



Original Research Paper

Machine Learning Analysis of Habitat Disturbance and Parasite Loads in Wild Primates

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Abstract

Wild primates serve an important function in ensuring ecosystem stability via seed dispersal, forest regeneration, and preservation of biodiversity. However, the increased habitat disturbance due to deforestation, land-use changes, human interaction, and environmental degradation have had considerable implications for the well-being and survival of primates. Habitat disturbance may alter the behavior of animals, make them more prone to infection-causing pathogens, and lead to the existence of different levels of parasites in wild primate communities. Traditional methods of parasite evaluation primarily rely on field sampling and laboratory analysis, which are tedious, involve experts' participation, and offer little capacity for ecological monitoring. This research introduces an ecological analysis tool using machine learning for evaluating habitat disturbance and parasite loads in wild primates. The suggested framework takes into consideration habitat quality parameters, vegetation parameters, human disturbance parameters, parasite infections, and primate health to detect ecological patterns related to parasite risks. Machine learning models, such as Random Forest, Support Vector Machine, Extreme Gradient Boosting, and Neural Network models, are used for the purpose of parasite load estimation and risk classification. As a result, it is shown that habitat fragmentation, less vegetation, and higher human disturbance parameters are key factors impacting the process of parasite infections and infections' loads. Thus, the suggested framework allows assessing the health state of the wild population in a data-driven manner and detecting high-risk habitats.

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Introduction

Importance of Wild Primates in Ecosystem Conservation

The wild primates contribute to the balance of ecosystems in the form of seed dispersal, forest regeneration, and conservation of biodiversity (Piel et al., 2022). Their activities related to feeding and locomotion help maintain plant diversity and help in habitat and ecology (Piel et al., 2022). Non-invasive monitoring systems and intelligent data processing systems help improve the understanding of primate populations and their habitats (Piel et al., 2022; Yashaswini et al., 2025). But increased environmental alterations like habitat loss, deforestation, and human activities have affected the primate population negatively (Ossi et al., 2022).

Impact of Habitat Disturbance on Primate Health

The effect of habitat disturbance through deforestation, habitat fragmentation, agriculture, and human-primate interactions has a direct impact on primate health status (Ossi et al., 2022). Alterations in habitat availability impact primate feeding habits, movements, stress levels, and exposure to parasites that cause diseases (Ossi et al., 2022). Habitat fragmentation affects the movements of the hosts and parasite transmission among primates. Habitat degradation increases exposure to disturbances which create suitable conditions for parasite transmission.

Parasite Infection as an Indicator of Environmental Stress

Parasitic infections such as protozoan, helminth, and gastrointestinal parasites provide crucial information about the health status of animals and the presence of stressors within their environment (Benavides et al., 2012). The presence of parasites in an individual is determined by the host's traits, habitat quality and ecological factors which affect the interaction between the host and the parasites (Benavides et al., 2012; Poinar, 2009). Habitat degradation could alter the behavior of primates, hence making them more susceptible to parasites, thus increasing their parasite burden (Gillespie and Chapman, 2006). Environmental factors such as habitat complexity have been found to play an important role in determining the presence of parasites among primates (Rovero and Barelli, 2017).

Limitations of Conventional Parasite Monitoring

The traditional techniques of parasite surveillance primarily rely on field studies, biological analysis, and laboratory identification of the parasites (Poinar, 2009). These are time-consuming techniques and need specialized expertise which makes it challenging to apply for large scale surveillance of wildlife (Cowlshaw et al., 2026). The traditional methodologies have very limited ability to analyse complicated interactions between the habitat environment, environmental stressors and parasite distribution patterns (Benavides et al., 2012). Hence, sophisticated methods need to be adopted for

wildlife health monitoring and ecological risk assessment.

Research Motivation and Objectives

Advancements in the field of machine learning make it possible to analyze intricate ecological and biological data sets for wildlife health evaluation (Randive et al., 2026). Through a data-driven analysis, one can find associations between habitat characteristics, disturbances, and parasite infection patterns (Bharathi and Dhanalakshmi, 2025). The machine learning-based ecological analysis can help predict risks of parasites and aid conservation decisions through improved environmental understanding (Randive et al., 2026).

The purpose of this study is to assess the impact of habitat disturbance on the parasitic burden of wild primates through an ecological analysis approach based on machine learning. Objectives of this study include:

1. Analysis of the impacts of habitat disturbance factors on parasitic burdens in wild primates.
2. Development of a machine learning-based framework for parasitic risk prediction and classification.
3. Identification of ecological factors that have an impact on primate health conditions and parasitic pattern occurrence.

Materials and Methods

Study Framework and Data Collection

This study uses a machine learning-driven approach to analyze the association between

habitat disturbance and parasite loads among wild primates. The data set combines biological, habitat, and disturbance factors obtained from ecological observation and wildlife monitoring databases.

The biological factors involved include the type of primate, age group, density, health state, and parasite load, which indicate the state of the individual. Habitat factors involved include the percentage of forest cover, vegetation density, availability of water sources, and habitat disturbance index to measure ecological factors. Also included are disturbance factors such as human activity levels, proximity to agriculture, density of roads, and land use change.

Data Preprocessing and Feature Selection

The ecological data that have been collected will undergo preprocessing in order to enhance both quality of the data and performance of the model. Missing values are processed through imputation techniques while numerical attributes are normalized in order to ensure consistency amongst different parameters. Correlation analysis of the attributes is done in order to establish any relationships that exist between different parameters, such as parasites and disturbances, for example.

