



The cultural evolution of witchcraft beliefs

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ABSTRACT

Witchcraft beliefs are historically and geographically widespread, but little is known about the cultural inheritance processes that may explain their variation between populations. A core component of witchcraft belief is that certain people ('witches') are thought to harm others using supernatural means. Various traits, which we refer to as the 'witchcraft phenotype' accompany these beliefs. Some can be classified as 'symbolic culture', including ideas about the typical behaviour of witches and concepts such as familiars (witches' magical helpers), and demographic traits such as the age and sex of those likely to be accused. We conducted an exploratory study of the cultural evolution of 31 witchcraft traits to examine their inferred ancestry and associations with historic population movements. We coded a dataset from ethnographic accounts of Bantu and Bantoid-speaking societies in sub-Saharan Africa ($N = 84$) and analysed it using phylogenetic comparative methods (PCMs). Our results estimate that while some traits, such as an ordeal to test for witchcraft, have deep history, others, such as accusations of children, may have evolved more recently, or are limited to specific clusters of societies. Demographic and symbolic cultural traits do not typically co-evolve. Our findings suggest traits have different transmission patterns, and these may result from benefits they provide or from universal psychological mechanisms that produce their recurrent evolution.

1. Introduction

Anthropologists have long sought to understand processes of cultural change, asking what makes particular traits and behaviours more likely to be invented, transmitted or become extinct (Boas, 1940; Mesoudi, 2016; Perry et al., 2022). Researchers have studied cultural microevolutionary processes affecting the diffusion and conservation of cultural variants, including those within supernatural belief systems (Atran & Henrich, 2010; Boyer, 2001; Boyer & Ramble, 2001; Norenzayan et al., 2006). Examining the macroevolution of traits over a historic time period is a complementary approach that has received less attention. Here we examine the evolution of traits related to witchcraft beliefs across cultures using phylogenetic comparative methods, to analyse their distribution across space and time in societies across sub-Saharan Africa (Fig. 1).

We refer to the suite of traits concerning witches and witchcraft beliefs within a society as the 'witchcraft phenotype': these are large, interlinked bodies of concepts that display cross-cultural similarity and

regional variation (Gershman, 2016; Geschiere, 2015; Singh, 2021). Witchcraft phenotypes are interlinked with beliefs in ancestors, spirits, ghosts and high gods (Boyer, 2001; Le Rossignol et al., 2022; Singh, 2021). Like other cultural traits, they may evolve through a variety of mechanisms. Such beliefs are frequently identified as attempts to explain and control random, fitness-relevant or unfortunate events (Boyer, 2001; Jackson et al., 2023; Keil, 2006; Legare & Gelman, 2008; Lombrozo, 2006; Murdock, 1980; Singh, 2021). They can be classified as superstitious attempts to identify cause and effect that may be favoured to evolve if they occasionally produce fitness benefits (Foster & Kokko, 2009). They have been posited as resulting from innate, adaptive aspects of human psychology, leading to their recurrence across cultures (Atran & Henrich, 2010; Boyer, 2001; Legare & Souza, 2012). Those that appear most effective will be selectively retained (Singh, 2018).

At their common core, witchcraft beliefs represent the idea that some individuals ('witches', or sometimes traditional religious practitioners) inflict harm through supernatural means (Gershman, 2016). They are used to explain misfortune, illness, injury and death (Evans-Pritchard,

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1937; Hutton, 2017; Singh, 2021). Motivated by envy, spite and aggression, witches commit harmful acts that threaten communities (Hutton, 2017; Sanders, 1995). Research suggests witchcraft beliefs are associated with decreased prosocial behaviour due to the fear and mistrust they create (Gershman, 2016; Kundtová Klocová et al., 2022).

Suspicion or accusations of black magic, and very often harm to those accused, occur in almost all societies where such beliefs exist (Boyer, 2001; Hutton, 2017; Kelkar & Nathan, 2020). The negative reputational tag of ‘witch’ appears to legitimize mistreatment of the accused, who may be exiled, physically hurt or killed. Such behaviours can portrayed as a public good because they are targeting a supposedly malevolent person who causes supernatural harm (Antal et al., 2009; Boyer, 2001; Briggs, 2002; Mace et al., 2018; Mair, 1969; Singh, 2021). Accusers and others may then access resources the ‘witch’ would have used. This does not imply such acts are cynical: fear of black magic is often deeply held (Hutton, 2017). Instead beliefs concerning witches may act as a proximate mechanism for competitive advantage, without intentional calculation (Scott-Phillips et al., 2011). These beliefs were historically widespread and are still prevalent in many parts of the world (Foxcroft, 2017; Gershman, 2022; Hutton, 2017). They are often accompanied by persecution and violence, meaning that they are a significant area of human rights concern (Forsyth et al., 2019; Foxcroft, 2017; Schnoebelen, 2009; V. Thomas et al., 2017).

Demographic traits associated with the likelihood of being targeted in accusations form part of witchcraft phenotypes, with pronounced variation in who is likely to be accused, even between geographically and culturally close societies (Hutton, 2017). Men or women may be targeted more or less in different populations (Hutton, 2017; Levack, 2016; Peacey et al., 2022). Individuals frequently accused can be elderly or very young, but there are also societies where age appears unimportant (Hutton, 2017).

Witchcraft phenotypes also include aspects of ‘symbolic culture,’ or fantastical imagery, representations, conventions, and superstitions, such as ideas about witches’ supernatural abilities and behaviours (Behringer, 2004). ‘Witches’ participate in abhorrent acts such as cannibalism and embody the opposite of prosocial traits (Briggs, 2002;

Sanders, 1995). They can separate their soul from their body, fly, become invisible, transform into animals and command the assistance of magical helpers or ‘familiars’ (Behringer, 2004; Hutton, 2017; Mair, 1969).

Supernatural belief systems such as the witchcraft phenotype are complex and explorations of the evolutionary patterns of these traits have not been previously undertaken.

The general approach to the evolutionary study of culture holds that cultural traits have differential levels of survival and reproduction, as in biological evolution, and are transferred between individuals and groups through a variety of mechanisms (Boyd & Richardson, 1985; Claidière et al., 2014).

One school of thought examines their evolution in relation to socioecology, with the hypothesis that where the benefits of a trait in an environment outweigh costs, it will spread (e.g. Barsbai et al., 2021; Bateson et al., 2006; Cronk, 1991; Holden & Mace, 2003; Watts et al., 2016). Some studies suggest what might be perceived as purely symbolic cultural traits, such as parents’ choice of baby names, are connected to geography and climate (Huey & Miles, 2022). Religious beliefs may evolve because they (or associated behaviours such as participation in rituals) enhance individuals’ fitness, by promoting a prosocial reputation (CaiRangDongZhi et al., 2023; Power, 2017, 2018) or fostering cooperative breeding (Shaver, 2017). Moralising gods may evolve in larger, more complex societies because they promote cooperation with unrelated individuals (e.g. Peoples & Marlowe, 2012; Roes & Raymond, 2003; Swanson, 1964) although see Ge et al. (2019) and Lightner et al. (2022).

