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A Study about the Piggery Sector Sustainability, Pig Breed Diversity and Its Ecological Implications in Urban Districts of Uttarakhand †

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Abstract: Uttarakhand is situated on the southern slope of the world's youngest (geo-dynamically sensitive) mountain system "the Himalayas". Owing to rapid deforestation in the planar districts due to increase in infrastructural growth, the wildlife–livestock–human interfaces has blurred. This has increase the chances of contact exposure of wild boars to humans and domestic animals. The study identify the location of pig rearers and their pig rearing practices with its ecological effects and also study the mitochondrial DNA diversity using control region from the 68 samples collected from the surveyed household. Analysis showed that 60.7%, 10.7% and 21.4% of the household raised pig near seasonal streams (slum settlements), the residential areas and near the forest, respectively. 28.6% maintained breeding boar of feral origin and 96.94% followed semi-intensive pig rearing practise; hence human settlement is staying in close association with pigs (domestic and wild) and other domestic animals. The possibility of the emergence of zoonotic and non-zoonotic disease and its easy transmission to humans become more prominent in the urban setting. 18 mtDNA haplotypes were observed with 34 segregating sites in 68 analysed sequence. High level of haplotype diversity and nucleotide diversity suggested an increase crossbreeding among the species.

Keywords: pig husbandry; urbanisation; socio-economic; mtDNA; diversity

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1. Introduction

Unlike the other domesticated animal species, the abundance of domestic pigs in a particular region is influenced by the religion, culture, and tradition for pork consumption. The worship and significance of wild boar in India are seen since time immemorial [1] but when the question of pig rearing comes, the scenario depends on the other aspect of Hinduism called the caste system, which is the oldest form of surviving social stratification and its effect cannot be ignored in modern society as well. According to the traditional caste system, the lower caste prefers pig rearing. Hence, in India, pigs are raised mostly by scheduled caste and tribes to maintain their social identity and traditional culture [2]. The present study aims to (1) identify the location of pig rearers and their pig rearing practices in urban districts of Uttarakhand and analyse its ecological implications to the urban landscape and human settlement (2) investigate the mtDNA diversity among the domestic pig of the study area.

2. Methods

Household Survey and Rapid appraisals approach was adopted as a "survey and monitoring tools" to identify more geographical locations in Uttarakhand where pig rearers were localized [3]. 28 households (HH) (25 Dehradun, 2 Haridwar, and 1 Nainital), were interviewed by preparing semi-structured questionnaire from March 2019 - December 2019 in the urban districts of Uttarakhand. The geographical position of each participating family was recorded using android based software Google Map.

2.1. Sample Collection, DNA Extraction, Amplification and Sequencing

Non-invasive biological sample (hairs and tissues) were collected from 68 un-relatable pig from the surveyed household for mtDNA studies. Genomic DNA was extracted using DNeasy Blood & Tissue kit (Qiagen, Hilden, Germany) protocol and amplification of approximately 419 bp mtDNA hypervariable control region was done using control region-specific primer pair [4].

2.2. Sequence Data Analysis

Sequences were confirmed using the BLAST tool on NCBI and were clean and edited with SEQUENCHER® version 4.9. We obtained 2826 cleaned and aligned global control region sequences (404 bp) representing *Sus scrofa* (wild/domestic/feral) from GenBank. The global control region sequences were aligned with 68 samples of Uttarakhand using the CLUSTAL W algorithm [5] in program MEGA X [6]. Haplotype (Hd) and nucleotide diversities (Pi) were calculated using program DnaSP v.5.10 [7]. Haplotypes were derived by removing non-informative sites, and gaps were considered. The haplotypes sharing with global sequences was reconstructed using the median-joining network in PopART v.1.7 [8].

3. Results and Discussion

3.1. Map Plotting Analysis

60.7% of households raise pigs near slum settlements that have inadequate sanitation, these unhygienic environments poses a risk to animal health and human health. 21.4% of households interviewed raise pigs near forest areas, this increase the chances of contact exposure of wild boars which itself harbour several viruses, bacteria, and parasites diseases. Thus, the transmission of pathogens between wild boars and humans becomes more conspicuous in highly populated districts either by consumption of wild boar meat (which has been reported in Uttarakhand) or through cross-breeding of domestic with the wild population.

