Characterization of *Phytophthora infestans* and Late blight forecasting in Nepal

NARC
Nepal Agricultural Research Council

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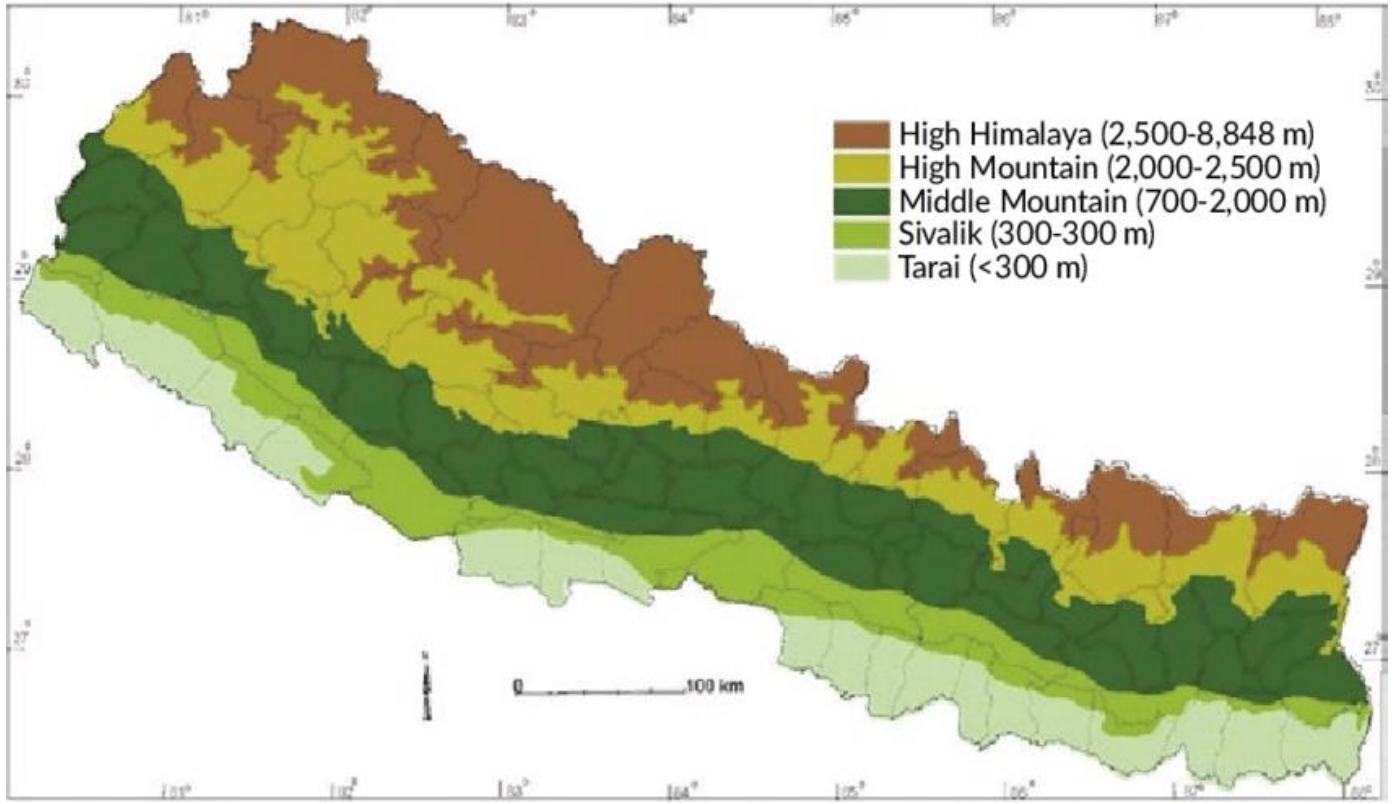
Potato in Nepal

- In Nepal, potatoes are grown across varying geographic areas ranging from 75 to 4700 m a s l with Area: 182,600 ha
- Production: for the total production of 2,508,044 Mt, with a
- Productivity: 13.74 t ha-1 (MOAC, 2011) and
- Contribution 9.4% of the national agriculture gross domestic product (AGDP) (MOF, 2010).



Potato growing seasons in Nepal

High Himalayan:

High mountains: February/ March planting

Middle Mountains: September and January (two season planting)

Sivalik: November planting

Lowlands (Terai): November planting

Late blight (*Phytophthora infestans*)

- One of the major biotic constraints
- Estimated loss more thanUS$104 million
- Account: 15% average loss
- Average potato price of 176 US$ ton^{-1}
- Large amount of money is routinely spent to manage the crop by frequently applying fungicides
- 10-15 sprays per crop y (Sharma, Khatri-Chhetri, Dhital, Khatri-Chhetri, & Chand, 2007).

