam and ZSI, NRC Dehradun: 98.46 meters and 197.2 metres respectively, 7. Vegetation types, of sample collection zone of Golghat Assam and ZSI, NRC Dehradun: grasses and Bushes and grasses respectively, 8. Habitat types, of sample collection zone of Golghat Assam and ZSI, NRC Dehradun: terrestrial and garden respectively, 9. Status of the specimen collected from Golghat Assam and ZSI, NRC Dehradun are general : No variation

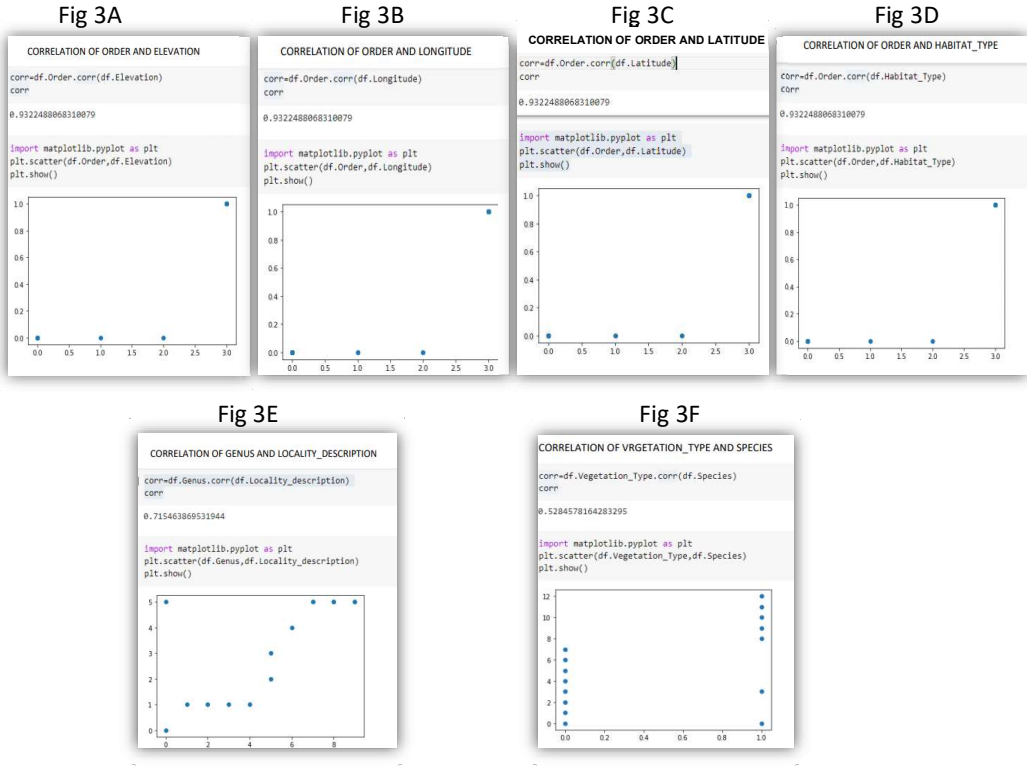

Fig. 3. Correlation

CONCLUSION

The study revealed higher diversity of orders of earthworms including species. *E. kempi, M. posthuma, L. mauritii, A. diffringens, P. excavatus, P. pulvinatus,* under Order Haplotaxida, *D. nepalensis*, under Order Moniligastrida, *O. tyrtaeum* under Order Lumbricida in lower latitude, lower elevation and eastern longitudes in Assam as compared to that in Dehradun were observed revealing only collection of species *E. kempi, M. posthuma, A. hawayanas, A. alexandri, M. peguana,* under Order Haplotaxida in Sept-Nov 2019 while *E. kempi M. posthuma and L. mauritii* under Order Haplotaxida revealed common distribution in both locations. There were strong positive correlations between order and elevation, order and longitude, latitude and order and habitat with positive high correlation between genus and locality description and moderate positive correlation between genus and vegetation type. This is the first report of application of correlation and heatmaps by Python in understanding earthworm distribution and the study highlighted the importance of parameters including longitude, latitude, elevation and habitat in predicting earthworm distribution.

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