Coevolution of Mutualistic Species Assemblages

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Extended Hypersociality and Extended Ultrasociality

By

Aurelio José Figueredo,
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PREFACE

By all accounts, the coevolution of humans with nonhuman animals and plants, a process sometimes referred to as “domestication”, is an important milestone for all the species involved. The so-called *Neolithic Revolution*, the prehistoric period during which most of this presumably occurred, is hailed by historians as pivotal in the development of socially and politically complex human societies, sometimes called “civilizations”. For the nonhuman animals and plants involved, the evolutionary changes that they have experienced as a result of being drawn into symbiotic association with human societies have been remarkable, including the massive diversification of domesticated varieties since that time. In spite of this, the evolutionary changes to our own species, both genetic and cultural, that presumably must have occurred as a result of the radical changes in the human ecological niche occasioned by involvement in these systems of symbiotic associations are often underestimated. Furthermore, the evolutionary changes to the behavioral dispositions of our own species that must have occurred to even make the establishment of these elaborate systems of symbiosis with phylogenetically distant species possible have never been addressed.

In this volume, we attempt to address these important scientific problems systematically. Owing partly to our areas of expertise and research experience, we concentrate more on symbioses with nonhuman animals than plants; we also concentrate more on human-nonhuman animal and plant *mutualistic* symbioses than on other forms of symbiosis with other living things (for example, our various *parasitic* relationships with microbial pathogens). Nevertheless, we hope to develop a general theory from these more specific and well-documented cases that we believe will be more broadly applicable. Our main question is, can we do this by drawing upon the concepts of *hypersociality* and *ultrasociality*, as evolved by humans to facilitate relationships with other humans, by developing *extended* versions of these two theoretical constructs in application to the incorporation of nonhuman animals and plants therein? We examine the two major hypotheses regarding the temporal and presumably causal ordering among the major evolutionary milestones involved, including the conventional view and the more contemporary view based on a wealth of recent evidence.

CHAPTER 1.0

INTRODUCTION

1.0 Foundational Concepts and Theoretical Outlines

This chapter contains three parts. This section introduces a theory about the relation between the evolution of human sociopolitical complexity and that of symbiotic relationships with nonhuman animals and plants, which requires an outline of these two concepts. First, in Section 1.1, we review the web of species assemblages within which humans are embedded. Second, in Section 1.2, we review the theoretical underpinnings of group formation, group size, and group cohesion. Together, these two theories situate individuals within ecological systems and social groups. With these two theoretical concepts reviewed, we outline the subsequent chapter's content by questioning if animal husbandry and agriculture gave rise to complex civilizations or whether civilizational complexity arose in a stepwise fashion, with humans becoming preadapted to post-agricultural civilization.

1.1 Symbiotic Portmanteau Assemblages

Histories of human migrations have been supplemented with a measure of ecological evolutionary biology since the publication of Alfred W. Crosby's *Columbian Exchange* (1972) and his later work, *Ecological Imperialism*. For example, one could understand the New World as being invaded, not just by European humans, but by their *portmanteau biota*—a sort of cooperative conglomerate displacing native flora, fauna, and Amerindian populations. Europeans arrived with guns and swords, but also with horses, cattle, slaves, myriad cultivars, and a devastating variety of communicable diseases, plagues which Crosby described as *virgin soil epidemics*. This process started with the discovery of the New World and continued Westward for hundreds of years, such that, in late 19th Century North America, “whites, blacks, cattle, pigs, horses, wheat and its weeds thrived, and around the houses, barns, and water troughs, Old World mice, rats, grasses, and forbs did so, too” (Crosby, 1986; p, 291).

Hertler and colleagues (2018) extended and elaborated Crosby’s (1972, 1986) original idea of *portmanteau biota* to propose the theory of *Symbiotic Portmanteau Assemblages* (SPAs). Such SPAs evolved over multiple millennia by human-nonhuman coevolutionary processes as *constructed niches*[1]. SPAs are assemblages of microbial, plant, and nonhuman animal species that have been incorporated into the expanded ecological niche constructed by humans. Such SPAs are associated with every post-Neolithic human society and largely determine the biogeographical ranges across which human biocultural groups have been able to expand. The Neolithic demographic expansions (see Diamond, 1997) were also necessarily expansions of these SPAs at the expense of truly native flora and fauna.

