A Cultural Phylogenetic Approach to the Evolution of Complex Societies

Oliver Sheehan

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy,
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Abstract

Human societies became vastly more complex over the course of the Holocene. Cultural evolutionists seek to understand how and why this transition occurred. Key questions are the extent to which cultural evolution follows consistent paths, and the importance of the various factors thought to drive the process. Cultural phylogenetic methods provide a relatively new way of exploring these questions and others. This thesis presents four studies that employ a cultural phylogenetic approach to investigate a range of questions about the course, causes, and consequences of cultural evolution. Three of these studies involve Austronesian-speaking societies, and one is global. In Chapter One, I provide a broad overview of the theoretical and methodological background to these studies. I define key terms, outline the domains into which cultural traits are traditionally divided, and discuss the distinction between 'materialist' and 'idealist' theories of cultural evolution. I also describe phylogenetic methods, their applicability to the study of cultural evolution, and the ways in which they complement and extend upon more traditional methods, before providing a brief overview of the chapters that follow. In Chapter Two, I present a coevolutionary study of intensive agriculture and socio-political complexity, which relates directly to the question of material versus social and ideational drivers of cultural evolution. I find strong evidence that the two traits coevolve, and that the relationship between the two is reciprocal rather than directional. In Chapter Three, I present a study that tests models of the sequential evolution of political complexity in a global sample of societies, and find that political complexity increases, and perhaps also decreases, by one level at a time. In Chapter Four I present a second coevolutionary study, this time focusing on the relationship between two different forms of authority: religious and secular. Again I find strong evidence of coevolution, but no consistent evidence of a directional relationship. In Chapter Five, I present a study of the predictors of population decline in the

Pacific Islands, which includes cultural as well as other variables. In Chapter Six, I provide a brief discussion of the overall implications of these studies.

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Extent of contribution by PhD candidate (%)	67

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Predictors of population decline in the Pacific Islands

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Sam Passmore	Assisted with analyses

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CHAPTER ONE: Introduction

The societies that most humans live in today are orders of magnitude larger, and correspondingly more complex, than those that characterised most of our evolutionary history (Johnson & Earle, 2000; Marcus, 2008; Turchin, 2013). How and why the transition from small-scale to large-scale, complex societies occurred is a central question in the study of cultural evolution. This thesis presents four studies that apply phylogenetic comparative methods to address these and related questions.

Definitions

Let us begin by defining some key terms.

Culture and society. In the broadest sense, culture is defined as ‘information that is acquired from other individuals via social transmission mechanisms such as imitation, teaching, or language’ (Mesoudi, 2011, p. 2-3). The fact that social transmission is what distinguishes culture from other kinds of information means that culture is inextricably linked to social relationships. Often the terms ‘culture’ and ‘society’ are used interchangeably. When a distinction is made, the relationship between the two is conceptualised differently in various fields. Walker (2001) draws a distinction between the ‘social sciences’ (social anthropology and sociology) and the ‘cultural sciences’ (cultural anthropology and archaeology). In the social sciences culture is seen as an aspect of society, whereas in the cultural sciences society is seen as an aspect of culture. To complicate matters further, both terms can be used in either an abstract or a concrete sense: one can speak of ‘culture’ and ‘society’ as general attributes of groups of humans and other social species, but one can also refer to specific ‘cultures’ or ‘societies’.

In this thesis, the term ‘society’ is generally used in a concrete sense and ‘culture’ in an abstract sense. In keeping with how the terms are generally used in the social sciences, culture is seen as a property of societies. The units of analysis are of the same kind in each of the studies presented in this thesis, with a minor difference in terminology. These units are called ‘societies’ throughout the thesis with the exception of Chapter Six, in which they are for the most part referred to as ‘populations’. This reflects the different emphasis of the study presented in Chapter Six, which looks at the impact of cultural and other predictors on demography, from that of the preceding chapters, which investigate relationships between cultural traits.

In delineating the units of analyses in the studies presented in this thesis, I have followed Ember and Ember (2000, p. 355), who define a society as ‘a group of people who occupy a particular territory and speak a common language not generally understood by neighbouring peoples’ (i.e. an ethnolinguistic group), but allow some flexibility, noting that ‘[i]f most of the cases fit [this] definition, any departures from it are likely to be random and not a threat to the validity of the comparison’. Most of the populations that feature in the studies presented here are ethnolinguistic groups. Exceptions are populations that speak a common language that they also share with neighbouring populations, and populations that speak multiple related languages.

Language is, of course, only one aspect of culture (Kroeber & Kluckhohn, 1963), but there are a number of reasons why it is well-suited to being used as a proxy for other aspects. Firstly, language provides an easier basis for dividing human populations into discrete groups than most other cultural traits. Language communities can overlap, but to a far lesser extent than, for example, technologies. Secondly, a common language facilitates the spread of other cultural traits, whereas language barriers impede it (Ember & Ember, 2000). Finally, language is not one of the cultural traits that is usually of direct interest in cross-cultural studies, and so is less likely to be a confounding variable (Mace & Pagel, 1994).

Social complexity. The term ‘social complexity’ (also known as societal complexity, cultural complexity, and sociocultural complexity) denotes a cluster of cultural traits that are characteristic of large-scale societies. Whether these traits represent a single underlying construct that corresponds to complexity in a general sense (see e.g. Gell-Mann, 1994) is not entirely clear. However, the traits themselves are strongly intercorrelated, as are different scales that have been developed to measure of social complexity, suggesting that they reflect either the same construct or a set of closely related ones (Chick, 1997; Denton, 2004; Turchin et al., 2018). More complex societies tend to be larger than less complex societies, to harvest more energy from their environments per head of population, and to be politically more integrated and socially more differentiated (Carneiro, 1967; Chick, 1997; Harris, 1979; Turchin, 2018). Social complexity and social scale are so closely related that the terms like 'complex society' and 'large-scale society' are often used interchangeably (see e.g. Turchin, 2013). However, the two are distinct concepts, at least in theory - one society may be more complex than another despite being the same size or smaller (Carneiro, 1967).

Cultural Evolution. Today, the term 'evolution' is often equated with the theory outlined by Charles Darwin in *The Origin of Species* that was initially called 'the theory of descent with modification'. This theory explains long-term changes in biological populations in terms of variation in heritable characteristics and the processes by which particular variants became more or less common (Kutschera, 2009). However, the term was used far more broadly prior to its adoption by Darwin (Carneiro, 2003), and continues to be used in areas other than biology to describe processes involving change over time (Ridley, 2004).

Cultural evolution, also known as social, societal, or sociocultural evolution, is the concept of evolution as applied to society and / or culture. A minimal definition of cultural evolution is the process of cultural change over time. Most definitions also require that the change be directional (i.e. non-random) or at least potentially so, and that the changes include a trend towards increasing complexity, or at least a greater likelihood that complexity will increase than decrease. The following definition is typical:

Sociocultural evolution can be characterized as a way of looking at human history. It implies an overall shape or direction to history that can be explained rationally and which endows human behaviour with special meaning. It also assumes that at least one aspect of directionality is a trend towards greater complexity. (Trigger, 1998, p. 2)

Human societies have become vastly more complex over the course of the Holocene (Johnson & Earle, 2000; Marcus, 2008; Turchin, 2013). How and why this increase occurred is perhaps the question most central to the study of cultural evolution, and is what theories of cultural evolution typically seek to explain.

Unilinearism. Studying cultural evolution requires generalisations to be made about how societies evolve. Historical particularism, the extreme view that every society has a unique history and that generalisations about social change are invalid, is not considered evolutionary. However, cultural evolutionists do differ in the extent to which they stress uniformity or diversity in how societies evolve in different times and places. The social evolutionists of the nineteenth century (Herbert Spencer, Edward Burnett Tylor, and Lewis Henry Morgan being the 'big three') are often considered (e.g. by Steward, 1955) to have advocated a 'unilinear' view of cultural evolution as a series of stages that all societies needed to pass through in order to become more complex. This characterisation is clearly a straw man (Carneiro, 2003). Although authors such as Morgan and Tylor did emphasise uniformities in the stages through which societies evolved, they were also aware of differences, a classic example being the fact that in Africa, there was no period corresponding to the 'Bronze Age' of Eurasia. Sanderson (2007) proposes that there are two forms of unilinearism, 'strong' and 'weak', and that the nineteenth-century evolutionists subscribed to 'weak unilinearism' - the view that societies tend to pass through the same stages as they become more complex, but that exceptions (e.g., the skipping of one stage) are possible. Thus defined, weak unilinearism remains a mainstream view (Carneiro, 2003). Multilinear evolution (Steward, 1955), which emphasises the different paths that cultural evolution can take in different environments, has been presented as an alternative to unilinear evolution. Subsequent authors have criticised the theoretical vagueness of the concept and questioned whether it is incompatible with or even distinct from unilinear evolution. As Carneiro (2003, p. 233) observes, the question of uniformity in cultural evolution is ‘not … a theoretical question, but … an empirical one: When we examine the evolutionary trajectories of those human societies that travelled far in their development, how much recurrence, how much regularity, how much parallelism do we find?’

Theories of cultural evolution

Theories of cultural evolution are numerous and diverse. The following is an overview of some representative examples, but is far from exhaustive. It is structured in terms of a division between materialist and idealist theories, which can be viewed as a continuum. Other schemes could have been chosen. For example, some authors divide theories of cultural evolution into conflict and integration theories, which respectively stress competition within societies and the functions that societies serve for their members as the main drivers of the evolutionary process (Tainter, 1988, and references therein). Others draw a distinction between theories that stress factors internal or external to particular societies (Carneiro, 2003). This thesis does not commit itself to any one theory, but draws upon hypotheses derived from a number of them.

Culture has traditionally been divided into three domains, which are usually given the names ‘material’, ‘social’, and ‘ideational’, or near equivalents (Kroeber & Kluckhohn, 1963). These names are fairly self-explanatory. Material culture involves direct interaction with the physical world, social culture involves social relationships, and ideational culture involves ideas. Every society has its own material, social, and ideational culture, and also operates in an environment that interacts with its culture without being part of it (See Figure 1). Every society has a physical environment, which consists of non-human phenomena and is thought to interact with culture primarily through the material domain (Harris, 1979). Almost all societies (the only exceptions being those that are completely isolated) also have a cultural environment, which consists of the material, social, and ideational culture of other societies, as well as cultural phenomena that cross social boundaries.

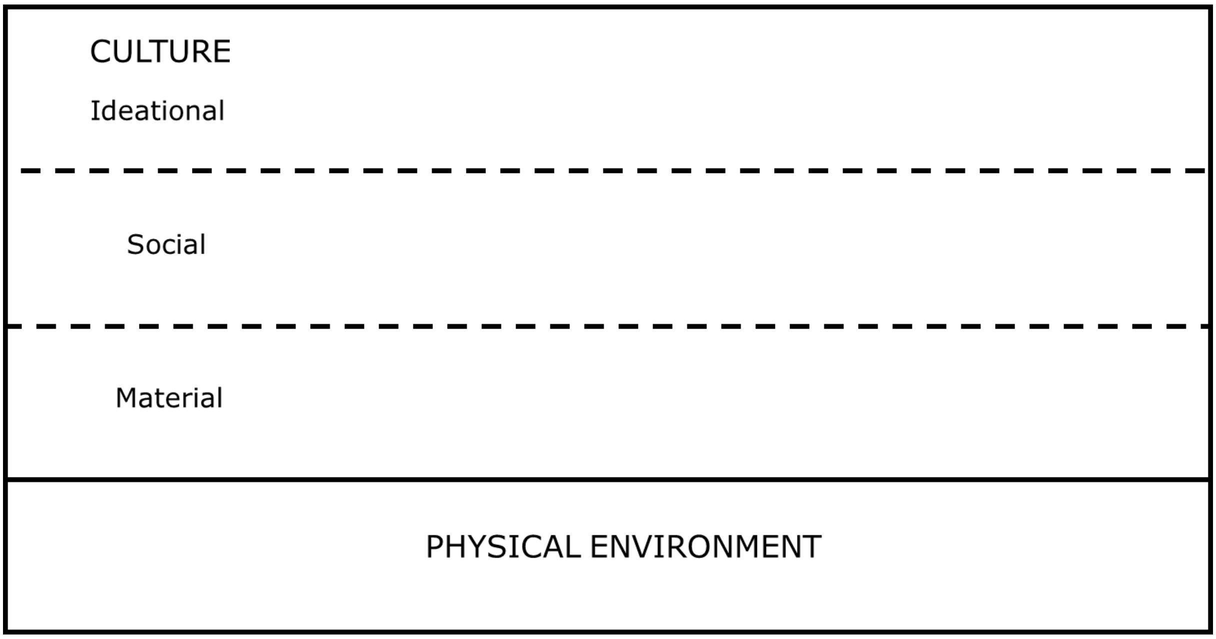

Figure 1. Culture and the environment.

The social evolutionists of the nineteenth century (Herbert Spencer, Edward Burnett Tylor, and Lewis Henry Morgan being the 'big three') tended to focus on describing the course of cultural evolution rather than explicitly identifying its causes (Carneiro, 2003; Sanderson, 2007). However, since the period beginning in the 1930s that Sanderson (2007) calls 'the evolutionary revival', many theories have been proposed that centre upon causation. Most include similar elements, but differ in their emphasis. Sanderson (2007) divides them into 'materialist' and 'idealist' theories, the former stressing material factors (material culture and the physical environment) and the latter ideas (ideational culture). Theories that stress social factors (social culture and the social environment) presumably fall somewhere between these two extremes. As Sanderson notes, the word ‘determinism’ is often used pejoratively to describe a theory that allegedly attributes causation to one factor alone, and as a consequence, some theorists express reluctance to describe their theories as deterministic (see e.g. Nolan & Lenski, 2009; Parsons, 1966). However, ‘determinism’ can also describe a theory that attributes causation to multiple factors, but considers one factor to be primary. The latter meaning will be used in the following overview. Materialist theories, which have been justified on the basis that material factors have ‘ontological priority’ (that is, they are more crucial to human survival and reproduction than social or ideational culture), tended to dominate the study of cultural evolution in the twentieth century (Carneiro, 2003; Sanderson, 2007).

The physical environment, technology, and demography are the factors that feature most often in materialist theories. Some theories emphasise one factor as ‘prime mover’, whereas others consider multiple factors to interact in such a complex way that their effects cannot be isolated. A prominent example of a theory that emphasises the physical environment is the circumscription theory, which focuses specifically on the evolution of the state, and which Sanderson (2007, p. 165) calls ‘one of the most impressive theories of political evolution we have’. Carneiro (1988, 2012) notes that the first states arose in environments that were ‘circumscribed’ – that is, that made it difficult to populations to respond to scarcity by expanding their range. The causal relationship between circumscription and the state, according to the most recent version of this theory (Carneiro, 2012) is as follows. In circumscribed environments, population pressure is likely to arise more quickly than in environments where large-scale emigration is possible. Population pressure leads to warfare over resources, and warfare results in a need for groups of otherwise independent local communities to accept a common war leader in order to fight more effectively. These war leaders are the first leaders to exercise power on a more than local scale. Initially their authority is confined to military matters, but some manage to expand it into other spheres, and eventually, this process results in the formation of states. The circumscription theory has been highly influential, but like all theories of cultural evolution it explains some cases better than others. While many early states did arise in circumscribed areas, there are highly circumscribed areas in which states have never arisen, as well as areas that are in no way circumscribed in which they have (Carneiro, 1988; Sneath, 2012). The theory has also been criticised for the vagueness of the term ‘circumscription’, and for allegedly treating population growth as a constant rather than seeking to explain it (Schacht, 1988).

While the circumscription theory involves many factors, the physical environment is primary. Theories of this nature, which see cultural change as originating outside the cultural sphere altogether, can be labelled ‘environmental determinist’. In other materialist theories, material culture is primary. Leslie White was an early and highly influential ‘technological determinist’. In his emphasis on technology, White (1943) claimed to be following the nineteenth-century evolutionists Morgan and Tylor, although, as noted previously, these early theorists were often vague about the causes of cultural evolution. White defined cultural evolution as a progressive increase in ‘the amount of energy per capita per year harnessed and put to work’, which he saw as a function of technology. Social and cultural changes, according to White, resulted from the increased energy made available from advances in technology, although White also acknowledged that social structures could play a role in either encouraging or suppressing technological development. A more recent ‘technological determinist’ theory is ecological evolutionary theory, developed by Gerhard Lenski (Lenski & Nolan, 1984; Nolan & Lenski, 2009). While ecological evolutionary theory acknowledges the influence of many factors, including ecology and demography, subsistence technology is seen as the limiting factor, and therefore the most important driver, of cultural evolution. Like other theories that stress one factor as the prime mover, ecological evolutionary theory leaves some questions unanswered, notably why some societies adopt technological innovations and others do not, despite having the opportunity to do so (Sanderson, 2007).

Demography is another factor that is often emphasised as a primary driver of cultural evolution. Jonathan Turner's theory of 'institutional differentiation' is a 'demographic determinist' theory in this sense. Institutional differentiation – the evolution of institutions beyond those that were present in hunter-gatherer societies of the distant past – is attributed to a complex array of forces, but population growth is considered fundamental: it places 'logistical loads' on societies, which are addressed by the development of new forms of social and political organization (Turner, 2003). An obvious limitation with this and other demographic determinist theories is that they leave population growth itself, which has varied greatly over both time and space, unexplained (Cowgill, 1975; Harris, 1979).

Many materialist theories of cultural evolution emphasise the combined influence of material factors rather than stressing any one particular factor. One example is Harris' theory of 'cultural materialism', which builds upon on Marx's proposition that the 'mode of production in material life determines the general character of the social, political, and spiritual processes of life' (Marx, 1859, quoted in Harris, 1979, p. 55). Unlike Marx, Harris sees demography as equally important. Harris defines the 'mode of production' as the cultural phenomena that enable subsistence, and the 'mode of reproduction' as the phenomena that enable population growth. The mode of production and the mode of reproduction constitute the 'infrastructure' of a given society. The infrastructure as a whole is considered to determine the 'structure' (political and economic organisation) and the 'superstructure' (religion, art, etc.) of a society. Sanderson (2007) sees this theory as providing an excellent explanation of cultural evolution in pre-industrial societies, but as inadequate in explaining the evolution of industrial and post-industrial societies. In response to this limitation, Sanderson presents evolutionary materialism, which draws heavily upon cultural materialism and its intellectual parents but has, the author claims, greater generalisability. Like Harris, Sanderson sees ecology, technology and demography (the factors that make up Harris' 'infrastructure') as among the basic causes of cultural evolution. However, Sanderson also includes 'economic forces' as one of these basic causes, whereas in Harris' theory economic organization is part of the structure, which is causally secondary to the infrastructure. Sanderson also proposes that the importance of each of these forces (or specific combinations of these forces) has varied over time. Specifically, Sanderson sees the Neolithic revolution as having been driven primarily by demography, the rise of the first states as having been driven by a combination of factors including demography, ecology and economy, and the rise of capitalism as having been driven primarily by economic forces, with ecological and demographic forces playing a secondary role.

Statements to the effect that ideas are the principle drivers of cultural evolution are labelled, usually pejoratively, as 'idealist' or 'cultural determinist'. Such views were fairly common among early evolutionists such as Auguste Comte, Adolf Bastian, and to a lesser extent Tylor and Morgan, but during the twentieth century theories of this nature were rare (Carneiro, 2003; Sanderson, 2007). A common criticism of idealist theories is that they leave the origin of particular ideas unexplained (Carneiro, 2003). One sociologist who identified himself, with qualifications, as a cultural determinist was Talcott Parsons. Parsons (1966) saw 'social systems' and 'cultural systems' as two of the four components of 'action systems', the other two being the 'personality system' and the 'behavioural organism'. In this scheme, the cultural system corresponds more or less to 'ideational culture', and the social system to a combination of 'social culture' and 'material culture', whereas the personality system and behavioural organism are properties of the individual members of a society. Parsons (1966, p. 9) saw these four components as forming a 'hierarchy of control … by which systems high in information but low in energy regulate other systems higher in energy but lower in information'. The cultural system was ranked as the highest level of this hierarchy, followed by the social system, the personality system, and finally the behavioural organism. Parsons (1966, p. 113) argued that:

> *Basic innovation in the evolution of living systems, both organic and socio-cultural, does not occur automatically with increases of factors or resources at the lower (conditional) levels of the cybernetic hierarchies, but depends on analytically independent developments at their higher levels.*

The anthropologist Marshall Sahlins has also been characterised as a cultural determinist, though he rejects this label (Sahlins, 1988), and much of his work does indeed emphasise the influence of ideas and beliefs upon more material factors. In his most recent work, for example, Sahlins (2017) argues that the institution of kingship was derived from religious beliefs, reversing the more usual view that gods are modelled on kings. While few authors have gone as far as Parsons or Sahlins in ascribing causal priority to ideas, many have noted their importance in recent years. The supernatural punishment hypothesis, for example, emphasises the role of beliefs in moralistic and punitive supernatural agents in promoting co-operation in large groups (e.g., Atkinson & Bourrat, 2011; Johnson & Krüger, 2004). Recently, Norenzayan (2013) has argued that belief in 'Big Gods' (i.e. powerful, moralistic deities) played a central role (though not necessarily the principal role) in the formation, maintenance and expansion of large groups during the Holocene.

Social relationships are less grounded in physical reality than material culture, but more so than ideas. Hence theories that emphasise social factors as the drivers of cultural evolution can be conceived as falling somewhere in the middle of the materialist-idealist continuum. Theories of cultural evolution rarely ascribe causal primacy to social culture, perhaps because these theories usually seek to explain the evolution of social complexity, which is itself defined largely in terms of social culture. However, many authors have seen social culture as an important driver of changes in material and ideational culture. As an example of the former, Sahlins (1972) saw leadership as a driver rather than a result of economic intensification, at least in small-scale societies, which reversed the prevailing view. With respect to the latter, Swanson (1960) saw religious beliefs as primarily a reflection of social structure – with beliefs about ancestral spirits, for example, being more common in societies in which kin groups played a prominent role. Many theories also emphasise the role of relationships between societies. According to the theory of 'cultural group selection' inter-group competition is a major driver of cultural evolution, since particular cultural traits can help groups to outcompete groups that lack these traits. The massive increase in social complexity that occurred during the Holocene has been attributed to the fact that larger societies, which by necessity tend to be more complex, tend to outcompete smaller ones (Boyd & Richerson, 2005; Turchin, 2013).

Research Methods in Cultural Evolution

While philosophical arguments are sometimes advanced in favour of particular theories of cultural evolution, ultimately these theories can only be evaluated through empirical testing. The following is an overview of the methods by which this can be achieved.

Diachronic and synchronic methods. Sanderson (2007) describes two methods for studying cultural evolution – the synchronic, or comparative method, and the diachronic, or historical method. The comparative method is synchronic or 'cross-sectional' in that it compares cultural traits in different populations at the same point in time. The historical method is diachronic or 'longitudinal' in that it examines changes in cultural traits over time.

Since cultural evolution is by definition a process that occurs over time, diachronic methods can in theory provide the best evidence for it. In practice, however, they have limitations. The historical record, which provides the most detailed information on past societies, is incomplete and unrepresentative. Written records for the most part pertain only to highly complex societies and, to a lesser extent, their neighbours (Tylor, 1920). Since the vast majority of past societies have been small-scale and non-literate, historical records can inform us about only a tiny, and unrepresentative, proportion of them. The archaeological record, which is the second major source of information on past societies, has far broader coverage as it allows inferences to be made about societies for whom little or no historical documentation exists. Indeed, archaeology has provided the strongest evidence to date that cultural evolution has occurred (Johnson & Earle, 2000; Marcus, 2008). However, archaeological data on past societies has its own limitations. Firstly, like the historical record, the archaeological record is neither complete nor representative. For various reasons, it is far more detailed for some parts of the world than for others (Blench, 2006; McIntosh, 1993). Secondly, even detailed archaeological evidence provides only indirect evidence about the social and cultural characteristics of past societies. As Marcus (2008, p. 254) puts it, archaeology 'deals with the residues of behaviour rather than directly observed behaviour'.

The comparative method, which involves making inferences about past societies from the study of ethnographically documented societies, has the advantage of being able to provide detailed information on a far larger number and greater range of societies than either the historical or archaeological records. The social evolutionists of the nineteenth century (Morgan, Spencer, Tylor, and others) relied primarily on the comparative method, partly because archaeological evidence on past societies was still scarce at the time (Sanderson, 2007). The comparative method as practiced by the nineteenth-century evolutionists involved using specific (usually technological) criteria to rate contemporary societies in terms of their cultural complexity, or, in the language of the time, the extent to which they were 'savage', 'barbarous', or 'civilised'. Levels of cultural complexity manifested by contemporary societies were equated with a series of stages through which human societies evolved, with less complex societies or cultural traits associated with them being labelled ‘survivals’ (Carneiro, 2003).

The comparative method, and the idea of cultural evolution in general, came under heavy criticism from Franz Boas and his followers from the late nineteenth century onwards. Their essential argument seems to have been that it was unjustified to draw diachronic conclusions (i.e. about social and cultural changes over time) from synchronic data (i.e. data on contemporary societies). Boas (1896) phrased this objection in terms of processes of growth and the results of these processes, the argument being that identifying the putative results of an evolutionary process did not prove that this process had ever occurred. Harris (1979) has countered that the comparative method as employed in evolutionary biology involves the same assumptions – that is, that because forms generally become more complex over time, less complex forms are likely to be better representatives of earlier forms than more complex ones - and yet is generally considered to be a valid methodological tool.

The comparative method as applied by the evolutionists of the nineteenth century can legitimately be criticised on some grounds. For example, the complexity of various societies was often graded based on arbitrary and simplistic criteria. Morgan (1877) notoriously assigned Polynesians to the ‘Middle Status of Savagery’ (which Morgan believed to be the lowest stage to which any contemporary society belonged) on the grounds that they lacked pottery and the bow and arrow, despite the fact that Polynesian societies showed high levels of social complexity in many other respects (Carneiro, 2003). However, the comparative method has since been improved and extended, and more sophisticated ways of measuring social complexity have been devised (see e.g., Murdock & Provost, 1973; Naroll, 1956; Turchin et al. 2018).

Cultural phylogenetics. One problem with any attempt to compare societies with respect to one or more traits is the non-independence of cross-cultural data. This is known as

Galton’s Problem, after the statistician Francis Galton’s criticism of a paper by the evolutionist Edward Burnett Tylor (1889). Tylor sought to show that certain social institutions arose in a particular order by establishing statistical correlations between particular institutions and the complexity of the societies in which they were found. Galton’s counter-argument was that correlations between cultural traits could not be assumed to imply any functional link between these traits, since these traits are not independent. The non-independence of cross-cultural data arises from the possibility that cultural traits can be transmitted from a ‘parent’ society to a ‘daughter’ society (vertical transmission), or that cultural traits can diffuse between societies (horizontal transmission) (Naroll, 1961). One way of addressing this problem is to model the relatedness of groups of cultures using cultural phylogenies.

Cultural phylogenies model cultural relatedness in terms of ancestor-descendant relationships. When a cultural group divides into multiple groups over time, the latter are considered the descendants of the former. According to this model, for example, Italian and French culture are contemporary descendants of Ancient Roman culture. Methods such as Phylogenetic Generalised Least Squares (PGLS) allow associations between cultural traits to be tested while cultural ancestry is ‘held constant’. This addresses one facet of Galton’s problem, namely the fact that cultures differ in the degree to which they share common origins. A version of this method, PGLS-Spatial, also allows the geographical distance between societies to be taken into account (Freckleton & Jetz, 2009). Assuming that cultural diffusion is more likely between societies that are geographically close, this also addresses the second facet of the problem and offsets the non-independence of the traits.

Phylogenetic comparative methods have other advantages beyond addressing Galton’s problem. Some phylogenetic comparative methods, such as correlated evolution, not only allow ancestry to be taken into account when comparing traits, but also allow inferences to be made about the evolutionary history of traits. That is, they provide a way of making diachronic inferences from synchronic data. As well as reconstructing the history of individual traits, phylogenetic comparative methods can also allow inferences to be made about the relationships between different traits, such as whether the presence of one trait affects the likelihood of another trait being lost or gained (Mace & Pagel, 1994). This addresses one of the key limitations of correlational research, namely the difficulty of inferring causal relationships from correlations. Phylogenetic comparative methods have the potential to show that traits are not only correlated, but causally related either directly or indirectly.

The studies in this thesis take a phylogenetic approach to cultural evolution, and employ both types of method described above – those that simply control for the effects of cultural ancestry, and those that use cultural phylogenies to reconstruct the histories of cultural traits.

General Characteristics of Cultural Evolution

Research on cultural evolution allows a number of broad conclusions to be drawn about its nature. The following section describes some of the most commonly described features of cultural evolution.

Social complexity tends to increase over time. The evidence that social complexity has increased throughout human history and for much of our prehistory is overwhelming. Archaeology has provided the strongest evidence for this trend (Johnson & Earle, 2000; Marcus, 2008), but historical and comparative data also provides support. Using historical data, Turchin (2009) found that the size of the largest empires in the world showed a consistent (though uneven) increase through the period 2800 BCE to 1800 CE. This indicates an increase in the maximum (though not necessarily median) global level of social complexity over time. More recently, Turchin et al. (2018) have drawn upon both historical and archaeological data to create a measure of social complexity based on 51 indices, and have shown that social complexity thus operationalised has shown a general increase in a sample of 30 regions from around the world. Phylogenetic comparative studies by Currie, Greenhill, Gray, Hasegawa and Mace (2010), Currie and Mace (2011) and Walker and Hamilton (2010) have reconstructed the history of political complexity (a key measure of social complexity) in samples of Austronesian and Bantu societies and found strong evidence for net increases in the level of this variable over time.