Research suggests relationships between languages and cultural traditions often share deep common ancestry and reflect patterns of historic population dispersals (Mace & Holden, 2005; Mace & Jordan, 2011; Mace & Pagel, 1994). Social norms and cultural traditions may be transmitted between generations within populations through social learning (Boyd & Richardson, 1985; Cavalli-Sforza et al., 1982; Cavalli-Sforza & Feldman, 1981; Hewlett & Cavalli-Sforza, 1986), with some studies finding vertical transmission appears crucial for explaining variation in traits such as religious beliefs and marriage systems

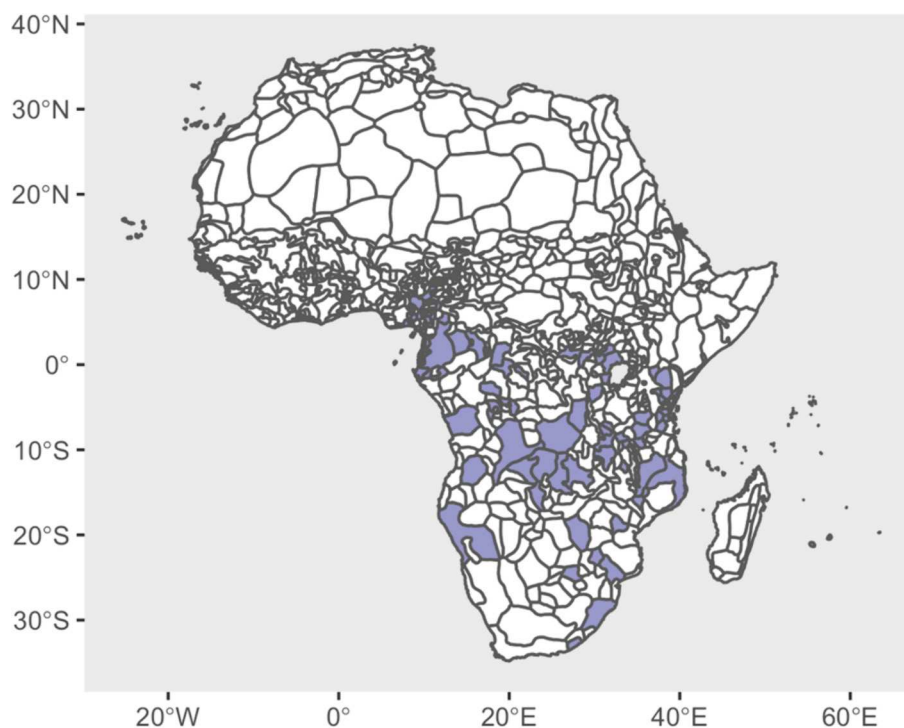


Fig. 1. Map showing the geographic locations of the Bantu and Bantoid linguistic groups in our sample ($N = 84$), using the map from Murdock’s Ethnographic Atlas and *ggplot2* (Boysel, 2022; Murdock, 1967; Wickham, 2016).

(Minocher et al., 2019; Peoples et al., 2016). Other traits whose evolutionary history has been explored using phylogenetic methods include folk tales (Graça da Silva & Tehrani, 2016), manuscripts (Howe et al., 2001), projectile points (O'Brien et al., 2001), genital mutilation (Saffa et al., 2022) and musical instruments (Aguirre-Fernández et al., 2020). Other research explores cultural transmission processes producing diversification, such as copying, or the content or complexity of the trait in question (Acerbi, 2019; Youngblood et al., 2023).

A further school of thought highlights 'cultural attraction' (Morin, 2016; Sperber, 1996). Often used to explain supernatural beliefs, this suggests traits are transformed in non-random ways as they are transmitted because they appeal to innate cognitive biases, or occur in response to pre-existing environmental constraints (Morin, 2016; Sperber, 1996). 'Cultural attractors' are points that traits converge towards, so certain variants become widely distributed and stable (Miton, 2023; Morin, 2016; Sperber, 1996). Supernatural beliefs are therefore a 'by-product' of evolved mental processes, such as systems for social cognition (e.g. Barrett, 2000; Boyer, 2001, 2003).

Our aim in this study is to explore the relationship between historic population dispersals, ancestry, geography and some of the traits that make up the witchcraft phenotype, thereby producing distinct cultural traditions in Bantoid-Bantu societies in sub-Saharan Africa that were observed mainly in the late nineteenth and first half of the twentieth centuries (Kirby et al., 2016; Murdock, 1967).

We use PCMs to examine how their variation is connected to population history (Mace & Holden, 2005; Mace & Pagel, 1994). A phylogenetic approach allows the ethnographic records of more recent societies to be used (with caution) to infer the ancestry of these beliefs, particularly with little available historic evidence (Graça da Silva & Tehrani, 2016; Teixidor-Toneu et al., 2021). Data from the ethnographic record cannot offer accounts of individual-level transmission, but can provide some insight into time depth, which can be used to draw inferences about the processes involved (Currie & Mace, 2014; Guglielmino et al., 1995).

Our study is exploratory but we predicted that some traits from the witchcraft phenotype would show evidence of phylogenetic transmission, with variation in their phylogenetic age and stability between populations. We hypothesised that demographic traits such as the age and sex of those commonly accused might show evidence of recent selection, possibly as a response to changeable socioecological factors, as has been suggested by previous phylogenetic research on rates of trait evolution and observational accounts of rapid developments in a society's witchcraft beliefs (Currie & Mace, 2014; Jorgensen, 2014; Wiessner, Tumu, & Pupu, 2016). We predicted demographic and symbolic traits in the phenotype might show evidence of co-evolution, as social norms and values might result in associations between accusations of different types of 'witch' with particular familiars (Eagly & Wood, 2012). We hypothesised the poison ordeal might be older than other traits, as it is a harmful if 'useful tool', providing an ostensibly supernatural form of decision-making to justify the removal or harming of certain individuals (Boyer, 2020; Park, 1963).

2. Materials and methods

2.1. Study population: Bantu and Bantoid ethnolinguistic groups

Bantoid and Bantu refer to a group of related languages within the Niger-Congo family in Africa, one of the world's largest phyla with 1550 languages (Eberhard et al., 2019). There are approximately 700 Bantu languages including ~500–600 Bantu languages constituting the largest subgroup within Niger-Congo. The terms 'non-Bantu Bantoid' or 'Wider Bantoid' (Grollemund et al., 2023) are generally used to refer to 150 languages spoken in Nigeria and Cameroon. The 'Narrow Bantu' or 'Bantu' languages evolved following a population divergence between Bantoid groups 5000 years ago in southern Cameroon. Groups that would become Bantu-speakers migrated across central, eastern, and

southern Africa.

The Bantu Expansion is considered to be the most important population event of Late Holocene Africa as it changed Africa's linguistic, cultural, and biological landscape. With witchcraft beliefs well-attested in Africa (Gershman, 2022) and the well-studied history of Bantoid and Bantu speakers, they constitute an object of strong interest for investigating cultural inheritance processes.

We selected these cultures (N = 84) because 1) they can be matched to our linguistic trees, 2) they are in the Ethnographic Atlas, a large global dataset created for cross-cultural analyses meaning we could identify ethnographic records (d-place.org) (Kirby et al., 2016; Murdock, 1967) and 3) they had enough detailed information on witchcraft beliefs for us to code our selected traits (Fig. 1). It was not because they had witchcraft beliefs: cognate terms for 'witch' are near-universal in Bantu societies, suggesting their presence in proto-Bantu groups (Vansina, 1990).

