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Research Article

USING MAXIMUM ENTROPY MODELING TO DELINEATE THE DISTRIBUTION PATTERNS OF SLOTH BEAR (*MELURSUS URSINUS*) IN SIMILIPAL BOISPHERE RESERVE, ODISHA, INDIA

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A B S T R A C T

Sloth bears (*Melursus ursinus*) are endemic to the Indian subcontinent. As a result of continued habitat loss and degradation over the past century, sloth bear populations have been in steady decline and now exist only in isolated or fragmented habitat across the entire range. So, the conservation program should be provided to overcome the extinction of the species of interest. In Similipal by using the Maximum Entropy model we develop a distribution pattern with reference to presence only data. It was found that 10% of Similipal are suitable for sloth bear habitat. The Sloth bear is very intensively distributed in the south western part of similipal biosphere reserve. The northern and eastern part has a non-habitable climate for the sloth bear and also found to be tigers core habitat region. Some what the core region provides some suitable habitat for the bears. Various environmental variables may be contributing for this spatial distribution of Sloth bear. We also get that the environmental variable that is the Bio 2, the mean diurnal temperature range has great effect on the distribution pattern of sloth bear whereas the Bio 3, Isothermality has less effect on the distribution pattern.

INTRODUCTION

In species diversity species are broadly categorised into two strategists that is *r* strategists and *k* strategists. The terminology was introduced by the ecologists Robert Macarthur and e.O. Wilson on the basis of ther work on island Biography (MacArthur, R.; Wilson, E.O. 1967; Reznick, D; Bryant, MJ; Bashey, F. 2002; John H. Duffus; Douglas M. Templeton; Monica Nordberg., 2009; Gadgil, M.; Solbrig, O.T. 1972; Luckinbill, L.S. 1978,). Species distribution modeling with *r* strategy (Uvarov BP. 1921; MacArthur RH, Wilson EO. 1967; Pianka ER. 1970; Reznick D, Bryant MJ, Bashey F. 2002; Engen S, Lande R, Sæther BE. 2013) is also represented as climate envelope-modelling, habitat modelling, and (environmental or ecological) niche-modelling. Maximum Entropy (MaxEnt) model is one of the latest software developed for the study of distribution pattern of animal by using habitat suitability map analysis (Phillips, S.J., Dudik, M., Schapire, R.E. 2004; Phillips, S. J., R. P. Anderson and R. E. Schapire. 2006; Phillips, S. J. and M. Dudik. 2008). It takes presence only input data (Bowring, B. R., 1985; Bugayevskiy, Lev and Snyder, 1995; Bugayevskiy, Lev and Snyder, 1995; Burford, B.J. 1985; Bursa, M. 1962) which by analysing (habitat vs non-habitat) provide a statistical distribution prediction value (Anderson, R.P., Peterson, A.T. & Gomez-Laverde.M, 2002;Elith J, Phillips SJ, Hastie T, Dudík M, Chee YE, et al. 2011; Elith J, Burgman M, 2002; Jeschke J, Strayer D. 2008 Sinclair S, White M, Newell G., 2010; Franklin J., 2009; Manly BFJ, McDonald LL, Thomas D., 1993; McCullagh P, Nelder JA, 1989). It analyse the input data and its coordinate climate condition which by overlaying the given environmental parameters and give a prediction suitability map for species of interest. It meant for conservation of the endangered or threatened species in tropical region. Similipal is one of the wild life national park and tiger reserve of Odisha, India (Saxena HO, Dutta PK; Saxena HO, Brahmam M. 1989; Saxena HO, Brahmam M., 1994-96). Similipal biosphere reserve has been selected for exploration which has neglected. Similipal biosphere reserve has mix type of vegetation know as Odisha semi-evergreen forests with tropical moist deciduous forest with dry deciduous hill forest and high level sal forests (Champion, H. G. and Seth, S. K., 1968). It is a representative ecosystem under Mahanadian Biogeographic Region. It has quite similar approach to Western Ghats and northeast India on the basis of flora and fauna. It is the bank 42 species of mammals, 242 species of birds and 32 species of reptiles (UNESCO 27 May 2009). The sloth bear *Melursus ursinus* is one of such species that is endemic to the Indian subcontinent. Despite their relatively extensive putative range (Yoganand, K., Rice, C.G. & Johnsingh, A.J.T., 2013) While the species has been listed as

