Saslis-Lagoudakis et al. The evolution of traditional knowledge: environment shapes medicinal plant use in Nepal

Electronic Supplementary Material (ESM)

1. Supporting studies

1.1 Phylogenetic versus taxonomic estimates of the similarity of medicinal floras

Our study incorporates an estimate of the phylogeny of cultures based on language group membership, and an explicit phylogeny of plant relatedness. Our rationale for incorporating a plant phylogeny is that substitution by a closely related plant may take place if the plant traditionally used is not present in the floristic environment. Whilst a phylogenetic approach can account for this type of vertical cultural transmission, more traditional taxonomic approaches cannot (Figure S1). Here we take a traditional taxonomic approach and compare the findings under traditional and phylogenetic estimates of the relatedness of medicinal floras. Traditional taxonomic approaches calculate overall similarity between pairs of samples, and use the numbers of taxa in each sample and the number of taxa found in both samples to calculate a quotient of similarity ranging from 0 to 1.

To calculate pairwise floristic distances for both the floristic environments and medicinal floras of the different ethnic groups, the Sørensen similarity index [1] was calculated and subtracted from unity. The resultant distance matrices are shown in Tables S5 and S6 for the floristic environments and medicinal floras, respectively. The phylogenetic estimate of relatedness of medicinal floras gave a significant correlation against the phylogenetic estimate of relatedness of floristic environment ($p<0.001$); the taxonomic estimate was also significantly correlated with floristic environment ($p=0.04$). Neither traditional nor phylogenetic estimates of the similarities between medicinal floras were significantly correlated with culture or geographical proximity of ethnic groups. We reason that use of the

same taxa in medicine may be more likely to be the result of horizontal transfer than use of a related taxon, which would be more likely due to vertical transfer. However, since neither proximity nor ancestry of cultures present significant correlations with medicinal floras the traditional approaches offer no additional insight over the phylogenetic approaches in this case. We suggest further studies at species level are needed to tease apart the impact of selection of same versus related plants.

1.2 The influence of background differences in floristic environment

We investigated if culture is correlated with medicinal flora after background differences in local floras have been accounted for by performing a partial Mantel test [2]. A basic Mantel test allows for the comparison between the distance matrices for two variables. In order to incorporate more variables into the comparison, a partial Mantel test is performed. The partial Mantel test compares two matrices while controlling for a third one. Partial Mantel tests [2] were performed in in the "vegan" package in R [3]. The partial Mantel test recovered a non-significant correlation between cultural and medicinal distances ($p>0.1$). This shows that residual variability in medicinal floras is not significantly structured by culture, even after removing the effects of the floristic environment.

References

1. Sørensen T.A. 1948 A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of the vegetation on Danish commons. *Kongelige Danske Videnskabernes Selskabs Biologiske Skrifter* **6**, 1-34.

2. Smouse P.E., Long J.C., Sokal R.R. 1986 Multiple regression and correlation extensions of the Mantel test of matrix correspondence. *Systematic Biology* **35**(4), 627-632. (doi:10.2307/2413122).

3. Oksanen J., Kindt R., Legendre P., O'Hara B., Simpson G.L., Solymos P., Stevens H.H., Wagner H. 2009 Vegan: community ecology package. R package version 1.15-4.

