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Research Application Summary

Selected soil properties for prediction of plague vectors and reservoirs in Mavumo area, Lushoto District, Tanzania

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Abstract

The importance of selected soil properties with respect to occurrence of plague vectors and reservoirs was studied in Lushoto District, Tanzania. Plague reservoirs showed significant correlation ($p<0.05$) with subsoil percent clay, topsoil percent total nitrogen, topsoil C/N, topsoil pH and topsoil DTPA extractable Cu. Plague vectors' occurrence showed significant correlation ($p<0.05$) with effective soil depth, topsoil percent total nitrogen, topsoil C/N, subsoil percent organic carbon and with topsoil DTPA extractable Zn. It is recommended that plague disease control should also employ knowledge on relationships between soil properties and plague reservoirs and vectors.

Key words: Flea-bite, human plague, soil attributes, Tanzania, *Yersinia pestis*

Résumé

L'importance des propriétés choisies du sol en ce qui concerne l'apparition des vecteurs et des réservoirs de peste a été étudiée dans le district de Lushoto, en Tanzanie. Les réservoirs de peste ont montré la corrélation significative ($p<0.05$) avec le pourcentage de l'argile de la couche inferieure du sol, celui de l'azote total de la couche supérieure, le C/N de la couche supérieure, le pH de la couche supérieure et le Cu extractible DTPA de la couche supérieure. L'apparition des vecteurs de la peste a montré une corrélation significative ($p<0.05$) avec la profondeur efficace du sol, le pourcentage de l'azote total de la couche supérieure, le C/N de la couche supérieure, celui du carbone organique de la couche inferieure et avec du Zn extractible DTPA de la couche supérieure. Il a été recommandé que la surveillance de la maladie de la peste devrait également utiliser la connaissance sur des rapports entre les propriétés du sol ainsi que les réservoirs et les vecteurs de peste.

Mots clés: Piqure d'une puce, peste humaine, attributs du sol, Tanzanie, *Yersinia pestis*

Background

Plague is a human disease which results from infection by *Yersinia pestis* bacterium. The disease can be transmitted through direct contact with an infectious source, inhalation of infectious respiratory droplets and commonly through flea-bite. In Lushoto District, Tanzania, human plague was reported for the first time in April 1980, and by 2004, more than 7,600 cases were recorded. The risk of human contagion may be explained by some forms of connectivity between the spatial pathways taken by humans and domesticated animals and conditions of the landscape with high potential risk for harbouring the disease pathogen. The information linking soil properties with occurrence of fleas as vectors and rodents as reservoir of plague pathogen in Lushoto District is limited. This study analysed the importance of soil attributes with respect to occurrence of plague vectors and reservoirs in Lushoto District, Tanzania.

Literature Summary

Many different animal species (mostly wild rodents) are natural reservoirs for *Y. pestis* (Dennis and Meier, 1997). Humans are incidental hosts for *Y pestis* and are not part of the natural life cycle of the organisms. The risk of spread of plague from rodents to humans is related to the density of rodents, the number of fleas per animal (flea index), and the rate of *Y. pestis* infection in the rodents and fleas (Dennis and Mead, 2010). Studies suggest that soils can have a bearing on plague reservoirs (Eisen *et al.*, 2008). Soil serves as the shelter for plague reservoirs and vectors. Burrowing animals act as the first link in the chain of transmission followed by spread to other animals and humans through ectoparasites (Drancourt *et al.*, 2006). Observation done by Liu *et al.* (2000) in China and Rotshild (2001) in the Altay mountains, Tuva (Trans-Baikal), Kyzyl Kum desert in Uzbekistan, and Caspian lowlands showed that the distribution of plague foci and epizootics were correlated with calcium and iron-enriched soil environments and with soils which had medium or high concentration of iron, cobalt, and titanium, and low concentrations of copper, nickel, and vanadium.

Study Description

The study area is in the Western Usambara Mountains in Lushoto District, Tanzania, located between UTM coordinates 9490000 to 9479000 N and 405000 to 423000 E. The altitude of the area ranges from 400 m in the lowland to 2260 m above sea level in the summits of the dissected mountain ridges and hills. The landform units were established from stereoscopic, visual and digital analysis of remote sensing materials focusing on the study area. A combination of both free soil survey and transect observations (Dent and Young, 1981) was used to collect data on landforms and soil related properties. Representative soil profile pits were dug to a depth of 2 m or to a limiting layer and described according to FAO Guidelines for Soil Description (FAO, 2006). In each profile pit, bulk and core samples were taken from designated natural horizons for physical and chemical analysis in the laboratory. Soil physical and chemical analyses were done using standard laboratory procedures (Moberg, 2000). Trapping of rodents was done within the established landform units for two consecutive days per site. Trapping was recorded every morning and the number of rodents and their associated fleas were recorded. Stepwise multiple linear regressions were employed in the Minitab (2004) software to obtain equations for predicting occurrence of plague vectors and reservoirs from selected topsoil and subsoil properties:

$$Y = a + b_1X_1 + b_2X_2 + \ldots\ldots + b_nX_n$$

Where: Y = predicted occurrence of plague vector or reservoir, $X_{1,}$ $X_{2,}$ X_n = soil attribute and a, $b_{1,}$ b_2, b_n = coefficients.

Research Application

Among the selected soil physical properties, there was a significant correlation between reservoir occurrence and subsoil percent clay (Y=82.6– 7.81%CLAY, R^2=99.53, $p<0.05$). The reservoir occurrence also showed significant correlation with topsoil percent total nitrogen, topsoil C/N ratio and topsoil pH (Y=134.92%N+0.3403C/N+1.97pH-27.065, R^2=100, $p<0.05$), among selected chemical properties. Significant correlation was observed with topsoil DTPA extractable copper (Y=9.3Cu-3.339, R^2=59.97, $p<0.05$) among soil micronutrients.

Significant correlation was observed between vector occurrence and effective soil depth, among the selected soil physical properties (Y=0.462Depth-49.9, R^2=99.85, $p<0.05$). The vector occurrence also showed significant correlation with topsoil percent total nitrogen, top soil C/N ratio and subsoil percent organic carbon (Y=225.22%N+0.825C/N-4.69%OC-22.04, R^2=100, $p<0.05$), among selected chemical properties. When vector occurrence was correlated with selected micronutrient contents of the studied soils, significant correlation was observed with topsoil DTPA extractable zinc (Y=66.86-181Zn, R^2=52.17, $p<0.05$).

Recommendation

These findings suggest that plague disease control should employ knowledge on relationships between soil properties and plague reservoirs and vectors.

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