Management

Resistant varieties

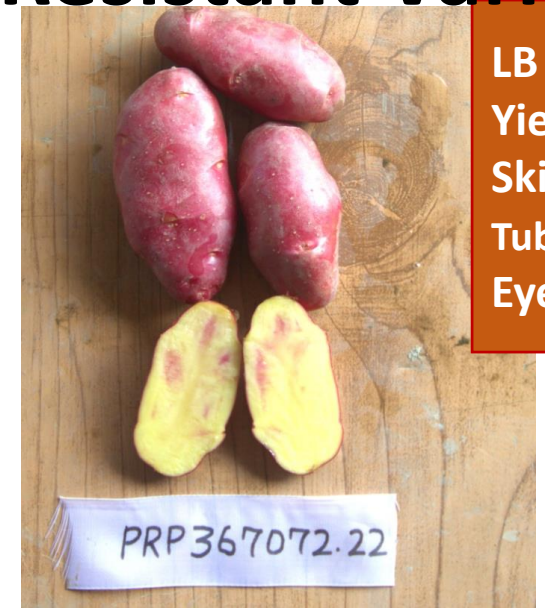
Fungicide spray: Metalaxyl, Mancozeb, Dimethomorph

- Fenamidone plus mancozeb

NARC recommendation: Mancozeb prophylactic + dimethomorph + (Fenamidone + mancozeb)+ Dimethomorph in rotation at 9 days interval

- Planting time

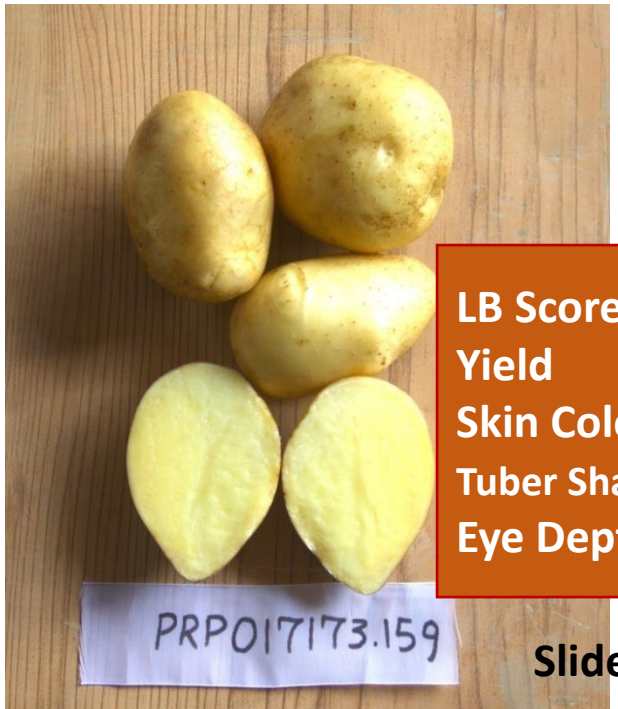
Resistant Varieties



LB Score : 1
Yield : 32.38 t/ha
Skin Color : Red
Tuber Shape : Oval
Eye Depth : Shallow

LB Score : 2
Yield : 30.38 t/ha
Skin Color : Red Eye
Tuber Shape : Round
Eye Depth :Deep

LB Score : 2
Yield : 22.54 t/ha
Skin Color : Purple
Tuber Shape : Oval
Eye Depth: Shallow



LB Score : 1
Yield : 28.48 t/ha
Skin Color : White
Tuber Shape : Oval
Eye Depth :Shallow

Slide from B. Rana, NARC-NPPRP

Frequent failure of resistance varieties is very common in Nepal

Genetic diversity of *P. infestans*

- There is an enormous gap between national averages and attainable yields
- Understanding of the distribution of pathogen population is critical
    - To identify effective fungicide
    - Manipulate resistant variety
    - Develop strategies for breeding and fungicide development
- Negligible information on genetic diversity of *P. infestans* in Nepal
- Societal resistance today against using potentially harmful chemicals.

Populations of *P. infestans* are dynamic

- mutation, migration, sexual reproduction,
- Increasing global challenges
- P. infestans remains dormant (latent) in seed tubers at low temperatures (4°C)
- The frequencies of A1 and A2 were 83 and 17%, respectively. Metalaxyl-resistant, intermediate and sensitive isolates were recorded as 10%, 12% and 78% respectively. Metalaxyl resistance was distributed in both mating types (Ghimire, 2001)

Disease Notes

OPEN

First Report of A1 and A2 Mating Types of *Phytophthora infestans* on Potato and Tomato in Nepal

S. K. Shrestha, K. Shrestha, K. Kobayashi, N. Kondo, R. Nishimura, K. Sato, and A. Ogoshi

Affiliations

Published Online: 28 Feb 2007 | https://doi.org/10.1094/PDIS.1998.82.9.1064D

Full Papers | Published: December 2001

Phenotypes of*Phytophthora infestans* in Nepal: mating types and metalaxyl sensitivity

S. R. Ghimire, K. D. Hyde, I. J. Hodgkiss & E. C. Y. Liew

Potato Research **44**, 337–347 (2001) | Cite this article

99 Accesses | **4** Citations | Metrics

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Summary

Potato late blight has appeared in epidemic proportions in Nepal since the mid 1990s and fungicides have been reported to be decreasingly effective in managing the disease.*Phytophthora infestans* isolates were collected from potato crops during 1999–2000

Study in population dynamics of *P. infestans* is critical in Nepal

- Microsatellites has proven to be a powerful tool for genetic studies of populations,

✓very polymorphic,

✓co-dominant (Both alleles at a locus are amplified

✓discriminated simultaneously),

✓ they present simple Mendelian heredity, easy to measure and analyze,

✓trustworthy, repetitive

✓only tiny amount of DNA is needed.