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'vulnerable' by IUCN and placed in Schedule I of India's Wildlife Protection Act (1972), this assessment is based on crude population estimates and two reserve-level radio-telemetry studies (Yoganand, K., Rice, C.G., Johnsingh, A.J.T. & Seidensticker, J., 2006). Habitat degradation due to increased human population (Cowan, I.M, 1972; Johnsingh, A.J.T. 1986; Schoen, J.W., 1990,), diminished food resources (Rajpurohit, K.S., and N.P.S. Chauhan., 1996), and increased poaching for its gall bladder (Laurie, A., and J. Seidensticker., 1977; Servheen, C. 1990; GEE, E.P. 1964) have led to declines in sloth bear populations. The sloth bear is included in Schedule I of the Indian Wildlife (Protection) Act 1972 and (amended) Act 2002 and in Appendix I of CITES.

MATERIALS AND METHODS

Study area

Similipal biosphere is the suitable habitat for Indian sloth bear. These are fond abundantly in North east part. The study was carried out in 35 villages of buffer and core areas of the Similipal Biosphere Reserve during 2016-2017.Similipal was officially designated as a 'Tiger reserve' in 1956 and included under national conservation programme 'Project Tiger' in 1973. The Government of Odisha declared Similipal as a wildlife sanctuary in 1979 (Chauhan, N.P.S., 2006; Champion, H.G. and S.K. Seth., 1968; Palei, H.S., P.P. Mohapatra, and H.K. Sahu., 2014a; Palei, N.C., H.S. Palei, B.P. Rath, and C.S. Kar., 2014b). The presence only data of the sloth bear taken from the Similipal tiger reserve office, Mayurbhanj, Odisha.

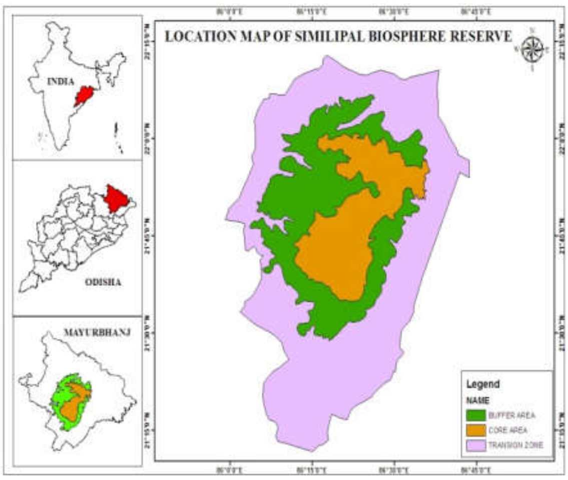

Fig 1 Location map of the Study area

Species occurrence data

Eighty-eight points are taken as presence only input for maximum entropy modelling for species distribution. Fifty-eight location points are taken as primary data also known as field data or ground data. The ground data have recorded by using global positioning system. Another thirty points are collected from Similipal Tiger Reserve office as a secondary data.

Environmental data

For environmental information, 19 bioclimatic variables derived from globally interpolated datasets (source: http://www.worldclim.org) representing annual trends, seasonality and extreme or limiting environmental factors, were used for the modelling study which are presumed to be maximum relevant to Animal existence (Pearson, R.G. and T.P. Dawson., 2003; Pearson, R.G. 2007). All analyses were conducted at the 1 x 1 km pixels spatial resolution of the environmental data sets since, bioclimatic variables with finer than 1 km resolution is not available at this moment (Stockwell, D.R.B., Peterson, A.T., 2002b). All environmental data layers were finally cropped for the study area (Similipal biosphere reserve Region) to perform the modelling experiment.