We used a phylogeny of 573 languages, comprising 424 on the Narrow Bantu tree from Grollemund et al. (2015) and some Wider Bantoid languages from the tree base (Grollemund et al., 2023). A 1000 tree sample was taken from the Bayesian posterior distribution after burn-in. This was pruned to 84 languages and societies we had data on, using the *Bayes Trees* program.

2.2. Data and coding

We created 31 variables relating to 13 traits (some traits were categorised into more than one variable for analysis). Details of the variables are given in Table 1.

We did not code some universal traits: all societies in the sample (and probably all with witchcraft beliefs) believe illness, deaths, and other forms of misfortune, are caused by black magic (Behringer, 2004; Evans-Pritchard, 1937; K. Thomas, 1971). Examining all the many components of witchcraft phenotypes would not be feasible, but we have selected a sample. The evil eye belief can be viewed as distinct from general witchcraft belief, but there is also considerable overlap (see SI Section 1 for further discussion).

Some ethnographic materials were accessed through the British Library and UCL libraries. Others were accessed through the electronic Human Relations Area Files (eHRAF) World Cultures database, a large online collection of ethnographic documents from societies all over the world where every paragraph is indexed by topic. Using eHRAF we ran searches using the Outline of Cultural Materials (OCM) on the topic of 'Sorcery' and a keyword search for the terms 'witch*witchcraft*sorcery'.

Our variables were coded by two coders from 143 ethnographic documents, published between 1827 and 1995 (listed in SI Section 6).

Further details of coding procedures can be found in the SI Section S1.

2.3. Variables

The coding schema for 31 variables used in the study is presented in Table 1.

2.4. Data analysis

2.4.1. Phylogenetic signal

We used the D statistic to estimate phylogenetic signal in our binary traits (Fritz & Purvis, 2010), using the R package *caper* (Orme et al., 2015). The statistic measures the number of state changes required to produce the known distribution of traits at the tips of the tree, under a Brownian motion of evolution and the expected distribution if the trait is randomly (rather than phylogenetically) distributed (Fritz & Purvis, 2010). This was calculated with 1000 permutations across the phylogeny, using a consensus tree from a sample of 1000 phylogenies. A D close to 1 or higher indicates no phylogenetic pattern, while a D close to 0 or lower indicates a trait is phylogenetically distributed. Results are given

Table 1

An outline of the coding schema for the variables in the study is given below. All traits are classified as either 1) present or 0) absent. We coded a variety of traits from the witchcraft phenotype, which can be classified as either symbolic or demographic. Further details are given in the SI (Section 1).

Variable	Description
Symbolic Culture Traits	
Poison ordeal	An ordeal to determine witchcraft guilt. A suspected 'witch' or sometimes an animal, was given a drink containing poison. If the accused vomited or were unaffected, they were innocent. The 'guilty' would be killed by the poison or after failing to recover from its effects.
Cannibalism	Witches are believed to be cannibals.
Witchcraft substance	Witchcraft is believed to be a physical substance in the body, often above the liver or the heart, that can be detected through autopsy.
The evil eye	Some individuals (not necessarily 'witches') are believed to cause supernatural harm through an envious glance.
Unconscious witchcraft	Witches are not consciously aware they are harming others through magic (but sometimes they are).
Conscious witchcraft	Witches are believed to be aware that they are harming others through magic (but sometimes they are not).
Innate witchcraft	Witchcraft is congenital/innate.
Acquired witchcraft	Powers of bewitchment are acquired through teaching or ingesting specific substances.
Divination	The use of practices (separate from the poison ordeal) to test for witchcraft.
Covens	Witches meetings at night, often involving cannibalistic feasts.
Familiars	Belief in the existence of witches' magical helpers of any type.
Types of familiar	We had 10 variables for commonly mentioned familiars. These were often animals: hyenas, owls, leopards, aardvarks, insects, snakes and baboons. Other familiars take the form of supernatural beings: spirits/ghosts, small and human-like and snakes with a human head.
Familiars are predominantly animals	Societies believed in animal familiars, or a mixture of animals and supernatural beings (but not solely supernatural familiars).
Familiars are predominantly supernatural beings	Societies believed in supernatural being familiars, or a mixture of supernatural beings and animals (but not solely animal familiars).
Deaths caused by witchcraft	The majority of deaths in a society are believed to result from witchcraft.
Maternal inheritance of witchcraft	Witchcraft ability is mainly inherited through the female line (but may be inherited through the male line).
Paternal inheritance of witchcraft	Witchcraft ability is mainly inherited through the male line (but may be inherited through the female line)
Demographic Traits	
Elderly 'witches'	Witchcraft accusations often target elderly individuals.
Child 'witches'	Witchcraft accusations may target children.
Male 'witches'	Accusations predominantly target men.
Female 'witches'	Accusations mostly target women.
Both sexes	'Witches' are equally likely to be of either sex

in Table 2.

2.4.2. Bayes traits software

The ancestral state and co-evolutionary analyses were performed in Bayes Traits.

Bayes Traits software is released under GNU Public License V3 and is available at:

<http://www.evolution.reading.ac.uk/BayesTraitsV4.0.1/BayesTraitsV4.0.1.html>.

2.4.3. Ancestral state analysis

We used information from historical records at the tree tips to

estimate character states of internal nodes on our phylogeny across our 1000-tree sample. The scarcity of earlier written records meant we could not find suitable 'fossils'. We used the 'most-recent common ancestor' method in *Bayes Traits* v3 to estimate the character states of internal nodes (Pagel et al., 2004; Pagel & Meade, 2006). This identifies the node in the posterior sample with a set of descendant taxa, including that of a hypothetical 'last common ancestor' for all societies in the sample. We used the addMRCA command in BayesTraits v3.0.2 (Pagel, 2017) and the Markov-Chain Monte Carlo method (MCMC). MCMC is a class of algorithms used for sampling from a probability distribution. It is useful when dealing with complex or high-dimensional probability distributions that are difficult to sample from directly. The burn-in period was set to 50,000,000 and the chain iteration was set to 100,000,000. The MCMC chain was sampled every 1000th iteration. We used 1000 trees to account for uncertainty and set an exponential prior distribution with a mean of 10.

Each estimated ancestral state of an internal node where the character state is unknown is a probability distribution of the posterior sample. Results are given in Table 2. We show estimates for ancestral states at the root of the Bantoid-Bantu tree and the Proto-Bantu, where the Narrow Bantu family is estimated to have separated from the Wider Bantoid at the beginning of the Bantu expansion.

Bayes Traits can also assess whether a trait is phylogenetically structured: the D-statistic is based on the continuous-state Markov process, i.e. Brownian motion (random walk with constant trait variance over time) (Felsenstein, 1985). BayesTraits is based on the continuous time discrete-state Markov process, and can also incorporate adaptive evolution (O'Meara, 2012). These methods employ different models, but both can be viewed as assessing phylogenetic patterning.