It is important to note that the fact that social complexity has increased over time does not imply that it has increased in a linear fashion, or that it has increased in all societies. Decreases in social complexity ('collapses') are well-documented both historically and archaeologically (Diamond, 2005; Tainter, 1988), as are long periods of stasis (Nolan & Lenski, 2009). Furthermore, even though human history as a whole is characterised by massive cultural change, most societies of the past never underwent any major changes of this nature. Nolan and Lenski (2009, p. 54-55) refer to this as 'the great paradox', and attribute it to 'inter-societal selection' (labelled 'cultural group selection' by Boyd & Richerson, 2005), i.e. the fact that societies that became large and complex out-competed societies that did not (see also Turchin, 2013). Nor does it imply that the trend toward greater complexity was inevitable, or that it will continue indefinitely into the future. Some authors have argued that highly complex societies are intrinsically unstable and may be maladaptive in the long term. Rappaport (1977), for example, proposed that complex societies offer suffer from a range of problems such as 'hyper-coherence' or 'hyper-integration', whereby '[d]isruptions occurring anywhere … spread everywhere' (p. 61). It seems possible that like many phenomena in the natural and social world, the trend toward greater social complexity will prove to be curvilinear or even quadratic, increasing up to a point and subsequently stabilising or decreasing.

Cultural evolution is 'weakly unilinear'. Research on cultural evolution suggests that the process is 'weakly unilinear', much as the evolutionists of the nineteenth century argued. That is, different societies tend to follow the same paths to complexity, but alternative pathways also exist. Social complexity as operationalised using existing scales appears to be a polythetic category – that is, it consists of elements that tend to be found together, but of which no single element is essential in order for a society to be described as complex. Consequently, there are different ways for complexity to evolve.

This is evident when comparing complex societies with respect to their subsistence base. Agriculture in general and intensive agriculture specifically are considered defining characteristics of complex societies (see e.g. Murdock & Provost, 1973). Ethnographic evidence from contemporary societies and archaeological evidence from past societies indicate that complex societies (at least prior to the industrial revolution) have indeed tended to have economies based on intensive agriculture (Denton, 2004; Smith, 2004), although the exact causal relationship between intensive agriculture and other facets of social complexity is still debated (see Chapter Two). However, not all complex societies have had intensive agriculture, and some fairly complex societies have lacked agriculture altogether, notable examples being some fishing societies of the pre-Columbian Americas (Fox, 2011).

For the most part, however, the traits that constitute social complexity tend to evolve in a predictable order. Scale analysis, which involves itemising the presence of different traits in a sample of different societies, and arranging them in order of frequency, has provided both synchronic and diachronic evidence for unilinearity. If some traits are rarely or never found except in the presence of other traits, reasonable inferences can be made about the order in which the traits evolved. For example, if some societies in a sample lack pottery but have agriculture, but none that lack agriculture have pottery, this suggests that agriculture precedes pottery (Carneiro, 1962; Guttman, 1944). Although originally designed for use with contemporary societies, Guttman scaling has also been applied to societies of the past. Ember and Peregrine (2000) found a near-perfect correspondence between a proposed Guttman scale developed from a contemporary sample of societies and the order in which the traits that made up this scale could be shown to have arisen in a random sample of 20 archaeological sequences. Cultural phylogenetic methods have also provided some evidence of unilinearity. Studies of the evolution of political complexity in Austronesian and Bantu-speaking societies (Currie et al., 2010; Walker & Hamilton, 2010) found strong evidence that political complexity increased (and perhaps also decreased) in a predictable sequence, a pattern that had already been noted in historically documented polities (Turchin & Gavrilets, 2009).

Both material phenomena and ideas drive cultural evolution. The distinction between 'materialist' and 'idealist' theories has been outlined above. Although theories that stress material drivers have historically dominated the study of cultural evolution, the relative importance of material versus social and ideational culture in the evolution of complex societies is still very much an open question. Factors belonging to all three of these domains have been shown to promote the evolution of complex societies, and evidence as to which are the most fundamental is difficult to weigh. Even historical evidence is ambiguous. Historians still disagree, for example, as to whether the causes of the Industrial Revolution were material (e.g., technological innovations) or social and cultural (e.g., the development of new institutions) (Van Zanden, 2009), despite an abundance of sources from this period being available. There have been no attempts, to my knowledge, to quantitatively and systematically test materialist theories against idealist theories using historical data. However, some quantitative studies have yielded results with a bearing on the specific material, social, and ideational factors that promote social complexity. Turchin (2009) showed that 'mega-empires' were most likely to emerge along 'steppe frontiers', suggesting a strong environmental influence on the evolution of complex societies. Whitehouse et al. (2019) drew on both historical and archaeological data to examine the role of religion in the evolution of complex societies, and found evidence that doctrinal rituals, but not belief in moralising gods, tended to precede increases in the rate at which societies become more complex. Evidence from archaeology on the relative importance of material and social-ideational factors is inherently problematic, since archaeological evidence is material by nature. With this caveat, Ember and Peregrine (2004) found that trade and agriculture tended to proceed less obviously material traits in their scale, such as social inequality.

Comparative studies provide some evidence in favour of material factors as the main drivers of cultural evolution. Denton (2004) found that subsistence determined the range of other aspects of social complexity, suggesting that it had causal priority. On the other hand, scale analysis on contemporary societies does not reveal any obvious relationship between the materiality of a trait and the order in which it is inferred to have appeared (see e.g., Carneiro & Tobias, 1963). Evidence from cultural phylogenetic studies is equivocal. Reciprocal relationships between material and social culture have been shown. For example, Mace and Holden (2011) showed that Bantu-speaking societies that adopted cattle-raising were consequently more likely to lose matrilineal descent, but the reverse also applied – societies that adopted matrilineal descent were more likely to lose cattle (see Chapter Two for a similar result). At least one cultural phylogenetic study suggests that ideas can influence social culture. Watts et al. (2015a) found that Austronesian-speaking societies with beliefs in supernatural punishment for immoral behaviour were more likely to develop high levels of political complexity, but that the reverse did not apply.

The Austronesian-Speaking World

Cultural phylogenetic studies typically model cultural ancestry in terms of language, though occasionally other traits are used (see e.g., Matthews, Edmonds, Wildman & Nunn, 2013, who use religion). Aside from the advantages of language in delineating cultural groups, and the fact that it facilitates the transmission of other aspects of culture, language is thought to evolve in a more ‘tree-like’ manner than other cultural traits (Mace & Pagel, 1994). Historical linguistics frequently conceptualise language families using a ‘tree model’, and even those who prefer the ‘wave model’ (the main rival to the tree model) accept the idea that ‘genealogical’ relationships exist between languages (see e.g. François, 2014). For these reasons, most cultural phylogenetic studies focus on cultural variation within a single recognised language family. Because they allow a larger number and greater variety of societies to be sampled, large language families are best-suited to testing cultural evolutionary hypotheses. Three of the four studies in this thesis involve a single language family, Austronesian. With around 1,200 members, the Austronesian language family is one of the largest recognised language families in the world (Greenhill, Blust, & Gray, 2008). Austronesian languages, whose common ancestor is generally agreed to have been spoken in Taiwan 5,000 or 6,000 years ago, are now spoken by the majority of the indigenous populations of Island Southeast Asia and Oceania (excluding Australia and New Guinea), as well as Madagascar and parts of Mainland Southeast Asia (Bellwood, Fox, & Tryon, 1995; Blust, 2009). Austronesian-speaking peoples have been noted for their biological and cultural diversity, as well as the range of environments that they occupy (Fox, 1995). Altogether, the Austronesian-speaking world is exceptionally well-suited to the study of cultural evolution using phylogenetic methods.

Outline of Following Chapters

Chapters Two through Five present four studies which apply a variety of methods to a range of datasets in order to investigate different facets and consequences of cultural evolution. The studies presented in these chapters are ‘Coevolution of landesque capital intensive agriculture and socio-political complexity’, ‘The evolution of political complexity’, ‘Coevolution of religious and secular authority’, and ‘Predictors of population decline in the

Pacific Islands' respectively. Henceforth these studies will be referred to as Studies One, Two, Three, and Four. Study One is published, whereas the remaining three are manuscripts in preparation. Chapter Six is a general discussion.

Studies One, Three, and Four involved Austronesian-speaking societies only. Studies One and Three include societies from throughout the Austronesian-speaking world, whereas Study Four is limited to Oceania, most of whose languages belong to one major branch of the family (Oceanic). I created the datasets used in these studies by coding cultural traits and other data pertaining to a number of societies based on a range of sources. The number of societies included in each study varies: 155 in Study One, 103 in Study Two, and 57 in Study Three. The difference in sample size between Studies One and Two largely reflects the nature of the cultural traits involved. The variables in Study One could be coded based on less detailed sources than those in Study Two, and also applied to a broader range of societies – since Study Two focused on religious traits, societies that had converted a world religion and whose indigenous religions could not be reconstructed in detail were excluded. The sample size of Study Three was limited by the fact that it was geographically restricted, as well as by the limited availability of contact population figures. There was considerable overlap between the societies included in these three studies. Most featured in two, and many featured in all three. Altogether, the number of distinct societies included in one or more of the studies was 164. Bellwood (1995, p. 229) has estimated that there are 'at least eight hundred contemporary Austronesian societies', though it is unclear what definition of a society this is based on. If so, the societies included in these studies constitute a relatively small subset of the total. However, based on my knowledge of the ethnographic literature I am confident that they represent the majority, and perhaps a large majority, of Austronesian societies about which detailed ethnographic data is widely available.

Study Two is on a global scale. This study uses a version of a global language phylogeny which is still in the process of being refined. The data from Study Two are from the Ethnographic Atlas (Murdock, 1967), retrieved from the online database D-Place (Kirby et al., 2016). The advantage of comparative studies on a global scale is that they allow the universality of trends in cultural evolution to be assessed. Disadvantages of a global approach are that deep language relationships are controversial (Dunn, Terrill, Reesink, Foley, & Levinson, 2005), and that the practical difficulties of coding a global sample of cultures usually necessitates the use of existing data, which limits the range of hypotheses that can be tested.

In terms of method, Studies One, Two, and Three have more in common with each other than with Study Four. All involve testing different models of the evolution of cultural traits using a Bayesian approach. Study One tests for correlated evolution, modelled as the effect of one binary cultural trait on rates of loss or gain of another trait. Study Two tests for sequential evolution – that is, whether a single cultural trait evolves through a particular sequence of states. Study Three tests for both correlated and sequential evolution. Culture plays a less prominent role in Study Four, which examines the effects of a range of factors, including but not limited to cultural ones, on a variable that is not directly cultural.

In terms of theoretical underpinnings, the four studies are diverse. Study One explicitly tests materialist and idealist theories of cultural evolution by investigating the coevolution of a cultural trait that clearly falls within the material domain (intensive agriculture) with two traits that are primarily social and ideational (political complexity and social stratification). Study Two focuses on the course of cultural evolution rather than its drivers. Specifically, it focuses on the extent to which cultural change is unilinear – whether it proceeds along similar pathways across the globe. Study Three can also be viewed in terms of the materialist-idealist dichotomy, though this theoretical orientation is less central than it is in Study One. This study models the coevolution of two cultural traits that both belong partly in the social and partly in the ideational realm, but one of which, religious authority, is arguably based more heavily on ideas than the other, secular authority. This study is also linked to unilinearity in that it tests a putatively universal cultural sequence. Finally, the thesis ends with a brief general discussion drawing together the main themes and threads from the thesis as a whole.

CHAPTER TWO: Coevolution of Landesque Capital Intensive Agriculture and Socio-Political Complexity

Introduction

The societies in which most human beings live today are vastly more complex than any that existed at the beginning of the Holocene (Johnson & Earle, 2000; Marcus, 2008). Theories of cultural evolution seek to explain how and why this occurred. Such theories have been described as falling into two major types (Sanderson, 2007), or as occupying a spectrum between two extremes (Trigger, 1998), based on the factors that they emphasise. According to 'materialist' theories, the key drivers of cultural evolution are factors that relate directly to human survival and reproduction, such as technology and population growth. Other theories, sometimes labelled 'idealist' or 'cultural determinist,' stress factors that are less directly related to these basic needs, such as ideology and social structure. Historically, the first type of theory has been advocated far more often than the second (Sanderson, 2007). However, most if not all scholars in the area have acknowledged that both material and more abstract factors play a role in cultural evolution, and some have stressed the importance of ideological phenomena such as norms, institutions and even supernatural beliefs (Atkinson & Bourrat, 2011; Boyd & Richerson, 1992; Norenzayan, 2013; Parsons, 1966; Tomasello, Melis, Tennie, Wyman, & Hermann, 2012).

The term 'complexity,' when applied to societies, refers to a cluster of highly intercorrelated social and cultural traits (Turchin et al., 2018). Two such traits are intensive use of resources and sociopolitical hierarchy. Systems of resource use can be said to be intensive when they harvest more energy from a given resource than a previous or alternative system. Typically, the relevant resource is land (Broughton, 1994). All else being equal, agriculturalists harness more energy per unit of land than foragers do, and intensive agriculturalists harness more energy than those who practice less intensive forms of agriculture (Harris & Johnson, 2000). Hence a society that shifts from foraging to agriculture, or from a less intensive to a more intensive form of agriculture, can be said to have intensified its resource base. More intensive systems of resource use are relevant to the evolution of social complexity because they can support larger populations and produce more reliable surpluses, both of which are usually thought to allow or facilitate the emergence of more elaborate forms of social differentiation (Harris, 1959, and references therein). Hierarchy involves the culturally sanctioned subordination of one group or individual to another within the same social system (Turchin & Gavrilets, 2009). A previously egalitarian society that develops social classes, or a society of previously independent villages that appoints a supralocal chief, can be said to have become more hierarchical. Like other traits considered characteristic of complex societies, hierarchy and intensive use of resources are strongly linked cross-culturally. Some foraging societies are hierarchical, and some intensive agriculturalists are egalitarian (Flannery & Marcus, 2012), but, in general, intensive agriculturalists tend to be more hierarchical than peoples who practice less intensive forms of agriculture, who in turn tend to be more hierarchical than foragers (Denton, 2004).

Since subsistence is clearly more 'material' than socio-political organization, materialists typically view intensification as a driver of rather than a response to sociopolitical hierarchy (Harris, 1979; Johnson & Earle, 2000; Turner, 2003). According to one materialist model (Johnson & Earle, 2000), population pressure drives 'intensification,' the logistical requirements of which lead to 'institutionalization.' Other materialist theories present a subtly different view whereby intensification and hierarchy lack a direct causal link, but both result from a third variable. Usually this third variable is population pressure, which is a key component of the influential 'Boserup model' (Boserup, 1965). According to one such theory (Harner, 1970), population pressure drives both an increased dependence on agriculture (via the need to feed more people with the same amount of land) and increased hierarchy (as a result of intragroup competition over resources). ‘Cultural determinist’ explanations of the relationship argue that, in at least some conditions, it is more accurate to attribute intensification to hierarchy than vice versa. Perhaps the best-known proponent of this view is Marshall Sahlins, who argued that whereas many anthropologists (including himself at an earlier stage in his career) had assumed that leadership arose in response to economic surplus, the relationship between the two had in fact been ‘at least mutual, and in the functioning of primitive society . . . rather the other way around. Leadership continually generates domestic surplus’ (Sahlins, 1972, p. 140).

Theories of cultural evolution have traditionally been evaluated using diachronic and synchronic methods (Sanderson, 2007). Diachronic methods examine changes over time as observed in the historical or archaeological record. While studies of this nature have proven valuable in clarifying the relationship between intensification and social complexity in many parts of the world (see e.g., Adams, 1974; Kirch, 1994; Schurr & Schoeninger, 1995), the incompleteness of the historical and archaeological records makes synchronic methods a useful complement (Marcus, 2008). Synchronic methods have traditionally involved examining patterns of cross-cultural variation and comparing them to the predictions made by particular theories. Cross-cultural studies of this nature made a major contribution in assessing whether or not particular theories were plausible (Ember & Levinson, 1991), but were unable to conclusively test them due to their inability to uncover causal relationships. The problem of inferring causation from correlation is common to all correlational research, but is particularly salient in cross-cultural studies due to the nonindependence of cultural traits, labelled ‘Galton’s Problem’ (Naroll, 1961). Given that human societies are related to differing degrees by common origins and cultural diffusion, simple correlations between cultural traits need not imply causal relationships. Although various techniques can be used to reduce the effects of nonindependence (see e.g. Dow, Burton, White, & Reitz, 1984; Naroll, 1961), the problem of establishing the direction of causation remains: different theories can and often do predict the same cross-cultural associations.

In recent years, this limitation has begun to be addressed via the use of phylogenetic methods originating in biology. These methods seek to identify independent instances of cultural change by comparing societies whose shared 'cultural ancestry' can be modelled using a phylogeny (Mace & Pagel, 1994). Some of these methods allow inferences to be made about not only whether cultural traits are causally related but also the direction of causation (Holden & Mace, 2003). Phylogenetic studies of cultural evolution typically model cultural ancestry using language phylogenies, targeting variation in the cultural traits of interest within a single recognised language family (Opie, Schultz, Atkinson, Currie, & Mace, 2014). The Austronesian language family, which extends across a vast swathe of Southeast Asia and the Pacific, is uniquely suited to this purpose, and, perhaps for this reason, a number of phylogenetic studies involving Austronesian-speaking societies have already been conducted (see e.g., Currie , 2010; Jordan, Gray, Greenhill, & Mace, 2009; Watts et al., 2015a; Watts, Sheehan, Atkinson, Bulbulia, & Gray, 2016). Firstly, with around 1,200 members, it is the largest language family in the world to be widely recognised by linguists (Greenhill et al., 2008). Secondly, Austronesian-speaking societies have historically been diverse in terms of social organization and subsistence. Some, like the Ilongot of the Philippines, were egalitarian and acephalous, whereas others, such as Hawaiians and Javanese, lived in centralised, hierarchical states (Fox, 1995). Austronesian-speaking societies also varied considerably in their economies. The great majority were subsistence horticulturalists, but, whereas most practiced shifting or 'slash-and-burn' horticulture, traditionally considered the least intensive form of cultivation (Boserup, 1965), a considerable number used intensive agricultural techniques such as irrigation (Kirch & Lepofsky, 1993). Hence Austronesian-speaking societies provide an ideal sample for a phylogenetic study of how resource intensification—specifically agricultural intensification—and sociopolitical hierarchy have coevolved.

The present study investigated the coevolution of intensive agriculture and hierarchy in the Austronesian-speaking world using analyses of correlated evolution. This method models the evolution of pairs of binary traits under a dependent model (in which rates of loss and gain in one trait can depend on the presence or absence of the other trait) and an independent model (in which rates of loss and gain in either trait are independent of the state of the other trait) (Pagel & Meade, 2008). The degree to which the dependent model is favoured over the independent model, as indicated by a Log Bayes Factor (BF), indicates support for coevolution (Kass & Raftery, 1995). As well as evaluating evidence for coevolution, this method also provides insight into the underlying direction of causation by inferring the specific rates at which a trait is lost or gained in the presence or absence of another trait.

Both materialist and cultural determinist theories predict that intensive agriculture and sociopolitical hierarchy will coevolve, but make different predictions as to the causality underlying the relationship. Materialist theories predict that the relationship will primarily be attributable to intensive agriculture promoting and/or sustaining hierarchy, that is, making hierarchy more likely to be gained and/or less likely to be lost. Cultural determinist theories predict the opposite: The relationship between the two should primarily be due to hierarchy promoting and/or sustaining intensive agriculture. If intensive agriculture and hierarchy were found to promote and sustain each other to a similar extent, this would suggest that neither materialist nor cultural determinist theories accurately characterise this relationship, and that a reciprocal relationship or one involving a third variable is more likely.

One hundred and fifty-five Austronesian societies (See Figure 2 and Table A1) were coded with respect to three traits: social stratification, political complexity, and landesque capital intensive agriculture. Social stratification and political complexity were chosen to represent sociopolitical hierarchy. Originally ordinal, these variables were binarised using two different cutoff points to create four binary variables: medium-high social stratification, high social stratification, medium-high political complexity, and high political complexity. Landesque capital intensive agriculture (henceforth 'landesque capital') is a form of intensive agriculture that involves permanent changes to the landscape, such as the construction of terraces and irrigation canals (Blaikie & Brookfield, 1987). 'Cropping cycle' intensive agriculture, by contrast, involves practices that increase the productivity of land but are not necessarily intended to change the landscape permanently (Kirch, 2004). The decision to focus on landesque capital but not cropping cycle intensive agriculture was made for three reasons. First, landesque capital is inherently more suited to being treated as a binary trait, since it involves physical structures that can be deemed present or absent. Second, landesque capital is more likely to be identified in ethnographic sources because it is more obvious: a structure like an irrigation canal is far less likely to be overlooked than a practice like crop rotation. Third, landesque capital appeared to be the dominant mode of intensification within the sample; agricultural systems that were clearly intensive but lacked landesque capital did exist (see e.g., Kirch, 1994; Kirch & Yen, 1982) but were rare and appeared to be confined to Remote Oceania.

Unlike many cultural traits, landesque capital often leaves clear archaeological evidence. Since extensive archaeological work has been carried out in the Pacific and parts of Island Southeast Asia (Bellwood, 2007; Kirch, 2000), two sets of analyses were conducted, one of which incorporated archaeological evidence. On the basis of this evidence, intensive agriculture was constrained ('fossilised') to be absent at five nodes of the Austronesian language phylogeny that could be linked with confidence to specific archaeological cultures (see Methods and Table A2). In the second set of analyses, no assumptions were made about the presence or absence of any trait at any internal node of the phylogeny.

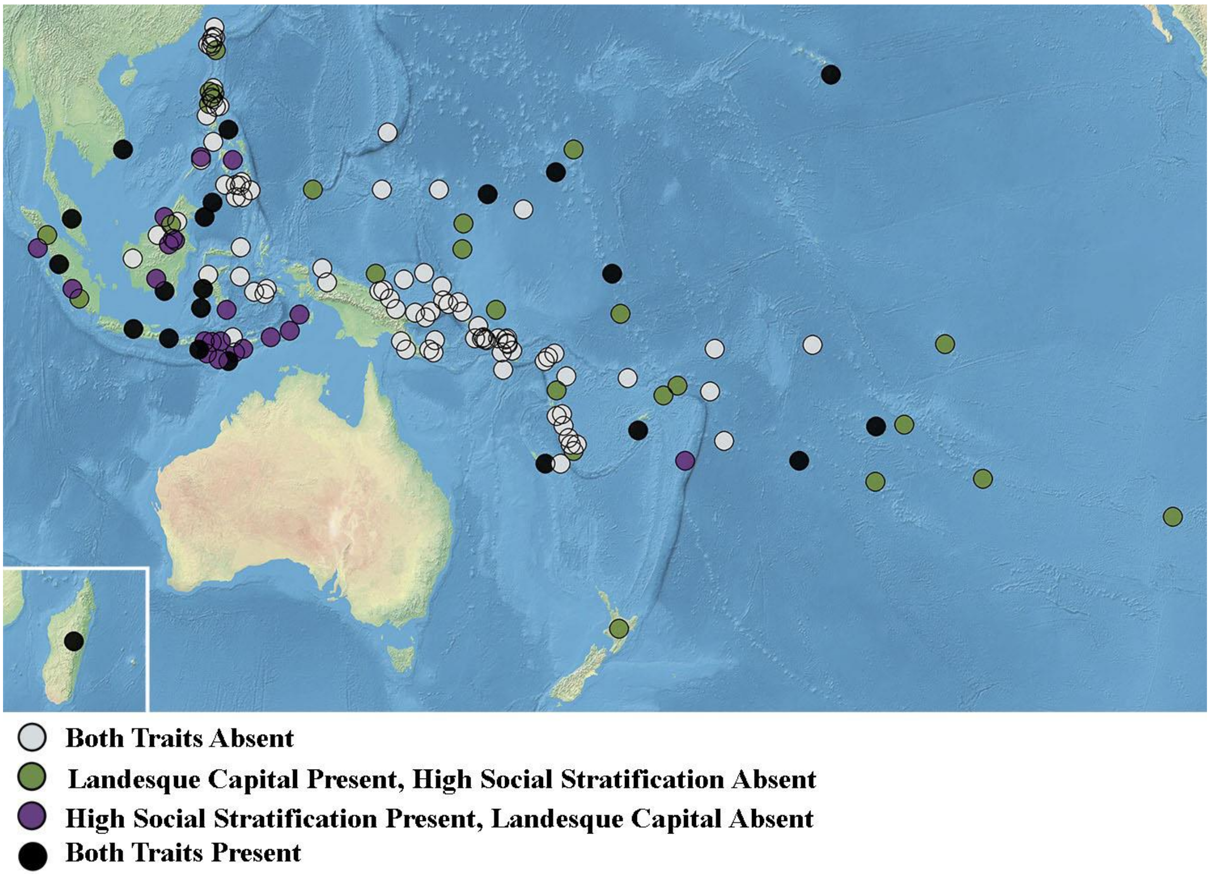

Figure 2. Distribution of landesque capital and high social stratification in the sample. Each filled circle represents one of the 155 societies in the sample, and its colour corresponds to which traits are present in that society (See Table A11). While the sample does not include all Austronesian-speaking societies, it does represent the entire spatial extent of the Austronesian-speaking world. (Image created using map data from Natural Earth, www.naturalearthdata.com).

Methods

Phylogenies

Cultural ancestry was modeled using a sample of Austronesian language phylogenies originally created by Gray, Drummond, and Greenhill (2009). This sample consists of 4,200 trees, each incorporating 400 Austronesian languages. Of the 400 languages in the sample, 213 could be matched to a society for which adequate ethnographic information was available. These societies numbered 155, of which 131 spoke only one of the languages in the phylogeny. The language that was numerically or culturally dominant was chosen to represent each of the remaining 24 societies, and the original sample was pruned so as to include only the 155 selected taxa.

Coding of Variables

Societies in the sample were coded with respect to three variables: landesque capital, political complexity, and social stratification. The first variable was coded in binary form, with 0 representing societies in which landesque capital was absent or of minor importance, and 1 representing societies in which it was present and made a major contribution to subsistence. The two sociopolitical variables, social stratification and political complexity, were originally created by Murdock and Provost (1973) as ordinal variables with the same five states (0, 1, 2, 3, and 4) representing increasing levels of hierarchy. In societies in which different subgroups showed different levels of hierarchy, the level characteristic of the majority of communities within the society was coded, or, if the latter was unknown, the highest level. These two ordinal variables were subsequently binarised to make them suitable for the intended analyses of correlated evolution. The same two cutoff points (0, 1 → 0 and 2, 3, 4 → 1; 0, 1, 2 → 0 and 3, 4 → 1) were applied to each variable, resulting in the creation of four binary variables: medium-high social stratification, high social stratification, medium-high political complexity, and high political complexity.

A range of ethnographic sources, including encyclopaedias, ethnographies, and archaeological surveys, were used in the process of coding the five variables. Each coding decision was justified with citations (See Table A1). Since many Austronesian societies underwent major cultural changes as a result of colonization, and because endogenous rather than externally imposed change was of interest in the present study, societies were coded as they were immediately before the colonial period.

Phylogenetic Signal

The strength of phylogenetic signal in the binary variables of interest was assessed by calculating Fritz and Purvis' (2010) D statistic, using the package 'caper' (Orme, Freckleton, Thomas, & Petzoldt, 2013), in the programming language R (R Core Team, 2015). D is the sum of differences between the state of a trait in sister clades (including observed states and the tips and estimated states at the nodes), scaled by the values expected in a randomly distributed trait and those expected under a Brownian model of trait evolution. A value of D = 1 represents the degree of phylogenetic signal expected in a phylogenetically random trait, whereas 0 represents the amount of phylogenetic signal expected under a Brownian model of trait evolution. D may also assume values of less than 0 (if the trait his highly 'clumped') or more than 1 (if the trait is 'overdispersed'). Ten thousand permutations of the test were run for each binary variable.

Correlated Evolution

Two sets of analyses of coevolution were run. The first involved fossilised nodes. On the basis of archaeological evidence (Bellwood, 2007; Kirch, 2000), landesque capital was constrained (fossilised) to be absent at five internal nodes of the phylogeny (Table A2), corresponding to proto-Austronesian, proto-Malayo-Polynesian, proto-Oceanic, proto-Central Pacific, and proto-Polynesian. In the second set of analyses, no nodes were fossilised. In all other respects, the two sets of analyses were identical.

Correlated evolution was investigated using a Bayesian Reversible-Jump Markov Chain Monte Carlo approach implemented in the ‘Discrete’ component of the computer package BayesTraits (Pagel & Meade, 2007). This method involves the testing of an independent model (in which rates are independent) against a dependent model (in which rates can covary). Each set of analyses involved four pairs of individual analyses, each pair consisting of a dependent and an independent model. Each individual analysis involved a pair of binary variables, i.e., landesque capital and one of the four binarised socio-political variables. Based on the results of Maximum Likelihood estimations, an exponential hyperprior with a mean of between 0 and 0.5 was chosen for all analyses. Each analysis involved running the Markov Chain for 100,000,000 iterations, with the first 10,000,000 removed as burn-in. A stepping-stone sampler with 100 stones was run for 10,000 iterations to compute a marginal likelihood for the dependent and independent models. On the basis of these marginal likelihoods, Log BFs were calculated. Log BFs were interpreted following Kass and Raftery (1995) who consider a Log BF of less than 2 to be ‘not worth more than a bare mention,’ 2 to 6 to be ‘positive evidence’ in favour of the dependent model, 6 to 10 ‘strong evidence’, and 10 or greater ‘very strong’ evidence.

Results

Phylogenetic Signal

A value of D = 1 represents the degree of phylogenetic signal expected in a randomly distributed trait, whereas 0 represents the amount of phylogenetic signal expected under a Brownian model (Fritz & Purvis, 2010). The values of D estimated for the five binary variables ranged from −0.27 (high social stratification) to 0.15 (medium-high social stratification), indicating a good fit of the data to the sample of trees. The probability of obtaining these values in the absence of phylogenetic signal was in all cases estimated to be 0.0001 or less (see Methods and Table A3).