Sample collection
2018, 2019, and 2022

19 districts

Four provinces

Both from potato and tomato

Submitted to Dr. Didier Andrivon' lab at French National Institute for Agriculture, Food, and Environment (INRAE) for genotyping in 2023

Data preparation and analysis

Microsatellite data was obtained from 98 samples.

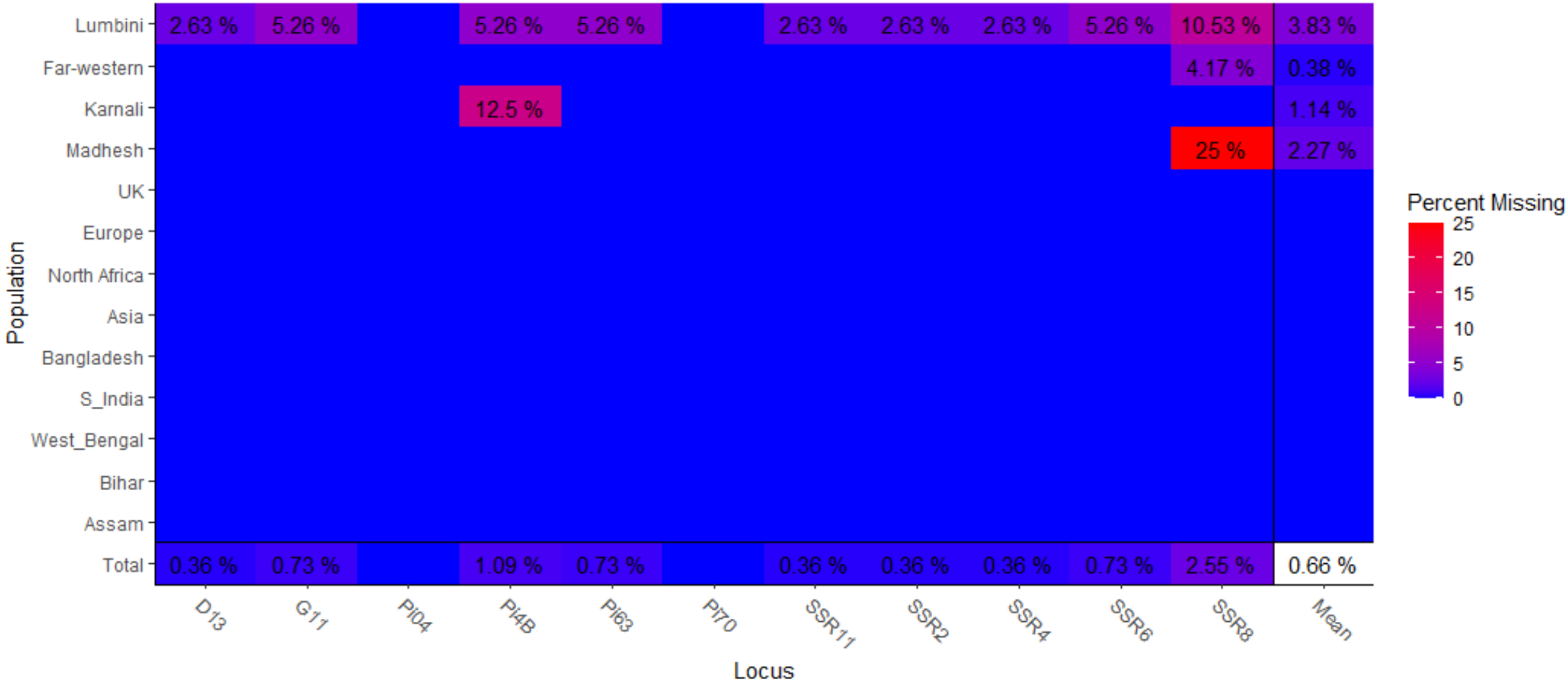
Data from the same location from multiple years were combined and analyzed based on geographical locations.

Previously published data by Dey *et al*. (2018) compared for SSR fingerprints to assign specific genotypes.

Frequency-based analysis such as neighbour-joining (NJ) tree and minimum spanning network to see how our data correlated to them.