2.4.4. Co-evolution test

We used the Discrete algorithm in *BayesTraits V3* to examine co-evolution between demographic traits and different familiar types (Pagel, 1994; Pagel & Meade, 2006). 'Reversible Jump' (RJ) MCMC analyses were employed for the independent evolution model and the dependent evolution model respectively. In the independent model, the two traits evolve independently. In the dependent model, the transition rate of one trait depends on the state of the other trait. The branch lengths of the tree were rescaled by a factor of 0.001 (Pagel & Meade, 2006). We used the RJ-MCMC method because it facilitates the testing of the transition rate for each direction by visiting the large number in proportion to their posterior probabilities, with the reversible-jump searching for an optimal solution by setting some rate parameters to zero. The burn-in period was set to 50,000,000 and chain iteration was set to 100,000,000. The RJ-MCMC chain was sampled every 1000th iteration (Xie et al., 2011). We used 1000 trees to take uncertainty into consideration and set an exponential distribution for priors with a mean of 10. We ran each model 5 times and chose the median value. Log Bayes factors (logBF) (Kass & Raftery, 1995) were used with the marginal likelihood of each model for likelihood ratio testing. A logBF greater than two indicates positive evidence for dependent evolution while a logBF larger than five indicates strong evidence.

For ancestral state and co-evolutionary analyses, missing data are treated as if they could take any of the other states, with equal probability (Pagel, 2017).

2.4.5. Mantel test

We used the Mantel test to examine the correlation between all traits in the sample of societies and the geographic distance between them (Mantel, 1967). We used the *gdist()* function in R to calculate the great circle distance between societies, based latitude and longitude. We then calculated the Hamming Distance, meaning the number of positions at which the corresponding traits are different (Hamming, 1950). We then performed the Mantel Test in R, using the *Ape* programme (Paradis, 2017).

For the Mantel Test controlling for phylogeny, we used *cophenetic*.

Table 2

Results for all variables ($N = 31$) [page below]: Columns 1–3. Descriptive statistics. Column 4. Ancestral state analysis results showing the average probability from the posterior sample that traits were present in a hypothetical common ancestor for the Bantoid-Bantu linguistic tree (closer to 1 indicates greater probability the trait was present). Column 5. Results from the ancestral state analysis showing the probability from the posterior sample that the trait was present in Proto-Bantu societies. Column 6. Results from the D-statistic test. An estimate close to 0 indicates support for a trait being phylogenetically distributed, while close to 1 indicates the trait is not phylogenetically patterned. Columns 6–7. *P*-values for the D-statistic. *P*-values are shown for where the trait is present 1) and absent 0). Significant results are shown in bold.

Trait	Present	Absent	No information	Bantoid-Bantu Ancestral State	95 % CIs	Proto-Bantu (Narrow Bantu) Ancestral State	95 % CIs	Estimated D	P-value (D = 1)	P-value (D = 0)	Co-evolution Traits
Poison ordeal	62	14	8	0.72	(0.72, 0.72)	0.85	(0.85, 0.85)	0.74	0.17	0.04	
Cannibalism	31	16	37	0.63	(0.63, 0.63)	0.75	(0.75, 0.75)	0.66	0.14	0.11	
Witchcraft Substance	13	30	41	0.86	(0.85, 0.86)	0.87	(0.87, 0.87)	0.25	0.02	0.34	
Evil Eye	17	28	39	0.50	(0.50, 0.50)	0.35	(0.35, 0.35)	0.33	0.02	0.29	
Mostly Unconscious Witchcraft	20	28	36	0.59	(0.59, 0.59)	0.79	(0.79, 0.79)	0.77	0.2	0.06	
Mostly Conscious Witchcraft	46	2	36	0.81	(0.81, 0.81)	0.47	(0.47, 0.47)	−0.17	0.16	0.54	
Innate Witchcraft	22	22	40	0.55	(0.55, 0.55)	0.80	(0.79, 0.80)	1.06	0.54	0.01	
Acquired Witchcraft	38	6	40	0.86	(0.86, 0.86)	0.71	(0.71, 0.71)	0.69	0.26	0.18	
Divination	59	2	23	0.90	(0.90, 0.90)	0.94	(0.94, 0.95)	2.17	0.85	0.07	
Covens	27	9	48	0.59	(0.58, 0.59)	0.21	(0.21, 0.21)	1.26	0.69	0.02	
Familiars	34	5	45	0.71	(0.71, 0.71)	0.91	(0.90, 0.91)	0.77	0.32	0.14	
Hyena	8	27	49	0.30	(0.30, 0.30)	0.23	(0.23, 0.23)	0.48	0.12	0.23	
Owl	17	18	49	0.56	(0.56, 0.56)	0.44	(0.44, 0.44)	0.78	0.21	0.06	
Leopard	6	29	49	0.29	(0.28, 0.29)	0.16	(0.16, 0.16)	0.79	0.32	0.13	
Aardvark	3	32	49	0.13	(0.13, 0.13)	0.10	(0.10, 0.10)	0.33	0.25	0.37	
Insect	3	32	49	0.30	(0.30, 0.30)	0.13	(0.13, 0.13)	1.26	0.62	0.12	
Snake	11	24	49	0.47	(0.47, 0.48)	0.24	(0.24, 0.24)	1.16	0.67	0.01	
Baboon	4	30	50	0.09	(0.09, 0.09)	0.07	(0.07, 0.07)	−1.39	0	0.96	
Small Human-Like	6	29	49	0.37	(0.37, 0.37)	0.19	(0.18, 0.19)	0.38	0.10	0.32	
Spirit-Ghost	8	27	49	0.15	(0.15, 0.15)	0.37	(0.37, 0.37)	0.78	0.29	0.09	
Snake-human	4	80	0	0.10	(0.10, 0.11)	0.05	(0.05, 0.05)	−0.56	0	0.77	Elderly 'Witches' (BF = 3.04)
Mostly Animal Familiars	25	6	53	0.82	(0.81, 0.82)	0.66	(0.66, 0.66)	1.02	0.49	0.02	
Mostly Supernatural Being Familiars	15	16	53	0.47	(0.47, 0.47)	0.57	(0.57, 0.57)	0.38	0.12	0.29	
Death Usually Caused by Witchcraft	46	14	24	0.55	(0.55, 0.55)	0.75	(0.75, 0.75)	1.02	0.51	0	
Inheritance: Maternal and Both	21	6	57	0.73	(0.73, 0.73)	0.69	(0.69, 0.69)	2.23	0.99	0	
Inheritance: Paternal and Both	15	12	57	0.37	(0.37, 0.37)	0.45	(0.45, 0.45)	0.50	0.12	0.27	
Elderly 'Witches'	12	42	30	0.41	(0.41, 0.41)	0.20	(0.20, 0.20)	0.94	0.41	0.03	
Child 'Witches'	10	44	30	0.25	(0.25, 0.25)	0.03	(0.03, 0.04)	0.34	0.05	0.30	
Male 'Witches'	12	62	10	0.29	(0.29, 0.29)	0.16	(0.15, 0.16)	0.99	0.47	0.01	

(continued on next page)

Table 2 (continued)

Trait	Present	Absent	No information	Bantoid-Bantu Ancestral State	95 % CIs	Proto-Bantu (Narrow Bantu) Ancestral State	95 % CIs	Estimated D	P-value (D = 1)	P-value (D = 0)	Co-evolution Traits
Female ‘Witches’	25	49	10	0.52	(0.52, 0.52)	0.35	(0.35, 0.35)	0.79	0.16	0.01	Insect (BF = 5.94)
Both Sexes	37	37	10	0.48	(0.48, 0.48)	0.66	(0.65, 0.66)	0.76	0.12	0.01	Leopard (BF = 2.58)

phylo() function in R to compute the pairwise distances between the pairs of tips from a phylogenetic tree using its branch lengths.