Table 1 Environmental Variables

Variables	Details
BIO-1	Annual mean temperature
BIO-2	Mean diurnal temperature range [mean of monthly(max temp–min temp)]
BIO-3	Isothermality (P2/P7) (×100)
BIO-4	Temperature seasonality (standard deviation×100)
BIO-5	Max temperature of warmest month
BIO-6	Min temperature of coldest month
BIO-7	Temperature annual range (P5–P6)
BIO-8	Mean temperature of wettest quarter
BIO-9	Mean temperature of driest quarter
BIO-10	Mean temperature of warmest quarter
BIO-11	Mean temperature of coldest quarter
BIO-12	Annual precipitation
BIO-13	Precipitation of wettest month
BIO-14	Precipitation of driest month
BIO-15	Precipitation seasonality (coefficient of variation)
BIO-16	Precipitation of wettest quarter
BIO-17	Precipitation of driest quarter
BIO-18	Precipitation of warmest quarter
BIO-19	Precipitation of coldest quarter

Software developer

We use Maximum Entropy (MaxEnt) model version 3.3.3. Maximum entropy model is java developer software. It can run in all windows including windows 7 to windows 10. The maximum entropy (MaxEnt) approach estimates a species' environmental niche by finding a probability distribution that is based on a distribution of maximum entropy (with reference to a set of environmental variables) (Phillips, S. J., R. P. Anderson and R. E. Schapire., 2006). Default values of different parameters, maximum iterations = 500, convergence threshold = 0.00001 and 50% of data points were used as random test percentage in our study.

Model validation

Prediction accuracy of Maximum entropy model outputs was measured through receiver operating characteristics (ROC) analysis because of its wider application in the modelling studies despite some recent arguments (Boubli, J.P.and M.G. de Lima, 2009; Lobo, J.M., A. Jime´nez-Valverde and R. Real., 2008; VanDerWal, J., L.P. Shoo, C. Graham and S.E. Williams., 2009; Yates, C.J., A. McNeill, J. Elith and G.F. Midgley., 2010). A ROC plot can be generated by putting the sensitivity values, the true positive fraction against the false positive fraction for all available probability thresholds. A curve which maximizes sensitivity against low false positive fraction values is considered as good model and is quantified by calculating the area under the curve (AUC). An AUC statistic closer to1.0 indicates total agreement between the model and test data and considered as good model. An AUC with value closer to 0.5 considered to be no better than random.

threshold the omission rate should be closer to the predicted omission. Here the Area Under curve is 0.732