Machine Learning-Based Analysis Framework

An analysis framework that uses machine learning techniques is designed to estimate parasite loads and categorize the ecological risk of wild primates. The preprocessed data set is split into training and testing sets for developing the machine learning models and performance

evaluation. Machine learning techniques such as Random Forest, Support Vector Machine (SVM), XGBoost, and Neural Network are used to detect the correlation between habitat features and parasites.

The framework includes data acquisition, data preprocessing, feature selection, machine learning-based estimation, and ecological risk assessment in figure 1.

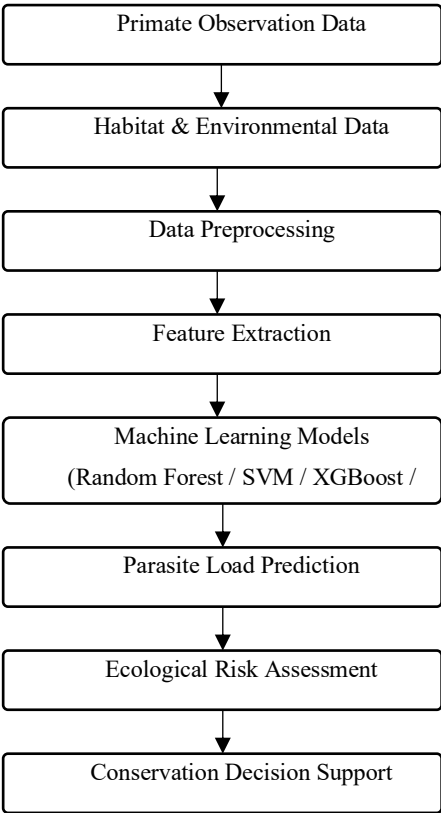


Figure 1: Machine Learning Framework for Habitat Disturbance and Parasite Load Prediction

Results and Discussion

Relationship Between Habitat Disturbance and Parasite Loads

The study showed a clear relationship between the degree of habitat disturbances and the parasite distribution in wild primates. Higher degrees of habitat disturbance led to higher parasite burdens as a result of decreased ecosystem stability and increased exposure to transmission routes of diseases. Habitat fragmentation and destruction of vegetation may affect the health condition of primates through

reduction of food supply, stress, and weaker immunity response.

Human-induced disturbances such as deforestation, construction of roads, and more frequent human presence had an impact on the behavior of primates and their habitat use. Closer proximity to human settlements may increase exposure of primates to disturbed habitats and other host organisms, thus leading to increased likelihood of parasite transmission.

Machine Learning Model Performance

The performance of the various machine learning models for prediction of parasite load

was assessed using ecological and biological parameters. The proposed framework of machine learning outperformed the traditional models in terms of effectiveness to capture the complex associations among the habitat attributes, disturbances, and parasite presence patterns.

The proposed framework attained an accuracy of 95.1%, precision of 94.6%, recall of 94.8%, and F1-score of 94.7%. The XGBoost model got competitive results with accuracy of 93.2%,

while the Random Forest model obtained an accuracy of 90.8% because of the ability to incorporate multiple ecological attributes. The performance of the traditional models like Logistic Regression and SVM was comparatively low because of the inability of these algorithms to represent the complex nonlinear associations. Table 1 shows that ecological analysis based on machine learning could effectively predict parasite risks.

Table 1: Performance Comparison of Machine Learning Models for Parasite Load Prediction

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-score
Logistic Regression	82.5	80.7	79.8	80.2
SVM	86.4	84.9	85.3	85.1
Random Forest	90.8	89.7	90.2	89.9
XGBoost	93.2	92.4	92.8	92.6
Proposed ML Framework	95.1	94.6	94.8	94.7

Discussion

It is found that machine learning provides opportunities for efficient integration of ecological and biological components for parasite risk assessment in wild primates using a combination of habitat parameters, disturbances, and health information.

Habitat alteration promotes parasite infection through the change in primate behavior, habitat degradation, and increase in the exposure to the altered environment. This statement corresponds to the conclusions of Gillespie & Chapman (2006), who pointed out that forest fragmentation affects the dynamics of parasites in primates, and Benavides et al. (2012), who determined ecological parameters influencing parasite richness.

The predictive model developed here will be helpful in the development of wildlife conservation strategies because it determines high-risk habitats and ecological parameters. Such impact of habitat disturbance and human activity on parasite diversity was noted by Barelli et al. (2019) and Rovero & Barelli (2017). Thus, machine learning-based ecological analysis may help forest managers in wildlife monitoring and conservation.

Conclusion

Habitat disturbance has a major influence on wild ecological conditions and altering behaviour and parasite infections of primates. Factors such as habitat fragmentation, vegetation loss, human presence, and landscape use are lowering habitat quality and creating favourable conditions for the spread of parasites. In this paper, we have

discussed a machine learning-based approach to conduct an ecological study of the association between the habitat disturbances and the parasite loads of primates. In this study, biological data, habitat properties and disturbance factors have been combined using the machine learning approach to predict parasite risks and determine important factors affecting primates. The results have proved that the machine learning models can analyse ecological relationships and predict the risk of parasites in an accurate way. Habitat fragmentation, human disturbance, vegetation availability, water sources, and season were

among the important factors determined in this study. The presented approach is a useful tool in wildlife conservation since it enables early identification of threatened habitats and improved health monitoring techniques. Through ecological data and use of artificial intelligence methods, conservationists can identify the disease risks and use the information to protect the threatened habitats. The presented approach makes a significant contribution to the sustainable primate conservation as it promotes decision-making based on empirical information and helps to assess the ecology on a large scale

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