Competition between human groups often entails contention between their rival SPAs (Crosby, 1986), and the outcome of that process can be either wholly or partially determined by the relative *biological productivities*[2] (Diamond, 1997) and *systems complexities*[3] (Hertler et al., 2018) of the rival species assemblages. In fact, human niche-constructed SPAs appear to have historically competed with each other even absent direct human intervention (Crosby, 1986; see also Woodley, 2006), with introduced exotic human domesticates often going feral and becoming invasive and thereby expanding into new environments significantly in advance of the human settlers who originally transported them there. As the feral domesticates originated in the ancestral ecology of the exotic human settlers, this process has been theorized to actually, if unintentionally, prepare the transformed ecology into one more suitable for settlement by the exotic human settlers (Crosby, 1986). This was partially because many of the nonhuman species in the invasive SPA had evolved mutualistic relationships of their own that helped them spread in close association with each other, such as: (1) between exotic herbivores and exotic weeds; and (2) between exotic weeds and exotic pollinators (Crosby, 1986).

The Eurasian SPA, for example, can be conceptualized as primarily composed of the following eight ecological components, or *ecomorphs*[4] (Hertler et al., 2018): (A) *Homo*, meaning the niche-constructing humans themselves; (B) *Canis*, meaning dogs, their most ancient associate; (C) *Food Crops*, such as wheat, barley, and rye; (D) *Forage Crops*, such as grasses and legumes; (E) *Artiodactyla*, such as cows, pigs, sheep, and goats; (F) *Perissodactyla*, such as horses and donkeys; (G) *Galliformes*, such as chickens; and (H) *Apidae*, meaning honeybees. However, the essence of an SPA cannot be captured by a simple listing of its constituents. Instead, it must be viewed as a network of ecological relationships, such as that shown in Figure 1, with the letters in the ovals keyed to the ecomorphs listed above:

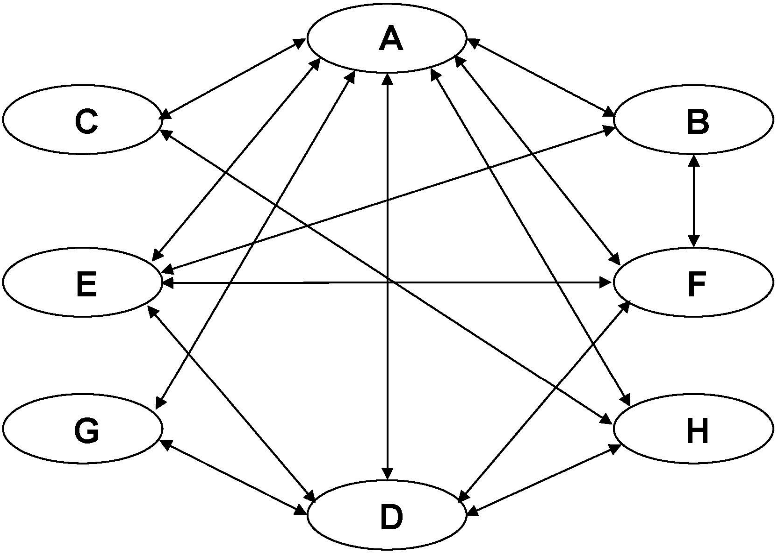

Figure 1. *The Eurasian SPA: The System of Mutualistic Symbioses Coevolving in Eurasia.*

The Eurasian SPA can thus be characterized as composed of at least 11 complex and interconnected categories of mutualism, each represented by a double-headed arrow in Figure 1:

1. Omnivore - Carnivore Mutualism [Homo - Canis]
2. Omnivore - Carnivore - Herbivore Mutualism 1 [(Homo + Canis) - Perissodactyla]
3. Omnivore - Carnivore - Herbivore Mutualism 2 [(Homo + Canis + Perissodactyla) - Artiodactyla]
4. Omnivore - Herbivore Mutualism 3 [Homo - Galliformes]
5. Herbivore - Plant Mutualism [(Artiodactyla + Perissodactyla + Galliformes) - Forage Crops]
6. Omnivore - Herbivore - Plant Mutualism [(Homo + Artiodactyla + Perissodactyla + Galliformes) - Forage Crops]
7. Omnivore - Plant Mutualism [Homo - Food Crops]
8. Plant - Pollinator Mutualism [(Forage Crops + Food Crops) - Apidae]
9. Omnivore - Pollinator Mutualism [Homo - Apidae]
10. Omnivore - Plant - Pollinator Mutualism [Homo - (Forage Crops + Food Crops) - Apidae]
11. Herbivore - Plant Mutualism [(Artiodactyla + Perissodactyla + Galliformes) - (Forage Crops + Food Crops) - Apidae]