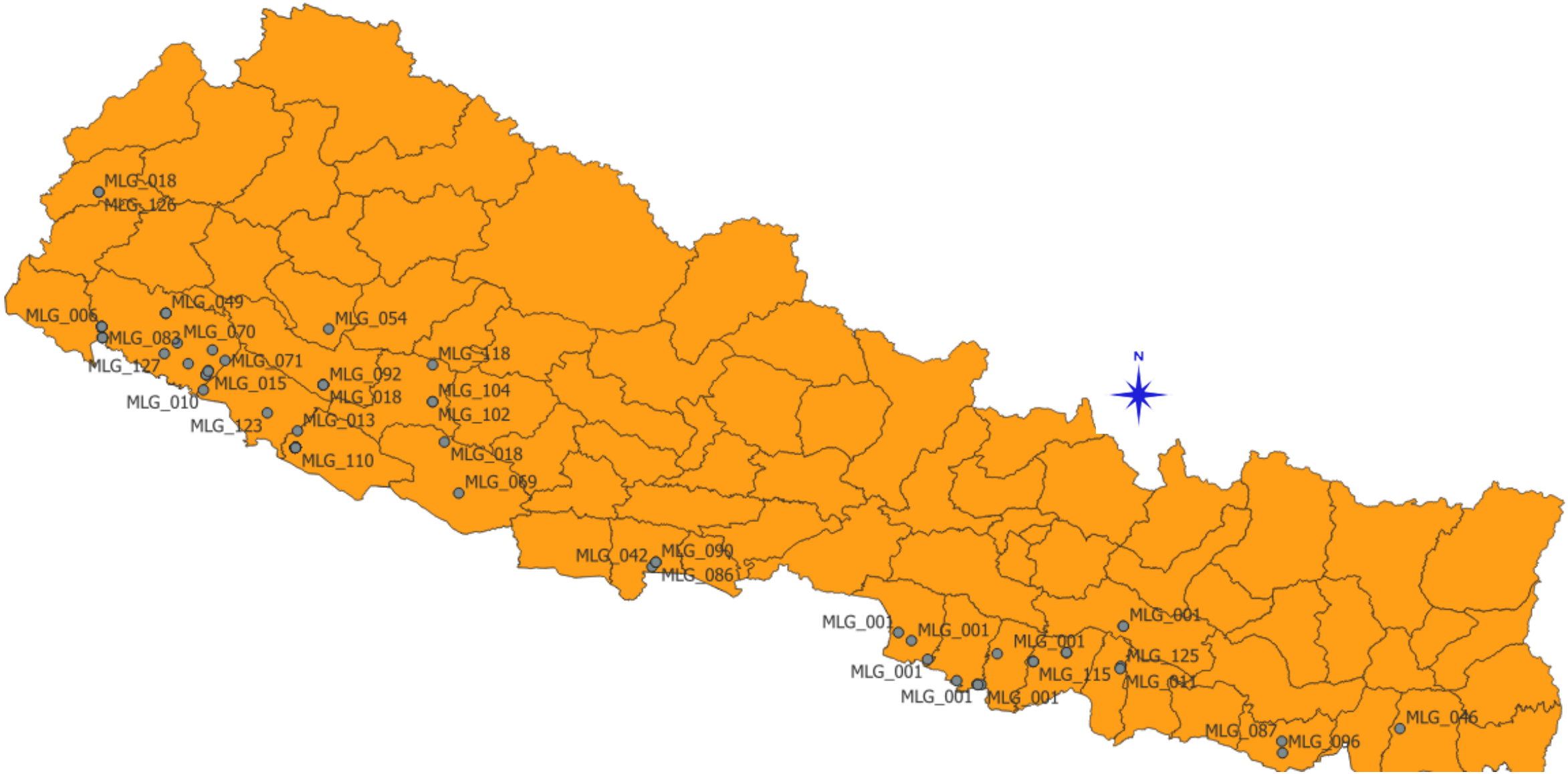
Data were analyzed in R package poppr v. 2.3.0. as described by Grünwald et al. (2017), Kamvar et al. (2014, 2015), and Shakya et al. (2018).

SN	Region	Number
1	Lumbini	23
2	Farwestren	18
3	Karnali	6
4	Madhesh	8
5	UK	72
6	Europe	28
7	North Africa	4
8	Asia	9
9	Bangladesh	1
10	S_India	2
11	West_Bengal	14
12	Bihar	2
13	Assam	1
14	Total	188