Correlated Evolution

All four pairs of analyses favoured the dependent model, although one only marginally so (see Tables A4 and A5). The weakest result was for the pair of analyses involving medium-high political complexity, which yielded a Log BF of 1.0, considered 'not worth more than a bare mention' (Kass & Raftery, 1995). Support for the dependent model was stronger in the pair of analyses involving high political complexity: In this case, the dependent model was favoured with a Log BF of 5.3, considered 'positive evidence.' The analyses involving medium-high and high social stratification (see Figure 3) returned Log BFs of 5.9 and 8.4 considered 'positive evidence' and 'strong evidence' respectively.

Examining the rates at which one trait was lost or gained in the presence or absence of the other provided further insight into the relationship (See Figures 3, A1-A3, and Table A4). Certain traits promoted certain other traits. Landesque capital was six times as likely to be gained when medium-high social stratification was present, and four times as likely to be gained in the presence of either high social stratification or high political complexity. High social stratification was nearly five times as likely to be gained, and high political complexity just under twice as likely to be gained, when landesque capital was present. Evidence that traits sustained other traits – that is, made them less likely to be lost – was very weak. The largest difference in rates of loss in one trait in the presence or absence of another trait was in the opposite direction to what had been predicted: high political complexity was a little more likely to be lost in the presence of landesque capital than in its absence.

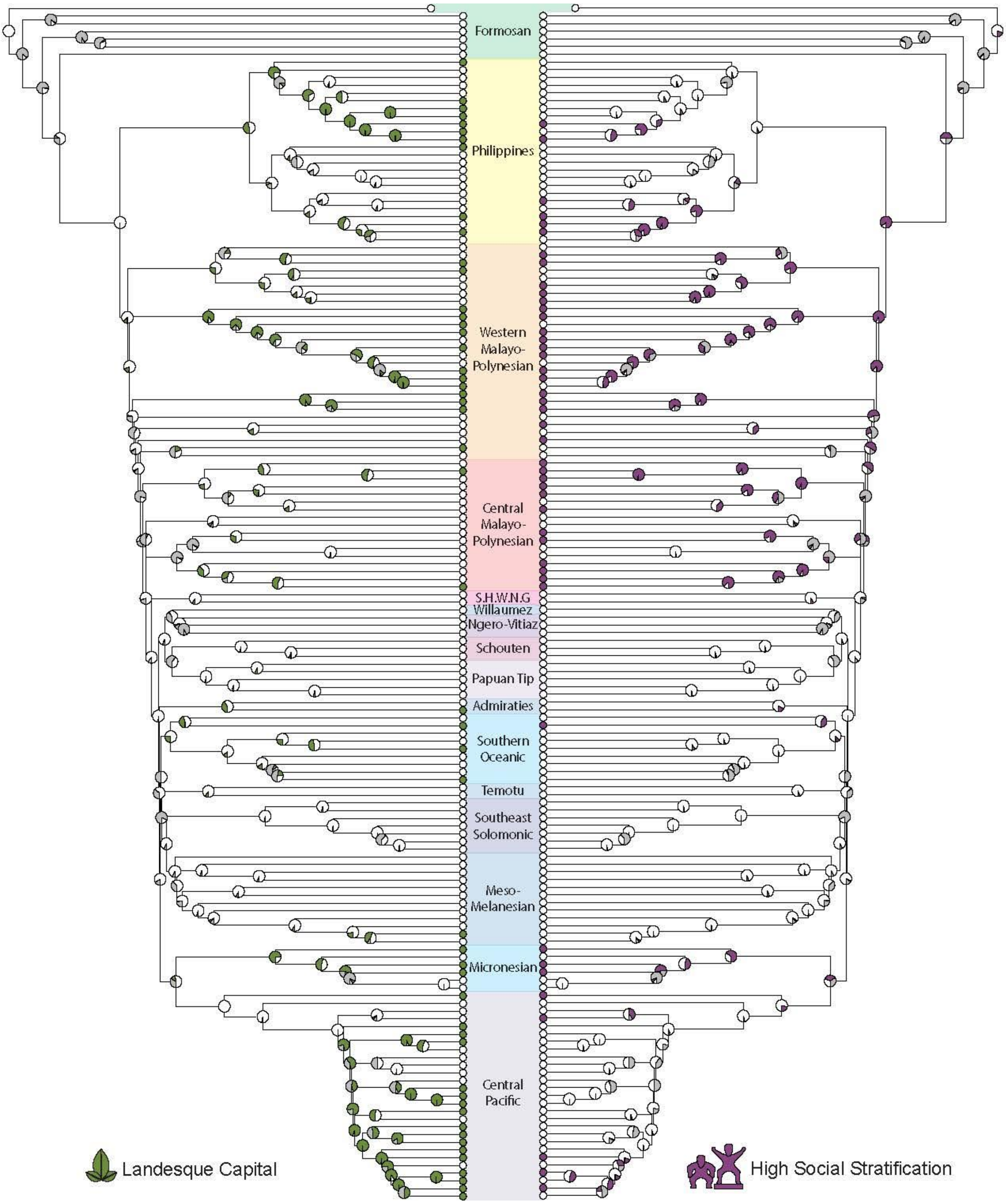

Figure 3. Coevolution of landesque capital and high social stratification, with fossilised nodes. Shown is ancestral state reconstruction of landesque capital and high social stratification from the dependent analysis, plotted on a maximum clade credibility tree. Pie charts at the internal nodes of the tree represent the proportion of models in which the trait

was inferred to be present at that node; grey represents the proportion of trees in the sample from which that particular node was absent. In this analysis, landesque capital was constrained (fossilised) to be absent at five internal nodes, including the basal node. Taxa in this figure are grouped, labelled, and colour-coded following Gray et al. (2009), figure S5. See Figure A1 for a version of this figure that includes all taxa names, and Figures A2 and A3 for reconstructions of the two other combinations of variables for which the dependent model was favoured. S.H.W.N.G. = South Halmahera-West New Guinea.

All other differences were very small, but were in the predicted direction.

The analyses that lacked fossilised nodes yielded results that were broadly similar to those already reported, but that favoured coevolution more strongly. While the pair of analyses involving medium-high political complexity was also inconclusive, the remaining three pairs of analyses all returned Log BFs corresponding to ‘strong’ or ‘very strong’ evidence of coevolution (see Tables A6 and A7).

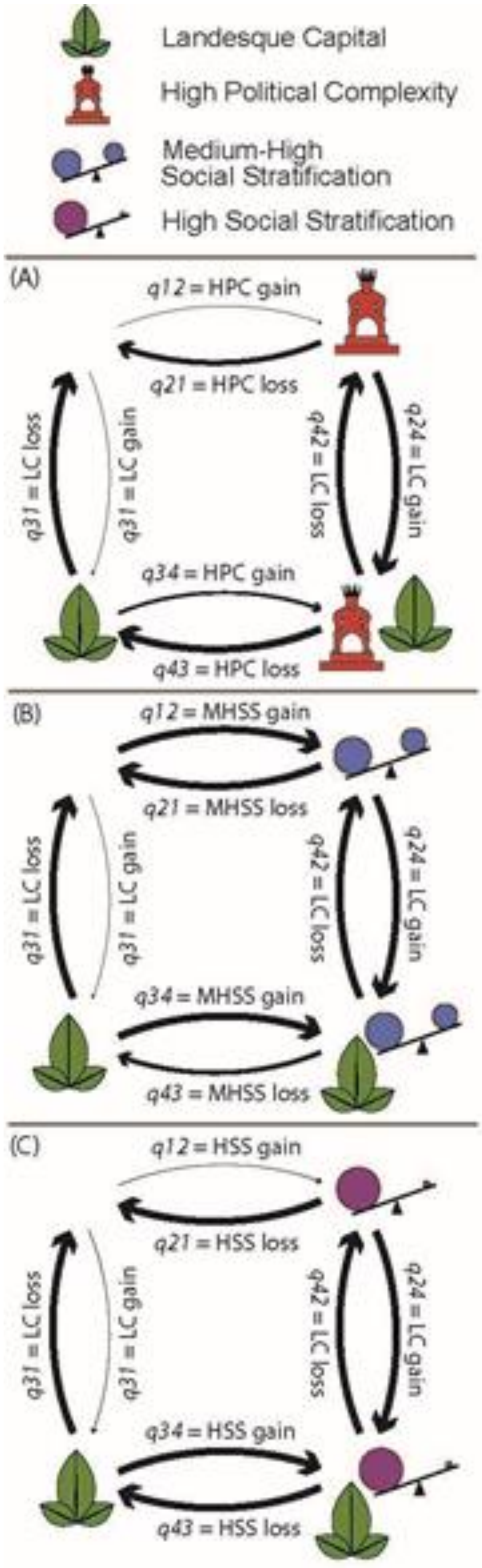

Figure 4. Transition rate matrices for the three dependent models with fossilised nodes that were favoured over the corresponding independent models. Each matrix represents the coevolution of landesque capital with one sociopolitical variable: (A) high political complexity, (B) medium-high social stratification, and (C) high social stratification. The analysis of landesque capital and medium-high political complexity is not depicted here as it did not favour the dependent model. Width of the arrows is proportional to rates of change between different states (see Table A4 for details).

Discussion

The results supported the coevolution of sociopolitical hierarchy and landesque capital, but also underscored the probabilistic rather than deterministic nature of this relationship. Many societies in the sample had landesque capital but were not hierarchical, or vice versa, and ancestral state reconstructions showed that while landesque capital and sociopolitical hierarchy tended to appear at similar points in the phylogeny, either trait could appear independently (see Figures 2, A1-A3). Support for coevolution was strongest in the analyses involving specifically high levels of the two sociopolitical variables. This was particularly evident in the case of political complexity, only high levels of which were found to coevolve with landesque capital. Possibly, this reflects a dynamic whereby the economic and sociopolitical realms become increasingly integrated as societies become more complex.

No prediction had been made as to whether political complexity or social stratification would be more strongly linked to landesque capital. Nevertheless, the fact that support for coevolution was stronger for social stratification than for political complexity is worth noting. Explanations of the relationship between intensification and hierarchy often see leadership as either a driver (Sahlins, 1972) or a result (Johnson & Earle, 2000) of intensification. Political complexity, by definition, involves leadership (Murdock & Provost, 1973), whereas social stratification need not – an elite may possess economic influence but not formal political power. If leadership were the key to this coevolutionary relationship, the reverse should have been found: coevolution should have been favoured more strongly in the case of political complexity than of social stratification. This result suggests that the existence of an economic elite is more closely linked to intensification than political leadership is. Economic elites could have promoted intensification using a range of strategies, either direct (e.g., commissioning and/or financing landesque capital projects) or indirect (e.g., making demands for rent or repayment of debts that commoners could more easily meet by farming more intensively). Conversely, intensification could have facilitated the emergence of economic elites by providing larger surpluses that could be appropriated and/or redistributed. Intensification may also have allowed populations to expand to a size at which greater inequality could be sustained, and made them more sedentary and hence easier to control both politically and economically (Drennan, 1991).

No support was found for the materialist view that intensification is primarily a driver rather than a result of hierarchy. In two of the three sets of analyses in which the dependent model was favoured (those involving medium-high social stratification and high political complexity), hierarchy promoted landesque capital to a far greater extent than the reverse. In one (involving high social stratification), the effect of landesque capital on hierarchy was marginally greater than the reverse. Sahlins' (1972, p. 140) observation that the relationship was 'at least mutual' and often 'the other way around' seems apt.

Although landesque capital and hierarchy promoted each other, evidence that they sustained each other was weak. One post hoc explanation for the fact that hierarchy promoted but did not sustain landesque capital relates to the different labor requirements of cropping cycle and landesque capital intensification. Whereas cropping cycle intensification requires a sustained increase in labour for each unit of productivity gained, landesque capital may require only an initial investment of labour (Kirch, 1994). If it is assumed that farmers avoid increasing their workloads unless under pressure to do so (Boserup's 'law of least effort'), that such pressure is often applied by elites, and that maintaining a system of landesque capital is less laborious than adopting one, it seems reasonable that hierarchy would promote but not maintain this type of intensive agriculture. Further studies could test this hypothesis by assessing whether cropping cycle intensification is sustained as well as promoted by sociopolitical hierarchy. It is less clear why landesque capital promoted but did not sustain hierarchy, but a possible explanation is that the influence of intensive agriculture upon hierarchy is mediated rather than direct. Intensive agriculture could have promoted hierarchy indirectly by increasing population size. It seems reasonable to assume that hierarchy develops more easily in larger than in smaller populations (Drennan, 1991), but it is not obvious why hierarchy would be more likely to persist in a larger than in a smaller population. The results of this study are not consistent with materialist models wherein social and political hierarchies develop as a result of intensification, although neither are they entirely consistent with a cultural determinist model involving the reverse. Instead, they suggest that intensification and hierarchy promoted each other to a comparable extent, perhaps as a part of a feedback loop that may also have involved population growth. These results also underline two important points about human cultural evolution. First, social and political factors, far from being epiphenomenal or secondary to the process, are among its most important drivers. Second, the evolution of complex societies is itself complex. Not only are many factors involved, but the relationship between these factors is rarely deterministic.

CHAPTER THREE: The Evolution of Political Complexity: A Global Phylogenetic Analysis

Introduction

That human societies have become increasingly larger and more complex since the beginning of the Holocene is not in doubt (Johnson & Earle, 2000; Marcus, 2008), but how this increase unfolded remains contentious. A central question is the extent to which social complexity evolved according to predictable patterns (Carneiro, 2003). One such pattern that has been proposed is that political complexity evolves sequentially. Political systems in large-scale societies are hierarchically organised – that is, they consist of nested levels of authority. Smaller social groups form parts of larger groups, and the leaders of the smaller groups are subordinate to those of the larger groups. Hierarchy appears to have been indispensable in allowing large-scale societies to evolve, since it allows decisions to be made on behalf of groups that are too large for most members to know each other personally. Hierarchical political systems vary in their complexity, defined as the number of levels that they include. It has been argued that political complexity increases, and perhaps also decreases, by one level at a time (Currie et al., 2010; Turchin & Gavrilets, 2009; Walker & Hamilton, 2010).

Hypotheses about cultural evolution have traditionally been tested with reference to the archaeological and historical records (Johnson & Earle, 2000; Marcus, 2008). Most relevant scholarship informed by these records has either relied upon qualitative methods or been confined to a regional rather than global scale (Carneiro, 2003). The handful of quantitative studies that have used archaeological and historical data to assess the uniformity of patterns of cultural evolution on a global scale suggest that many cultural traits evolve in a predictable order (Peregrine & Ember, 2004), and reliably coevolve across the globe (Turchin et al., 2018). While invaluable, the historical and archaeological records have limitations that make other sources of information desirable. The historical record for the most part pertains only to highly complex societies and their neighbours, and while the archaeological record has far broader coverage, there is a limit to what can be inferred about a society from its material culture. As Marcus (2008) notes, archaeology 'deals with the residues of behavior rather than directly observed behavior'.

Political complexity is one trait that cannot be observed directly in the archaeological record, although some inferences can be made through proxies such as settlement hierarchies (see e.g., Steponaitis, 1981). Ethnographic data from contemporary societies can supplement the archaeological record in a number of ways. Ethnographic analogy, which makes use of cross-cultural correlations between cultural traits, is one with a long history. If an archaeologically observable trait is correlated with an archaeologically invisible one in contemporary societies, inferences can be made about the likelihood that the latter trait was present in a society known only from the archaeological record in which the former trait has been observed (Peregrine, 1996). In recent years, phylogenetic comparative methods have extended these possibilities further. These methods, which originated in biology but are increasingly being applied to cultural evolution, allow what has been referred to as 'virtual archaeology' (Jordan et al., 2009) - the reconstruction of the evolutionary histories of cultural traits from their contemporary distributions. Virtual archaeology greatly increases what can be inferred about past societies, and while it can never replace or override the historical and archaeological records, it can complement them. Phylogenetic comparative studies of cultural evolution typically use language phylogenies to model cultural ancestry. Language is well-suited for this purpose because it evolves in a way that can be modelled using a phylogeny, and because its transmission is closely linked to the transmission of other cultural traits (Mace & Pagel, 1994).

Two studies published in 2010 used phylogenetic methods to address the question of how political complexity has evolved. These studies, which appear to have been independent but were methodologically very similar, involved mapping political complexity data from the Ethnographic Atlas (Gray, 1999) onto the tips of language phylogenies, reconstructing their evolutionary history in these families, and testing models of how this trait evolved. Currie et al. (2010) tested six models of the evolution of political complexity in the Austronesian speaking-world, only two of which received any support. The ‘unilinear model’, which required both increases and decreases in political complexity to be sequential, performed best, but the ‘relaxed unilinear model’, which required increases to be sequential but allowed non-sequential decreases, was a close second. The ‘full model’, which did not require any transitions to be sequential, was a distant third. Walker and Hamilton (2010) tested only two models: the ‘saw-tooth’ model, which corresponded to the relaxed unilinear model of Currie et al., and the ‘wave-like’ model, which corresponded to the unilinear model. Like Currie et al., Walker and Hamilton also tested these models using a (slightly different) sample of Austronesian-speaking societies, and obtained broadly similar results, though with greater support for the saw-tooth / relaxed unilinear model over the wave-like / unilinear model. However, when they performed the same tests on a sample of Bantu-speaking societies, the results favoured the wave-like model.

The fact that political complexity was found to increase sequentially in both the Bantu and Austronesian language families is compelling evidence that this may be a rule with global applicability, though similarities between Austronesian and Bantu societies suggest that a degree of caution is warranted. Both are the result of mid-Holocene expansions involving horticulture, and both are characterised by moderate levels of political complexity – there were many Austronesian and Bantu-speaking chiefdoms and a few states prior to colonisation, but large states and empires were scarce (Walker & Hamilton, 2010). It is difficult to interpret the discrepancy between the two families in whether or not political complexity was found to decrease as well as increase sequentially. The explanation that

Walker and Hamilton offer involves geography. Whereas the Bantu languages expanded over a contiguous area, much of the Austronesian expansion involved the settlement of isolated islands by small founding populations. This resulted in ‘demographic bottlenecks’, which would almost inevitably have involved decreases in political complexity, since political complexity is closely related to population size. This explanation implies that the ‘unilinear’ or ‘wave-like’ model is more typical of how political systems evolve globally, and that the ‘relaxed unilinear’ or ‘sawtooth’ model is an aberration resulting from unusual geography. While plausible, other explanations are also possible – for example, the fact that whereas the Bantu expansion appears to have been primarily driven by migration (De Filippo, Bostoen, Stoneking, & Pakendorf, 2012), language shift played a major role in the Austronesian expansion (see e.g. Posth et al., 2018). Moreover, it is possible that the relatively strong support for the unilinear model over the relaxed unilinear model in both Austronesian and Bantu simply reflects the fact that in both families, high levels of political complexity had evolved too recently for there to have been many non-sequential decreases. (This is a possibility that Currie et al. explicitly acknowledge in their supplementary discussion). In order to draw conclusions about which models fits the data best on a global scale, a global sample is needed. However, until now the lack of a credible global language phylogeny has precluded the application of cultural phylogenetic methods on a global scale.

Here we overcome these limitations by modelling the evolution of political complexity on a global scale using ethnographic data from the cross-cultural database D-PLACE (Kirby et al., 2016). We model the cultural ancestry of these societies using a novel Bayesian phylogeographic approach to derive a principled global language phylogeny. This approach allows us to overcome the limitations of conventional approaches to tree-building by modelling language diversification in time and space, and by combining knowledge of recognised language groupings identified by the comparative method with Bayesian analysis of structural language data. We test five models from Currie and colleagues (see Figure 5). The unilinear (UNI), relaxed unilinear (RU), and full models (FULL) have been described above. The alternative trajectories (AT) and reversible alternative trajectories (ATR) models allowed only non-sequential increases in political complexity. AT does not allow decreases of any kind, whereas ATR allows only non-sequential decreases. It is not clear that either of these models represents a serious scholarly view, or even the view of the author to whom it is attributed (Yoffee, 1993). However, they were retained in the sake of the present study to replicate the original study more fully, and because they do represent a possible interpretation of Yoffee's argument. Currie and colleagues also tested a sixth model, rectilinear (REC), which allowed only sequential increases and no decreases. This model, which according to Currie and colleagues is 'often associated with the classical evolutionists such as Spencer and Morgan', was not included because it has clearly been shown to be a mischaracterisation (Carneiro, 2003).

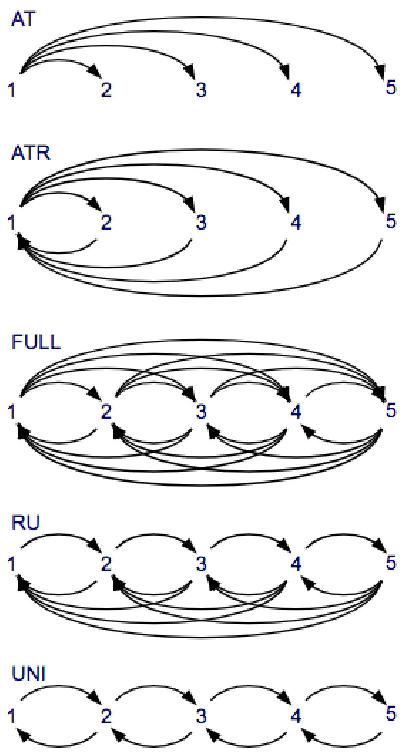

Figure 5. Models of the evolution of political complexity. Alternative Trajectories (AT), Alternative Trajectories Reversible (ATR), Full (FULL), Relaxed Unilinear (RU), and Unilinear (UNI).

Methods

Bayesian Inference

Bayesian methods allow information from a diverse set of sources to be integrated in a mathematically sound way. Based on structural data obtained from the World Atlas of Language Structures (WALS) (Haspelmath, Dryer, Gil, & Comre, 2005), and geographical data from Glottolog (Hammarström, Forkel, & Haspelmath, 2017), we inferred a global language phylogeny using a Bayesian model implemented in BEAST (Bouckaert et al., 2014) for inferring a distribution over sets of trees (see e.g., Bouckaert et al., 2012; Bouckaert, Bowern, & Atkinson, 2018). The languages used to construct the tree were the 1314 languages represented in D-PLACE, excluding ancient languages (Ancient Egyptian, Akkadian, Latin, and Sanskrit) since they violate the assumption of the tree prior that all languages are contemporary, and colonial languages (Afrikaans, Brazilian Portuguese, Haitian, Hebrew, Ndyuka, and Saramaccan), since they do not follow the usual geographical dispersion process. We used a multi-Yule distribution, which assumes a birth rate change at the most recent common ancestor of each language family and is a special case of the multi-rate model (Barido-Sottani, Vaughan, & Stadler, 2018). The birth rates for families have a uniform prior with 1 as upper bound, while the birth rates for the root and related branches have an upper bound of 0.01, resulting in a sufficiently wide root age prior distribution of 105 kya (65-162 kya 95% HPD). We used data from Glottolog, which is considered to be conservative in defining language groupings (see e.g., Blasi, Wichmann, Hammarström, Stadler, & Christiansen, 2016) to implement monophyletic constraints on our tree.

Time Calibrations

The most recent common ancestor (mRCA) of each language family was constrained by an age distribution obtained from the literature. If no distribution was known, we used a log normal with an offset 1 ky, mean in real space of 4.5, and a standard deviation of 0.5. This empirical distribution is based on a mixture of distributions of known language family ages. Since not all languages in each language family were used, a simulation was run to determine the distribution of the remaining set of languages. This was done by running an MCMC analysis for the full set of languages in a family under the Yule tree prior (Yule, 1925), Glottolog constraints, and the age distribution specified above for the root of the family tree. The resulting distribution of the mRCA of languages represented in D-PLACE were approximated by a log normal distribution and were used in our full analysis. The immediate ancestor of each language family's mRCA, as well as of each language isolate, was constrained to between 5 and 60 kya. Internal nodes were constrained through timing information based on lexical analyses for Austronesian (Gray et al., 2009), Bantu (Currie, Meade, Guillon, & Mace, 2013), Indo-European (Bouckaert et al., 2012), Semitic (Kitchen, Ehret, Assefa, & Mulligan, 2009), Turkic (Hruschka et al., 2015), and Uralic (Honkola et al., 2013). The first coalescent event above each language was constrained to be at least as old as the oldest society associated with that language in D-PLACE. Time calibrations were also included for a number of macro groups, based on archaeological evidence of first settlement and, in the case of the Americas, evidence of genetic divergence. The mRCA of Sahul was constrained to 55 kya (+/- 2.55 ky) (O'Connell & Allen, 2004). The mRCA of the Americas was constrained to 14.5 kya (+/- 0.77 ky) and its immediate ancestor to 21.65 kya (+/- 1.66 kya) (Llamas et al., 2016). The mRCA of Eurasia was constrained to 70 kya (+/- 5.1 kya) (Mellars, 2006).

Geographical Model

We assume that languages spread by spherical diffusion - a random walk across a sphere (Bouckaert, 2016). The fact that language families differ in size in different regions (e.g., Indo-European and Nuclear Trans New Guinea) suggest different rates of migration, which we capture using a log normal relaxed clock (Drummond, Ho, Phillips, & Rambaut, 2006). We assume an origin in Africa, with a first branch out of Africa in the Middle East or India. Since we believe that geographical dispersal strongly influences language spread, we put a strong prior on the precision (uniform with lower bound 1000, upper bound 10000), which is the parameter governing the diffusion process (Bouckaert, 2016).

Structural Data

Structural data was obtained from the WALS database (Haspelmath et al., 2005). Features were selected to avoid dependence (Maurits, Bouckaert, Heled, Gray, & Atkinson, 2019) providing us with 16 binary features and 126 multi-level features following an Mk model (Lewis, 2001), 9 ordinal and 4 nested ordinal features following an ordinal and nested ordinal model respectively, and 1 special feature (Maurits et al., 2019) (See Table B1).

From Language Tree to 'Society Tree'

Bayesian inference was used to infer a tree over 1314 languages. Ancient languages and colonial languages were grafted onto the tree by randomly placing them at a location constrained by the Glottolog tree, resulting in a tree with 1324 taxa. Each language that corresponded to multiple societies was randomly split to accommodate one taxon per society, yielding a tree with 1428 societies. Leaf heights were adjusted to reflect the most recent focal year in D-PLACE.

Validation of Ancestral States

Twenty-nine nodes of the tree could be identified with reasonable confidence with historically documented polities. For example, the common ancestor of the Romance languages was Latin, which is known to have been the dominant language of the Roman Empire. In order to validate the ancestral states reconstructed by the best-fitting model, we compared the level of political complexity reconstructed at these nodes with the level expected based on historical sources (see Table B2). Due to changes over time and ambiguity in the data, most of the expected states were ranges of levels rather than single levels. In these cases, the midpoint was assigned as the expected state. For example, if the sources suggested a range of 2 to 3, the expected state was 2.5. The mean of the states reconstructed for each node weighted by their posterior probabilities was assigned as the reconstructed state. Spearman's rank correlation coefficient was calculated to test the extent to which expected and reconstructed states were associated.

Model Comparisons

Global. Five different models of the evolution of political complexity were tested (see Figure 5). The unilinear model (UNI) allowed only sequential increases and decreases in political complexity. The relaxed unilinear model (RU) allowed only sequential increases, but allowed both sequential and non-sequential decreases. The alternative trajectories model (AT) allowed only non-sequential increases and no decreases. The reversible alternative trajectories model (ATR) allowed only non-sequential increases and decreases. The full model (FULL) allowed both sequential and non-sequential increases and decreases. Data on political complexity (EA033: Jurisdictional hierarchy beyond the local community) was obtained from D-PLACE for 1150 of the 1428 societies in the tree. We assumed that prior to 12 kya there was no supralocal authority (Schultziner et al., 2010) and hence constrained all branches to be in a state of 1 ('no political authority beyond local community') prior to this point. From 12 kya, we used a substitution model in which non-zero rates only occurred if a transition were allowed. Hence we considered two epochs (Bielejec, Lemey, Baele, Rambaut, & Suchard, 2014). Rates were estimated under a Dirichlet prior. We used a set of 200 trees representing the posterior distribution, and randomly sampled them during the MCMC. A strict clock was assumed with a Gamma (0.001, 1000) prior. We used nested sampling (Russel, Brewer, Klaere, & Bouckaert, 2019) with 25 active points to estimate marginal likelihoods for the models. Marginal likelihoods were used to calculate Log Bayes Factors (BFs) that indicated support for one model over another. These factors were interpreted following Kass and Raftery (1995), who consider a Log BF to be 'not worth more than a bare mention' if less than 2, 'posiive evidence' in favour of one model if between 2 and 6, 'strong evidence' if between 6 and 10, and 'very strong evidence' if more than 10.

Regional. In order to investigate the extent to which model performance varied between regions, we divided the data into four subsets corresponding to Africa, Eurasia, the Americas, and Sahul. Language families that spanned more than one region (e.g., Afroasiatic) were assigned to one based on monophyletic constraints.

Global, with fossilised states. In order to test the robustness of the model to specific reconstructions, we conducted two sets of analyses. In the first, all nodes of the tree younger than 12 kya were free to assume any state. In the second, nodes that corresponded to one of the 29 validation points (See Table B2) were fossilised to states consistent with the historical evidence.

Results

Validation of Ancestral States

Reconstructed states at the twenty-nine nodes that corresponded to historical societies were compared with the states expected at these nodes based on historical sources. The two correlated ($\rho = 0.382$, one-tailed $p = 0.023$). There were only two nodes, corresponding to Proto-Slavic and Proto-Northwest Germanic, at which the state reconstructed as most likely fell outside the range suggested by the sources (see Table B2).

Model Comparisons

Global. The five models are evaluated in Table 1. RU was the best-supported, narrowly outperforming UNI (Log BF of 2.56, considered 'positive evidence'). UNI decisively outperformed FULL (Log BF of 13.20, 'very strong evidence'). FULL vastly outperformed both AT and ATR, which were placed fifth and fourth respectively (see Table 1).