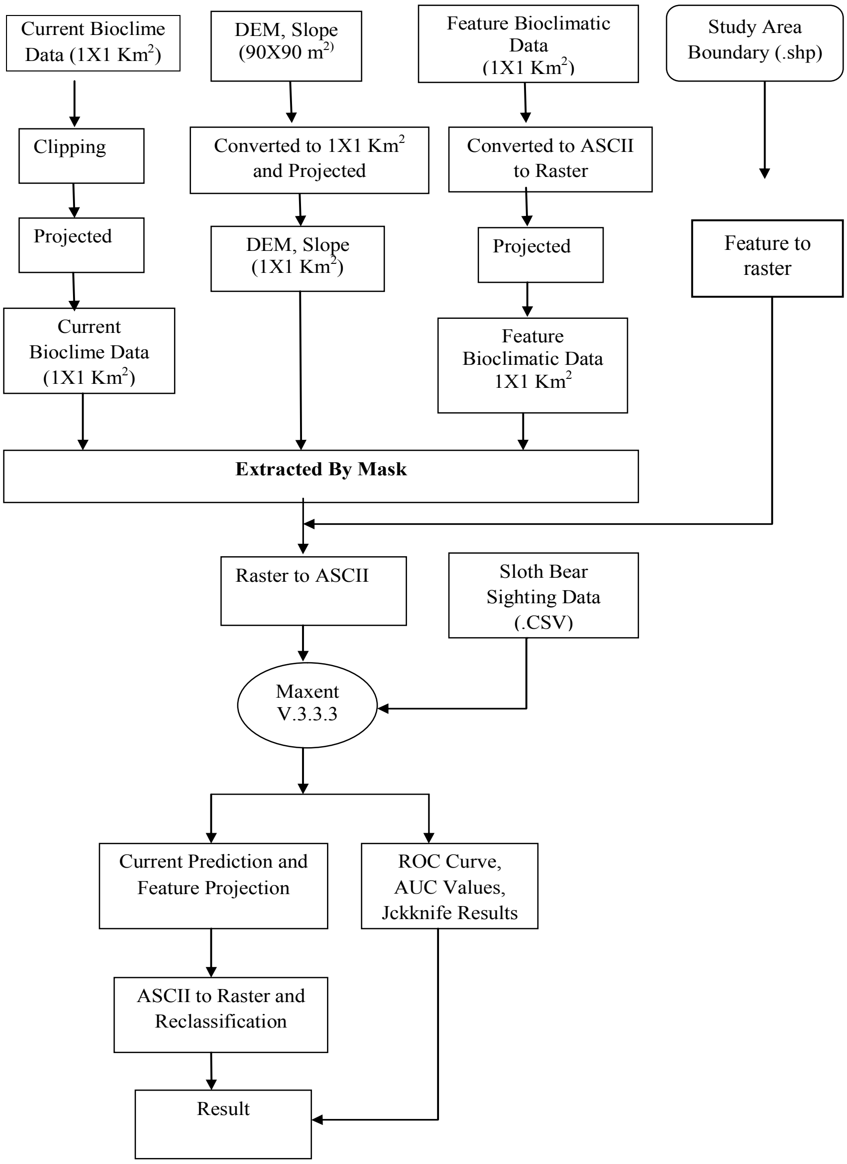

Fig 2 Flow chart for Maxent modelling.

RESULT AND ANALYSIS

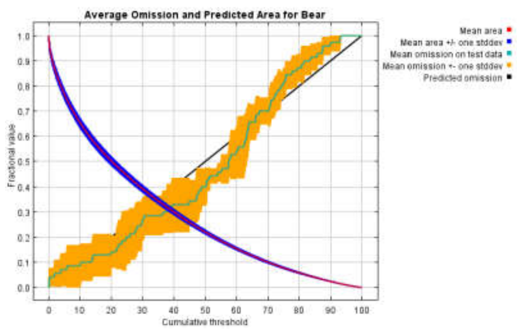

Fig 3 Average Omission and Predicted Area for Bear

The analysis of this graph revels the omission rate and predicted area as a common function of the cumulative threshold. The omission rate is calculated both on the training presence records, and (if test data are used) on the test records. According to the definition of the cumulative

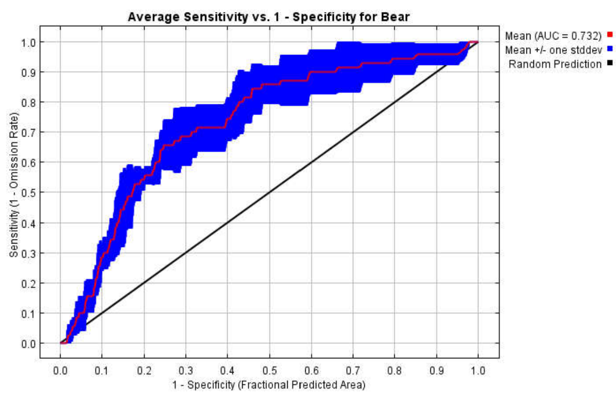

Fig 4 Average Sensitivity vs.1- Specificity for Bear

This graph shows the Receiver Operating Characteristics (ROC) for the data modelling. Specificity for habitat conformation can be defined by using predicted area rather than true commission (Phillips, Anderson and Schapire, 2004). This implies that the maximum output value of AUC is less than 1.