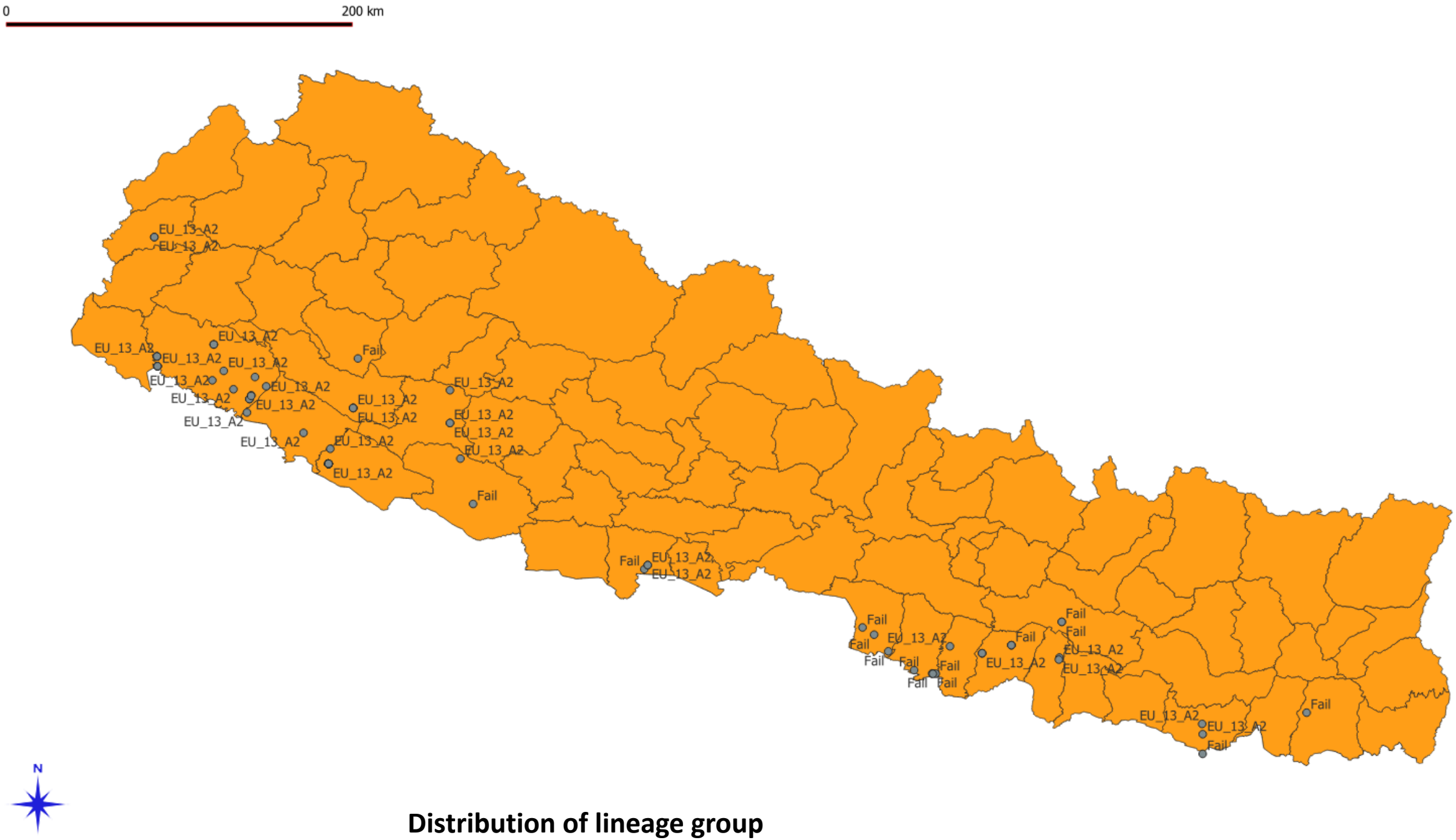

Lumbini
Far-western
Karnali
Madhesh
UK
Europe
North Africa
Asia
Bangladesh
S_India
West_Bengal
Bihar
Assam
Total
Population
2.63 %
5.26 %
5.26 %
5.26 %
2.63 %
2.63 %
2.63 %
5.26 %
10.53 %
3.83 %
4.17 %
0.38 %
12.5 %
1.14 %
25 %
2.27 %
0.36 %
0.73 %
1.09 %
0.73 %
0.36 %
0.36 %
0.36 %
0.73 %
2.55 %
0.66 %
D13
G11
Pi04
Pi4B
Pi63
Pi70
SSR11
SSR2
SSR4
SSR6
SSR8
Mean
Locus
Percent Missing
25
20
15
10
5
0

SN	Region	N	MLG	eMLG	E5	H_{exp}	Standardized index of association	P-value	Loci under HWE
1	Europe	38	28	9	0.804	0.408	-0.13	1	4
2	Lumbini	38	23	8.34	0.776	0.437	0.287	0.01	1
3	Madhesh	8	8	8	1	0.436	-0.03	0.92	3
4	Karnali	8	6	6	0.831	0.501	0.600	0.01	9
5	Far-western	24	18	8.44	0.754	0.427	0.077	0.01	2
6	UK	113	72	9.36	0.709	0.405	-0.086	1	4