Table 1

Marginal Likelihood (ML) Estimates, with Standard Deviations (SD) and Associated Log BFs for Each of the Five Models Compared to Each of all the Others.

			Log BFs				
Model	**ML Estimate**	**SD**	**AT**	**ATR**	**FULL**	**UNI**	**RU**
AT	-1917.75	1.39		-1040.24	-1307.48	-1320.68	-1323.24
ATR	-1397.63	3.49	1040.24		-267.24	-280.44	-283.00
FULL	-1264.01	0.36	1307.48	267.24		-13.20	-15.76
UNI	-1257.41	0.30	1320.68	280.44	13.20		-2.56
RU	-1256.13	0.32	1323.24	283.00	15.76	2.56	

Regional. Separate analyses for subsets of the data corresponding to four different world regions yielded somewhat different results to the global analysis (see Table B3). RU, which performed best in the global analysis, performed second-best in all four regions, though in Eurasia the difference between the two best-supported models was marginal. The best-supported model was UNI in Africa, Eurasia and the Americas, and FULL in Sahul. AT was the worst-supported model in all world regions, and ATR was the second-worst supported in all regions except the Americas, where it marginally outperformed FULL.

Global, with fossilised states. A follow-up analysis of the global dataset in which nodes corresponding to historically known societies (see Methods section) were constrained to states consistent with historical sources was performed. Four out of the five models (ATR, FULL, UNI, and RU) were compared - AT could not be evaluated since some of the fossilised states implied decreases in political complexity over time, which AT does not allow. This analysis yielded results that differed in some respects from the global analysis that lacked fossilised nodes (see Table B4). As in the first global analysis, RU performed best, and ATR was decisively outperformed by FULL, UNI, and RU. Unlike in the first analysis, FULL performed second-best and UNI third-best, though the difference between the two was not great (Log BF of 2.3, at the low end of the 'positive evidence' range). RU outperformed UNI more decisively than in the first analysis (Log BF of 5.88, at the high end of the 'positive evidence' range).

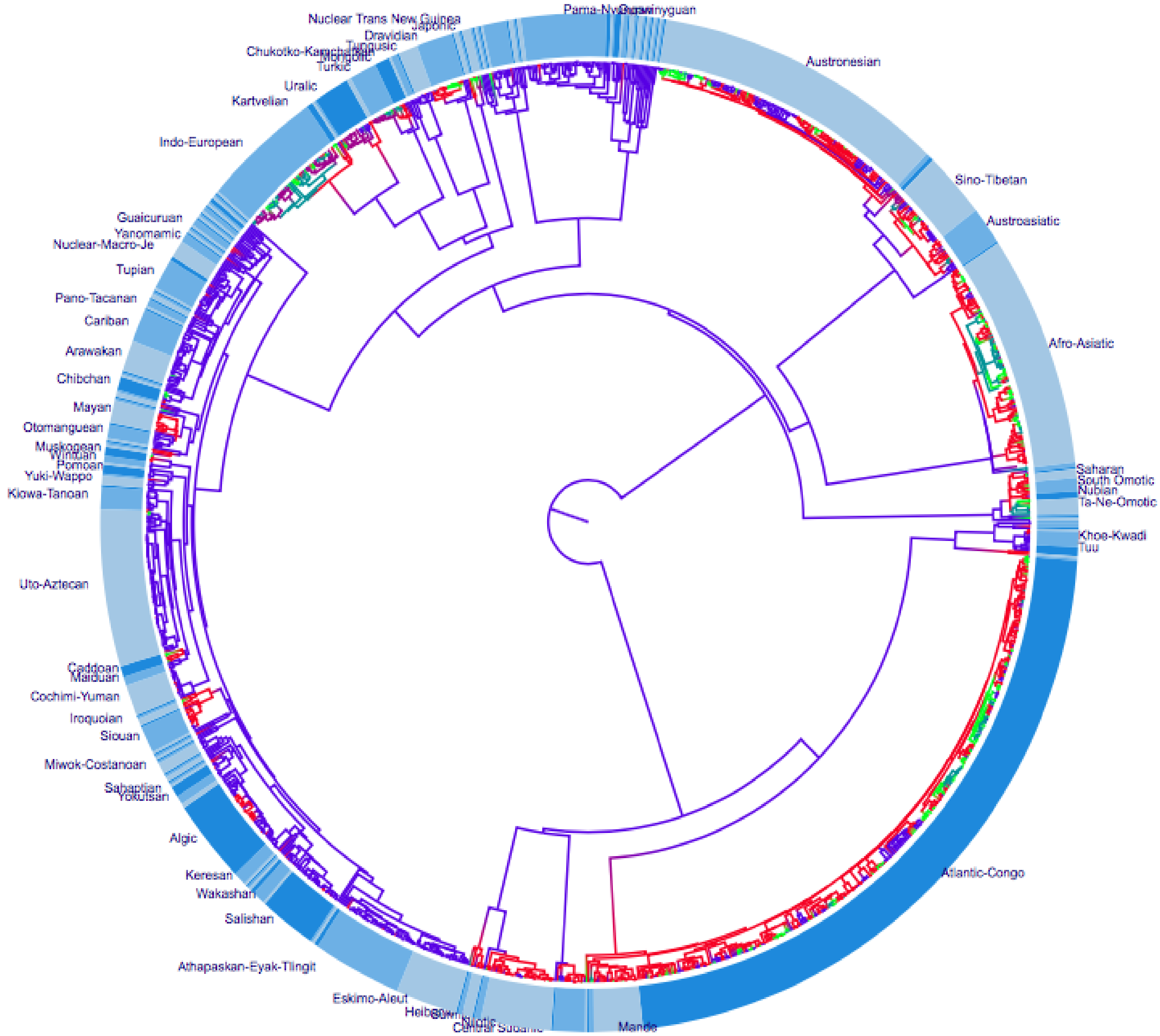

Figure 6. Maximum Clade Credibility tree for Global Language Phylogeny, with major language families labelled. Colours of branches represent levels of political complexity - 'no levels' for purple, 'one level' for red, 'two levels' for light green, and 'three or four levels' for dark green.

Discussion

Our results indicate that political complexity has a strong tendency to increase sequentially. This tendency has previously been shown in Austronesian and Bantu-speaking societies, and the present study shows it to apply globally. In the two global analyses (with and without fossilised nodes), either one or both of the unilinear models decisively outperformed the full model. We found no clear evidence for a global tendency for political complexity to decrease sequentially. RU prevailed on a global scale, though as Currie and colleagues also found, the difference between the two unilinear models was not great.

The regional analyses revealed both commonalities and variation in how political complexity evolves. One of the two unilinear models was the decisive winner both on a global scale and in three out of the four world regions. That this was not the case in Sahul is easily explicable in terms of sample characteristics (see Table B5). Societies in Sahul were not only far less numerous - they made up only four percent of the sample - but were also far less varied. Eighty-seven percent of Sahul societies were coded as having the lowest possible level of political complexity (1, 'no levels'), compared to 44% of societies in the other three world regions. Altogether, these results suggest that the tendency for political complexity to increase sequentially varies little between world regions.

There was a striking discrepancy between the global results, in which RU won narrowly, and the regional results, in which UNI performed better. There was also variation in the extent to which UNI was favoured over RU - the difference was clear in Africa and the Americas, but marginal in Eurasia. There are a number of possible explanations for these differences. Sampling bias is one. The Ethnographic Atlas samples Eurasia and particularly Europe less comprehensively than other world regions, as Murdock (1967) himself admitted. A higher prevalence of what appear to be non-sequential drops in political complexity in Eurasia might be artifacts of there being more missing taxa there. Differences in the prevalence and phylogenetic depth of high levels of political complexity may also be relevant. Only political structures with two or more levels (corresponding to states 3 and 4 in our analysis) can decrease non-sequentially. These states were more common, and present at a greater phylogenetic depth, in Eurasia compared to Africa and the Americas (see Figure 6, Table B5). It is possible that there has simply not been time in Africa and the Americas for many non-sequential drops to have occurred. Given that the highest levels of political complexity are most common in Eurasia, the fact that Eurasia is under-represented means that higher levels of political complexity are under-represented in the sample as a whole. This may explain why, despite a much larger and more varied sample, the present study did not produce clearer evidence in favour of the relaxed unilinear model.

As well as testing models of the evolution of political complexity, our analyses also allow us to reconstruct the history of political complexity over time (see Figure 6). Comparing the reconstructed states at particular nodes to the states predicted from archaeological and historical evidence allowed us to assess the accuracy of the reconstructions. The correlation between reconstructed states and known states was statistically significant but not large, though much of the error must have resulted from the predicted states, most of which were ranges rather than points. The fact that the validation points were concentrated in the least comprehensively sampled regions may also account in part for the relatively weak correlation between the predicted and expected states – 27 out of the 29 validation points were in in Eurasia, and 14 were in Europe. In any case, rerunning the analysis with fossilised nodes corresponding to historically documented societies did not greatly change the results, although it increased support for RU over UNI, and reduced support for UNI over FULL.

The results of this study show that whatever indeterminacies exist in the evolution of complex societies, patterns can be inferred on a global level. That these patterns are probabilistic rather than deterministic does not make them unimportant. Although the cultural evolutionists of the late nineteenth and early twentieth centuries have been much maligned (Carneiro, 2003), it seems they were largely correct in their claim that despite regional variation, some human institutions do indeed evolve ‘in series substantially uniform over the globe’ (Tylor, 1889, p. 269).

CHAPTER FOUR: Coevolution of Religious and Secular Authority

Introduction

During the Holocene the scale and complexity of human societies increased massively. Authority played an essential role in this transition. In small groups in which a large proportion of members know each other personally, communal decisions can be made on an informal and non-authoritarian basis. However, groups with populations of more than a few thousand appear to require authoritative leadership in order to act as cooperative units (Turchin & Gavrilets, 2009). Definitions of authority vary (Uphoff, 1989), but the term is usually understood to refer to a form of power that is considered legitimate by those subject to it, and that is vested in a formally recognized 'role' or 'office' (Cohen, 1970; Wirsing, 1973).

Types of authority can be distinguished in various ways, one of the most common being as primarily secular or religious. Religious authority can refer to authority whose legitimacy rests on the supernatural (Chaves, 1994), or more narrowly to authority over matters of religion (Garland, 1984). Secular authority is a residual category encompassing all forms of authority that are not religious. The present study uses the narrower definition of religious authority, and hence secular authority refers to authority over matters that are not directly religious. Two hypotheses regarding the relationship between religious and secular authority enjoy widespread support. Firstly, religious authority is thought to have preceded and enabled the evolution of secular authority. Secondly, religious and secular authority are thought to have become more distinct as societies became more complex. The second hypothesis follows from the first - if secular authority emerges from religious authority, it is to be expected that the earliest forms of religious and secular authority would have been combined – but does not depend upon it. Differentiation of religious and secular authority could simply reflect the fact that complex societies are more differentiated and specialised than simpler ones (Carneiro, 2003).

Versions of the first hypothesis have been put forward by a number of authors. Service (1975, p. 16) characterised the chiefdom, a transitional form between the egalitarian society and the state, as a ‘universally theocratic’ organization in which the deference of followers to their leader was ‘that of a religious congregation to a priest-chief’. Aldenderfer (1993) proposed that in simple foraging societies, ‘wielders of ritual power’ were ideally positioned to extend their power into other fields of social life. While arguments to the effect that religious authority precedes and enables secular authority are common, at least one author has proposed a different order of precedence. Carneiro (2012) has argued that the first leaders to exert more than local authority were temporary war chiefs who managed to make their positions permanent and extend their power into other spheres. ‘Theocratic chiefdoms’, according to Carneiro (2002), are more likely to have resulted from secular war leaders gaining religious authority, perhaps as a way of maintaining their legitimacy as the importance of war decreased, than the reverse.

The hypothesis that religious and secular authority become more clearly distinguished as societies become more complex is also widely accepted, though details differ. Bellah’s (1964) model of ‘religious evolution’ involves a progression from ‘primitive religion’, which lacks ‘religious organization as a separate social structure’, to ‘archaic religion’ with a ‘single religio-political hierarchy’, to ‘historic religion’ in which the religious hierarchy is ‘at least partially independent’ from the political one. Only the world religions (such as Christianity and Islam) are categorised as ‘historic’, implying that differentiation of religious and secular authority does not begin until societies have become highly complex. However, others have noted that a distinction between religious and secular authority can be observed in fairly small-scale societies. Smith (1977, p. 38) noted that whereas ‘unstratified acephalous societies’ tend to either lack authority altogether or to combine religious and secular authority, a distinction between ‘priests or priest chiefs’ and ‘war leaders and secular chiefs’ is characteristic of many ‘weakly differentiated societies’.

Archaeological and historical evidence provides some support for both hypotheses. For example, in both Mesopotamia and Mexico, monumental temples pre-date any large-scale structures with obvious secular utility, which provides suggestive though not conclusive evidence of the precedence of religious authority. Furthermore, in Mesopotamia the earliest written records clearly indicate that religious and secular authority were initially unified and later became partially distinct (Adams, 1973). However, both the archaeological and historical records are highly incomplete in their coverage of past societies, and there is a limit to what can be inferred about a society from its archaeological traces (Marcus, 2008). Hence the extent to which these hypotheses are true on a global scale remains unclear. Religious authority may have preceded secular authority in some parts of the world but not in others. Flannery and Marcus (2012, p. 366) have suggested that different kinds of state may have evolved from different types of chiefdoms: states ruled by ‘divine monarchs’ may have evolved from ‘rank societies in which religious authority was paramount’, whereas more secular kingdoms may have evolved from ‘militaristic rank societies, where religious specialists were little more than witch doctors’.

In recent decades, phylogenetic comparative methods have provided a useful complement to the archaeological and historical records in reconstructing patterns of cultural change. These methods allow the evolutionary histories of cultural traits to be reconstructed from contemporary ethnographic data, a process that has been labelled ‘virtual archaeology’ (Jordan et al., 2009). Phylogenetic methods typically model cultural ancestry using language phylogenies, and hence usually focus on cultural variation within a single language family. The Austronesian-speaking world has proven particularly well-suited to the application of cultural phylogenetic methods (see e.g., Currie et al., 2010; Jordan et al., 2009; Sheehan, Watts, Gray, & Atkinson, 2018; Watts et al., 2016). It is one of the largest language families in the world to be recognised as such by the majority of linguists (Greenhill et al., 2008), and hence allows the cultural ancestry of many societies to be modelled. Furthermore, Austronesian societies are highly diverse. As well as having a great variety of social and political structures (Fox, 1995), the Austronesian world was until recently home to a large number of indigenous religions that were similarly diverse and are fairly well-documented (Watts et al., 2015b). Systems of religious and secular authority within these societies varied in their scale as well as the extent to which they were differentiated. The two usually overlapped to an extent, but in some cases were distinct and independent (Douglas, 1979).

The present study tested the two hypotheses outlined above by applying a cultural phylogenetic approach to ethnographic data on Austronesian-speaking societies of the recent past. Societies were coded as to the presence and scope of systems of religious and secular authority, as well as the extent to which the two systems were differentiated. These traits were mapped onto the specific Austronesian languages spoken by these societies, and their evolutionary histories were reconstructed under different models. There were two components to this study. The first tested the coevolution of religious and secular authority – that is, the extent to which the two have interacted with each other over their evolutionary history, as well as the nature of this interaction. The second focused on the sequential evolution of the structure of religious and secular authority - that is, whether the two became more or less differentiated over time.

Methods

Phylogenies

Cultural ancestry was modelled using a sample of 1,000 trees from the posterior distribution of Gray et al.'s (2009) reconstruction of the Austronesian language family. The sample of 400 languages used by Gray et al. (2009) was pruned so as to include only the 103 languages that corresponded to societies for which the relevant variables could be coded. Societies that corresponded to more than one of the languages in the tree were assigned the language that according to Ethnologue (Simons & Fennig, 2018) had the largest number of speakers. Pruning of phylogenies was conducted using the packages 'ape' (Paradis, Claude, & Strimmer, 2004) and 'geiger' (Harmon, Weiner, Brock, Glor, & Challenger, 2007) in the programming language 'R' (R Core Team, 2015).

Coding of Variables

One hundred and three Austronesian-speaking societies were coded with respect to three variables: religious authority, secular authority, and the structure of religious and secular authority. Authority was defined as the existence of one or more offices conferring the right to direct or perform one or more activities by or on behalf of a defined group of people. The distinction between religious and secular authority lay in the nature of these activities. Most if not all definitions of religion emphasise the supernatural (Steadman & Palmer, 1995, and references therein), hence activities were deemed religious or secular based on the extent to which they involved the supernatural. Activities were considered religious if the justifications offered for them were, or could reasonably be assumed to be, primarily supernatural. All other activities were considered secular. Some activities were clearly religious in all of the societies in which they appeared – sacrifice and magic, for example, can hardly be explained without reference to the supernatural. Others activities, such as feasting and warfare, were more ambiguous, since although they often involved references to supernatural agents or powers, they could also be explained in pragmatic terms. Generally, these activities were considered secular unless there was an explicit statement in the sources that they were primarily oriented towards supernatural ends. However, in order to avoid inflating the degree of support for coevolution, the same activity was never coded as both religious and secular within the same society.

The two variables were intended to capture not only whether or not religious and secular authority existed, but also their scope. Societies were coded '0' if they lacked any office in which the relevant form of authority was vested, or in which the group over which any such office conferred authority was no larger than a domestic unit. Societies in which the relevant offices existed were coded '1' if the highest of these offices were sub-local (over a group larger than a domestic unit but smaller than the local community), '2' if local (over a local community, or multiple sub-local groups), and '3' if supralocal (over multiple local communities). These two ordinal variables were subsequently binarised using the same three cutoff points (1, 2 and 3) in order to make them suitable for the planned coevolutionary analyses. This yielded six binary variables – three for religious authority and three for secular authority. The first simply represented the presence or absence of the relevant form of authority, the second the presence or absence of that form of authority at the local level or higher, and the third the presence or absence of specifically supralocal religious or secular authority (see Table 2).

Table 2

Binarisation of Ordinal Variables with States 0, 1, 2, and 3.

Binary variable	**Absent**	**Present**
Authority	0	1,2,3
Authority at the local level or higher	0,1	2,3
Supralocal authority	0,1,2	3

The variable 'structure of religious and secular authority' was aimed at capturing the extent to which religious and secular authority were distinct. Societies that did not have both religious and secular authority were coded '0'. Societies were coded '1' if they had both religious and secular authority, and supreme religious and secular authority were 'unitary' (vested in the same office). Societies were coded '2' if they had both religious and secular authority, and religious and secular authority were 'weakly differentiated'. This was a residual category that included societies in which the two forms of authority were incompletely partitioned between different offices (e.g., secular authority being vested in one office, and religious authority shared between this office and another) and those in which they were vested in different offices that were part of the same hierarchy (e.g., a high priest being the subject of a secular high chief, or vice versa). Societies were coded '3' if they had both religious and secular authority, and religious and secular authority were clearly differentiated (vested in distinct offices that were not part of the same hierarchy).

Austronesian societies have undergone dramatic changes in their religious and political organization as a result of contact with the civilizations of the Old World, particularly over the last few centuries. In almost all Austronesian-speaking societies, traditional religious beliefs and practices have been superseded by Christianity or Islam (Reid, 1995). Furthermore, almost all Austronesian societies were at one time or another subject to colonisation by European powers, and this has left a lasting legacy in their political structures - present-day states such as the Solomon Islands or the Philippines, for example, had no pre-colonial predecessors. Since the cultural phylogenetic methods used in the present study assume predominantly vertical cultural transmission (Mace & Jordan, 2011), they cannot justifiably be applied to ethnographic data from Austronesian societies today. For this reason, societies were coded as they were immediately prior to colonisation and / or large-scale conversion to a world religion (whichever occurred earlier). Coding was based on a range of ethnographic sources, and each coding decision was justified with citations (Table C1).

Phylogenetic Analyses

Phylogenetic analyses were conducted using the software package BayesTraits Version 3.0 (Meade & Pagel, 2017). Two components of this package were used: 'Discrete' to investigate the coevolution of religious and secular authority, and 'Multistate' to test the sequence in which the structure of religious and secular authority evolved. 'Discrete' tests dependent and independent models of the evolution of pairs of binary traits. In a dependent model, the traits can co-evolve – that is, the presence or absence of one trait can affect the rates at which the other trait is lost or gained. In an independent model, the rates at which one trait is lost or gained are not affected by the presence or absence of the other trait. Multistate is used to test models of the evolution of a single trait that adopts two or more discrete states. Both Discrete and Multistate can be run using a Maximum Likelihood (ML) or Markov Chain Monte Carlo (MCMC) approach. The primarily analyses conducted in the present study used an MCMC approach, but the choice of priors was guided by analyses involving an ML approach.

Maximum Likelihood Estimations. In order to inform the choice of priors for the Discrete and Multistate Markov Chain Monte Carlo (MCMC) analyses described below, Maximum Likelihood estimations (MLEs) were performed. One hundred optimisation attempts were made for each tree in the sample.

MCMCs. The Discrete and Multistate MCMCs were run using the same settings. Each involved 100,000,000 iterations of the chain, with the first 10,000,000 removed as burn-in. Based on the results of the MLEs, a reverse-jump hyperprior with an exponential distribution that can range between 0 and 10 was chosen for all analyses. A stepping-stone sampler with 100 stones was run for 100,000 iterations to estimate the log marginal likelihoods for the models in the posterior distribution of each analysis. All analyses were independently replicated three times, and each replication converged on highly similar rate and log marginal likelihood values (see Tables C2-C8).

Initially, three pairs of Discrete MCMCs were run, each of which tested a dependent and independent models of the evolution of one of the binarised religious authority variables and one of the binarised secular authority variables. The first pair of Discrete MCMCs involved authority at any level – sub-local, local, or supralocal. The second involved authority at the local level or higher, and the third specifically supralocal authority (see Table 2).

To further investigate how religious and secular authority co-evolved, a series of constrained follow-up analyses were performed. For each level of authority, the same four series of constraints were placed on the models in the dependent analyses. The first series of constraints tested whether religious authority facilitated the emergence of secular authority by constraining the analyses to include only models in which cultures with and without religious authority gained secular authority at the same rate (rate q12 was restricted to be equal to rate q34). The second series of constraints tested whether secular authority facilitated the emergence of religious authority by constraining the analyses to include only models in which cultures with and without secular authority gained religious authority at the same rate (rate q13 was restricted to be equal to rate q24). The third series of constraints tested whether religious authority helped to maintain secular authority by constraining the analyses to include only models in which cultures with and without religious authority lose secular authority at the same rate (rate q21 was restricted to be equal to rate q43). The fourth series of constraints tested whether secular authority helped to maintain religious authority by constraining the analyses to include only models in which cultures with and without secular authority lose religious authority at the same rate (rate q31 was restricted to be equal to rate q42).

In the Multistate analyses, five models were tested. In the ‘full model’, any transition between any two states was allowed. This allowed the analyses to select from all possible model structures. In the ‘differentiation model’, rates of transition from 0 to 2 (q02), 0 to 3 (q03) and 1 to 3 (q13) were set to zero. This constrained the analyses to include only models in which more differentiated authority structures evolved from less differentiated ones (i.e. 1 → 2 → 3). In the ‘unification model’, rates of transition from 0 to 1 (q01), 0 to 2 (q02), and 3 to 1 (q31) were set to zero. This constrained the analyses to include only models in which less differentiated authority structures evolved from more differentiated ones (i.e. 3 → 2 → 1). Since 2 (‘weakly differentiated’) is a more heterogeneous category than 0, 1, and 3, less stringent (‘weak’) versions of the differentiation and unification models were also tested. In the ‘weak differentiation model’, only rates q02 and q03 were restricted to zero (i.e. transitions from 1 → 3 were also allowed). In the ‘weak unification model’, the only rates restricted to zero were q01 and q02 (i.e. transitions from 3 → 1 were also allowed).

Model comparison. Support for the posterior distribution of analyses with different model structures was evaluated using Log Bayes Factors (BFs) calculated from the log marginal likelihoods obtained for each posterior distribution of models. These represented support for more complex model structures over less complex model structures (dependent vs. independent for the discrete analyses, and constrained vs. unconstrained for the multistate analyses). Log BFs were interpreted following a scheme in which 0-2 is ‘not worth more than a bare mention’, 2-6 is ‘positive evidence’, 6-10 is ‘strong evidence’, and 10 or higher is ‘very strong evidence’ (Kass & Raftery, 1995).

Results

General Observations

Religious and secular authority were both very common in the sample and usually co-occurred. There were only 13 societies in the sample that had neither religious nor secular authority at any level, and 71 societies had both. Of the remainder, 9 had religious authority but not secular authority, and 10 had secular authority but not religious authority. Of the 71 that had both, the structure of religious and secular authority was unitary in 26, weakly differentiated in 34, and clearly differentiated in 11 (See Figure 7, Table C1).

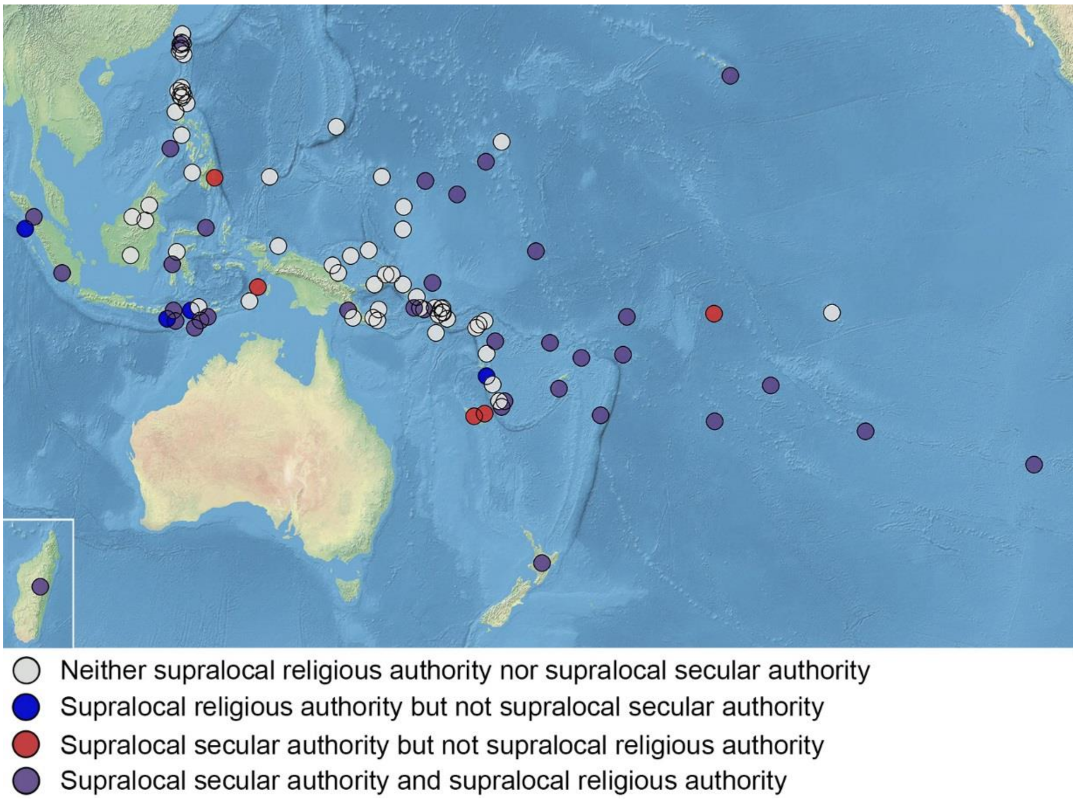

Figure 7. Supralocal religious and secular authority in the sample. Each filled circle represents one of the 103 societies in the sample, and its colour represents the particular combination of supralocal religious and secular authority present in that society. See Table C1 for further details. (Image created using map data from Natural Earth, www.naturalearthdata.com).

MCMCs

The results of the discrete MCMC analyses supported the coevolution of religious and secular authority at all levels. For religious and secular authority at any level, the models in the posterior distribution of the dependent analyses were favoured over the models in the posterior distribution of the independent analyses with a Log BF of 7.41. The corresponding figure for religious and secular authority at the local level or higher was 15.97, and for supralocal religious and secular authority, 61.53 (see Figure 8, Tables C2, C3). All of these Log BFs represent either strong or very strong support for the co-evolution of religious and secular authority in the history of Austronesian societies (Kass & Raftery, 1995).

The constrained follow-up dependent analyses suggested that the nature of the coevolutionary relationship varied according to the level of authority (see Tables C4-C7). For the analyses involving authority at any level, there was no substantial evidence that secular authority facilitated the gain of religious authority (Log BF = 0.58), or that religious authority facilitated the gain of secular authority (Log BF = 1.72). While there was weak evidence that secular authority helped to sustain religious authority (Log BF = 2.46), there was no substantial evidence that religious authority helped to sustain secular authority (Log BF = 1.72). For the analyses involving authority at the local level or higher, there was also no substantial evidence that religious authority facilitated the gain of secular authority (Log BF = 0.99), or that secular authority facilitated the gain of religious authority (Log BF = 0.18). Again, there was some evidence that secular authority helped to sustain religious authority (Log BF= 4.73), but no evidence that religious authority helped sustain secular authority (Log BF = 0.31). For the analyses involving supralocal leadership, there was no substantial evidence that religious authority facilitated the gain of secular authority (Log BF = 1.56), that secular authority facilitated the gain of religious authority (Log BF = 0.60), that secular authority sustained religious authority (Log BF = 1.31), or that religious authority sustained secular authority (Log BF = 0.85). Across all of these follow-up analyses, the constrained models fitted substantially better than the models from the independent analyses (see Tables C3, C5-C7). This means that while the constrained models were unable to find consistent evidence for specific pathways of evolution, there remained strong evidence that religious and secular author have co-evolved. Furthermore, the tight clustering of these two forms of authority over time clearly shows that religious and secular leadership were tightly coupled throughout their evolutionary histories (see Figure 8).