2. Supplementary Figures

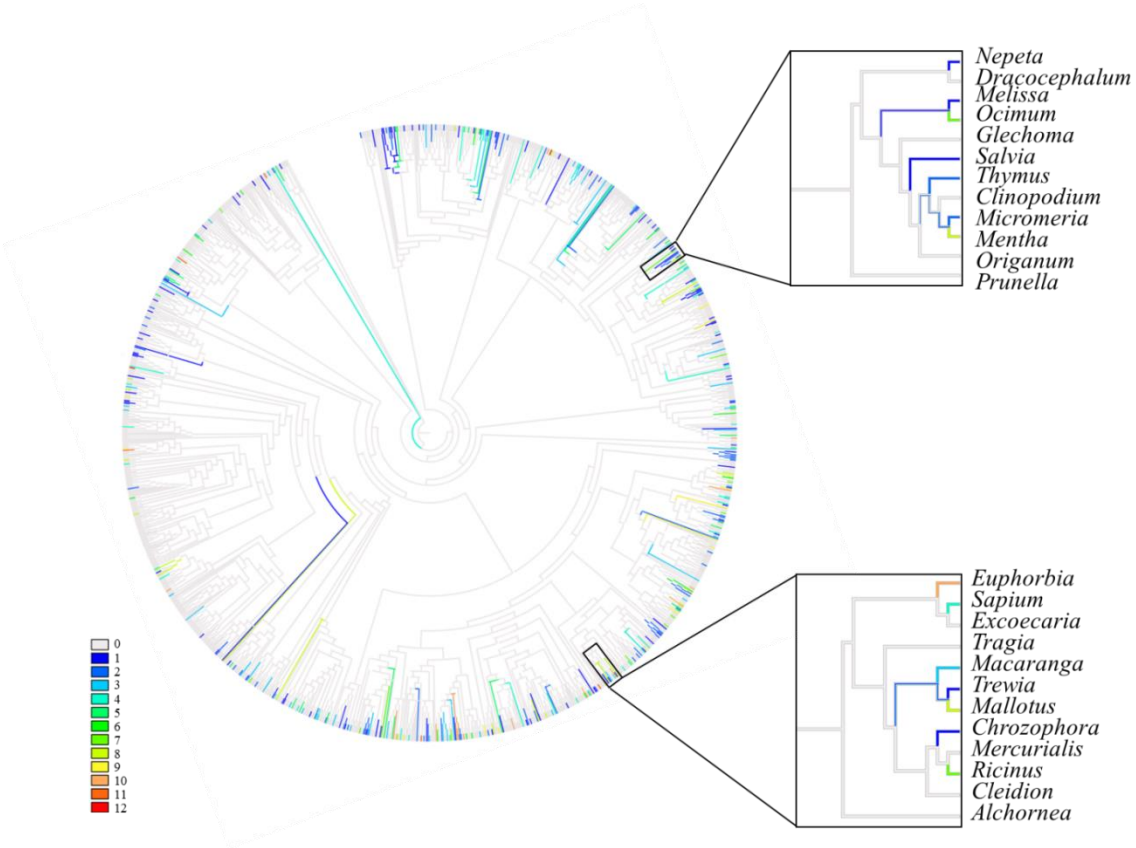

Figure S1. Phylogeny of the flora of Nepal showing phylogenetic distribution of medicinal plants and consensus in use. Branches on the tree are coloured to show the number of cultures using each genus. Red branches show genera used by all cultural groups (12), and dark blue those genera used only by one group. Two example lineages, from the families Lamiaceae and Euphorbiaceae are expanded. Genera marked in orange and green are used by many cultures and would be highlighted as genera with shared use in an approach using taxonomic or phylogenetic measures of similarity. Genera of this kind do not contribute to the signal we recover of medicinal floras converging in floristic environments. On the contrary, genera marked in blue are used by one or few cultures. Phylogenetic shared use of this kind would not be recovered using a taxonomic approach, because it is based on numbers of taxa used in common. However, our phylogenetic measures of similarity are able to distinguish between the use of unrelated or closely related taxa.

3. Supplementary Tables

Table S1. Distance matrix of languages of the 12 ethnic groups in Nepal calculated based on language classification.

	Chepang	Danuwar	Tamang	Magar	Majhi	Limbu	Sunuwar	Tharu	Gurung	Raute	Sherpa	Lepcha
Chepang	0	10	6	2	11	4	2	10	6	4	7	5
Danuwar	10	0	10	10	3	10	10	1	10	10	11	9
Tamang	6	10	0	6	11	6	6	10	0	6	3	3
Magar	2	10	6	0	11	4	2	10	6	4	7	5
Majhi	11	3	11	11	0	11	11	3	11	11	12	10
Limbu	4	10	6	4	11	0	4	10	6	2	7	5
Sunuwar	2	10	6	2	11	4	0	10	6	4	7	5
Tharu	10	1	10	10	3	10	10	0	10	10	11	9
Gurung	6	10	0	6	11	6	6	10	0	6	3	3
Raute	4	10	6	4	11	2	4	10	6	0	7	5
Sherpa	7	11	3	7	12	7	7	11	3	7	0	4
Lepcha	5	9	3	5	10	5	5	9	3	5	4	0

Table S2. Distance matrix of floristic environments for the 12 ethnic groups in Nepal calculated with “comstuctnn” in PHYLOCOM using a phylogenetic tree of the flora of Nepal, based on plant and ethnic group distribution data.