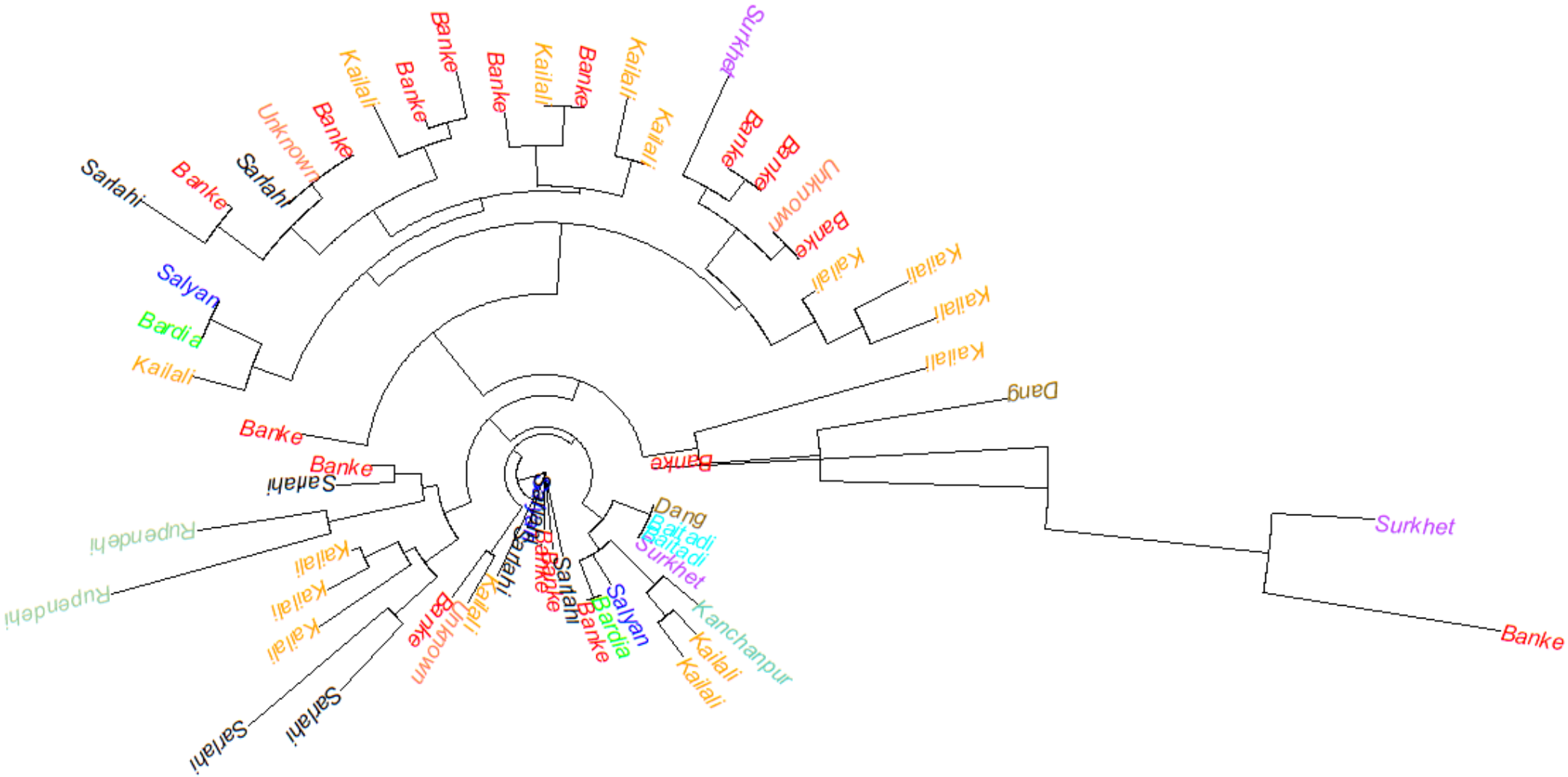
N, number of individuals
MLG, number of multilocus genotypes.
eMLG, expected number of MLGs
H_{exp}, Nei's unbiased gene diversity.