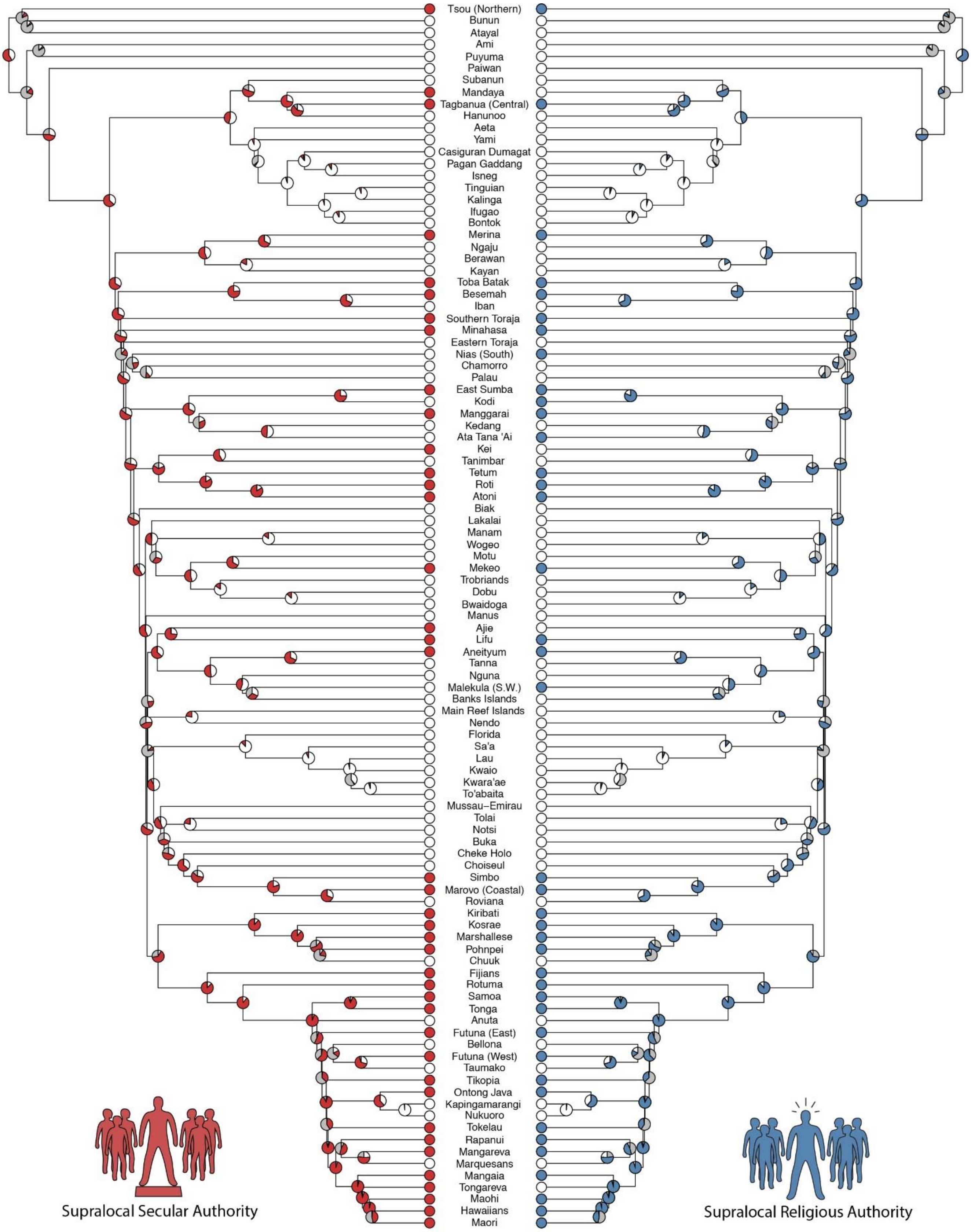

Figure 8. Coevolution of supralocal religious and secular authority. Ancestral state reconstruction of supralocal religious and secular authority, plotted on a maximum clade

credibility tree. Pie charts at the internal nodes of the tree represent the proportion of models in which the trait was inferred to be present at that node, with grey representing the proportion of trees in the sample from which that particular node was absent.

The results of the Multistate MCMC analyses provided little support for the hypothesis that religious and secular authority become either more or less differentiated over time, though without ruling out the latter. No model substantially outperformed the full model, though both the strong and weak versions of the unification model performed slightly better (Log BFs of 1.96 and 1.66 respectively). The full model did not, however, perform substantially better than the either the strong or weak version of the differentiation model (Log BFs of 1.82 and 1.32 respectively). Both versions of the unification model substantially outperformed both versions of the differentiation model (Log BFs of between 2.92 and 3.78) (see Table C8).

Discussion

The present study found strong evidence that religious and secular authority co-evolved, but did not find clear evidence that either trait had causal precedence. For authority in general and at the local level, there was some evidence that secular authority sustained religious authority rather than the reverse, which is contrary to the direction of causation that has usually been proposed. At the supralocal level, where evidence of coevolution was the strongest, the effects of one upon the other could not be disentangled. No clear evidence was found that religious and secular authority became more or less differentiated over time, but the differentiation model was rejected more decisively than the unification model.

That religious and secular authority co-evolved was not unexpected, but the strength of the relationship was striking, as was its lack of clear directionality. Both of these findings are likely to be attributable at least in part to the fact that in most if not all of the societies that had both secular and religious authority, the two were closely linked. In many cases they were vested in the same office, the 'divine kingship' of Hawaii (Valeri, 1985) being perhaps the most famous example. In other cases, the office in which secular authority was vested was subordinate to the office carrying religious authority, or vice versa. In Tonga in the eighteenth-century, the Tu'i Tonga was the religious head of the archipelago and in theory outranked the *hau* ('temporal ruler'), although the latter was far more powerful (Douglas, 1979). In the chiefdoms of Roviana Lagoon the situation was different – the chief (*banara*) outranked the priest (*hiama*), despite religious ritual being largely in the hands of the latter. Even in cases in which religious and secular leaders were in theory independent, in practice they usually headed the same social group and worked together closely. In Tahiti, for example, high priests are reported to have 'exercised immense influence' in secular affairs, 'depending more or less on the character of the king' (Oliver, 1974, p. 869). It appears that when secular and religious authority co-occurred, a close relationship between them was all but inevitable. There are obvious ways in which religious and secular authority might have promoted and/or sustained each other. Religious authority might have strengthened secular authority by increasing its legitimacy and reinforcing it with supernatural sanctions, whereas secular authority could have supported religious authority by providing it with prestige, resources, and protection.

It could be argued that the strength of the relationship between religious and secular authority found in the present study results from a false dichotomy. Some authors have made statements to the effect that religious and secular authority are the same phenomenon. Graeber and Sahlins (2017, p. 3) put forward a particularly strong version of this argument, claiming that 'human authorities emulate the ruling cosmic powers', and that consequently 'there are no secular authorities: human power is spiritual power'. However, whether or not religious and secular authority are distinguishable depends on definitions. In this study, religious authority and secular authority were defined on the basis of whether the activities involved were secular or religious. Thus defined, the two overlapped to a large extent but were clearly not identical – some societies had one but not the other, and the highest levels of each were often vested in different offices. However, other authors have defined religious and secular authority in terms of their bases rather than their spheres of control. For example, Chaves (1994) considers authority to be religious if the basis of its legitimacy 'includes some supernatural component, however weak'. If this broad definition is accepted, it may well be the case that no meaningful distinction can be drawn since all authority is to some extent religious, at least in pre-industrial societies.

The results of the present study do not support the hypothesis that religious authority preceded and enabled the evolution of secular authority, but there are reasons for caution in interpreting them as conclusive evidence against it. Firstly, as noted above, the terms 'religious authority' and 'secular authority' were used in specific senses in the present study. Defined differently, religious authority may have preceded secular authority - earlier forms of authority may have relied more heavily on religious sanctions than later ones. Future studies could investigate this possibility further, though operationalising and coding the extent to which authority is based on religious or secular considerations is likely to be a difficult task. Secondly, 'secular' activities are arguably more varied than 'religious activities', and hence religious and secular authority may be on different levels of generality. Examining the coevolution of religious authority with specific types of secular authority –military, economic, or judicial – might result in stronger evidence of a directional relationship.

The results of this study were inconsistent with an evolutionary progression from unitary to more differentiated forms of religious and secular authority, and were equivocal at best in their support of a progression in the opposite direction. This may in part reflect the characteristics of the sample. Pre-colonial Austronesian societies varied greatly in their complexity, but highly complex societies were under-represented – in Service's (1975) terminology, there were many egalitarian societies and chiefdoms, but few states, and fewer still among peoples who retained their indigenous religions until the modern era. It is possible that a sustained trend towards differentiation or unification of religious and secular authority does not appear until societies reach or approach the state level. It may be noted in passing that the two clearest examples of state-level societies in the sample – the Hawaiians and the Merina of Madagascar – both had unitary systems of religious and secular authority. The king (*alii nui*) of a Hawaiian state was the 'supreme mediator between men and gods' (Valeri, 1985, p. 140), and the ruler of the Merina Kingdom was 'also the high-priest of the nation' (Sibree, 1870, p. 316). This is more consistent with a progression towards unification of religious and secular authority than the reverse. A stronger test of this hypothesis could be conducted using a sample with more state-level societies.

In summary, the present study found evidence for a strong coevolutionary relationship between religious and secular authority. While many authors have argued that the two are closely linked, the present study provides quantitative evidence of the strength of this relationship. We found no support for the hypothesis that religious authority precedes and enables secular authority or that religious and secular authority become more clearly differentiated over time, nor consistent evidence for the reverse. Future research may be able to resolve these questions further by operationalising religious and secular authority in different ways and using samples with more state-level societies.

CHAPTER FIVE: Predictors of Post-Contact Population Decline in the Pacific Islands

Introduction

Oceania and the Americas have been described as constituting the ‘New World’, in contrast to the ‘Old World’ made up of Africa and Eurasia. These worlds had limited contact with each other until the modern era, when Europeans began to explore and colonise the New World. When sustained contact finally began, its effects on New World peoples were often damaging. One of the clearest indicators of the destructive effects of contact was population decline, which was common throughout the New World (Kunitz, 1994).

‘Virgin-soil’ epidemics – outbreaks of disease in populations that lack immunity to them (Crosby, 1976) – are generally agreed to have been the principal cause of population decline following contact. The fact that these epidemics occurred in the New World but not the Old World is explained by the fact that in pre-modern times diseases were more varied and prevalent in the former than in the latter (Diamond, 1997; Kunitz, 1994). The virgin soil factor does not, however, explain the considerable variation in the extent to which different New World populations suffered. Decline was catastrophic for some populations but minimal for others, and a few appear to have enjoyed near-consistent growth following contact (Kunitz, 1994). Attempts to explain this variation can for convenience be divided into two broad categories: those emphasising internal (or endogenous) factors that made particular populations more or less vulnerable, and those emphasising external events (exogenous factors) that were more or less damaging.

Immunological, demographic, and cultural traits are among the internal factors that are most often invoked to explain variations in the extent of population decline. According to immunological explanations, the virgin soil factor was not equally present within New World populations – some had greater levels of immunity prior to contact because they were less isolated from the Old World. For example, White and Mulvaney (1987) suggest that

Aboriginal Australian populations in the north of the continent declined less following European contact than those further south, since the former had already had contact with Indonesians prior to encountering Europeans. The demographic factors that are most often linked to variation in population decline are population density and connectedness. A fundamental principle of epidemiology is that diseases spread more quickly in dense populations whose members are strongly interconnected than in sparse populations that are divided into isolated subgroups (Ramenofsky, 1987). Epidemics would have been more frequent in conditions conductive to the rapid spread of disease, and frequent epidemics that gave populations little time to recover would have been more likely to cause sustained population decline (Kunitz, 1994; Rallu, 2007). Cultural factors, when invoked, are usually seen as exacerbating or mitigating population decline via their influence on some other factor. For example, political integration has been proposed to have facilitated the spread of epidemics in North America by increasing the connectedness of local communities within larger societies (Milner & Chaplin, 2010).

The external factors to which variation in population decline is most often attributed concern the nature of interactions between Europeans and indigenous peoples. Perhaps the most obvious way that Europeans could have contributed to population decline over and above the introduction of new diseases was by intentionally killing indigenous people. Mass killings did occur in parts of the New World during this period and no doubt played a leading role in the decline of some groups, though in aggregate they appear to have been far less important than disease (Caldwell, Missingham, & Marck, 2001; Dobyns, 1983). Less extreme actions on the part of colonists have also been blamed. For example, Kunitz (1994) argues that some of the differences in the extent and timing of population decline between different Polynesian populations can be explained by the type of colonisation that these groups underwent. According to Kunitz, those subjected to 'settler capitalism' – a form of colonisation involving massive immigration and land expropriation by non-indigenous people, which impoverished indigenous peoples and made them more susceptible to disease – continued to decline long after those who had been spared this particular kind of colonisation had begun to recover.

Intensity of contact is another factor that is often invoked, the argument being that more frequent contact with Europeans would have provided more opportunities for transmission of Old World diseases (Kunitz, 1994; Rallu, 1991; Wilson, 1997). That the damaging effects of intensive contact must have decreased over time is often left unstated. Almost all indigenous New World peoples eventually came into frequent contact with Europeans (and / or other Old World peoples), and for most, this contact never ended. But population decline did end - by the early twentieth century the indigenous populations of Oceania and the Americas had stopped declining and were beginning to recover, though some individual populations continued to decline for longer (Caldwell et al., 2001; Kunitz, 1994). Clearly, the intensity of contact must have interacted in some way with the timing of contact in order to exert its effect on population decline. Populations for whom contact with Europeans was frequent from the beginning may have suffered greater population loss than those for whom the onset of intensive contact was gradual, since the former would have been at risk of more frequent epidemics that gave them little time to recover. Furthermore, populations that were contacted later than their neighbours may already have been indirectly exposed to European diseases and gained some immunity to them.

The present study seeks to identify some of the factors that protected against or exacerbated post-contact population decline in one region of the New World, namely the Pacific Islands. As defined in this study, these islands extend west to east from New Guinea to Easter Island, and north to south from Hawaii to New Zealand, but exclude Australia (D’Arcy, 2008). Contact with Europeans began in the sixteenth century and accelerated in the eighteenth (Kirch, 2000), though some Pacific peoples avoided direct contact until well into the twentieth century (Meleisea & Schoeffel, 1997). The indigenous population of the Pacific Islands suffered an overall decline in the centuries following contact (Caldwell et al., 2001; Denoon, 2008), but like elsewhere in the New World, this decline was highly uneven. Some populations suffered catastrophic losses (Kirch & Rallu, 2007), but others were affected minimally or not at all (Howe, 1977). A number of authors have compared individual cases and proposed explanations of their differences (Kirch & Rallu, 2007; Kunitz, 1994; McArthur, 1967), but there has never been a systematic effort to quantitatively test hypotheses about population decline using a sample from across the entire region.

For a number of reasons, the Pacific Islands are particularly well-suited for a comparative study of this subject. Firstly, most peoples of this region (with the exception of New Guinea) speak languages belonging to a single family, Austronesian. Linguistic relationships within the Austronesian language family can be used to model the cultural relatedness of different Pacific Island populations. To the extent that cultural and genetic relatedness correlate (Cavalli-Sforza, 1997), the former can also provide an indirect measure of the latter. Since both genes and culture can affect the susceptibility of populations to disease (Ramenofsky, 2003), it is important to take population relatedness into account in any comparative study. Secondly, Pacific Island societies are famously diverse in terms of their culture, demography and environments (D'Arcy, 2008). This variation allows a range of hypotheses about the predictors of population decline to be tested. Finally, estimates of pre-contact population sizes in the Pacific Islands are in better agreement than those from elsewhere in the New World. Controversies exist (see e.g., Kirch & Rallu, 2007), but are less extreme to those relating to the Americas, where estimates often vary by an order of magnitude or more (Henige, 1998).

The factors investigated as possible predictors of population decline in the present study were population density, political integration, timing of contact, and intensity of contact. The first two are internal or endogenous factors. Populations that were denser and more politically integrated were predicted to decline more following European contact, since according to epidemiological models epidemics spread more easily in dense and interconnected populations. The second two are external or exogenous factors, though they may also have been influenced by internal characteristics, such as attitudes to outsiders. Populations that were contacted earlier and were exposed to more intense contact with Europeans were predicted to have suffered greater decline following contact.

Methods

Sample Selection

The units of analysis in this study were indigenous Pacific Island populations. Populations were included based on three criteria: firstly that adequate data on the response and predictor variables were available, secondly that they were large and / or isolated enough that they could reasonably be assumed to be self-sustaining (that is, grow or decline primarily as a function of birth or death rates rather than migration), and thirdly that they could be matched to one or more of the 400 Austronesian languages in a sample of phylogenies created by Gray et al. (2009). Where possible, populations were selected that corresponded to ethnolinguistic groups – that is, groups that shared a common native language and constituted the entire population (or the vast majority) of native speakers of that language. However, to increase sample size, populations that corresponded to parts of ethnolinguistic groups, or to a number of related ethnolinguistic groups, were also included in cases where estimates at the ethnolinguistic group level were not available. The final sample consisted of 57 populations (See Table D1). Of these, 35 were ethnolinguistic groups (e.g., Aneityum, Samoa), 11 were parts of ethnolinguistic groups (e.g., Nguna, Tubuai), and 11 were aggregates of related ethnolinguistic groups (e.g., Malaita, Tanna).

Coding of dependent variable. Population decline was operationalised as the proportion by which a population declined following contact, and was calculated as follows:

$$1-(P_{Nadir}/P_{Contact})$$

$P^{Contact}$ represents the population at the time that sustained contact with Europeans began, and P_{Nadir} the population at its lowest point following contact. (For populations that were never smaller after contact than they were at contact, P_{Nadir} was the same as $P_{Contact}$.) Possible values of this variable ranged from 0 (no decline) to 1 (extinction).

The limiting factor in coding this variable was in most cases the availability of contact population estimates. Preference was given to estimates by experts such as historical demographers and archaeologists (e.g., Kirch & Rallu, 2007; McArthur, 1967), but these were not abundant. To increase the size of the sample, estimates from non-experts such as missionaries and explorers were included on a case-by-case basis. No fixed criteria were used when evaluating non-expert estimates, but factors included reasoning, plausibility, lack of obvious bias, and the size of the area whose population was being estimated. In a few cases, the earliest population figures or estimates dated to considerably after contact, but were accompanied by a statement to the effect that there was no evidence for any decline. In these cases, it was assumed that the population had been stable since contact. When estimates of the same population varied, and there was no obvious reason for preferring one estimate over the other, a midpoint was chosen.

In 1862-1863, labour recruiters or ‘slavers’ (Maude, 1981) from Peru visited several Pacific islands and took thousands of people from their homes, some voluntarily but most through force or deception. These events occurred in the context of the labour trade, which was active for much of the nineteenth and early twentieth centuries and often involved deception and abuse, especially in its early stages. However, the Peruvian raids were an extreme case, and were considered criminal even by the standards of the time. The great majority of those ‘recruited’ died of disease or maltreatment either en route to Peru or shortly after arriving there. The majority of those who survived were returned to the Pacific Islands, though in most cases not to their islands of origin. Since many of these survivors were had been infected with smallpox and dysentery in Peru, their return resulted in epidemics that caused further mortality. Maude (1981) estimates that around 3,000 people died as a direct result of these events, and about the same number in the epidemics that followed. Since many of the populations that were targeted were very small, these events constituted a demographic disaster for them (Maude, 1981; Munro, 1993). The focus of the present study was unexplained variation in population decline, whereas mortality among the recruits is easily explained - there is no mystery as to why they would have died in large numbers when exposed to a novel disease environment under harsh conditions. For this reason, population decline figures were adjusted downward to exclude the direct effects of the Peruvian raids. Estimates from Maude (1981) of the number of people taken from a given population, if any, was subtracted from $P_{Contact}$. This adjustment slightly over-corrected for deaths that were a direct result of raids, since an unknown (but small) number of those recruited eventually returned home. No attempt was made to adjust for the epidemics that were an indirect result of the raids, since these, like other epidemics, would have been influenced by various characteristics of the host population. Population figures that were not adjusted for the direct effects of the raids were retained for use in a follow-up analysis to check the robustness of the results to this correction.

Based on the recommendations of Warton and Hui (2011) for working with response variables that are proportions, the logit transformation was applied to the population decline figures, with a constant of 0.04 (the minimum non-zero decline figure) added to allow values of 0 or 1 to be transformed.

Selection and coding of predictor variables. Four predictor variables were coded, each of which was intended to represent a factor that has been proposed to have influenced population decline. These factors were timing of contact, intensity of contact, population density, and political integration. These variables were selected based on theoretical grounds, balanced against the ease with which they or a proxy for them could be coded.

Some of the factors that were not included are also worth noting. One is violence towards indigenous peoples by Europeans. Instances did occur in the Pacific Islands, but were less common and less extreme than elsewhere in the New World - examples of mass killings comparable to those that occurred in Australia and the Americas are hard to find. Similarly, although almost all Pacific Island societies were under colonial rule at one time or another (Firth, 1997), colonisation was rarely of the 'settler capitalism' variety. Only in Hawaii, New Caledonia and New Zealand did European immigration and land alienation occur on a massive scale (Denoon, 1997a, 1997b). Although massacres, displacement and dispossession no doubt had demographic effects in the places where they occurred, it seems unlikely that they could explain much of the variation within the region as a whole.

Timing of contact was operationalised as the calendar year at which sustained contact with Europeans began, sustained contact being defined as face-to-face contact that occurred at least once a year on average. There were two reasons why sustained contact rather than first contact was chosen. Firstly, most demographers agree that the majority of population decline in the New World post-dated sustained contact (McCracken, 2000). The second reason was pragmatic: few population estimates pertaining to the time of first contact could be found. Intensity of contact was more difficult to operationalise. Proximity to a contemporary sea port or roadstead (anchorage) was ultimately chosen as a proxy, the assumption being that this would provide a crude measure of how accessible a given population was to European ships. This variable was coded in binary form. Populations were assigned a score of '1' if they were located within 162 km of one or more of the ports or roadsteads depicted in Lloyd's Maritime Atlas (Beresford, Dobson, & Holmes, 1987), or '0' if they were not. A threshold of 162 km (100 miles) was chosen based on Marck (1986), who identifies this as the maximum distance that could be travelled overnight using traditional Micronesian voyaging technology. The assumptions made when coding this variable were that voyaging technology was similar across the Pacific Islands, that contemporary ports and roadsteads roughly correspond to those of the contact period, and that populations located within an overnight voyage of a port or roadstead would have been more exposed than more remote ones to diseases introduced by European ships. Population density was calculated simply by dividing the size of a given population at the time of sustained contact by the area (in square kilometres) that it inhabited. Since both population size and population density varied widely, these variables were log-transformed. Political integration was operationalised as political complexity – the 'number of jurisdictional levels … transcending the local community' (Murdock, 1967). To make the results more straightforward to interpret, all predictor variables were centred on the mean.

Analyses

Phylogenetic Generalised Least Squares Spatial (PGLS-Spatial), like Ordinary Least Squares Regression (OLS), models the effects of one or more predictor variables upon a continuous dependent variable. Unlike OLS, PGLS-Spatial also estimates the effects of phylogenetic and geographic relatedness on the dependent variable. This makes it suited to investigating variation in traits of non-independent units such as species or other types of population (Freckleton & Jetz, 2009).

Two matrices were created, one representing phylogenetic distances and the other geographic distances between each population in the sample. Phylogenetic distance was modelled using a sample of 1,000 language phylogenies derived from a larger sample from Gray et al. (2009). Of the 57 populations in the sample, 48 could be matched to only one of the languages in our sample of phylogenies. Populations that corresponded to more than one language were matched to whichever language was listed by Ethnologue (Simons & Fennig, 2018) as having more speakers. Relatedness between two languages within a given phylogeny was defined as the distance separating them from their common linguistic ancestor. Geographic distance was represented in the form of great-circle distances calculated from geographical coordinates using the haversine formula. These coordinates represented the centre of the most populous contiguous area occupied by each population (or the largest contiguous area if it was unclear which was the most populous). Log-likelihood ratio tests were used to compare the fit of the models that included the phylogenetic matrix, the geographic matrix, both matrices, and neither matrix.

The main analysis included all 57 populations and used population decline figures adjusted for mortality directly resulting from the Peruvian raids as its dependent variable. The main effects of 'sustained contact', 'port', 'log population density', and 'political complexity' were modelled, as well as an interaction between sustained contact and port. Eight follow-up analyses were conducted to test the robustness of the results and to suggest directions for future studies. Two were multivariate analyses. The first used population decline figures that were not adjusted for the Peruvian slave raids as its dependent variable, and the second excluded one population, Chamorro, which was a clear outlier in terms of sustained contact. Five were bivariate analyses, each of which involved the dependent variable from the initial round of analyses (population decline adjusted for the Peruvian raids), and one of the five predictor variables (sustained contact, port, sustained contact x port, log population density, and political integration). Finally, one analysis involved the phylogenetic and spatial distance matrices, but no predictor variables. Analyses were run in R Studio version 1.0.136 (RStudio Team, 2016) using a script from Freckleton and Jetz (2009).

Results

General Observations

Populations at contact summed to just under 1.2 million. Caldwell et al. (2001) estimated that the total population of Oceania at the time of European contact was less than two million. However, this estimate appears conservative (see 'Discussion'), and applies to a region with somewhat different boundaries to the Pacific Islands as defined in the present study. In any case, the populations in the sample constituted a large proportion of the total, and perhaps the majority. They were also fairly evenly spread (see Figure 9). However, they were not particularly representative of the diversity of Austronesian ethnolinguistic groups in the Pacific Islands. The number of languages spoken by populations in the sample (see Table D1) summed to less than a quarter of the total number of Oceanic languages, implying a bias towards larger ethnolinguistic groups. Furthermore, Melanesian ethnolinguistic groups were clearly under-represented compared to Polynesian and Micronesian ones. Since linguistic diversity is higher in Melanesia than elsewhere in the Pacific Islands (Pawley, 1981), these two issues are almost certainly related. Expressed in percentage terms, population decline within the sample ranged from 0 to 97%, with a median of 50% and a mean of 46%. The weighted mean – calculated from the sum of all contact and nadir populations – was 65%.

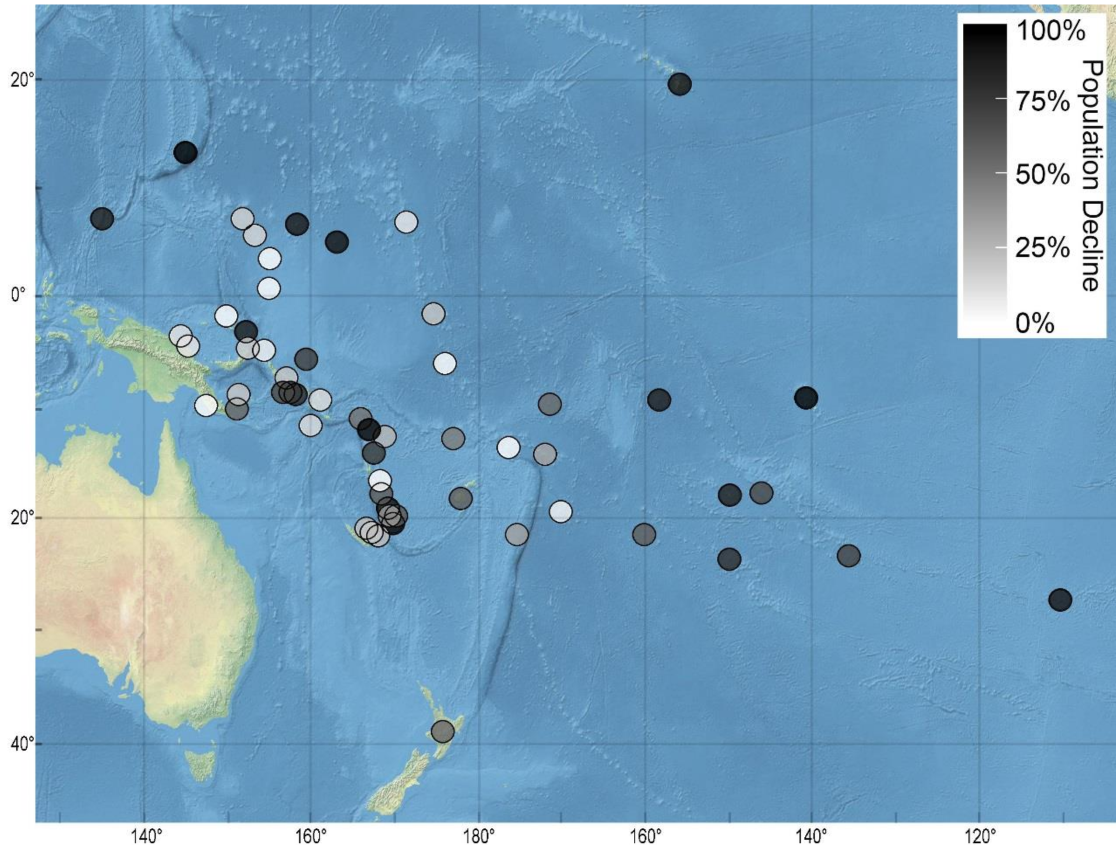

Figure 9. Population decline in the Pacific Islands, shaded according to extent.

Phylogenetic and Spatial Dependence

Neither the initial multivariate analysis nor any of the follow-up analyses supported phylogeny as a predictor of population decline - likelihood ratio tests did not show the model that included the phylogenetic matrix to be a significantly better fit to the data than the null model (which included neither the phylogenetic nor the geographic matrix) (see Tables 3, D3-D5). Evidence for spatial dependence was mixed. The model that included the geographic matrix did not perform significantly better than the null model in any of the multivariate analyses (see Tables 3, D2-D3). However, in the bivariate analysis involving 'port', the model that included the geographic matrix performed significantly better than the null model ($p = .04$). In three of the other bivariate analyses – those involving log population density, political complexity, and sustained contact * port – the model that included the geographic matrix outperformed the null model by a margin approaching statistical significance (p = .05, 08, and .07 respectively) (see Table D4). This was also the case for the model that did not include any predictors (p = .06) (see Table D5).