3. Results

3.1. D statistic

D values for our 31 traits ranged between -1.39 to 2.23 , with 5 traits showing more phylogenetic clustering than would be expected by chance: witchcraft substance, the evil eye, baboon familiars, snake-human familiars and child ‘witches’.

3.2. Ancestral states: symbolic culture

8 symbolic culture variables had a high probability of having been present in a hypothetical common ancestor to the Bantoid-Bantu family: the poison ordeal, witchcraft substance, mostly conscious witchcraft, acquired witchcraft, divination, familiars (in some form), mostly supernatural familiars, and the belief witchcraft is inherited through the maternal or both maternal and paternal lines. 8 had an uncertain ancestral presence (cannibalism, the evil eye, innate witchcraft, covens, owl and snake familiars, mostly animal familiars, the idea witchcraft causes most deaths). Several of these traits (ordeal, cannibalism, substance, innate witchcraft, acquired witchcraft, divination, familiars, spirit-ghost familiars, animal familiars, most deaths caused by witchcraft and inheritance of witchcraft through the paternal line or both maternal and paternal lines) had a higher probability of being present at the Proto-Bantu node than in the more ancestral hypothetical root of the family. 8 were unlikely to have been present at the root of the tree (hyena, leopard, aardvark, insect, baboon, small and human-like, spirit-ghost and snake-human familiars).

3.3. Ancestral states: demographic traits

None of the 5 demographic variables had a high probability of being present at the Bantoid-Bantu root. Instead, our results estimate that accusations of children and male ‘witches’ may be more recent. Our results are uncertain (with probabilities of ~ 0.50 for either state) as to whether accusations of women or accusations of both sexes were present ancestrally. Accusations of the elderly were likely to have been absent, with a posterior probability of 0.41 . One demographic trait was estimated as more likely to have been present in the Proto-Bantu than the Bantoid-Bantu root: accusations of both sexes.

3.4. Co-evolution results

There was no evidence that most pairwise combinations of traits had co-evolved (see SI Tables 4 and 5). The majority had negative logBFs, indicating independent evolution. There was positive support for the co-evolution of insect familiars and female ‘witches’ (BF 5.94), elderly ‘witches’ and Snake-human familiars (BF = 3.04), and for leopard familiars and accusations targeting both sexes (BF = 2.58).

3.5. Mantel test results

The Mantel test suggests no significant correlation between the distribution of our traits and the geographical location of the societies ($p = 0.86$). The Mantel test controlling for phylogeny also did not show a significant correlation between traits and geographic location ($p = 0.45$).

4. Discussion

The existence of general witchcraft beliefs was detailed in ethnographic texts for every society in our sample. Given their ubiquitous presence, it is likely they existed in ancestral populations several thousand years ago and were transmitted vertically throughout the historic dispersals of Bantoid-Bantu populations (Currie et al., 2013; Grollemund et al., 2015). The idea that witchcraft beliefs are globally ancient is suggested by discovery of an 11,000–12,000 year-old site in Australia containing artefacts matching the description of a ‘witchcraft ritual’ that was ethnographically documented in the nineteenth century (David et al., 2024). But as such finds are rare in the archaeological record, our phylogenetic approach is a complementary means of making inferences about their historic origins.

All of the traits in our sample (except some types of familiars) are widespread and stable enough (not replaced or extinct for a significant amount of time) to suggest cultural selection: they are successful, society-level variants perhaps indicating either the presence of cultural attractors or fitness-relevance. This is notable because as with other cultural traits, ideas about witchcraft within societies are not always consistent but can vary between individuals and over time (Culwick & Culwick, 1935; Evans-Pritchard, 1937; Malinowski, 1953). However, they show distinct patterns of inheritance. Several, such as the poison ordeal (Fig. 2), divination (SI Fig. 3) and the general belief in familiars (Fig. 3) appear to have deep ancestry and are widely-distributed throughout the tips. Some have a higher estimated probability of being present at Narrow Bantu than the Bantoid-Bantu root. This could mean those traits were invented within Proto-Bantu societies, and were not present earlier, although scarce data (particularly for Bantoid groups) means such interpretations should be treated cautiously. Some traits, such as witchcraft substance (Fig. 2), are phylogenetically patterned and consistent with historical population dispersals and linguistic relationships, suggesting vertical cultural inheritance. Yet belief in witchcraft substance appears to have then become extinct in certain clades. Other traits, such as specific types of familiar (Table 2; SI Figs. S5, S6), appear to have evolved rapidly and recently in small clusters of societies. Demographic variables on the sex and age of those most likely to be accused mostly did not show a phylogenetic signal, with the exception of child ‘witches’ (SI Fig. S10). The ancestral state analyses indicate it is unlikely or uncertain that the traits relating to accusations were present at the root of the tree.

We focus on discussing the results for five symbolic cultural traits (the poison ordeal, familiars, witchcraft substance, mostly conscious witchcraft and mostly unconscious witchcraft) and the demographic traits. It seems likely the latter are connected to socioecology and may evolve rapidly following environmental change (Miguel, 2005; Oster,