Distribution of multilocus genotypes across the country



Distribution of lineage group


Surkhet
Banke
Dang
Kailali
Kailali
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Rupendehi
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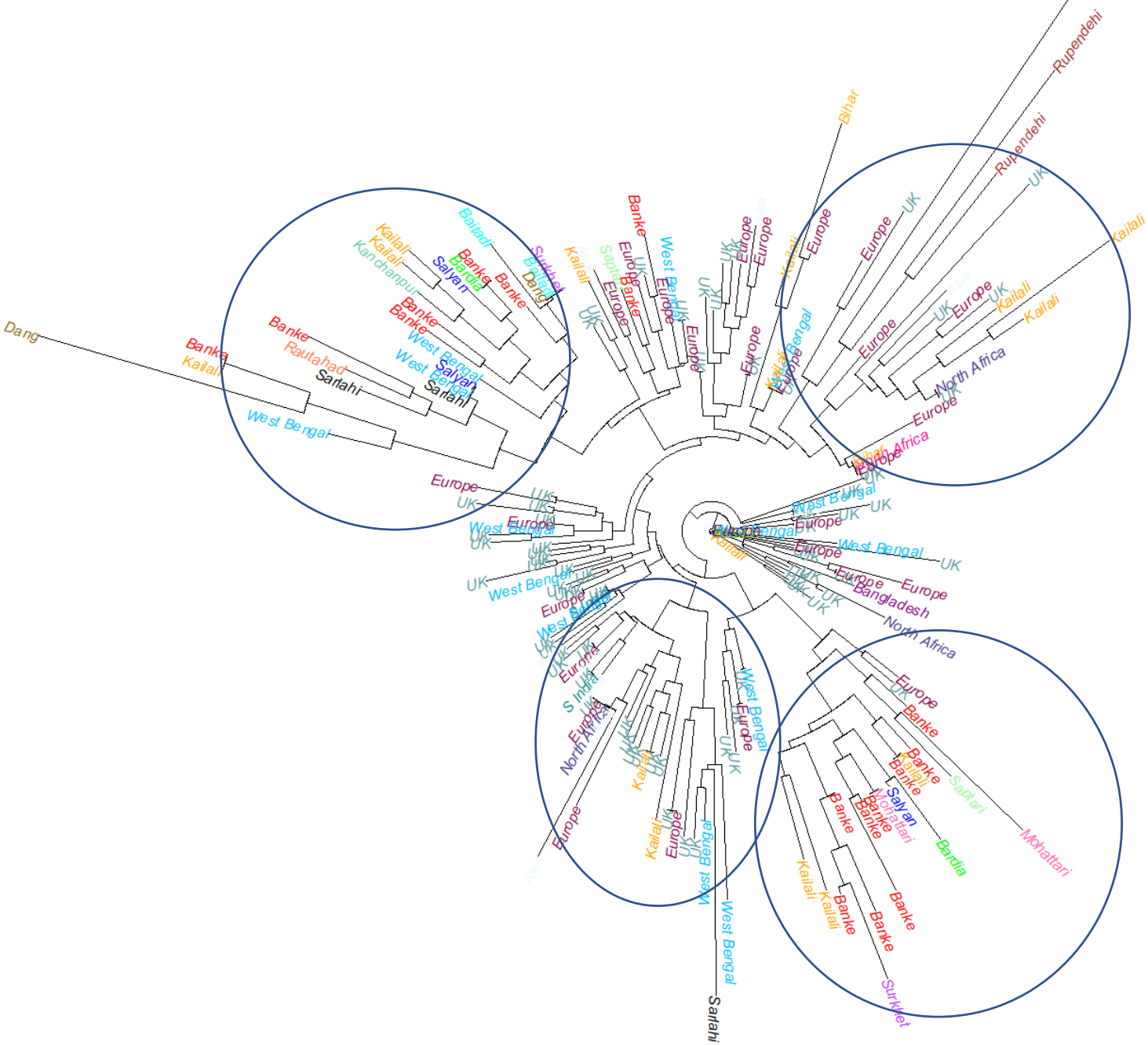
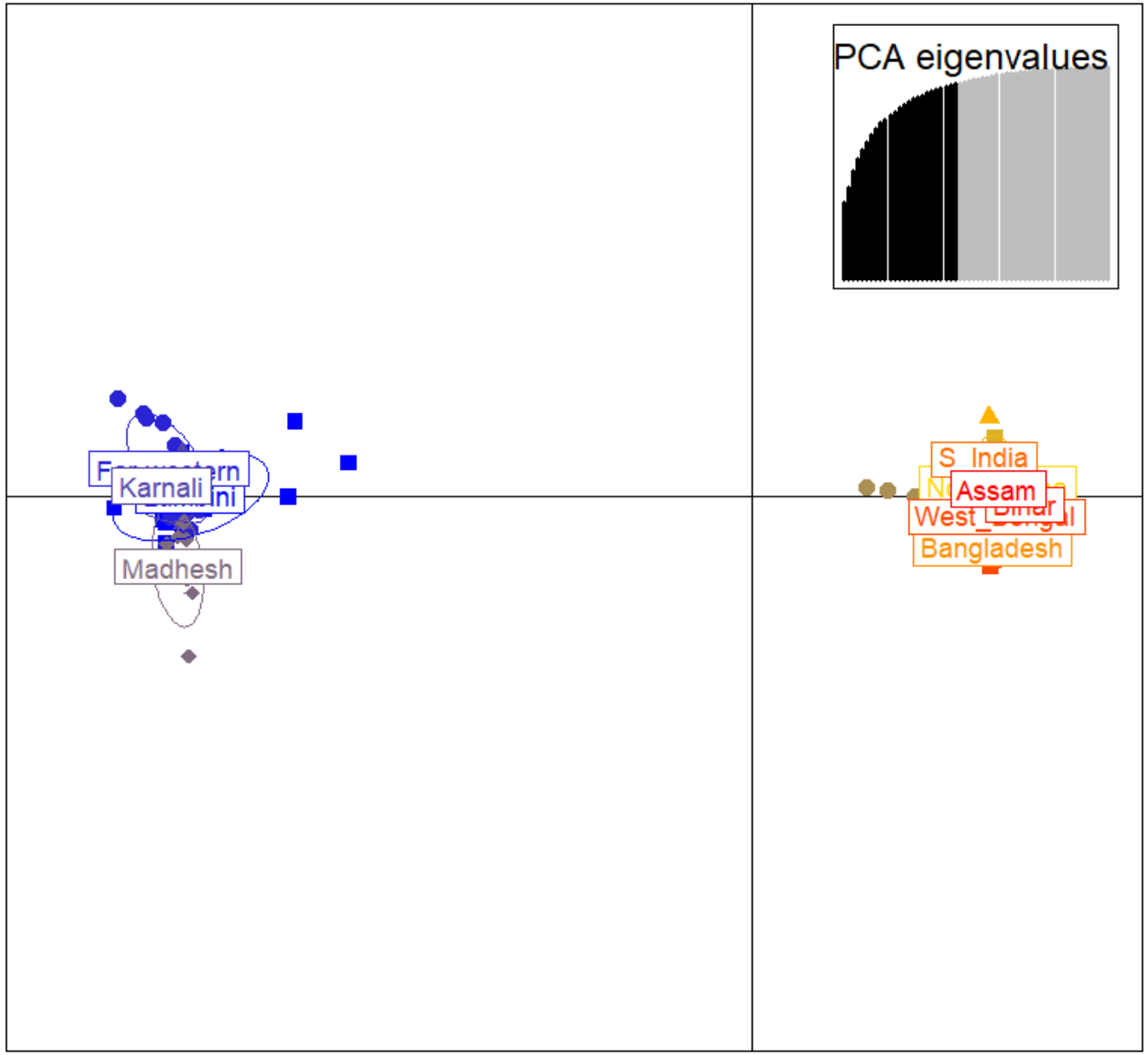
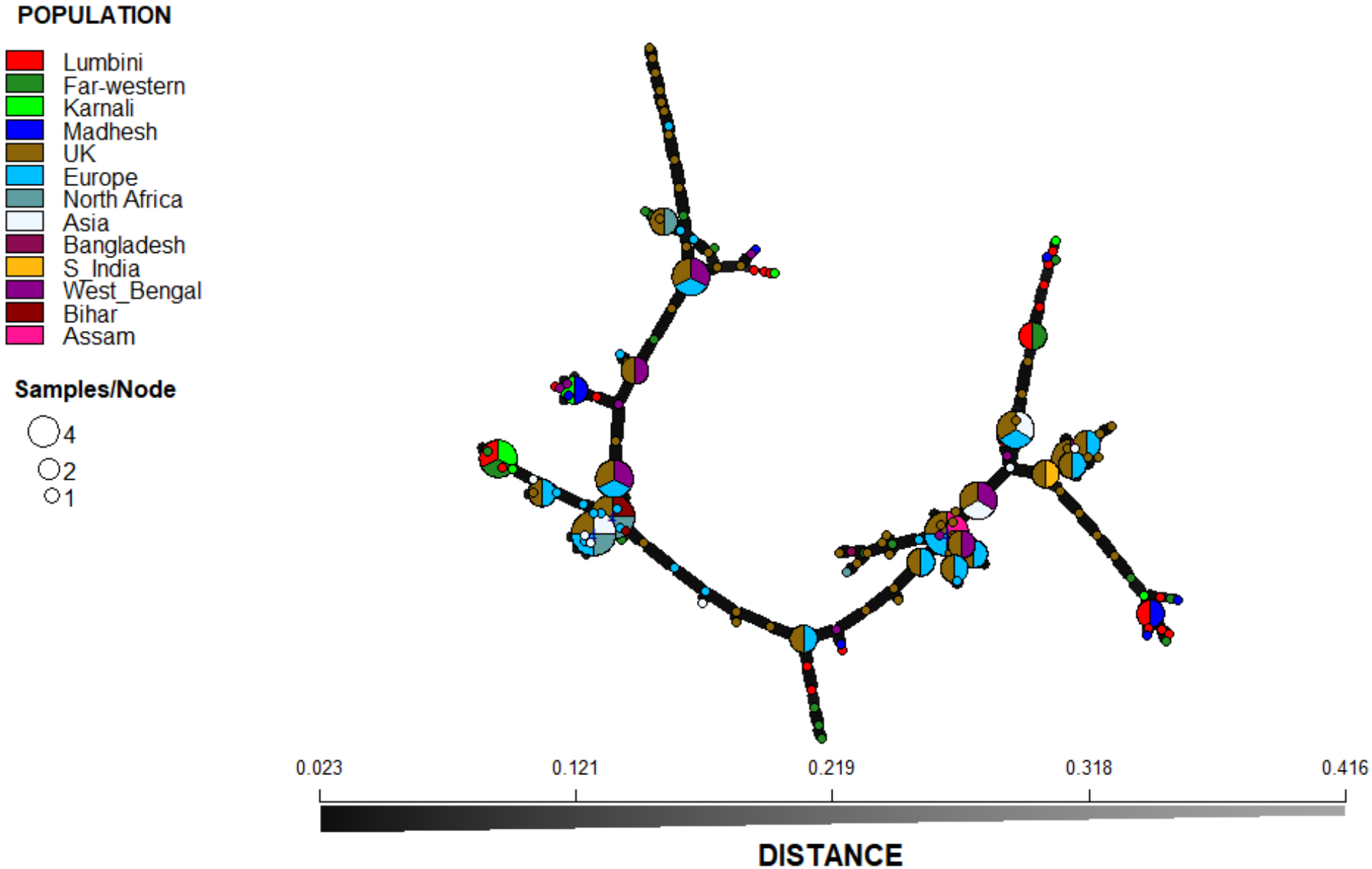
Dang
Baitadi
Baitadi
Surkhet
Kanchanpur
Kailali
Kailali