Predictors

In the initial multivariate analysis, the only predictor that significantly improved the model was sustained contact. Populations that experienced sustained contact later suffered less population decline (see Tables 3, D2). This was also the case in the follow-up multivariate analyses in which the dependent variable was not adjusted for the Peruvian raids, and in which the Chamorro were excluded (see Tables D2 and D3). In the bivariate analyses, the only predictor that significantly improved the model was sustained contact (p = .0003).

Table 3

Results of Main Analysis (Population Decline Adjusted for Peruvian Raids).

Predictor	**β**	**P value**
Sustained Contact	-0.02	0.0006
Port	-0.54	0.32
Log Population Density	-0.07	0.83
Political Complexity	0.09	0.77
Sustained Contact * Port	0.02	0.17
Dependency	**Mean**	**P value**
Phylogeny (λ)	0.16	0.93
Spatial (φ)	0.06	0.91
Independent (γ)	0.83	-

Discussion

Although population decline varied between regions, there was no evidence of a phylogenetic effect, and evidence for a spatial effect was mixed. Population density, which is widely thought to have influenced population decline, was not found to be a significant predictor. A main effect of intensity of contact on population decline was not supported as a predictor of greater population decline, and there was little if any support for an interaction between timing and intensity of contact. However, timing of contact was in itself a strong predictor – populations that were contacted later declined less.

Lack of support for a phylogenetic effect on population decline suggests that cultural ancestry made little difference to how populations fared when encountering European diseases. It does not necessarily rule out an effect of genetic ancestry, since although linguistic and genetic ancestry correlate strongly on a global scale (Cavalli-Sforza, 1997), this relationship may be weaker in the Pacific Islands than elsewhere (see e.g., Friedlaender et al., 2008; Posth et al., 2018; Skoglund et al., 2016). Future studies could investigate the effects of genetic ancestry on population outcomes. While the genes of Pacific Island populations are not nearly as well-documented as their languages, this situation is changing (see e.g., Friedlaender et al., 2008, Pugach et al., 2018; Santos et al., 2016).

Other authors have noted differences in the extent to which population decline affected different regions of the Pacific Islands. For example, Denoon (2008, p. 398-400) suggests that Polynesians and Micronesians suffered from population decline to a greater extent than Melanesians did, since many of the latter 'were shielded from the worst effects of the encounter with the West' by the presence of endemic diseases that made the region unattractive to Europeans. There was some evidence for an effect of geography in our data. That this effect was not clearer may be partly attributable to the fact that Melanesian populations were under-sampled in our dataset. The bivariate analyses suggested that the effect of geography was mediated by sustained contact, since adding this variable removed even marginal support for a spatial effect. Sustained contact tended to begin later in Melanesia than in Polynesia and Micronesia, and later in Near Melanesia than Remote Melanesia (Denoon, 2008; Meleseia & Schoeffel, 1997).

The fact that population density was not a significant predictor of population decline is at odds with what is known about epidemiology, a fundamental principle of which is that diseases spread more easily in denser populations (Ramenofsky, 1987), as well as explicit statements in the literature that population decline was more severe in densely populated areas (Kunitz 1994; Rallu 1991). One possible explanation is that the measure of population density used in the present study was simply too crude to capture the effect. Firstly, the areas used to calculate population density represented the 'range' or 'territory' of a given population, rather than the area of land inhabited or in use at any one time. The latter as a proportion of the former would have varied between populations, making the densities calculated for some populations misleadingly low. This problem can be illustrated using estimates of the amount of arable land that Kirch (1984, p. 98) provides for several Polynesian archipelagos. Based on the contact population estimates used in the present study, Tonga had a crude density around twice that of Hawaii (43 vs. 21 P/km^2). However, 70% of the Tongan archipelago was arable land, as opposed to only 10% of the Hawaiian Islands. Hence density per unit of arable land was in fact more than three times as high in Hawaii as in Tonga (206 vs 60 P/km^2). Future studies could use finer-grained measures of population density, though this would require data on settlement and land use patterns that is unlikely to be available for all populations. Some measure of population concentration independent of density may also be worth including. Populations that inhabited an archipelago rather than a single island, for example, may have been protected from epidemics even if the islands themselves were densely populated.

Lack of support for intensity of contact as a predictor, or for an interaction between this variable and the timing of contact, may reflect the inadequacy of proximity to a contemporary port or roadstead as a proxy. Future research could use a more precise measure, such as such as the frequency of recorded ship visits during a certain time period per head of population. This would, of course, require information that would be time-consuming to collect and be unobtainable for many populations. A compromise might be to use a proxy measure similar to what was used in the present study, but pertaining to the time at which the majority of population decline took place (the eighteenth and nineteenth centuries) rather than the present day.

The timing of contact has not been particularly emphasised in the literature as a predictor of variation in population decline, but there are a number of reasons why populations that were contacted later might have been expected to fare better. Firstly, a later onset of sustained contact is likely to have been more a gradual onset – the later sustained contact began, the longer the period of sporadic contact preceding it would generally have been. Epidemics resulting from sporadic contact would have been less frequent and given populations more opportunity to recover and gain immunity without collapsing. Secondly, sustained contact that began later is more likely to have been preceded by indirect contact. Few Pacific Island populations were ever completely isolated from their neighbours (Kirch & Green, 1987), and it seems likely that many were exposed to European diseases prior to coming into face-to-face contact with Europeans. Sporadic or indirect contact may have caused some populations to decline before sustained contact began, resulting in less decline following sustained contact, but not necessarily less decline overall. In at least one of the populations in the sample, there is direct evidence that this occurred - on Wogeo, an island off the north coast of New Guinea, the anthropologist Ian Hogbin (1935) heard of ‘a disastrous epidemic of smallpox which spread from the mainland before any European ships had called at the island', in which 'hundreds' died but the population subsequently stabilized. If undocumented cases like this were widespread, the effect of the timing of contact upon the extent of population decline may have been more apparent than real. Finally, historical factors may have made contact less damaging over time. European attitudes towards indigenous people generally became more humane between the sixteenth and the nineteenth centuries, and cross-cultural encounters less violent (Meleseia & Schoeffel, 1997).

The predictor variables used in the current study are by no means exhaustive. Other possible predictors that future studies could consider include warfare, aspects of the contact experience such as the labour trade, and the presence or absence of particular diseases (such as malaria, which was present in most of Melanesia but absent from Micronesia and Polynesia) prior to European contact (Denoon, 2008; Spriggs, 1997). Missionisation might be another factor worth investigating. McArthur (1981) blamed the depopulation of Aneityum on missionaries, whom, she argues, inadvertently created ideal conditions for the spread of disease by organizing an islandwide government and conducting large-scale church services.

In aggregate, the populations in the sample declined by 65%, though since the timing of decline varied, the total decrease across the sample would have been slightly lower. Caldwell et al. (2001) estimate that the population of Oceania declined by around 40% following contact, though excluding Australia would reduce this figure to 20%. These figures are probably too low, since many of the estimates upon which they are based appear conservative. (A figure of 25,000 for Vanuatu in 1850 is particularly at odds with other sources – see e.g., Spriggs, 1997). However, there are good reasons why the populations included in the present study may have declined more than the indigenous population of the region as a whole. Firstly, the present study was limited to Austronesian-speaking populations, which appear to have suffered more than the Papuan populations of New Guinea and nearby islands. Many of the latter lived deep inland and were not contacted until well into the twentieth century, when modern medicine was available to counteract the effects of new diseases (Denoon, 1997b). Secondly, the literature on population decline in the Pacific Islands, which furnished many of the contact population estimates used in the present study, presumably focuses on the worst cases. Altogether it seems likely that total population decline in the Pacific Islands was greater than the 20% estimated by Caldwell et al. (2001), but less than the 60-65% reduction of the populations in the present study – 50% is a mere guess, but is probably as good as any. Pacific Islanders certainly appear to have fared better demographically than the indigenous peoples of Australia and the Americas, whose reduction in numbers is often estimated to have been on the order of 90% or more (Denoon, 2008; Kunitz, 1994).

Limitations of the predictor variables, and suggestions for improving them, have been provided. The dependent variable also has obvious limitations. The population estimates used to calculate the extent of population decline were far from exact, and the populations included were not particularly representative of the region as a whole. Furthermore, the time to which they pertained was sustained contact, whereas initial contact would have been preferable. These problems may be mitigated in years to come by methods of estimating past populations based on evidence that has survived to the present day. Bayliss-Smith (1978, 1980, as cited in Spriggs, 2007) has proposed methods of estimating the ‘standard’ and ‘maximum’ populations of areas based on archaeological evidence of production systems supplemented by ethnographic accounts of how they operated. This model has been successfully applied to a number of Pacific Island populations, and several of the contact population estimates used in the present study are based primarily or in part on this approach. More such studies might increase the size of the available sample as well as the accuracy of the data. Genetics may also be informative. Comparison of ancient and modern DNA can detect ‘bottlenecks’ in effective population size (which does not, however, map onto ‘census population size’ in a consistent way). This approach has been applied in the Solomon Islands, where no evidence of a bottleneck was found (Ricaut et al., 2010), consistent with estimates that suggest moderate rather than catastrophic population decline in this part of the region.

Operationalising the dependent variable as overall decrease following European contact was a pragmatic way of summarizing the demographic outcomes of different populations. However, this variable was an over-simplification in that it took neither variation over time nor population increase into account. The importance of timing can be illustrated using the example of the Tolai, who are estimated to have numbered about 30,000 when they came into sustained contact with Europeans in the 1870s (Epstein, 1991). By 1942 their population had increased to 38,000, but subsequently dropped to 25,000 during the Japanese occupation, before quickly recovering and continuing to grow after the war (Irwin, 1963). To state that the Tolai population decreased by a sixth following European contact is hence technically true, but misleading. Measuring only decrease but not increase means that no distinction was made between populations that remained stable in the decades following European contact and those that grew consistently, or between populations that decreased to a similar extent but subsequently recovered at different rates. One way of addressing both of these problems might be the use of annual rate of decrease rather than overall decrease as a dependent variable, and conducting multiple analyses representing different time points after contact.

The present study represents a first attempt to systematically investigate the predictors of population decline in the Pacific Islands while controlling for non-independence. The results highlight the extent of population decline this region, but also its variability. They also suggest that some common assumptions about population decline, such as the importance of population density, may not be justified. Future research could build upon this work by operationalising the predictor variables more precisely as well as including others.

CHAPTER SIX: General Discussion

As each chapter provided a discussion of the particular study's findings, this section will provide a brief summary of the broader theoretical implications and contributions of the overall thesis.

Theoretical Implications

The main theoretical questions addressed in this thesis were the extent to which cultural change is unilinear, and the relative importance of material phenomena versus social culture and ideas in driving cultural evolution. Considerable evidence for unilinearity was found, but there was little evidence that one group of factors drove the process to a greater extent than any other.

Materialism and Idealism. Study One, and to a lesser extent Study Three, were structured in terms of the opposition between materialist and idealist theories of cultural evolution. Both tested the coevolution of cultural traits that had different levels of 'materiality'. This difference was more pronounced in Study One than in Study Three. Intensive agriculture is clearly a more material phenomenon than political complexity and social stratification. Religious and secular authority, on the other hand, are both partly social and partly ideational. However, I consider religious activities to belong more firmly to the ideational realm than most secular activities do, since they centre upon ideas almost by definition. Although both of these studies found strong evidence that the traits in question co-evolved, neither found consistent evidence that one trait influenced the other to a greater extent than the reverse. In Study One the relationship between intensive agriculture and socio-political complexity was clearly reciprocal, whereas in Study Three the extent to which secular authority and religious authority affected each other depended on the level of authority being examined. The opposition between materialism and idealism was also present, though far less central, in Study Four. Some of the proposed predictors of population decline in this study were more material than others – population density, for example, is more of a material phenomenon than political complexity. The results of this study did not allow conclusions to be drawn on the relative importance of material and social phenomena, though they conceivably could have. Study Three, which focused on the evolution of a single cultural trait, had no bearing on the materialist-idealist question.

In summary, no clear evidence was found for either the materialist or the idealist view of cultural evolution. This may reflect limitations of the method or sample characteristics, but may also suggest that given the complexity and non-deterministic nature of cultural evolution, neither view can consistently be supported.

Unilinearity. The study most directly related to unilinearity was Study Two, which investigated the extent to which a particular cultural trait, political complexity, evolved along a single pathway across the globe. This study found strong evidence of unilinearity in that political complexity was found to increase sequentially both on a global scale and in the three world regions in which adequate variation existed for testing the various models. Evidence that political complexity also decreased sequentially was equivocal – the relaxed unilinear model was favoured (weakly) on a global scale but not in any of the four world regions. This could reflect regional differences, but may simply result from reduced statistical power in the world regions compared to the global sample. Studies One and Three were linked less directly to unilinearity. However, both investigated coevolutionary relationships that have been proposed to apply globally. The fact that these relationships were observable in the Austronesian-speaking world adds to the evidence for their universality. Study Four had little if any relationship to unilinearity, but did investigate a phenomenon – population decline – whose relevance extends far beyond the Austronesian-speaking world.

Methodological Aspects and Novelty

The phylogenetic approach used in this thesis has a number of advantages. Firstly, it addresses the non-independence of cultural data, known as Galton's Problem, by modelling cultural ancestry. Secondly, it allows the reconstruction of cultural sequences that might not otherwise be recoverable. Finally, it can allow inferences about causation to be drawn rather than simply showing correlation. Studies One and Three focused primarily on the causal relationships between cultural traits. Intensive agriculture and socio-political complexity, as well as religious and secular authority, have long been observed to be associated, but to my knowledge the studies presented in this thesis present the first systematic effort to quantify their relatedness while controlling for cultural ancestry. Furthermore, they present some of the strongest evidence to date that these traits are not only associated, but causally related. Study Two focused on reconstructing the history of a single cultural trait and testing models of how it evolved. In Study Four, phylogeny featured as one of a number of predictors. Since there was no evidence of a phylogenetic effect on population decline, the results of this study were equivalent to those that might have been obtained using non-phylogenetic methods. However, there was no *a priori* reason why this should have been the case.

Limitations and Directions for Future Research

The limitations of each of the studies presented in this thesis have already been described in some detail. Some of these may be improved upon in the future. In Studies One, Two, and Three, the nature of the methods required traits that were arguably more continuous than discrete to be coded as binary or ordinal variables. The development of new computational methods in the future may allow richer ethnographic data to be incorporated. The response variable in Study Four was continuous but of limited accuracy. Higher-quality data on population decline in the Pacific may become available in the future as new estimates based on ethnographic and archaeological evidence are made. Other limitations pertained to characteristics of the sample. The Austronesian-speaking world is well-suited to cultural phylogenetic methods, but some of its characteristics may limit the generalisability of findings from this region. Despite its diversity, it still represents only a subset of the variation to be found in human societies and the environments that they inhabit, and may be in some respects atypical. Study Two, which employed a global language phylogeny that is still a work in progress, foreshadows new possibilities for cultural phylogenetics on a global scale.

Concluding Statements

The societies we live in today are vastly larger and more complex than those that characterised most of our evolutionary history. How and why this change occurred is still not fully understood. However, cultural phylogenetics, as well as more traditional methods, are in the process of uncovering the causes, course, and consequences of cultural evolution. This thesis represents a modest contribution towards that project.

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Appendix A: Appendix to Chapter Two

Table A1

Coding Decisions.

Society	ABVD (Austronesian Basic Vocabulary Database) Code	Landesque Capital Intensive Agriculture	Political Complexity	Social Stratification	Sources
Aeta	444	0	0	0	Brosius (1983), Reed (1904)
Agta	417	0	0	0	Headland (1993)
Alune	199	0	2	2	Boulan-Smit (2006)
Ambonese	53	0	2	2	Cooley (1967), Lebar (1972)
Ami	350	0	1	2	Lebar (1975), Mabuchi (1960 / 1971)
Aneityum	149	1	2	2	Humphreys (1926), Spriggs (1982, 1986)
Anuta	253	1	1	2	Feinberg (1988, 1991), Kirch (2002)
Atayal	255	0	1	1	Lebar (1975)
Atoni	42	0	4	3	Cunningham (1965, 1967, 1993), Schulte Nordholt (1971)
Austral Islands	128	1	2	2	Aitken (1971), Bollt (2008), Edwards (2003)
Bali	1	1	3	3	Geertz and Geertz (1975), McCauley (1993)
Banjarese	150	1	4	4	Knapen (2001), Saleh (1975)

Banks Islands	376	1	0	0	Campbell (1990), Codrington (1881), Ward (1979)
Berawan	45	0	0	1	Huntington and Metcalf (1979), Metcalf (1976, 1982)
Besemah	107	1	2	1	Collins (1979), Jaspan (1972b)
Biak	106	0	1	1	Galis (1970), Kamma (1972)
Bikol	47	1	1	3	Scott (1994)
Bilaan	291	0	1	0	Cole (1913)
Bontok	36	1	0	4	Jenks (1905), Lebar (1975), Keesing (1949)
Brunei Malays	263	0	4	4	Brown (1968), Maxwell (1996, 1997)
Bugis	48	1	4	4	Pelras (1996)
Bugotu	37	0	0	1	Bogesi (1948), Jackson (1975)
Buka	187	0	2	1	Blackwood (1935)
Bukidnon	415	0	1	1	Cole (1956), Edgerton (1993)
Bunun	202	0	1	1	Huang (1993)
Buru	50	0	2	1	Forbes (1885), Grimes (1996, 2006)
Butonese	192	0	3	4	Babcock (1982), Schoorl (1993)
Bwaidoga	51	0	0	0	Jenness and Ballantyne (1920), Young (1991a)
Canala	19	1	3	4	Doumenge (1974)

Cham	371	1	3	4	Hall (2010), Southwarth (2011), Sox (1972), Whitmore (2011)
Chamorro	18	0	1	2	Cordy (1983), Thompson (1945 / 1971)
Cheke Holo	209	0	1	1	White (1991, 1992)
Choiseul	44	0	1	1	Scheffler (1965, 1991)
Chuuk	349	0	2	2	Goodenough (1991, 2002), Mahony (1960)
Cotabato Manobo	438	0	2	0	Kerr (1988), Maceda (1964, 1975)
Dobu	218	0	0	0	Fortune (1932), Young (1991b)
East Sumbanese	32	0	2	3	Forth (1981), Lebar (1972)
Eastern Toraja	208	0	1	1	Downs (1956), Lebar (1972)
Eromanga	463	0	2	2	Humphreys (1926), Spriggs and Wickler (1989)
Fijians	11	1	3	3	Kuhlken (2002), Scarr (1984), Walter (1978)
Futuna	210	1	2	2	Kirch (1994), Sahlins (1958)
Futuna and Aniwa	156	0	2	2	Capell (1958)
Hanunóo	13	0	0	0	Lebar (1975)
Hawaiians	52	1	4	4	Kirch (1994, 2010)
Ibaloi	423	1	1	2	Lebar (1975), Moss (1920)
Iban	28	0	0	1	Freeman (1944), Sather (1996), Sutlive (1993)

Ifugao	419	1	0	4	Barton (1922)
Ilongot	31	0	0	0	Rosaldo and Rosaldo (1975)
Isneg	424	0	0	0	Keesing (1962)
Javanese	20	1	4	4	Raffles (1817 / 1830)
Kairiru	30	0	0	1	Smith (1994)
Kalinga	429	1	0	1	Barton (1949), Dozier (1966)
Kapingamarangi	217	1	1	1	Buck (1950), Emory (1965)
Kayan	237	0	1	3	Hose and McDougall (1912)
Kédang	236	0	1	1	Barnes (1974, 1993)
Kei	59	0	3	3	Hooe (2012), Koentjaraningrat (1972A)
Kelabit	60	1	0	1	Harrison (1949, 1959); Janowski (1991), Talla (1979)
Kenyah	62	0	1	3	Hose and McDougall (1912), Lebar (1972)
Kilenge	82	0	1	1	Zelenietz (1991)
Kiribati	346	1	2	4	Lambert (1966, 1975, 1991); Macdonald (1982)
Kosrae	65	0	3	2	Athens (2007), Graves (1986), Peoples (1991)
Kwaio	66	0	0	1	Keesing (1982)
Kwara'ae	213	0	0	1	Burt (1994)
Lak	364	0	0	0	Albert (1991)
Lakalai	281	0	1	1	Chowning (1991a), Chowning and Goodenough (1965)

Land Dayak	125	0	0	1	Lebar (1972), Geddes (1961)
Lau	68	0	0	1	Ivens (1930)
Madang	7	0	1	1	Hannemann (1996)
Main Reef Islands	501	0	0	0	Davenport (1969)
Makassar	166	1	3	3	Bulbeck (1987), Cummings (2001), Rössler (1993)
Malekula (Southwest)	453	0	0	0	Deacon and Wedgwood (1934), Larcom (1991)
Manam	168	0	1	2	Lutkehaus (1990, 1991, 1995), Wedgwood (1934)
Mandaya	442	0	1	1	Cole (1913), Yengoyan (1975)
Mangareva	239	1	2	2	Buck (1938 / 1971), Conte and Kirch (2004), Green and Weisler (2000)
Manggarai	84	0	3	4	Erb (1987, 1997), Koentjaraningrat (1972B)
Manus	71	0	1	1	Carrier (1991), Schwartz (1963)
Maohi	173	1	4	3	Sahlins (1958), Lepofsky (1991), Oliver (1974)
Maori	85	1	2	2	Buck (1952), Kirch (1984), Sahlins (1958), Van Meijl (1995)
Maranao	86	1	2	2	Mednick (1965, 1975)
Maré	99	0	3	2	Dubois (1984), Guiart (1952)

Marovo (Coastal)	87	0	1	1	Hviding (1996)
Marovo (Inland)	54	1	0	0	Hviding (1996)
Marquesas	38	1	1	2	Addison (1996), Ferdon (1993), Sahlins (1958), Thomas (1990, 1991)
Marshallese	344	1	3	4	Carrucci (1991), Erdland (1961), Williamson and Sabath (1982)
Mekeo	89	0	2	2	Hau'ofa (1981), Mosko (1991), Seligman (1910)
Merina	92	1	4	4	Larson (2000), Sibree (1870)
Minahasa	137	0	2	1	Henley (2005), Schouten (1998)
Minangkabau	172	1	1	3	Graves (1981 / 2010)
Modang	232	0	2	4	Guerreiro (1993)
Motu	26	0	0	1	Goddard (2001), Groves (1963, 1991)
Mussau-Emirau	79	0	1	1	Chinnery (1927), Parkinson (1907 / 2010)
Nendö	502	0	0	0	Davenport (1964, 1991)
Ngadha	100	0	2	4	Barnes (1972)
Ngaju	154	0	0	3	Lebar (1972), Miles (1970), Schärer (1946 / 1963)
Nguna	103	0	2	2	Facey (1981, 1991)
Nias	104	0	2	3	Beatty (1993), Loeb (1935 / 1974), Suzuki (1958)
Nissan	105	0	1	0	Nachman (1991)

Niue	247	0	2	1	Loeb (1978), Smith (1983), Walter and Anderson (1995)
Nukuoro	64	1	1	1	Carroll (1966, 1975), Eilers (1934)
Ontong Java	238	1	1	1	Sahlins (1958), Bayliss-Smith (1974)
Paiwan	177	0	1	2	Lebar (1975), Matsuzawa (1989)
Palau	109	1	1	2	Force (1960), Koshiba et al. (2014), Parmentier (1987)
Palawan Batak	265	0	0	0	Eder (1987), Warren (1975)
Peninsular Malays	468	1	3	3	Gullick (1958), Hill (2012)
Pohnpei	179	1	2	3	Hanlon (1988), Haun (1984), Raynor and Fownes (1991), Riesenberg (1968)
Puyuma	271	0	1	0	Cauqulin (2004)
Rapanui	264	1	2	2	Sahlins (1958), Kirch (1984), Métraux (1940/1971)
Rejang	114	0	3	4	Jaspan (1972b), Marsden (1811)
Rennell-Bellona	206	0	2	2	Birket-Smith (1956 / 1969), Monberg (1991)
Roti	115	1	2	3	Fox (1977, 1993)
Rotuma	116	0	3	1	Gardiner (1898), Howard (1963, 1991)

Roviana	117	0	1	2	Aswani (2008), Nagaoka (1991), Sheppard and Walter (2013)
Sa'a	221	0	1	2	Ivens (1927 / 1972)
Sagada Igorot	432	1	0	1	Eggan (1960)
Samoa	118	0	3	2	Sahlins (1958), Buck (1930), Keesing (1934), Watters (1958)
Savu	119	0	2	3	Fox (1972, 1977)
Sengseng	123	0	0	0	Chowning (1980, 1991b)
Sika	124	0	3	3	Fox and Lewis (1993), Lewis (2006)
Simbo	473	0	2	1	Bayliss-Smith and Hviding (2014), Burman (1981), Scheffler (1962)
Siraya	276	0	1	0	Campbell (1903), Ferrell (1969)
Southeast Ambrym	120	0	1	2	Tonkinson (1981)
Southern Cook Islands	58	1	2	4	Bellwood (1971), Buck (1934), Crocome (1967), Gilson and Crocombe (1980), Walter (1996)
Southern Toraja	226	1	3	3	Adams (1993), Bigalke (2005), Nooy-Palm (1972, 1979)
Southwestern Islands	301	0	1	4	Lebar (1972)
Subanun	447	0	0	0	Finley and Churchill (1913), Frake (1957, 1993)

Tabar	372	0	0	0	Groves (1934), Gunn (1986)
Tagbanua (Central)	450	0	2	3	Fox (1982), Warren (1975)
Taliabu	127	0	0	0	Baldwin (1991)
Talise	469	0	0	0	Bennett (1974)
Tanimbar	78	0	1	4	Koentjaraningrat (1972C), McKinnon (1991)
Tanna	162	0	0	1	Adams (1987), Lindstrom (1978, 1991)
Taumako	375	0	0	0	Davenport (1968)
Tausug	452	1	4	4	Junker (1999), Kiefer (1975), Sather (1993)
Tetum	134	0	3	4	Hicks (1972, 2004)
Tikopia	155	0	2	2	Firth (1939, 1959, 1991), Kirch (1994), Sahlins (1958)
Tinguian	426	1	1	1	Cole and Gale (1922)
To'abaita	223	0	0	0	Hogbin (1939)
Toba Batak	188	1	2	1	Sibeth (1991), Vergouwen (1964)
Tokelau	245	0	2	1	Hooper and Huntsman (1973), MacGregor (1937)
Tolai	382	0	0	1	Epstein (1968, 1991)
Tonga	136	0	3	4	Cummins (1977), Ferdon (1987), Kirch (1984)
Tongareva	235	0	2	2	Buck (1932, Roscoe, 1991)

Trobriands	159	0	2	2	Malinowski (1922), Powell (1960), Weiner (1991), Young (1979)
Tsou (Northern)	138	0	2	1	Lebar (1975)
Tuamotu	246	1	2	2	Emory (1975)
Tuvalu	163	1	2	2	Macdonald (1982), Goldsmith (1991)
Uvea	258	1	2	2	Burrows (1937 / 1971), Pollock (1995)
Visayans	153	0	2	3	Junker (1999), Scott (1994)
Waropen	142	0	0	1	Held (1957)
Western Bukidnon Manobo	144	0	1	0	Elkins (1966)
Weyewa	326	1	2	3	Kuipers (1990)
Wogeo	146	0	1	1	Hogbin (1970, 1978)
Woleai	347	0	2	1	Alkire (1991), Burrows and Spiro (1953)
Wuvulu-Aua	148	1	1	2	Parkinson (1907 / 2010), Pitt-Rivers (1927)
Yami	254	1	0	1	Lebar (1975), Kano and Segawa (1956)

Table A2

Fossilised Nodes.

Node	**Landesque Capital**	**Source**
Proto-Austronesian	Absent	Bellwood (2007)
Proto-Malayo-Polynesian	Absent	Bellwood (2007)
Proto-Oceanic	Absent	Kirch (2000)
Proto-Central Pacific	Absent	Kirch (2000)
Proto-Polynesian	Absent	Kirch (2000)

Table A3

Phylogenetic Signal.

Trait	**Estimated D**	**Probability of E(D) resulting from no (random) phylogenetic signal**	**Probability of E(D) resulting from Brownian phylogenetic structure**
Landesque Capital	-0.02	0	0.55
Medium-High Political Complexity	-0.08	0	0.61
High Political Complexity	0.008	0.0001	0.54
Medium-High Social Stratification	0.15	0	0.34
High Social Stratification	-0.27	0	0.78

Table A4

Summary of Dependent Analyses with Fossilised Nodes.

Analysis	**Log Marginal Likelihood**	**Mean transition rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
Landesque Capital, Medium-High Political Complexity	-186.64	0.17	0.12	0.18	0.21	0.20	0.16	0.21	0.14
Landesque Capital, High Political Complexity	-163.64	0.09	0.09	0.24	0.36	0.37	0.17	0.33	0.34
Landesque Capital, Medium-High Social Stratification	-194.19	0.33	0.06	0.35	0.35	0.35	0.35	0.35	0.28
Landesque Capital, High Social Stratification	-175.43	0.06	0.07	0.27	0.28	0.29	0.28	0.27	0.26

Table A5

Summary of Independent Analyses with Fossilised Nodes.

Analysis	**Log Marginal Likelihood**	**Mean Transition Rates**			
		α1	**β1**	**α2**	**β2**
Landesque Capital, Medium-High Political Complexity	-187.14	0.15	0.16	0.15	0.16
Landesque Capital, High Political Complexity	-166.306	0.12	0.19	0.12	0.19
Landesque Capital, Medium-High Social Stratification	-197.16	0.21	0.25	0.24	0.25
Landesque Capital, High Social Stratification	-179.63	0.15	0.17	0.15	0.17

Table A6

Summary of Dependent Analyses without Fossilised Nodes.