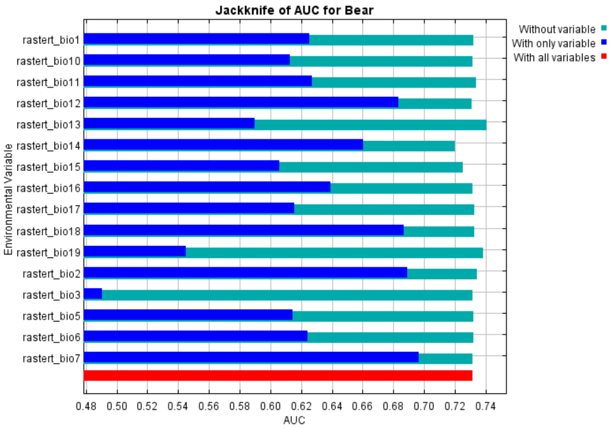

Fig 5 Jackknife Graph for AUC

Jackknife graph analysis shows the contribution of the nineteen environmental parameters in the distribution of species of interest at the study area. Here the bio 2 that is the mean diurnal temperature change greatly affects the distribution pattern as because the sloth bears are greatly sensitive to wards that environmental factor. But in bio 3 that is the isothermality has less role on the distribution pattern as because of less sensible environmental factor for the bears.

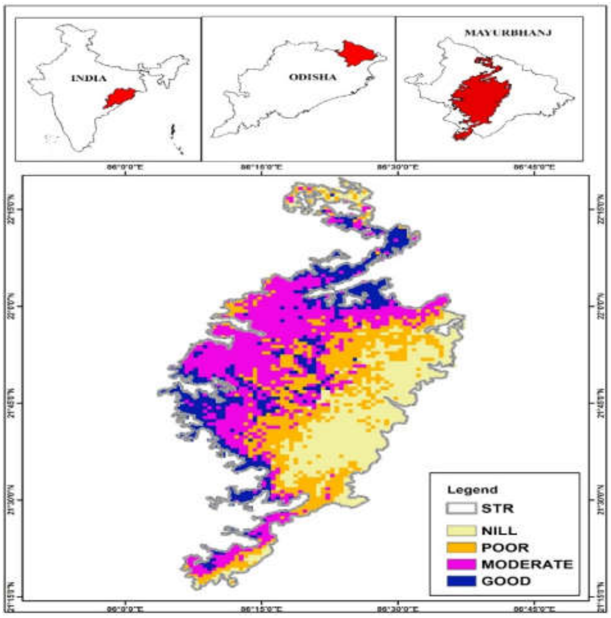

Fig 6 Habitat suitability map of sloth bear in Similipal

CONCLUSION

The maximum entropy model has been successfully used to model for the potential distributions of Sloth bear in Similipal Biosphere Reserve.About 10% of similipal are suitable for sloth bear habitat. It has been found that the Sloth bear is very intensively distributed in the south western part of similipal biosphere reserve. The northern and eastern part has a non-habitable climate for the sloth bear and also found to be tigers core habitat region. Some what the core region provides some suitable habitat for the bears. Various environmental variables may be contributing for this spatial distribution of Sloth bear. We also get that the environmental variable that is the Bio 2, the mean diurnal temperature range has great effect on the distribution pattern of sloth bear whereas the Bio 3, Isothermality has less effect on the distribution pattern. Any certain change in major contributing environmental parameters can leads to great fluctuation in habitat as well as in distribution pattern.

Acknowledgement

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