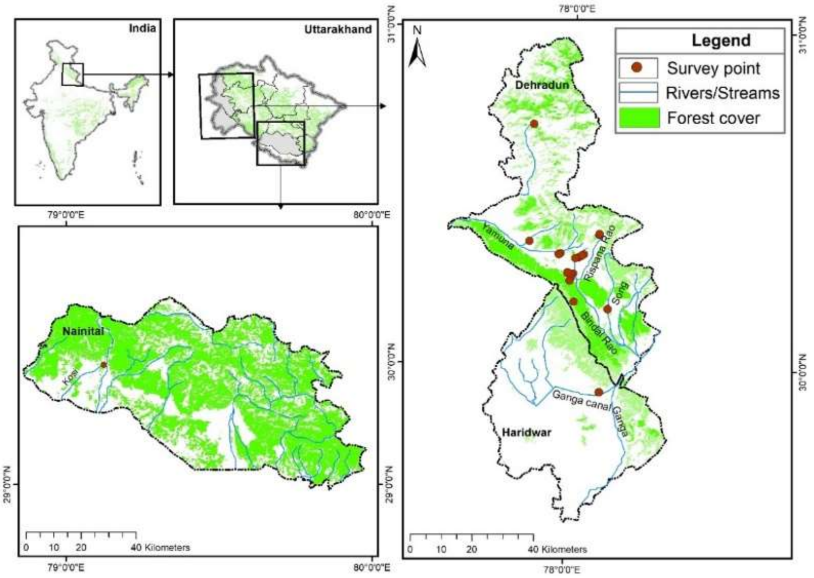

Figure 1. Map showing the location of surveyed household in the study area of Uttarakhand.

3.2. Pig Husbandry Practices in Uttarakhand

Households kept 2–4 adult sows and 1–3 hybrid boars with their piglets in their herd (Figure 2a–c). They identified the breeds as indigenous and mixed parentage of indigenous crossed with the exotic breed and putative crossed with a wild pig. 28.6% pig rearers maintained probable breeding boar of feral origin in secrecy due to its easy availability and high sale value (Figure 2d). The combination of farrow to finish and piglet production systems are observed in 85.7% of the households surveyed. Only 14.3% of the households practiced fattener production. The major rearing pattern observed in the study area was semi-intensive system (96.94%) (Figure 2e) followed by extensive (3.57%) (Figure 2f) system. Though these system needs less capital investment but disease incidences and parasite infestations are high.

Figure 2. (**a**) Pig herd in Ramnagar (Nainital district of Uttarakhand) (**b**) Pig herd of mixed parental origin observed in Chandrabani (Dehradun district of Uttarakhand) (**c**) Pig herd in Jwalapur (Haridwar district of Uttarakhand) (**d**) Possible hybridised feral origin or boar piglet for sale or mating purpose (**e**) Semi-intensive system of pig management with housing facility (all the pen is made of brick with tin as a roof within the house premises) (**f**) Extensive system of pig management with no housing facility.

3.3. Haplotype Analysis and Sequence Variability

18 mtDNA haplotypes with 34 segregating sites in 68 analysed sequence were observed. The haplotype (gene) diversity for the analysed sequence were Hd = 0.749 +/− 0.00243 and nucleotide diversity was Pi = 0.0132 +/− 0.002. 18 haplotype obtained from Uttarakhand sample shared the haplotype with n = 998 sequences from the GenBank. Figure 3 shows the region-wise haplotype sharing with the global sequences.