Analysis	**Log Marginal Likelihood**	**Mean transition rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
Landesque Capital, Medium-High Political Complexity	-185.82	0.16	0.12	0.22	0.25	0.27	0.17	0.28	0.14
Landesque Capital, High Political Complexity	-161.34	0.08	0.08	0.26	0.38	0.40	0.21	0.38	0.36
Landesque Capital, Medium-High Social Stratification	-193.00	0.29	0.07	0.38	0.31	0.40	0.39	0.39	0.25
Landesque Capital, High Social Stratification	-173.07	0.05	0.05	0.30	0.31	0.33	0.33	0.32	0.31

Table A7

Summary of Independent Analyses without Fossilised Nodes.

Analysis	**Log Marginal Likelihood**	**Mean Transition Rates**			
		α1	**β1**	**α2**	**β2**
Landesque Capital, Medium-High Political Complexity	-186.65	0.15	0.17	0.15	0.16
Landesque Capital, High Political Complexity	-164.81	0.11	0.30	0.11	0.30
Landesque Capital, Medium-High Social Stratification	-196.39	0.18	0.30	0.30	0.30
Landesque Capital, High Social Stratification	-179.33	0.14	0.20	0.14	0.19

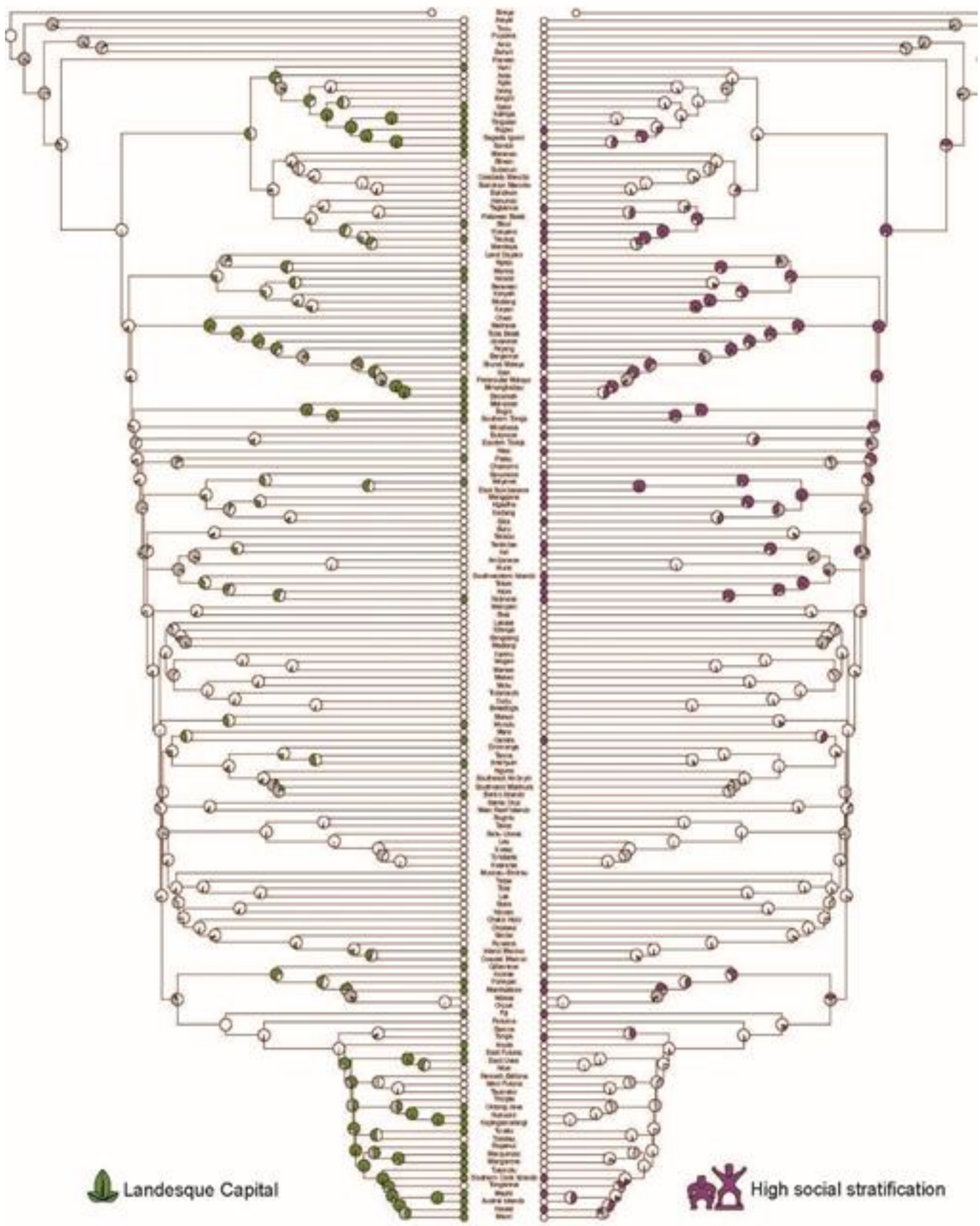
Landesque Capital
High social stratification

Figure A1. Coevolution of landesque capital and high social stratification, with fossilised nodes. Ancestral state reconstruction of landesque capital and high social stratification from the dependent analysis, plotted on a maximum clade credibility tree. Pie charts at the internal nodes of the tree represent the proportion of models in which the trait was inferred to be present at that node. (Grey represents the proportion of trees in the sample from which that particular node was absent.) In this analysis, landesque capital was constrained (fossilised) to be absent at five internal nodes, including the basal node.

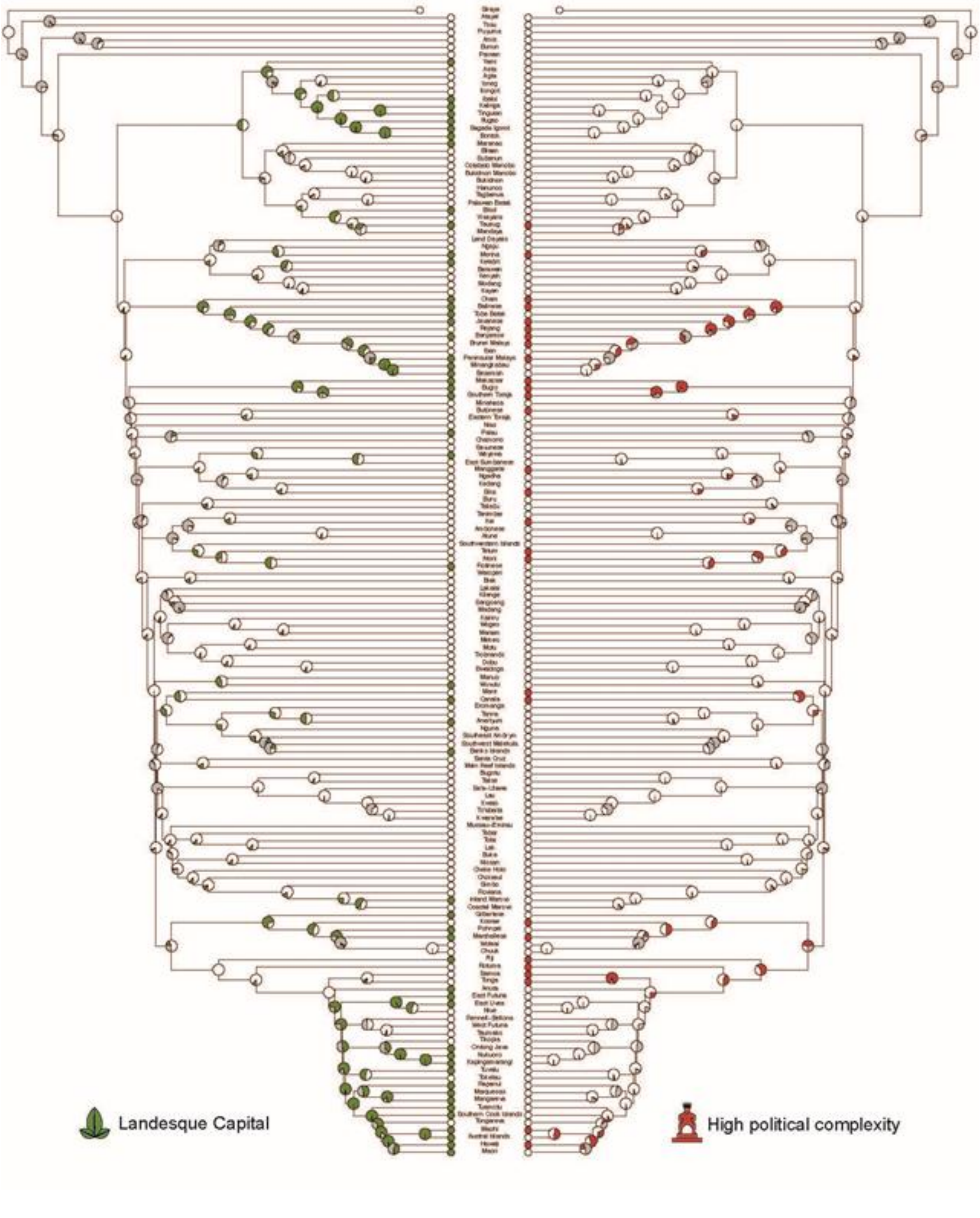
Landesque Capital
High political complexity

Figure A2. Coevolution of landesque capital and high political complexity, with fossilised nodes. Ancestral state reconstruction of landesque capital and high political complexity from the dependent analysis, plotted on a maximum clade credibility tree. Pie charts at the internal nodes of the tree represent the proportion of models in which the trait was inferred to be present at that node. (Grey represents the proportion of trees in the sample from which that particular node was absent). In this analysis, landesque capital was constrained (fossilised) to be absent at five internal nodes, including the basal node.

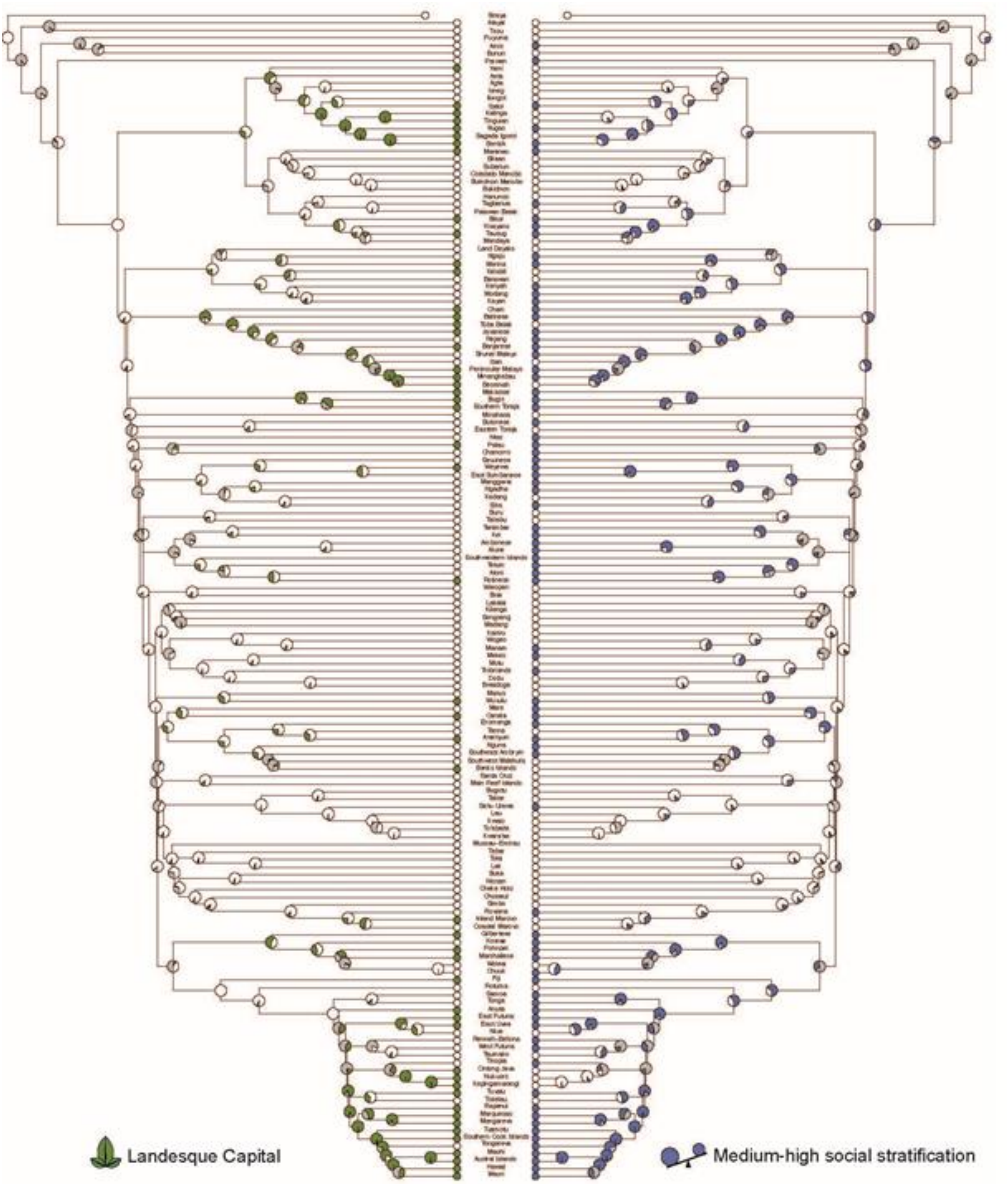
Landesque Capital
Medium-high social stratification

Figure A3. Coevolution of landesque capital and medium-high social stratification, with fossilised nodes. Ancestral state reconstruction of landesque capital and medium-high social stratification from the dependent analysis, plotted on a maximum clade credibility tree. Pie charts at the internal nodes of the tree represent the proportion of models in which the trait was inferred to be present at that node. (Grey represents the proportion of trees in the sample from which that particular node was absent.) In this analysis, landesque capital was constrained (fossilised) to be absent at five internal nodes, including the basal node.

Appendix B: Appendix to Chapter Three

Table B1

World Atlas of Language Structures features used to construct global tree

WALS ID	Name
1A	Consonant Inventories
2A	Vowel Quality Inventories
3A	Consonant-Vowel Ratio
4A	Voicing in Plosives and Fricatives
5A	Voicing and Gaps in Plosive Systems
6A	Uvular Consonants
7A	Glottalized Consonants
8A	Lateral Consonants
10A	Vowel Nasalization
11A	Front Rounded Vowels
12A	Syllable Structure
13A	Tone
14A	Fixed Stress Locations
15A	Weight-Sensitive Stress
16A	Weight Factors in Weight-Sensitive Stress Systems
17A	Rhythm Types
18A	Absence of Common Consonants
19A	Presence of Uncommon Consonants
20A	Fusion of Selected Inflectional Formatives
21A	Exponence of Selected Inflectional Formatives
21B	Exponence of Tense-Aspect-Mood Inflection

22A	Inflectional Synthesis of the Verb
23A	Locus of Marking in the Clause
24A	Locus of Marking in Possessive Noun Phrases
25A	Locus of Marking: Whole-Language Typology
25B	Zero Marking of A and P Arguments
27A	Reduplication
28A	Case Syncretism
30A	Number of Genders
33A	Coding of Nominal Plurality
34A	Occurrence of Nominal Plurality
35A	Plurality in Independent Personal Pronouns
36A	The Associative Plural
37A	Definite Articles
38A	Indefinite Articles
39A	Inclusive/Exclusive Distinction in Independent Pronouns
40A	Inclusive/Exclusive Distinction in Verbal Inflection
41A	Distance Contrasts in Demonstratives
42A	Pronominal and Adnominal Demonstratives.
43A	Third Person Pronouns and Demonstratives
44A	Gender Distinctions in Independent Personal Pronouns
45A	Politeness Distinctions in Pronouns
46A	Indefinite Pronouns
47A	Intensifiers and Reflexive Pronouns
48A	Person Marking on Adpositions
49A	Number of Cases
50A	Asymmetrical Case-Marking

51A	Position of Case Affixes
52A	Comitatives and Instrumentals
53A	Ordinal Numerals
54A	Distributive Numbers
55A	Numeral Classifiers
56A	Conjunctions and Universal Quantifiers
57A	Position of Pronominal Possessive Affixes
58A	Obligatory Possessive Inflection
58B	Number of Possessive Nouns
59A	Possessive Classification
60A	Genitives, Adjectives and Relative Clauses
61A	Adjectives without Nouns
62A	Action Nominal Constructions
63A	Noun Phrase Conjunction
64A	Nominal and Verbal Conjunction
65A	Perfective/Imperfective Aspect
66A	The Past Tense
67A	The Future Tense
68A	The Perfect
69A	The Position of Tense-Aspect Affixes
70A	The Morphological Imperative
71A	The Prohibitive
72A	Imperative-Hortative Systems
73A	The Optative
74A	Situational Possibility
75A	Epistemic Possibility

76A	Overlap between Situational and Epistemic Modal Marking
78A	Coding of Evidentiality
79A	Suppletion According to Tense and Aspect
80A	Verbal Number and Suppletion
81A	Order of Subject, Object and Verb
81B	Languages with Two Dominant Orders of Subject, Object, and Verb
82A	Order of Subject and Verb
83A	Order of Object and Verb
84A	Order of Object, Oblique, and Verb
85A	Order of Adposition and Noun Phrase
86A	Order of Genitive and Noun
87A	Order of Adjective and Noun
88A	Order of Demonstrative and Noun
90A	Order of Relative Clause and Noun
90B	Prenominal Relative Clauses
90C	Postnominal Relative Clauses
90D	Internally-Headed Relative Clauses
90E	Correlative Relative Clauses
90F	Adjoined Relative Clauses
91A	Order of Degree Word and Adjective
92A	Position of Polar Question Particles
93A	Position of Interrogative Phrases in Content Questions
94A	Order of Adverbial Subordinator and Clause
98A	Alignment of Case Marking of Full Noun Phrases
99A	Alignment of Case Marking of Pronouns
100A	Alignment of Verbal Person Marking

101A	Expression of Pronominal Subjects
102A	Verbal Person Marking
103A	Third Person Zero of Verbal Person Marking
104A	Order of Person Markers on the Verb
105A	Ditransitive Constructions: The Verb 'Give'
106A	Reciprocal Constructions
107A	Passive Constructions
108A	Antipassive Constructions
108B	Productivity of the Antipassive Construction
109A	Applicative Constructions
109B	Other Roles of Applied Objects
110A	Periphrastic Causative Constructions
111A	Nonperiphrastic Causative Constructions
112A	Negative Morphemes
113A	Symmetric and Asymmetric Standard Negation
114A	Subtypes of Asymmetric Standard Negation
115A	Negative Indefinite Pronouns and Predicate Negation
116A	Polar Questions
117A	Predicative Possession
118A	Predicative Adjectives
119A	Nominal and Locational Predictation
120A	Zero Copula for Predicate Nominals
121A	Comparative Constructions
122A	Relativization on Subjects
123A	Relativization on Obliques
124A	‘Want' Complement Subjects

125A	Purpose Clauses
126A	‘When' Clauses
127A	Reason Clauses
128A	Utterance Complement Clauses
129A	Hand and Arm
130A	Finger and Hand
132A	Number of Non-Derived Basic Colour Categories
133A	Number of Basic Colour Categories
134A	Green and Blue
135A	Red and Yellow
136A	M-T Pronouns
136B	M in First Person Singular
137A	N-M Pronouns
137B	M in Second Person Singular
138A	Tea
142A	Para-Linguistic Usages of Clicks
143A	Order of Negative Morpheme and Verb
144A	Position of Negative Word with Respect to Subject, Object, and Verb

Table B2

Validation Points.

Language family	**Society**	**Expected state**	**Reconstructed states (probabilities) (1-4)**	**Source (s)**
Afroasiatic - Arabic	Pre-Islamic Arabia or Caliphate	2-4	4 (0.653), 3 (0.293), 2 (0.054)	Lewis (1993), Versteegh (2014)
Afroasiatic - Ethiosemitic	Pre-Aksumite Ethiopia	3-4	2 (0.422), 4 (0.278), 3 (0.269), 1 (0.031)	Blažek (2014), Fattovich (1990)
Afroasiatic - Tuareg	Garamantes	2-4	2 (0.419), 3 (0.262), 4 (0.257), 1 (0.062)	Blažek (2014), Mattingly (2011)
Austroasiatic - Khmeric	Angkor	4	4 (0.875), 3 (0.096), 2 (0.029)	Hall (2011), Sidwell (2014)
Austronesian - Chamic	Classical Champa	2-3	1 (0.423), 2 (0.362), 3 (0.183), 4 (0.032)	Hall (2011), Vickery (2011)
Dravidian – Tamil-Malayalam	Early Medieval Southern India	3-4	3 (0.464), 4 (0.339), 2 (0.197)	Avari (2007), Krishnamurti (2003)

Indo-European – Indo-Iranian – Indo-Aryan	Vedic India	2-4	4 (0.739), 3 (0.158), 2 (0.1), 1 (0.003)	Anthony (2007), Avari (2007), Fortson (2009)
Indo-European – Indo-Iranian – Indo-Aryan - Sinhalaic	Sri Lanka, Medieval and Early Modern	3-4	4 (0.61), 3 (0.187), 2 (0.137), 1 (0.066)	Dharmadasa (1974), Gair (2007), Tennent (1860)
Indo-European – Indo-Iranian – Modern Southwestern Iranian	Persia, Late Antiquity and Early Medieval	4	4 (0.437), 2 (0.319), 3 (0.243), 1 (0.001)	Daniel (2000), Emmerick (2016), Katouzian (2009)
Indo-European – Imperial Latin	Roman Republic	3-4	4 (0.991), 3 (0.009)	Fortson (2009), Cornell (2000)
Indo-European – Imperial Latin - Romance	Roman Empire	4	4 (0.989), 3 (0.011)	Ando (2010, Eilers (2010), Fortson (2009),
Indo-European – Imperial Latin – Romance – Italo-Western Romance	Early Medieval Western Europe	3-4	4 (0.988), 3(0.012)	Fortson (2009), Ward-Perkins (2005)

Indo-European – Imperial Latin – Romance – Italo-Western Romance - Shifted Western Romance	Early Medieval Western Europe	3-4	4 (0.978), 3 (0.022)	Fortson (2009), Ward-Perkins (2005)
Indo-European – Imperial Latin – Romance – Shifted Western Romance – West Ibero-Romance	Early Medieval Western Europe	3-4	4 (0.978), 3 (0.022)	Fortson (2009), Ward-Perkins (2005)
Indo-European – Imperial Latin – Romance – Italo-Western Romance - Shifted Western Romance – West Ibero-Romance - Portuguese	Portuguese Empire	4	4 (0.973), 3 (0.027)	Anderson (2000), Disney (2009)
Indo-European – Imperial Latin – Romance – Italo-Western Romance - Shifted Western Romance – Oil	Early Medieval France	3-4	4 (0.97), 3 (0.03)	Fortson (2009), Ward-Perkins (2005), Turchin and Gavrilets (2009)

Indo-European – Imperial Latin – Romance – Italo-Western Romance - Shifted Western Romance – Oil – Macro-French	Early Modern France	4	4 (0.976), 3 (0.021), 2 (0.003)	Fortson (2009), Turchin and Gavrilets (2009)
Indo-European – Northwest Germanic	Early Germans	2-3	4 (0.622), 3 (0.248), 2 (0.129), 1 (0.001)	Fortson (2009), Todd (2004)
Indo-European – Northwest Germanic – Low Franconian	Dutch Republic	3-4	4 (0.696), 3 (0.272), 2 (0.032)	Buccini, Moulton, and Herzog (2010), Fortson (2009), Kennedy (2017), Thompson (1996)
Indo-European – Northwest Germanic -Macro-English	Early Modern England	4	4 (0.935), 1(0.049), 3 (0.012), 2 (0.004)	Fortson (2009), Braddick (2000), Smith (1994)
Indo-European – Northwest Germanic –Macro-English -English	Early Modern England	4	4 (0.936), 3 (0.0.11), 1 (0.05), 2 (0.003)	Fortson (2009), Braddick (2000)
Indo-European - Slavic	Early Slavs	1-2	4 (0.951), 3 (0.044), 2 (0.005)	Dvornik (1956), Fortson (2009), Vlasto (1970)

Indo-European – Slavic – East Slavic	Rus	3-4	4 (0.985), 3 (0.015)	Dvornik (1956), Fortson (2009), Franklin (2006)
Japonic	Yayoi Japan	2-3	2 (0.392), 4 (0.263), 3 (0.226), 1 (0.119)	Pellard (2013), Russell (2014)
Japonic - Ryukyuan	Gusuku Period	2-3	2 (0.43), 3 (0.283), 4 (0.197), 1 (0.09)	Pellard (2013), Pearson (2013)
Mongolic	Mongol Empire	2-4	4 (0.585), 3 (0.248), 2 (0.165), 1 (0.002)	Jackson (2009), Vovin (2014)
Sino-Tibetan – Sinitic	Han Dynasty	4	4 (0.659), 3 (0.178), 2 (0.154), 1 (0.009)	Loewe (2008), Norman (1988)
Sino-Tibetan - Tibetic	Tibetan Empire	3-4	4 (0.592), 3 (0.295), 2 (0.113)	Dotson (2007), Tournadre (2013)
Turkic	Xiongnu	3-4	4 (0.867), 3 (0.1), 2 (0.032), 1 (0.001)	Findlay (2005), Vovin (2014)

Table B3

Regional Analyses.

	Africa		**Eurasia**		**Americas**		**Sahul**	
	ML	**SD**	**ML**	**SD**	**ML**	**SD**	**ML**	**SD**
AT	-764.71	2.92	-701.63	1.87	-762.07	2.55	-32.02	2.04
ATR	-501.75	3.06	-495.20	3.09	-497.73	2.54	-31.25	2.30
FULL	-494.18	0.36	-474.26	0.44	-498.68	0.42	-23.54	0.16
RU	-493.23	0.38	-466.89	0.39	-492.92	0.38	-25.06	0.16
UNI	-490.03	0.34	-466.18	0.37	-489.67	0.33	-25.47	0.19

Note. Marginal Likelihood (ML) Estimates, with Standard Deviations (SD) and associated Log BFs for each of the five models compared to each of all the others, in four world regions.

Table B4

Global Analysis with Fossilised Nodes.

			Log BFs			
Model	**ML Estimate**	**SD**	**ATR**	**FULL**	**UNI**	**RU**
ATR	-1405.48	2.28		-264.48	-261.02	-267.86
FULL	-1273.34	2.14	264.48		2.30	-3.58
UNI	-1274.49	0.21	261.02	-2.30		-5.88
RU	-1271.55	0.22	267.86	3.58	5.88	

Note. Marginal Likelihood (ML) Estimates, with Standard Deviations (SD) and associated Log BFs for each of the five models compared to each of all the others, with fossilised nodes.

Table B5

Frequencies of Different Levels of Political Complexity, Regional, and Global.

Jurisdictional hierarchy above the local community	**World Region**				**Total**
	Africa	**Eurasia**	**Americas**	**Sahul**	
1 (No levels)	111	94	279	40	524
2 (One level)	163	107	66	4	340
3 (Two levels)	83	66	9	2	160
4 (Three or four levels)	34	91	1	-	126
Total	391	358	355	46	1150

Appendix C: Appendix to Chapter Four

Table C1

Coding Decisions.