	Chepang	Danuwar	Tamang	Magar	Majhi	Limbu	Sunwar	Tharu	Gurung	Raute	Sherpa	Lepcha
Chepang	0.0000	0.0000	0.0000	0.0000	0.0000	0.0123	0.0123	0.0000	0.0000	0.0193	0.0124	0.0124
Danuwar	0.0000	0.0000	0.0000	0.0000	0.0000	0.0123	0.0123	0.0000	0.0000	0.0193	0.0124	0.0124
Tamang	0.0000	0.0000	0.0000	0.0000	0.0000	0.0123	0.0123	0.0000	0.0000	0.0193	0.0124	0.0124
Magar	0.0000	0.0000	0.0000	0.0000	0.0038	0.0146	0.0146	0.0000	0.0104	0.0245	0.0146	0.0146
Majhi	0.0000	0.0000	0.0000	0.0038	0.0000	0.0109	0.0109	0.0000	0.0067	0.0238	0.0110	0.0110
Limbu	0.0123	0.0123	0.0123	0.0146	0.0109	0.0000	0.0000	0.0000	0.0082	0.0222	0.0001	0.0001
Sunwar	0.0123	0.0123	0.0123	0.0146	0.0109	0.0000	0.0000	0.0000	0.0082	0.0222	0.0001	0.0001
Tharu	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0104	0.0245	0.0146	0.0146
Gurung	0.0000	0.0000	0.0000	0.0104	0.0067	0.0082	0.0082	0.0104	0.0000	0.0193	0.0124	0.0124
Raute	0.0193	0.0193	0.0193	0.0245	0.0238	0.0222	0.0222	0.0245	0.0193	0.0000	0.0120	0.0120
Sherpa	0.0124	0.0124	0.0124	0.0146	0.0110	0.0001	0.0001	0.0146	0.0124	0.0120	0.0000	0.0000
Lepcha	0.0124	0.0124	0.0124	0.0146	0.0110	0.0001	0.0001	0.0146	0.0124	0.0120	0.0000	0.0000

Table S3. Distance matrix of medicinal floras for the 12 ethnic groups in Nepal calculated with "comstuctnn" in PHYLOCOM using a phylogenetic tree of the flora of Nepal, based on ethnobotanical information.

	Chepang	Danuwar	Tamang	Magar	Majhi	Limbu	Sunwar	Tharu	Gurung	Raute	Sherpa	Lepcha
Chepang	0.0000	0.0659	0.0190	0.0597	0.1136	0.1134	0.1217	0.0715	0.0372	0.1614	0.1340	0.1176
Danuwar	0.0659	0.0000	0.0227	0.0479	0.1025	0.0931	0.0943	0.0410	0.0345	0.1653	0.1282	0.0934
Tamang	0.0190	0.0227	0.0000	0.0717	0.1311	0.1267	0.1334	0.0918	0.0445	0.1760	0.1217	0.1330
Magar	0.0597	0.0479	0.0717	0.0000	0.1140	0.0860	0.0948	0.0579	0.0198	0.1680	0.1149	0.0950
Majhi	0.1136	0.1025	0.1311	0.1140	0.0000	0.1150	0.1227	0.0552	0.0391	0.1341	0.1384	0.1197
Limbu	0.1134	0.0931	0.1267	0.0860	0.1150	0.0000	0.0433	0.0333	0.0142	0.1867	0.1139	0.0383
Sunwar	0.1217	0.0943	0.1334	0.0948	0.1227	0.0433	0.0000	0.0127	0.0128	0.1745	0.1112	0.0219
Tharu	0.0715	0.0410	0.0918	0.0579	0.0552	0.0333	0.0127	0.0000	0.0355	0.1651	0.1278	0.0940
Gurung	0.0372	0.0345	0.0445	0.0198	0.0391	0.0142	0.0128	0.0355	0.0000	0.1808	0.1162	0.1230
Raute	0.1614	0.1653	0.1760	0.1680	0.1341	0.1867	0.1745	0.1651	0.1808	0.0000	0.1590	0.1127
Sherpa	0.1340	0.1282	0.1217	0.1149	0.1384	0.1139	0.1112	0.1278	0.1162	0.1590	0.0000	0.1501
Lepcha	0.1176	0.0934	0.1330	0.0950	0.1197	0.0383	0.0219	0.0940	0.1230	0.1127	0.1501	0.0000