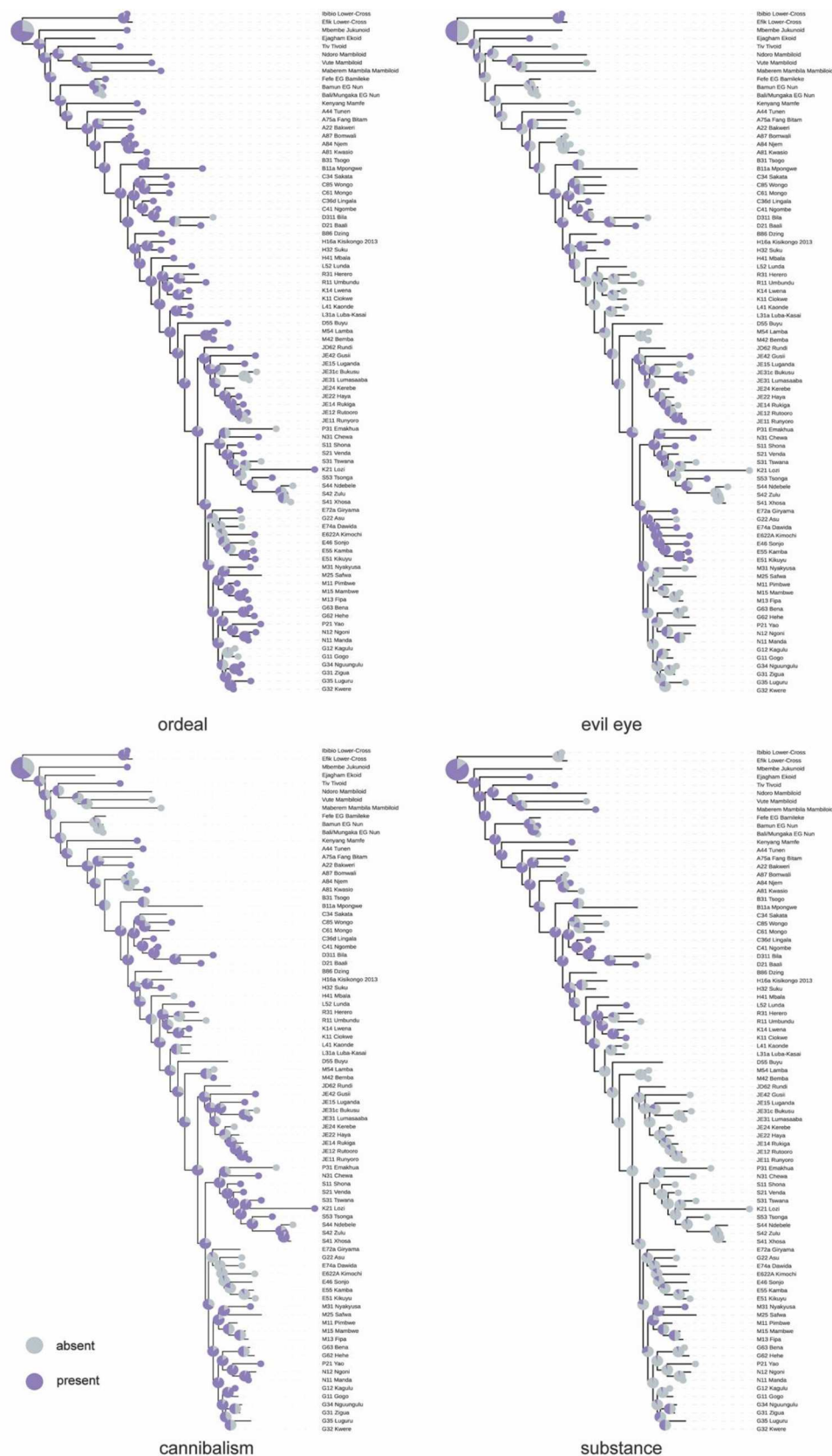


Fig. 2. [Page below]. Reconstructed ancestral states of the poison ordeal, the evil eye, the association of witchcraft with cannibalism and witchcraft substance. The 'Proto-Bantu node' where Bantu languages diverge from Wider Bantoid is located at the root of the clade beginning with 'A44 Tunen'. Purple tips denote the presence of a trait and gray denotes absence. The traits depicted were chosen to show a range of inferred presence at the root of the tree. The figures were made using the Ito website (<https://itol.embl.de>).

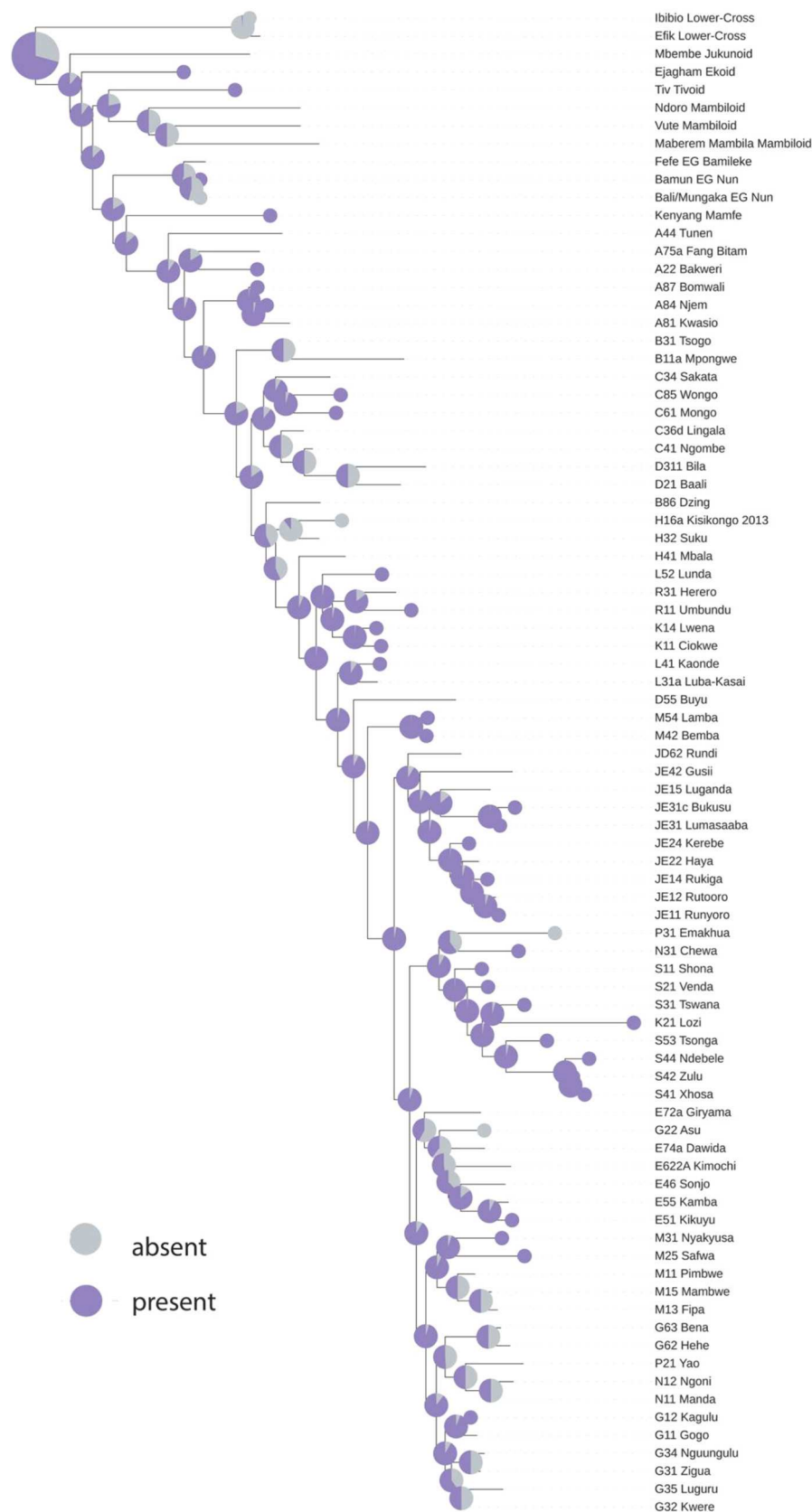


Fig. 3. Reconstructed ancestral states for the overall belief in familiars. The ‘Proto-Bantu node’ where Bantu languages diverge from Bantoid is located at the root of the clade beginning with ‘A44 Tunen’. Purple tips denote the presence of the belief and gray denotes absence. The figure was made using the Itol website (<https://itol.embl.de>). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2004), while symbolic traits may result from cultural transmission and attraction. But our results cannot truly distinguish which mechanism produces a phylogenetic pattern (or the absence of one).

Following other research, widespread child witchcraft accusations appear to be a relatively new phenomenon (SI Fig. S10). Some documents, such as the sources our data is based on, record them in parts of Africa, but they appear to have rapidly increased since the late twentieth century, and are now common in several locations, including urban parts of Nigeria, Zaire, DRC, Angola and Togo (Cimpric, 2010; Riedel & Marburg, 2012; Waddington, 2006). This may be attributable to changing demography. Children were once involved in agricultural production and contributed towards households' economic prosperity, but the transition to urban societies could lead to their being viewed as an additional cost (Cimpric, 2010), especially where they live with more distant relatives or step-parents (Cimpric, 2010; Daly & Wilson, 1985).