Dang
Banke
Kailali
Rautahat
Sarlahi
West Bengal
Baitadi
Kanchanpur
Bardia
Salyan
Europe
UK
Bihar
Rupendehi
North Africa
Bangladesh
Mohattari
Sapdari
Surkhet



Discriminant analysis of principal components (DAPC) of *Phytophthora infestans* populations collected from 2019 to 2022 in Nepal (data analysed in R package poppr v. 2.3.0)



Minimum Spanning Network (MSN) of Phytophthora infestans 13_A2 MLGs from Nepal compared to representative MLGs found amongst a global sample of isolates.

- We can see the diversity in population of *P. infestans in Nepal*
- Provides insights into the structure and diversity of P. infestans populations on Nepal
- More sampling is ongoing in hill and high hill regions
- Phenotypic characterization is planned

Acknowledgement

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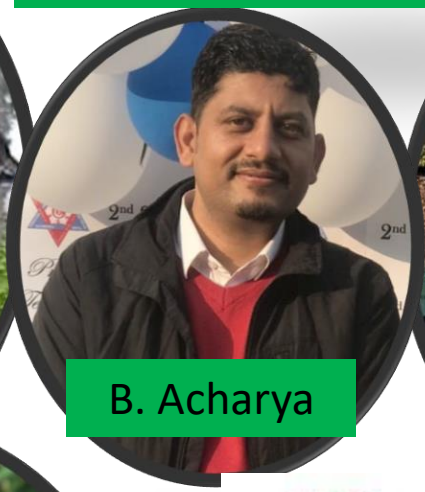
Sample collection

P. Wagle



B. Acharya

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Genotyping

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Data Analysis

NARC

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APS

Thank you