Table S4. Distance matrix of geographical distances for the 12 ethnic groups in Nepal based on their distributions in the country.

	Chepang	Danuwar	Tamang	Magar	Majhi	Limbu	Sunuwar	Tharu	Gurung	Raute	Sherpa	Lepcha
Chepang	0.0000	21.8378	47.4129	124.4317	133.9836	274.2496	134.4675	284.2675	82.7200	390.7776	171.8385	370.1825
Danuwar	21.8378	0.0000	52.7427	141.4247	117.9519	261.5355	122.3253	291.2171	104.1058	407.7229	163.4641	357.8052
Tamang	47.4129	52.7427	0.0000	149.9049	118.2826	251.2662	113.5822	303.6552	93.7172	412.4692	147.2930	346.2004
Magar	124.4317	141.4247	149.9049	0.0000	258.2183	396.8988	257.6362	243.8775	79.7628	266.7835	290.6042	492.1418
Majhi	133.9836	117.9519	118.2826	258.2183	0.0000	146.8490	29.8427	362.2232	206.3393	524.7555	74.8022	242.8618
Limbu	274.2496	261.5355	251.2662	396.8988	146.8490	0.0000	139.7848	470.9538	334.2985	661.2459	111.3024	96.3204
Sunuwar	134.4675	122.3253	113.5822	257.6362	29.8427	139.7848	0.0000	366.4528	198.8968	522.9973	48.6915	235.8206
Tharu	284.2675	291.2171	303.6552	243.8775	362.2232	470.9538	366.4528	0.0000	274.1602	248.5581	395.1657	563.0170
Gurung	82.7200	104.1058	93.7172	79.7628	206.3393	334.2985	198.8968	274.1602	0.0000	328.5834	224.6035	427.4945
Raute	390.7776	407.7229	412.4692	266.7835	524.7555	661.2459	522.9973	248.5581	328.5834	0.0000	552.2473	755.3131
Sherpa	171.8385	163.4641	147.2930	290.6042	74.8022	111.3024	48.6915	395.1657	224.6035	552.2473	0.0000	203.1308
Lepcha	370.1825	357.8052	346.2004	492.1418	242.8618	96.3204	235.8206	563.0170	427.4945	755.3131	203.1308	0.0000

Table S5. Distance matrix of floristic environments for the 12 ethnic groups in Nepal calculated with the Sørensen similarity index, based on plant and ethnic group distribution data.

	Chepang	Danuwar	Tamang	Magar	Majhi	Limbu	Sunuwar	Tharu	Gurung	Raute	Sherpa	Lepcha
Chepang	0.0000	0.0000	0.0000	0.1056	0.0654	0.1887	0.1887	0.1056	0.0000	0.2048	0.1887	0.1887
Danuwar	0.0000	0.0000	0.0000	0.1056	0.0654	0.1887	0.1887	0.1056	0.0000	0.2048	0.1887	0.1887
Tamang	0.0000	0.0000	0.0000	0.1056	0.0654	0.1887	0.1887	0.1056	0.0000	0.2048	0.1887	0.1887
Magar	0.1056	0.1056	0.1056	0.0000	0.0404	0.1476	0.1476	0.0000	0.1056	0.2341	0.1476	0.1476
Majhi	0.0654	0.0654	0.0654	0.0404	0.0000	0.1078	0.1078	0.0404	0.0654	0.2409	0.0793	0.0793
Limbu	0.1887	0.1887	0.1887	0.1476	0.1078	0.0000	0.0000	0.1476	0.1887	0.2766	0.0000	0.0000
Sunuwar	0.1887	0.1887	0.1887	0.1476	0.1078	0.0000	0.0000	0.1476	0.1887	0.2766	0.0000	0.0000
Tharu	0.1056	0.1056	0.1056	0.0000	0.0404	0.1476	0.1476	0.0000	0.1056	0.2341	0.1476	0.1476
Gurung	0.0000	0.0000	0.0000	0.1056	0.0654	0.1887	0.1887	0.1056	0.0000	0.2048	0.1887	0.1887
Raute	0.2048	0.2048	0.2048	0.2341	0.2409	0.2766	0.2766	0.2341	0.2048	0.0000	0.2766	0.2766
Sherpa	0.1887	0.1887	0.1887	0.1476	0.0793	0.0000	0.0000	0.1476	0.1887	0.2766	0.0000	0.0000
Lepcha	0.1887	0.1887	0.1887	0.1476	0.0793	0.0000	0.0000	0.1476	0.1887	0.2766	0.0000	0.0000