It is perhaps surprising that accusations of elderly individuals may not be ancestral or phylogenetically transmitted, given their cross-cultural prevalence. With traits without evidence of vertical transmission, where horizontal transmission is also unlikely given the Mantel tests, the most parsimonious explanation is they have evolved convergently. Accusations of the elderly were documented in early modern Europe (Briggs, 2002; Macfarlane, 1999), and modern-day India, Papua New Guinea (PNG), Ghana and Tanzania, among others (Adinkrah, 2004; Foxcroft, 2017; Miguel, 2005). This could relate to socioecology: poor harvests have been shown to lead to a rise in the targeting of elderly women as witches in modern Tanzania (Miguel, 2005), and food shortages were associated with an increase in witchcraft trials primarily targeting poor and widowed women across early modern Europe (Oster, 2004). This may be part of broader patterns of geronticide associated with harsh environmental conditions (Brogden, 2001), and it is possible such traits fluctuate with rapid changes in environmental factors rather than having longstanding phylogenetic history.

Although there is often a gendered element to witchcraft accusations (Adinkrah, 2004; Forsyth et al., 2019; Hutton, 2017; Jorgensen, 2014; Levack, 2016; Peacey et al., 2022), we found no strong indications that accusations of men, women or both sexes were present ancestrally (Table 2). This, and the lack of phylogenetic patterning, could indicate a labile trait. It may be attributable to distinctive factors within societies or the balance of competitive relationships that determine accusation patterns (Nadel, 1952; Peacey et al., 2022; Wilson, 1951).

Transmission of the poison ordeal to detect witchcraft guilt could result from various cultural evolutionary mechanisms. It was present in many tips of the Bantoid-Bantu tree (Fig. 2), and was inferred to have been conserved from the root. Its low phylogenetic signal is likely to result from its distribution. The d-statistic tests whether traits are more clustered between related than unrelated societies, so a widespread variant would not show phylogenetic patterning (Fritz & Purvis, 2010). Vertical transmission of the ordeal is supported by early written records from West Africa and it was probably in use to detect 'witches' in the early modern period (Paton, 2012). Evans-Pritchard discussed its use by the non-Bantu Azande of southern Sudan (Evans-Pritchard, 1937). It was used as recently as 2012 by Ngandu farmers and Aka foragers in the Central African Republic, although often for reasons other than the detection of witchcraft (Hewlett et al., 2013). These are culturally separate from the Bantoid linguistic group, particularly the Aka (Kirby et al., 2016), raising the question of whether it could have been horizontally transmitted between societies or developed independently and recurrently (including in Bantoid-Bantu cultures).

The ordeal had a high probability of being present in the Proto-Bantu, but may not have existed at the root. There are some early accounts from Bantu societies: it was used in the Congo by Kikongo-speakers to detect witchcraft at the end of the seventeenth century (Caltanisetta & de Caltanisetta & Bontinck, 1970/1690–1701), although this is still comparatively recent for the tree. The ordeal's probable usage by Proto-Bantu groups is further suggested by evidence of related linguistic cognate terms across the Narrow Bantu languages, suggesting

demic diffusion (Vansina, 1990).

Comparable tests for witchcraft detection, such as the use of ducking stools in Europe or other ordeals, where objects are identified as having agentic powers of sorcery-detection, are recurrent (Behringer, 2004; Park, 1963). The poison ordeal has mainly been documented within the African continent and PNG (Hutton, 2017), suggesting that while recurrent psychological processes may produce witchcraft ordeals, their form is defined through cultural transmission processes (Cavalli-Sforza et al., 1982; Sperber, 1996). As to why the ordeal was present in so many societies, divination in general may, according to Boyer (2020) be particularly compelling under certain conditions, such as when underlying circumstances are unknowable but it may be costly for individuals to express opinions. If accusations are an adaptive trait to nullify competitors (Mace et al., 2018; Peacey et al., 2022), the poison ordeal seemingly externalised this judgement. Like other divination forms, it provided an ostensibly detached, low-cost, legitimising mechanism for decision-making (Boyer, 2020; Park, 1963). Though the person preparing the drink could influence its outcome, perhaps reducing its believability (Boyer, 2020), nonetheless it has been widely diffused and sustained within these populations.

Familiars in some form are likely to have been present ancestrally; however, some clades showed clustering for certain types, while others showed no phylogenetic structure (Table 2; SI Figs. S5, S6). Some cultural traits appear to proliferate because of cultural attraction, and convergent evolution (Boyd & Richardson, 1985; Morin, 2016; Sperber, 1996). We suggest this may explain beliefs in familiars, which recur in most of Africa, India, South-East Asia, the south-western USA, Australia and New Guinea (Hutton, 2017). Furthermore they appear fantastical, rather than functional, and so less easy to explain (Behringer, 2004) except through cultural attraction.

Their arbitrary nature is further hinted at by their lack of co-evolution with the demographic traits in the phenotype. This is with the exception of mostly female 'witches' being inferred as co-evolving with insect familiars. There was some evidence for co-evolution between elderly 'witches' and snake-human familiars, and leopard familiars and 'witches' of both sexes. Ethnographic accounts indicate familiars sometimes vary by the sex of their owners: Ndembu men possessed the *ilomba*, or snake with a human head, while women had small men with reversed feet and animals such as hyenas (Turner, 1957). But this does not seem to have frequently been the case cross-culturally, and our hypothesis that the sex and age of those most commonly accused might co-evolve with different familiars was not supported. Instead our results suggest that traits in the witchcraft phenotype evolve separately.

There may be cognitive constraints on how supernatural ideas develop (Boyer & Ramble, 2001). Other studies indicate traits such as blood-letting and the magical removal of harmful 'objects' from the body may owe their widespread distribution among culturally independent groups to such mechanisms (Buckner, 2022; Miton et al., 2015) as well as, or instead of, phylogenetic history.

Animal familiars are generally drawn from indigenous wildlife. The distribution of those we investigated broadly matched with modern-day species (<https://www.awf.org>). So no hyena familiars appear in regions without hyenas, or leopards in regions without leopards to suggest diffusion. But baboons, which live in many parts of Africa, are only 'familiars' in Mozambique and South Africa within a small clade. Some 'familiars' such as snakes and owls, are present throughout the continent.

Following other research, we found familiars are usually nocturnal, like witches (Hutton, 2017; Sanders, 1995; Singh, 2021). The only exceptions in our sample are diurnal baboons and some insects. They are often dangerous to humans (leopards, hyenas and snakes), or harmful in other ways such as baboons who damage crops (Hutton, 2017; Singh, 2021). The clustering of the *ilomba*, or snake-human familiars, and diminutive, human-like familiars (similar to European 'imps') in closely-related societies suggests rapid vertical transmission of these variants. But perhaps the content of what constitutes a familiar is less crucial than

the concept of supernatural power over other beings as part of witchcraft phenotypes. Variation in supernatural concepts may appear limitless, but is perhaps subject to constraints with only a number of cross-culturally recurrent templates (Barrett, 2000; Boyer & Ramble, 2001).

The idea of witchcraft substance in the body of a 'witch' is unusually distributed throughout the tree tips (Fig. 2) with a high probability of being present in ancestral populations and phylogenetically patterned. Ethnographers frequently noted it in Bantoid and western Bantu societies in north-west sub-Saharan Africa. But it is absent in the clade starting from the internal node giving rise to external nodes L41, L31a and D55, among others, where there was a historic divergence between eastern and western Bantu groups (Grollemund et al., 2015). This appears to show the trait following historic dispersal patterns. This could be connected to the environment the eastern Bantu moved to, or other societal features, or stochastic drift. But the question of why it was lost in that clade is currently unanswerable.