Society	ABVD (Austronesian Basic Vocabulary Database) Code	Religious Authority	Secular Authority	Structure of Religious and Secular Authority	Source (s)
Aeta	444	0	0	0	Brosius (1983), Lebar (1975), Reed (1904)
Ajie	1188	2	3	1	Clifford (1982), Leenhardt (1979)
Ami	350	2	2	2	Lebar (1975), Mabuchi (1960/1971)
Aneityum	149	3	3	1	Spriggs (1986)
Anuta	253	2	2	1	Feinberg (1988, 1991)
Ata Tana' 'Ai	124	3	1	2	Lewis (1993)
Atayal	255	2	2	1	Lebar (1975), Mabuchi (1960/1971)
Atoni	42	3	3	1	Schulte Nordholt (1971)
Banks Islands	376	0	2	0	Codrington (1881, 1891)
Bellona	206	1	0	0	Monberg (1991)
Berawan	45	0	0	0	Huntington and Metcalf (1979)
Besemah	107	3	3	1	Collins (1979)
Biak	106	1	2	2	Kamma (1972)
Bontok	36	2	1	2	Keesing (1949), Lebar (1975)
Buka	187	0	2	0	Blackwood (1935), Ogan (1991)
Bunun	202	0	2	0	Huang (1993)

Bwaidoga	51	0	1	0	Jenness & Ballantyne (1920)
Casiguran Dumagat	417	0	0	0	Headland (1975, 1993)
Chamorro	18	0	2	0	Cordy (1983), Thompson (1945/1971)
Cheke Holo	209	1	1	1	White (1991)
Choiseul	44	2	2	1	Scheffler (1965)
Chuuk	349	2	2	2	Dobbin and Hezel (2011), Goodenough (2002)
Dobu	218	0	0	0	Fortune (1932)
East Sumba	32	3	3	2	Forth (1981)
Eastern Toraja	208	2	2	1	Adriani and Kruyt (1950), Downs (1956)
Fijians	11	3	3	2	Thomson (1908)
Florida	102	2	2	1	Codrington (1891)
Futuna (East)	210	3	3	1	Burrows (1936/1971), Kirch (1994)
Futuna (West)	156	3	3	3	Capell (1958)
Hanunóo	13	0	0	0	Lebar (1975)
Hawaiians	52	3	3	1	Kirch (2010), Valeri (1985)
Iban	28	2	0	0	Freeman (1955), Jensen (1974), Sutlive (1993)
Ifugao	419	2	0	0	Barton (1922), Conklin (1980), Lebar (1975)
Isneg	424	0	0	0	Keesing (1962)
Kalinga	429	0	0	0	Dozier (1966)
Kapingamarangi	217	2	2	3	Emory (1965)
Kayan	237	2	2	2	Hose and MacDougall (1912), Rousseau (1998)
Kédang	236	2	2	2	Barnes (1974)

Kei	59	2	3	2	Hooe (2012)
Kiribati	346	3	3	1	Dobbin and Hezel (2011), Lambert (1991)
Kodi	318	3	2	2	Hoskins (1993)
Kosrae	65	3	3	1	Athens (2007), Dobbin and Hezel (2011)
Kwaio	66	2	0	0	Keesing (1968, 1982)
Kwara'ae	213	2	0	0	Burt (1994)
Lakalai	281	2	2	2	Chowning (1991), Chowning and Goodenough (1965)
Lau	68	2	2	3	Ivens (1930)
Lifu	196	3	3	2	Leenhardt (1979), Ray (1917)
Main Reef Islands	501	0	0	0	Davenport (1969)
Malekula (South-West)	453	3	0	0	Deacon and Wedgwood (1934)
Manam	168	2	2	1	Lutkehaus (1991, 1995)
Mandaya	442	2	3	2	Cole (1913), Yengoyan (1975)
Mangaia	58	3	3	3	Buck (1934)
Mangareva	239	3	3	3	Buck (1938/1971)
Manggarai	84	3	3	2	Erb (1987)
Manus	71	0	1	0	Carrier (1991), Schwartz (1963)
Maohi	173	3	3	3	Oliver (1974)
Maori	85	3	3	2	Buck (1952)
Marovo (Coastal)	87	3	3	2	Hviding (1996)
Marquesans	38	2	0	0	Thomas (1990, 1991)
Marshallese	344	3	3	1	Carucci (1991), Dobbin and Hezel (2011)
Mekeo	89	3	3	2	Hau’ofa (1981)

Merina	92	3	3	1	Campbell (1992), Larson (2000), Sibree (1870)
Minahasa	137	3	3	3	Schouten (1998)
Motu	26	1	1	1	Groves (1963, 1991)
Mussau-Emirau	79	0	2	0	Chinnery (1927)
Nendö	502	0	0	0	Davenport (1991)
Ngaju	154	2	2	2	Avé (1972), Schärer (1946 / 1963)
Nguna	103	2	2	2	Facey (1981)
Nias (South)	104	3	2	2	Hummel and Telaumbanua (2007), Viaro and Ziegler (2006)
Notsi	64	0	2	0	Powdermaker (1935)
Nukuoro	238	2	2	2	Carroll (1966), Eilers (1934)
Ontong Java	418	3	3	3	Hogbin (1934)
Pagan Gaddang	177	0	0	0	Lebar (1975), Wallace (2013)
Paiwan	109	2	2	1	Matsuzawa (1989)
Palau	179	2	2	1	Dobbin and Hezel (2011), Parmentier (1987)
Pohnpei	271	3	3	2	Dobbin and Hezel (2011), Hanlon (1988)
Puyuma	264	2	2	1	Lebar (1975)
Rapanui	115	3	3	2	Métraux (1940/1971)
Roti	116	3	3	3	Fox (1968, 1977)
Rotuma	117	3	3	2	Howard (1991)
Roviana	221	2	2	2	Aswani (2008), Nagaoka (1999)
Sa'a	118	2	2	3	Ivens (1927)

Samoa	473	3	3	2	Bargatzky (1991), Keesing (1934), Meleisea (1987)
Simbo	226	3	3	2	Dureau (2000), Scheffler (1962)
Southern Toraja	447	3	3	1	Bigalke (2005), Nooy-Palm (1979)
Subanun	372	2	0	0	Finley and Churchill (1913), Frake (1957, 1993)
Tagbanua (Central)	450	3	3	2	Fox (1982), Warren (1975)
Tanimbar	78	2	2	3	Koentjaraningrat (1972)
Tanna	162	0	0	0	Adams (1987), Lindstrom (1978, 1991), Humphreys (1926)
Taumako	375	0	0	0	Davenport (1968)
Tetum	134	3	3	2	Fox (1996), Hicks (1972)
Tikopia	155	3	3	1	Firth (1959)
Tinguian	426	0	2	0	Cole and Gale (1922)
To'abaita	223	1	0	0	Hogbin (1939)
Toba Batak	188	3	3	2	Sibeth (1991), Vergouwen (1964)
Tokelau	245	3	3	1	Huntsman and Hooper (1996), MacGregor (1937)
Tolai	382	0	1	0	Epstein (1969, 1991), Simet (1991)
Tonga	136	3	3	2	Cummins (1977)
Tongareva	235	2	3	2	Campbell (1985), Roscoe (1991)

Trobriands	159	2	1	2	Malinowski (1922, 1935), Powell (1960), Weiner (1988)
Tsou (Northern)	138	3	3	1	Lebar (1975)
Wogeo	146	1	1	1	Hogbin (1970, 1978)
Yami	254	0	0	0	Lebar (1975), Yu (1991)

Table C2

Summary of Discrete Analyses (Dependent Unconstrained).

Religious and Secular Authority (Any Level)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-102.87	1.05	0.86	1.04	0.34	0.67	1.30	0.03	0.09
2	-102.98	1.06	0.89	1.04	0.31	0.67	1.30	0.02	0.08
3	-102.56	1.05	0.88	1.04	0.35	0.68	1.30	0.03	0.09
Mean	-102.80	1.05	0.88	1.04	0.34	0.68	1.30	0.02	0.09
Religious and Secular Authority (Local or Higher)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-113.56	0.71	0.57	0.90	0.83	1.12	0.88	0.08	0.18
2	-113.65	0.75	0.57	0.94	0.82	1.14	0.89	0.07	0.19
3	-113.53	0.73	0.61	0.94	0.77	1.14	0.87	0.07	0.18
Mean	-113.58	0.73	0.58	0.92	0.81	1.13	0.88	0.07	0.19
Religious and Secular Authority (Supralocal)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-103.43	0.15	0.23	3.61	4.78	3.67	4.57	0.66	0.55
2	-103.42	0.15	0.21	3.49	5.29	3.48	5.22	0.74	0.64
3	-103.42	0.14	0.23	3.52	4.88	3.59	4.79	0.69	0.57
Mean	-103.42	0.15	0.22	3.54	4.98	3.58	4.86	0.70	0.59

Table C3

Summary of Discrete analyses (Independent Unconstrained).

Religious and Secular Authority (Any Level)					
Run	**Log Marginal Likelihood**	**Transition Rates**			
		α1	**β1**	**α2**	**β2**
1	-106.48	0.10	0.09	0.11	0.09
2	-106.52	0.11	0.09	0.11	0.09
3	-106.52	0.10	0.09	0.11	0.09
Mean	-106.51	0.10	0.09	0.11	0.09
Religious and Secular Authority (Local or Higher)					
Run	**Log Marginal Likelihood**	**Transition Rates**			
		α1	**β1**	**α2**	**β2**
1	-121.57	0.14	0.14	0.14	0.14
2	-121.53	0.14	0.14	0.14	0.14
3	-121.60	0.14	0.14	0.14	0.14
Mean	-121.57	0.14	0.14	0.14	0.14
Religious and Secular Authority (Supralocal)					
Run	**Log Marginal Likelihood**	**Transition Rates**			
		α1	**β1**	**α2**	**β2**
1	-134.18	0.18	0.21	0.18	0.21
2	-134.19	0.18	0.21	0.18	0.21
3	-134.20	0.18	0.21	0.18	0.21
Mean	-134.19	0.18	0.21	0.18	0.21

Table C4

Summary of Discrete Analyses (Dependent, Gain of Secular Authority Constrained to be Equal with or without Religious Authority).

Religious and Secular Authority (Any Level)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-101.94	1.20	0.82	1.15	0.24	0.63	1.20	0.01	0.08
2	-101.96	1.22	0.83	1.17	0.23	0.63	1.22	0.01	0.08
3	-101.94	1.21	0.81	1.17	0.25	0.63	1.21	0.02	0.08
Mean	-101.94	1.21	0.82	1.16	0.24	0.63	1.21	0.01	0.08
Religious and Secular Authority (Local or Higher)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-113.04	0.82	0.53	0.86	0.56	0.99	0.82	0.03	0.17
2	-113.18	0.85	0.54	0.91	0.62	1.05	0.85	0.03	0.18
3	-113.04	0.82	0.53	0.88	0.59	1.01	0.82	0.03	0.18
Mean	-113.09	0.83	0.53	0.88	0.59	1.02	0.83	0.03	0.18
Religious and Secular Authority (Supralocal)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-103.97	0.32	0.17	4.46	3.13	4.82	0.32	0.23	0.28
2	-103.99	0.32	0.17	4.50	3.08	4.79	0.32	0.23	0.28
3	-104.04	0.33	0.17	4.48	3.12	4.84	0.33	0.23	0.29
Mean	-104.00	0.33	0.17	4.48	3.11	4.81	0.33	0.23	0.28

Table C5

Summary of Discrete Analyses (Dependent, Gain of Religious Authority Constrained to be Equal with or without Secular Authority).

Religious and Secular Authority (Any Level)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-103.32	0.78	0.61	0.77	0.61	0.72	0.84	0.03	0.07
2	-102.86	0.80	0.63	0.79	0.63	0.72	0.86	0.04	0.07
3	-103.11	0.80	0.62	0.78	0.62	0.72	0.86	0.03	0.07
Mean	-103.10	0.79	0.62	0.78	0.62	0.72	0.85	0.03	0.07
Religious and Secular Authority (Local or Higher)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-113.54	0.70	0.82	0.91	0.82	1.12	0.67	0.06	0.10
2	-113.40	0.65	0.78	0.89	0.78	1.09	0.71	0.07	0.11
3	-113.53	0.68	0.84	0.91	0.84	1.14	0.68	0.07	0.11
Mean	-113.49	0.68	0.82	0.90	0.82	1.12	0.69	0.07	0.11
Religious and Secular Authority (Supralocal)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-103.76	0.14	0.36	5.00	0.36	4.20	3.40	0.37	0.14
2	-103.75	0.14	0.36	5.03	0.36	4.16	3.41	0.37	0.14
3	-103.66	0.14	0.36	5.04	0.36	4.15	3.37	0.37	0.14
Mean	-103.73	0.14	0.36	5.02	0.36	4.17	3.39	0.37	0.14

Table C6

Summary of Discrete Analyses (Dependent, Loss of Secular Authority Constrained to be Equal with or without Religious Authority).

Religious and Secular Authority (Any Level)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-103.75	0.55	0.30	0.37	0.61	0.64	2.56	0.05	0.37
2	-103.71	0.56	0.28	0.37	0.60	0.64	2.46	0.05	0.37
3	-103.53	0.56	0.30	0.37	0.61	0.65	2.54	0.05	0.37
Mean	-103.67	0.56	0.30	0.37	0.61	0.65	2.52	0.05	0.37
Religious and Secular Authority (Local or Higher)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-113.79	0.37	0.33	0.31	0.54	1.11	1.22	0.03	0.31
2	-113.72	0.37	0.34	0.31	0.52	1.11	1.24	0.03	0.31
3	-113.70	0.38	0.34	0.31	0.54	1.12	1.24	0.03	0.31
Mean	-113.74	0.38	0.34	0.31	0.53	1.11	1.23	0.03	0.31
Religious and Secular Authority (Supralocal)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-104.09	0.03	0.09	1.14	9.03	2.62	7.94	1.13	1.14
2	-104.15	0.04	0.09	1.14	9.10	2.67	7.95	1.13	1.14
3	-104.00	0.03	0.09	1.14	8.98	2.62	7.88	1.13	1.14
Mean	-104.08	0.03	0.09	1.14	9.03	2.64	7.92	1.13	1.14

Table C7

Summary of Discrete Analyses (Dependent, Loss of Religious Authority Constrained to be Equal with or without Secular Authority).

Religious and Secular Authority (Any Level)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-103.60	0.88	0.65	0.94	0.80	0.13	1.31	0.13	0.10
2	-104.07	0.78	0.52	0.88	0.98	0.16	1.33	0.16	0.12
3	-104.42	0.83	0.59	0.91	0.94	0.16	1.30	0.16	0.11
Mean	-104.03	0.83	0.58	0.91	0.90	0.15	1.31	0.15	0.11

Religious and Secular Authority (Local or Higher)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-116.03	0.22	0.92	1.48	4.83	0.84	1.59	0.84	0.11
2	-115.87	0.22	0.95	1.52	4.96	0.87	1.57	0.87	0.11
3	-115.95	0.22	0.91	1.48	4.87	0.85	1.61	0.85	0.12
Mean	-115.95	0.22	0.93	1.49	4.89	0.85	1.59	0.85	0.11

Religious and Secular Authority (Supralocal)									
Run	**Log Marginal Likelihood**	**Transition Rates**							
		q12	**q13**	**q21**	**q24**	**q31**	**q34**	**q42**	**q43**
1	-103.86	0.09	0.05	2.93	6.70	1.00	8.06	1.00	0.96
2	-103.85	0.08	0.04	2.68	7.46	1.09	8.60	1.09	1.06
3	-103.84	0.07	0.04	2.56	7.77	1.14	8.83	1.14	1.10
Mean	-103.85	0.08	0.05	2.73	7.31	1.07	8.50	1.07	1.04

Table C8

Summary of Multistate Analyses.

Full model													
Run	**Log Marginal Likelihood**	**Transition Rates**											
		q01	**q02**	**q03**	**q10**	**q12**	**q13**	**q20**	**q21**	**q23**	**q30**	**q31**	**q32**
1	-137.73	1.21	1.08	2.52	1.24	2.90	1.93	1.00	2.97	2.41	2.58	2.19	2.78
2	-137.72	1.18	1.06	2.59	1.19	2.92	1.87	0.98	2.97	2.47	2.64	2.14	2.84
3	-137.85	1.21	1.05	2.59	1.25	2.85	1.90	0.97	2.92	2.48	2.63	2.19	2.88
Mean	-137.77	1.20	1.06	2.57	1.23	2.89	1.90	0.98	2.95	2.45	2.62	2.18	2.83

Differentiation model (strong version) (q02 q03 q13=0)													
Run	**Log Marginal Likelihood**	**Transition Rates**											
		q01	**q02**	**q03**	**q10**	**q12**	**q13**	**q20**	**q21**	**q23**	**q30**	**q31**	**q32**
1	-138.72	3.43	0.00	0.00	3.40	3.59	0.00	0.02	3.58	3.58	0.92	1.34	3.21
2	-138.71	3.50	0.00	0.00	3.47	3.65	0.00	0.02	3.64	3.64	0.90	1.41	3.26
3	-138.63	3.39	0.00	0.00	3.36	3.53	0.00	0.02	3.51	3.52	0.92	1.38	3.16
Mean	-138.68	3.44	0.00	0.00	3.41	3.59	0.00	0.02	3.58	3.58	0.91	1.37	3.21

Differentiation model (weak version) (q02 q03=0)													
Run	**Log Marginal Likelihood**	**Transition Rates**											
		q01	**q02**	**q03**	**q10**	**q12**	**q13**	**q20**	**q21**	**q23**	**q30**	**q31**	**q32**
1	-138.43	3.07	0.00	0.00	2.84	2.97	2.34	0.08	2.92	2.38	1.01	2.13	2.76
2	-138.37	3.08	0.00	0.00	2.83	2.98	2.27	0.10	2.93	2.39	1.04	2.06	2.79
3	-138.42	3.04	0.00	0.00	2.80	2.99	2.27	0.10	2.94	2.36	1.03	2.01	2.77
Mean	-138.40	3.06	0.00	0.00	2.82	2.98	2.29	0.09	2.93	2.37	1.03	2.07	2.77

Unification model (strong version) (q01 q02 q31=0)													
Run	**Log Marginal Likelihood**	**Transition Rates**											
		q01	**q02**	**q03**	**q10**	**q12**	**q13**	**q20**	**q21**	**q23**	**q30**	**q31**	**q32**
1	-136.85	0.00	0.00	4.99	0.01	5.01	0.64	0.00	5.01	5.00	4.99	0.00	5.03
2	-136.74	0.00	0.00	4.96	0.01	4.98	0.64	0.00	4.98	4.97	4.97	0.00	5.00
3	-136.77	0.00	0.00	4.99	0.01	5.00	0.64	0.00	5.01	5.00	5.00	0.00	5.02
Mean	-136.79	0.00	0.00	4.98	0.01	5.00	0.64	0.00	5.00	4.99	4.99	0.00	5.01

Unification model (weak version) (q01 q02=0)													
Run	**Log Marginal Likelihood**	**Transition Rates**											
		q01	**q02**	**q03**	**q10**	**q12**	**q13**	**q20**	**q21**	**q23**	**q30**	**q31**	**q32**
1	-137.00	0.00	0.00	4.51	0.13	4.38	2.64	0.01	4.40	3.77	4.35	2.78	3.96
2	-136.85	0.00	0.00	4.51	0.13	4.41	2.57	0.01	4.43	3.73	4.36	2.74	3.91
3	-136.97	0.00	0.00	4.57	0.14	4.42	2.65	0.01	4.44	3.78	4.40	2.82	3.98
Mean	-136.94	0.00	0.00	4.53	0.13	4.41	2.62	0.01	4.43	3.76	4.37	2.78	3.95

Appendix D: Appendix to Chapter Five

Table D1

Data on Pacific Island Populations.

Population	ABVD Code	Number Languages Spoken	Region	Lat.	Lon.	Sustained Contact	Contact Population	Nadir	Peruvian Raids	Population Density	Distance to Port	Political Complexity	Source (s)
Ana'a	246	1	P	-17.4	-145.6	1822	1,500	500	0	40.5	318	2	Danielsson (1956), Emory (1975), Emory and Ottino (1967), Torrente (2015)
Aneityum	149	1	RM	-20.2	169.8	1830	5,200	187	0	32.5	308	2	Bayliss-Smith (2006), Spriggs (1986), Spriggs (2007)
Banks Islands	376	13	RM	-13.8	167.5	1852	7,300	1,975	0	11.6	127	1	Blake et al. (1983), Campbell (1990), Codrington (1891), Elkins (1953), McArthur and Yaxley (1968)
Bellona	206	1	NM	-11.3	159.8	1856	500	440	0	32.3	206	1	Blake et al. (1983), Kuschel (1988, 1993), Monberg (1991)
Chamorro	18	1	M	13.4	144.7	1565	75,000	2,000	0	73.4	0	1	Cordy (1983), Rogers (2011), Shell (2001), Thompson (1945/1971), Underwood (1976)
Choiseul	44	4	NM	-7	156.9	1905	5,000	4,000	0	1.5	71	1	MacDonald (2009), Scheffler (1965)

Chuuk	349	1	M	7.4	151.6	1879	11,000	9,185	0	115.5	0	2	Goodenough (1951, 2002), Gorenflo (1995)
Cook Islands (Southern)	58	1	P	-21.2	-159.8	1823	15,000	6,250	11	70.1	0	2	Bellwood (1971), McArthur (1967), Sissons (1999)
Dobu Island	218	1	NM	-9.8	150.9	1884	2,000	900	0	129.0	73	1	Fortune (1932), Young (1983, 1991)
Erromango	463	2	RM	-18.8	169.2	1829	5,000	381	0	5.5	124	2	Crowley (1997), Spriggs and Wickler (1989)
Fijians	11	6	RM	-17.9	178	1800	200,000	84,475	0	10.9	0	3	McArthur (1967), Maude (1964), Ryan (2009), Scarr (1984)
Futuna-Aniwa	156	1	RM	-19.5	170.2	1850	1,000	400	0	52.6	213	2	Buxton (1926), Capell (1958), Diamond and Marshall (1977), Rallu (1990), Thomas (1992)
Hawaiians	52	1	P	19.6	-155.5	1786	350,000	37,656	0	21.0	0	4	Kirch (2010), Kuykendall (1938), Schmitt (1968)
Kapinga-marangi	217	1	M	1.1	154.8	1877	150	150	0	136.4	602	1	Emory (1965), Lieber (1991)
Kiribati	346	1	M	-1.2	174.7	1835	33,000	26,000	312	121.1	0	2	Bedford, Macdonald & Munro (1980), Macdonald (1982)
Kosrae	65	1	M	5.3	163	1830	3,000	300	0	27.5	641	2	Athens (2007), Gorenflo (1993)
Lifu	196	1	RM	-21	167.2	1842	5,800	5,488	0	5.0	112	2	Howe (1977)
Malaita	213	13	NM	-9	161	1870	45,000	40,000	0	10.7	0	1	Keesing (1991), Moore (2007)

Manam	168	1	NM	-4.1	145	1890	3,800	3,500	0	41.9	138	1	Lutkehaus (1995), Wedgwood (1934)
Mangareva	239	1	P	-23.1	-135	1824	1,500	463	0	61.5	0	2	Buck (1971), Kirch (2004), McArthur (1967),
Māori	85	1	P	-39	175.8	1802	90,000	41,993	0	0.3	0	2	Ballara (1998), King (2003), Pool (1991), Wilson (1990)
Maré	99	1	RM	-21.3	168	1841	4,300	3332	0	6.6	158	2	Howe (1977), Dubois (1984)
Marovo	87	4	NM	-8.5	158	1850	20,000	4,000	0	11.4	0	1	Bayliss-Smith, Hviding and Whitmore (2003), Hviding (1996)
Marquesans	38	2	P	-8.8	-140.2	1797	40,000	1,666	26	37.8	0	1	Rallu (1990), Ferdon (1993), Rallu (1992), Thomas (1990, 1991)
Marshallese	344	1	M	7.1	171.4	1852	10,000	9,163	0	55.2	0	3	Gorenflo and Levin (1994), Mason (1947), Williamson and Sabath (1982)
Motu	26	1	NM	-9.5	147.2	1872	4,500	4,500	0	17.1	0	1	Groves (1991), Vasey (1982)
Mussau	79	1	NM	-1.4	149.6	1900	1,000	1,000	0	2.5	168	1	Chinnery (1927), Clark and Bedford (2008), Parkinson (1907/2010)
Namoluk	345	1	M	5.9	153.1	1900	260	223	0	325.0	220	2	Marshall (1975, 2004)
Nendö	502	4	RM	-10.7	165.9	1875	3,600	1,800	0	7.1	133	1	Clark and Bedford (2008), Davenport (1964, 1991), Graebner (1909)

Nguna	103	1	RM	-17.5	168.4	1860	1,200	496	0	43.8	29	1	McArthur and Yaxley (1968), Diamond and Marshall (1977), Facey (1981, 1991)
Nissan	98	1	NM	-4.5	154.2	1870	1,500	1,427	0	52.6	218	1	Nachman (1991), Spriggs (1991)
Niue	247	1	P	-19.1	-169.9	1850	4,000	3,747	109	15.6	0	2	Ryan (1977)
Nukuoro	238	1	M	3.8	154.9	1870	120	120	0	70.6	528	1	Carroll (1966, 1975)
Ontong Java	418	1	NM	-5.3	159.3	1875	2,000	580	0	259.7	336	2	Bayliss-Smith (1974, 1975a,b), Hogbin (1934)
Palau	179	1	M	7.4	134.6	1783	20,000	3,000	0	45.1	0	1	Gorenflo (1996), Olsen (2009), Parmentier (1987)
Pohnpei	271	1	M	6.9	158.2	1834	15,000	1,705	0	44.6	694	2	Gorenflo and Levin (1992), Hanlon (1988, 1991)
Rapanui	115	1	P	-27.1	-109.4	1801	3,500	200	1,407	21.9	0	2	Métraux (1971), Pollard, Paterson, and Welham (2010)
Rotuma	117	1	RM	-12.5	177.1	1827	3,500	1,900	0	79.5	496	3	McArthur (1967), Gardiner (1898), Howard (1964, 1991)
Roviana	221	1	NM	-8.3	157.4	1870	3,500	918	0	13.6	0	2	McCracken (2000), Nagaoka (1999)
Samoans	473	1	P	-13.9	-171.8	1830	50,000	33,900	7	17.7	0	3	Green (2007), Keesing (1934), McArthur (1967)
Simbo	226	1	NM	-8.3	156.5	1820	1,200	400	0	92.3	36	2	Bayliss-Smith (2006), McCracken (2000), Scheffler (1962)

Southeast Ambrym	120	1	RM	-16.3	168.2	1880	1,200	1,200	0	9.3	136	1	Tonkinson (1968, 1981)
Tabar	372	1	NM	-2.8	152	1880	12,000	1,466	0	33.1	125	1	Fergie (1989), Groves (1934), Scragg (2010)
Tahiti	173	1	P	-17.6	-149.4	1789	40,000	5860	0	38.4	0	4	Oliver (1974), Rallu (2007), 'Tahiti' (2017)
Tanna	162	5	RM	-19.5	169.4	1840	8,000	5,310	0	14.3	205	1	Buxton (1926), Adams (1984), Lindstrom (1978, 1991)
Tikopia	155	1	RM	-12.3	168.8	1813	500	375	0	108.7	221	2	Bayliss-Smith (1974), Firth (1959)
Tokelau	245	1	P	-9.4	-171.2	1841	800	251	253	66.7	480	2	Green and Green (2007), MacGregor (1937)
Tolai	382	1	NM	-4.3	152.2	1875	30,000	25,000	0	36.2	0	1	Epstein (1962, 1991), Irwin (1963)
Tonga	136	1	P	-21.2	-175.2	1796	30,000	19,968	174	43.1	0	3	Maude (1964), Burley (2007), Ferdon (1987), Langdon (1977)
Tongareva	235	1	P	-9	-158	1853	2,000	218	467	206.2	1072	2	Buck (1932), Roscoe (1987, 1991)
Trobriands	159	1	NM	-8.5	151.1	1880	10,000	8,000	0	22.7	179	2	Austen (1936, 1945), Powell (1960), 'Trobriand Islands' (2013)
Tubuai	128	1	P	-23.4	-149.5	1822	700	150	0	14.9	0	2	McArthur (1967), Aitken (1930/1971), 'Tubuai Islands' (2018)
Tuvalu	163	1	P	-5.7	176.1	1860	2,800	2,357	445	109.8	0	2	Bedford, Macdonald & Munro (1980), Macdonald (1982)

Uvea (East)	258	1	P	-13.3	-176.2	1825	3,000	3,000	0	50.8	0	2	Burrows (1937/1971)
Uvea (West)	471	2	RM	-20.6	166.6	1842	2,400	1,884	0	18.2	95	3	Howe (1977), Ouvéa Island (2008)
Vanikoro	224	3	RM	-11.7	166.9	1888	1,250	60	0	9.3	0	1	Davenport (1969)
Wogeo	146	1	NM	-3.2	144.1	1900	930	839	0	28.2	60	1	Hogbin (1935, 1939)

Note. ‘ABVD’ stands for Austronesian Basic Vocabulary Database. ‘Number of languages spoken’ is the number of native languages spoken by the designated population according to Simons and Fennig (2018). Under Regions, P stands for Polynesia, M for Micronesia, NM for Near Melanesia, and RM for Remote Melanesia. ‘Lat.’ and ‘Lon.’ stand for latitude and longitude in decimal degrees. ‘Sustained Contact’ is the year at which sustained contact began. ‘Contact Population’ is the population at the time at which sustained contact began. ‘Nadir’ is the lowest point that the population reached following sustained contact. ‘Peruvian raids losses’ is the number of people taken, if any, in the Peruvian raids of 1862-1863, according to Maude (1981). ‘Population Density’ pertains to the time at which sustained contact began. ‘Distance to Port’ is the distance in kilometres to the nearest port or roadstead depicted in Beresford, Dobson & Holmes (1987). ‘Political complexity’, as operationalised by Murdock (1967), is the number of levels of jurisdiction beyond the local community.

Table D2

Summary of Multivariate PGLS with Population Decline Not Adjusted for Peruvian Raids.

Predictor	**β**	**P value**
Sustained Contact	-0.11	.0004
Port	-0.02	.41
Log Population Density	-0.43	.96
Political Complexity	0.02	.76
Sustained Contact * Port	0.09	.12
Dependency	**Mean**	**P value**
Phylogeny (λ)	.06	.98
Spatial (φ)	.01	.96
Independent (γ)	.94	-

Table D3

Summary of Multivariate PGLS Excluding Chamorro.

Predictor	**β**	**P value**
Sustained Contact	-0.03	0.0006
Port	-0.54	0.30
Log Population Density	0.09	0.81
Political Complexity	-0.10	0.78
Sustained Contact * Port	0.01	0.49
Dependency	**Mean**	**P value**
Phylogeny (λ)	0.37	0.99
Spatial (φ)	0.01	0.67
Independent (γ)	0.63	-

Table D4

Summary of Bivariate PGLS Analyses.

Predictor	**β**	**P value**
Sustained Contact	-0.02	0.0003
Dependency	**Mean**	**P value**
Phylogeny (λ)	0.03	0.99
Spatial (φ)	0.004	0.99
Independent (γ)	0.97	-
Predictor	**β**	**P value**
Port	-0.46	0.31
Dependency	**Mean**	**P value**
Phylogeny (λ)	0.92	0.09
Spatial (φ)	0.48	0.04
Independent (γ)	0.04	-
Predictor	**β**	**P value**
Log Population Density	0.277425131	0.511582881
Dependency	**Mean**	**P value**
Phylogeny (λ)	0.91	0.15
Spatial (φ)	0.45	0.05
Independent (γ)	0.05	-
Predictor	**β**	**P value**
Political Complexity	0.34	0.25
Dependency	**Mean**	**P value**
Phylogeny (λ)	0.92	0.28

Spatial (φ)	0.37	0.08
Independent (γ)	0.05	-
Predictor	**β**	**P value**
Sustained Contact * Port	-0.01	.40
Dependency	**Mean**	**P value**
Phylogeny (λ)	0.84	0.13
Spatial (φ)	0.44	0.07
Independent (γ)	0.09	-

Table D5

Summary of PGLS with No Predictors.

Dependency	**Mean**	**P value**
Phylogeny (λ)	0.88	0.15
Spatial (φ)	0.43	0.06
Independent (γ)	0.07	-