Table S6. Distance matrix of medicinal floras for the 12 ethnic groups in Nepal calculated with the Sørensen similarity index, based on ethnobotanical information.

	Chepang	Danuwar	Tamang	Magar	Majhi	Limbu	Sunuwar	Tharu	Gurung	Raute	Sherpa	Lepcha
Chepang	0.0000	0.4114	0.3362	0.3897	0.6151	0.5809	0.6169	0.4671	0.3740	0.7384	0.7665	0.5985
Danuwar	0.4114	0.0000	0.5000	0.4211	0.5600	0.4106	0.4184	0.3307	0.4817	0.7558	0.7813	0.4314
Tamang	0.3362	0.5000	0.0000	0.4335	0.7000	0.6081	0.6429	0.5279	0.3162	0.8205	0.7108	0.6453
Magar	0.3897	0.4211	0.4335	0.0000	0.6162	0.4146	0.4330	0.4683	0.3742	0.7882	0.6632	0.4851
Majhi	0.6151	0.5600	0.7000	0.6162	0.0000	0.7410	0.7813	0.6237	0.7077	0.6538	0.8710	0.7500
Limbu	0.5809	0.4106	0.6081	0.4146	0.7410	0.0000	0.1852	0.4093	0.5431	0.8198	0.7405	0.2448
Sunuwar	0.6169	0.4184	0.6429	0.4330	0.7813	0.1852	0.0000	0.3846	0.5859	0.8200	0.7333	0.1970
Tharu	0.4671	0.3307	0.5279	0.4683	0.6237	0.4093	0.3846	0.0000	0.4841	0.7215	0.7528	0.4211
Gurung	0.3740	0.4817	0.3162	0.3742	0.7077	0.5431	0.5859	0.4841	0.0000	0.7845	0.6349	0.5833
Raute	0.7384	0.7558	0.8205	0.7882	0.6538	0.8198	0.8200	0.7215	0.7845	0.0000	0.8750	0.7778
Sherpa	0.7665	0.7813	0.7108	0.6632	0.8710	0.7405	0.7333	0.7528	0.6349	0.8750	0.0000	0.7656
Lepcha	0.5985	0.4314	0.6453	0.4851	0.7500	0.2448	0.1970	0.4211	0.5833	0.7778	0.7656	0.0000

Table S7. Pearson product-moment correlation coefficient (*r*) and significance (*p*) of correlations among distance matrices. Floristic environment refers to the distance matrix between the total floras found in each floristic region. Medicinal flora refers to the distance matrix between the medicinal floras used by each ethnic group. Floristic environments and medicinal floras were calculated with a taxonomic approach (Sørensen similarity index). Culture refers to the distance matrix describing cultural relatedness, and based on linguistic affinities. Geography refers to the distance matrix describing geographic proximity of different cultures. n.s.= non-significant.

Distance Matrix 1	**Distance Matrix 2**	**Correlation coefficient (*r*)**	**Significance (*p* value)**
Floristic environment	Medicinal flora	0.65	$p<0.01$
Geography	Medicinal flora	0.56	n.s.
Culture	Medicinal flora	0.57	n.s.
Geography	Floristic environment	0.72	$p<0.001$