Belief in witchcraft substance also existed in the Azande, a society within the larger Niger-Congo language family tree that the Bantoid-Bantu clades are part of (Evans-Pritchard, 1937; Hammarström et al., 2019). This could suggest a deeper ancestry than is captured by our current tree, although transmission could have been horizontal.

The idea of cannibal witches was widespread, but not phylogenetically clustered, and ancestral state analysis was uncertain (Table 2; Fig. 2). This belief existed outside Africa, including in Europe and South-East Asia (Behringer, 2004; Mair, 1969) and was perhaps re-invented because of cultural attraction: it promotes demonizing narratives justifying persecution and mistreatment (Morin, 2016; Singh, 2021; Sperber, 1996). The notion appears to have existed more widely (and probably from earlier times) but the horrors of the transatlantic slave trade, when the enslaved Africans associated their captors with cannibalism and witchcraft, may have increased its prevalence (Gershman, 2020; Thornton, 2003). It is similar to vampirism, another common concept posited as resulting from attractors for disgust and disease avoidance (Bahna, 2015).

The evil eye belief was not inferred to have existed at the root of the tree, and nor was there evidence of phylogenetic clustering (Fig. 2). This supports previous research concluding that the evil eye evolved in Europe, India and the Near East, and appeared in Africa through cultural diffusion from these regions (Roberts, 1976). Our tree and its geographical distribution suggests it is not ancestral in Bantoid groups but may have been horizontally transmitted. In Africa the belief is most commonly found in the east above the equator, and is not present in the majority of societies in our sample (Kirby et al., 2016; Roberts, 1976). Yet in Kenya and the Kenya-Tanzania border, belief in the evil eye exists among Bantu groups such as the Gusii, Gisu, Nyoro and Kikuyu, where cultural, linguistic and marital exchanges with speakers of Nilotic languages such as Kalenjin, Luo, Samburu, Maasai and Turkana, and Cushitic languages such as Oromo and Somali have long taken place (Abdullahi, 2001; Amutabi, 2023; Okia, 2023; Wanyonyi, 2023; Were, 1967). The evil eye belief is more common in Nilotic and Kalenjin societies than the Bantu (DuPré, 1968; Emley, 1927; Hollis, 1927; Lewis, 2009; Merker, 1910; Omura, 1994; Riang'a et al., 2017; Spencer, 2004). Therefore although horizontal transmission cannot be proven, it seems plausible Bantu groups in this region acquired belief in the evil eye from their neighbours.

Our ancestral state analyses suggest belief in both conscious and unconscious witchcraft are likely to have existed at the root of the tree (Table 2). They are not mutually exclusive. They could be related to the 'punishment' of suspected witches. Those held to be unaware of their harmful acts may receive less harsh treatment. This was the case in the Azande, where children were especially likely to be viewed as unconscious of producing harmful bewitchments (Evans-Pritchard, 1937). It could be used to explain why many accused were perplexed when they knew they had not been attempting to cause supernatural harm (Evans-Pritchard, 1937).

We have provided some speculation as to why witchcraft traits

appear to vary in phylogenetic age and stability throughout the tree. Cultural traits evolve through various transmission processes, and this may be the case for different aspects of the witchcraft phenotype. If general belief in witchcraft is similar to religious belief it is likely to be transmitted vertically (Cavalli-Sforza et al., 1982; Guglielmino et al., 1995). Some traits in our sample may be the result of path dependent learning, or based on the transmission of historic practices, meaning that they are arbitrary and not connected to socioecology (Richerson & Boyd, 2005). There is also evidence from PNG suggesting witchcraft beliefs can change rapidly in decades. In Enga, belief in witchcraft was present in a restricted way, and no accusations of individuals occurred until approximately 30 years ago; but they are now extensive, and there has been a rapid growth of witchcraft belief-related homicides within the country as a whole (Forsyth et al., 2019; Jorgensen, 2014; Wiessner, Tumu, & Pupu, 2016). This does not appear to be the case in sub-Saharan Africa. There is a lack of written documentation before the fifteenth century and only a small amount for many locations before the nineteenth century (Ki-Zerbo, 1981; Vansina, 1990), but sources suggest that the idea of harmful witchcraft (and more benign magic) was present and widely espoused in the Congo in the seventeenth century (Caltanissetta & de Caltanissetta & Bontinck, 1970; Thornton, 1998). Some research suggests belief in witchcraft was not as prominent in earlier centuries as in the heyday of ethnographic research and increased following the Atlantic slave trade (Gershman, 2020; Mesaki, 1995), while others suggest it was common from prehistory (Ehret, 1998; Paton, 2012; Vansina, 1990).

There are limitations to this study. Studies using cross-cultural data coded from ethnographic materials commonly note that it can be difficult to differentiate between an absence of evidence and evidence of absence for a particular trait. Our codings for traits such as belief in the existence of witchcraft substance or whether witchcraft is associated with cannibalism are conservative estimates, as lack of evidence for a trait could be due to missing data rather than a genuine absence. Ethnographers may not have recorded a trait, and there is also the possibility of coding errors.

But missing data should not have influenced our results that suggest widespread distribution and ancestral presence of the poison ordeal. For the results showing the phylogenetic clustering of belief in witchcraft substance and snake-human familiars, it is possible (although maybe unlikely given their distribution) that the observed patterns are the result of omissions by ethnographers. This is the case for the evil eye, which was not always of primary interest for early anthropologists (Roberts, 1976).

Our sample sizes are small for some variables, including some varieties of familiar, and so these results should be treated with caution.

There is a further question concerning the reliability of ethnographic accounts: ethnographers may have misunderstood what their informants told them. Observers may have unwittingly confused their own notions of witchcraft with what they were told about the culture they were observing. However, the fact that numerous ethnographers recorded similar details about cultural traits in distant geographical locations suggests an overall level of reliability.

Furthermore, horizontal transmission is a potential issue for studies using PCMs (Gray et al., 2007), although simulation studies suggest that it is robust for some forms of analysis including ancestral states (Currie et al., 2010). The results of our phylogenetic signal tests indicate that some traits have been vertically transmitted, and taking tree topology into account decreases the likelihood of erroneously assigning widely-dispersed traits as ancestral (Gray et al., 2007). While the results of the Mantel test suggest it is unlikely traits spread based on geographical proximity alone, the possibility of some horizontal transmission cannot be ruled out.

5. Conclusion

Our exploratory study has demonstrated the possibilities of using a

phylogenetic approach for investigating the processes of cultural transmission for a widespread supernatural belief system such as witchcraft. We have highlighted several distinct traits within the witchcraft phenotype in the Bantoid-Bantu linguistic groups that have different patterns of phylogenetic signal and ancestral state, some dating back to the root of the tree ~6000 years B.P. Some, such as the poison ordeal were widespread and conserved; others such as types of familiars appear more labile. The study has raised possibilities for further exploration of how these traits are transmitted, for example using micro-evolutionary processes such as transmission chain mechanisms would give further indications about their role as ‘cultural attractors’. Our study indicates how complex and widespread systems of witchcraft belief may have evolved in the Bantoid-Bantu ethnolinguistic family.

CRediT authorship contribution statement

Sarah Peacey: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Baihui Wu:** Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Rebecca Grollemund:** Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Ruth Mace:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare no competing interests.

Data availability

The data associated with this research are available at [10.6084/m9.figshare.26381308].

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Appendix A. Supplementary data

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