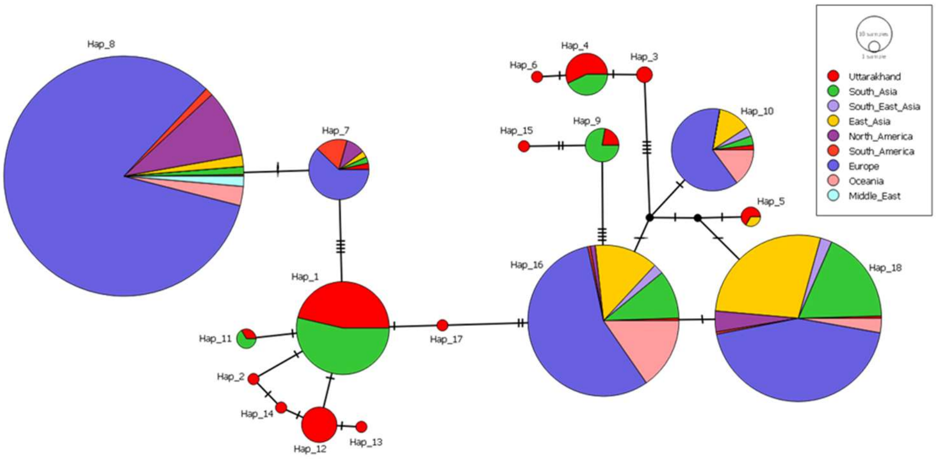

Figure 3. Median-joining haplotype network of 18 haplotypes identified in Uttarakhand sample and its sharing with global sequences (n = 998). Circle size represents the frequency of individuals, and colour defines the region-wise populations. Small black circles represent median vectors. Mutational steps are shown by bar on the respective branches.

The Hap_1 consist of 32 modern sequences of Uttarakhand that share its haplotype with domestic breed (Richengang) of Bhutan [9] and Indian wild population [10] from GenBank. Hap_1 has multiple connection and forming a star like pattern suggest that this haplotype is older and is widely distributed among domestic pigs of Bhutan and Northern/Central India. Moreover it also share the haplotype with the museum sample of Indian wild population of Kashmir and wild and domestic population of West Bengal [10]. This Haplotype is widely found in samples of Dehradun and Nainital districts of Uttarakhand.

Hap_11 which has only one sample of Uttarakhand share its haplotype with domestic pigs from Nepal [9]. Hap_12 have 10 sequences which include a sequence from Haridwar District of Uttarakhand and Hap_2, Hap_14, Hap_13, Hap_17 have only one sequence each of a single area of Dehradun near Song river shows that these are recently evolved population and their carrier are still localised in its evolved areas.

Hap_9 which have 2 sequences from Naintal Districts of Uttarakhand shared the haplotype with museum specimen of wild pig from Nepal and India [10] also from wild pigs from Northern and Central India. Hap_15 which is also recently evolved doesn’t share its haplotype with any sequence.

Hap_4 includes seven sequences of Uttarakhand that share its haplotype with Bhutan’s domestic breed Machay Madhuri and Nepal’s domestic pig breed. Hap_3 and Hap_6 is contain only Uttarakhand sequences. Hap_7, 8,10,16,18 each contain single sequence of Uttarakhand is globally distributed.

Hence the results shows a possibility of maternal gene flow between India, Bhutan and Nepal.

4. Conclusions

The findings from the small representation of the pig rearer in Uttarakhand suggests that the wild cross with domestic are included in the herd because of the easy availability, disease resistance, meat preference, and medicinal values; hence, they come in close contact with humans and other livestock species and These interactions create a potential threat for disease spill over from wild pigs to humans and other livestock species. The intensity of the risk of transmission becomes more profound with increase in urbanisation and anthropogenic influence beyond the carrying capacity of the area's ecological system. The government often neglects public health policies while planning for urban development. This neglect poses a higher risk for both zoonotic and non-zoonotic disease to the population living near slums and informal settlements. Hence these settlements can become an epicenter for the outbreak of infectious disease and due to pigs roaming in these areas, the chances of zoonotic disease will also increase. The location of the herd and its foraging should be strictly monitored. A report of multiple outbreaks of 'Human Trichinosis' caused by eating undercooked wild boar meat has been reported [11] hence sensitization of local community for avoiding the wild animal meat should be done.

The mitochondrial diversity is high and eight haplotype are unique to Uttarakhand hence effort should be taken for the conservation of the haplotypes and classifying the phenotypic characteristics of the indigenous breed.

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