Hertler and colleagues (2018) have characterized and graphically described several SPAs associated with different regional human populations in the same manner: (a) the Native North American SPA; (b) the Native Mesoamerican SPA; (c) the Native South American SPA; (d) the Polynesian SPA; and (e) the “Maori” SPA, which was an impoverished form of the Polynesian SPA. The conclusions reached from this type of analysis revealed that regional SPAs seemingly resisted invasion by the Eurasian SPA, and occasionally even counter-invaded, in direct proportion to their *systems complexity*. The structural complexity of a system is defined as the number of links between its elements (Sheard & Mostashari, 2011). SPA invasiveness and staying power appears to be a reflection of the number and strength of cross-linkages among its interrelated and interdependent components. Consistent with this reasoning, the Eurasian SPA was clearly the most complex and thus the most robust. This particular symbiotic assemblage of species often possessed a significant competitive advantage over the native assemblages, even when afforded minimal to negligible human intervention apart from the initial act of transportation. Given suitable climates, this particular invasive SPA was often able to ecologically destabilize the native SPAs upon which the indigenous peoples depended. Thus, many of the major conflicts of the age of European Colonialism were not fought directly between the colonizing and indigenous human societies but rather indirectly between the exotic and native biota. This competition between entire species assemblages has been characterized as the so-called *Battle of Biotas* (Crosby, 1986).

Multiple-species assemblages are not unique to our own species but have also coevolved numerous times with certain colonies of social insects, some of them comparable in complexity to human-constructed SPAs. For example, in one single colony of fire ants, *Solenopsis geminata saevissima*, the following additional species of *myrmecophilous* symbiota were also found (Wasmann, 1918): (a) 16 different types of staphylinid beetles; (b) 4 different types of pselaphid beetles; (c) 2 different types of phorid flies; (d) 1 type of lygaeid bug; (e) 1 type of cydnid bug; (f) 1 type of myriapod; (g) 1 type of bethylid wasp; (h) 1 type of silverfish; and (i) 2 other different types of ant. Fire ants are not unique in this respect, either. Of the 13,000 species of ants (*Formicidae*) identified so far, all of them are eusocial and many of them have evolved mutualistic relationships with other species. These mutualistic species include other kinds of ants as well as certain species of hemipterans (such as aphidid plant lice, membracid treehoppers, and coccid scale insects) and lycaenid or “gossamer-winged” butterflies (Stadler & Dixon, 2008). In addition, some species of ants have evolved mutualistic relationships with various species of plants, fungi, and even bacteria. Most famously, the attine tribe of “leaf-cutting” ants has been cultivating fungi (e.g., *Lepiotaceae, Tricholomataceae*), upon which they depend almost entirely for food, for as much as 60 million years (Chomicki & Renner, 2017). These mutualisms involve more than just the cultivating ants and cultivated fungi. For example, some leafcutter ants carry actinomycete bacteria (*Pseudonocardia*) that inhibit the growth of different species of fungi (*Escovopsis*) that parasitize the ants’ cultivated fungus gardens, and certain black ascomycete yeasts (*Phialophora*) in turn feed upon the mutualistic actinomycete bacteria (Institute of Medicine Forum on Microbial Threats, 2012).

Thus, we do not have to appeal to any kind of human exceptionalism to account for the coevolution of human niche-constructed SPAs, as there are numerous nonhuman examples of these kinds of symbiotic networks.

1.3 Sociopolitical Complexity

Sociopolitical complexity has been defined as the degree of social and political stratification and specialism (based on a division of labor) within a human society. We will follow Tainter's (1988) detailed review of the anthropological and political literature on the evolution of complex societies. According to the author, complexity is often described in terms of the following sociopolitical attributes: (1) The number of specialized roles found in society; (2) the frequency and particularity of social figures; (3) the number and uniqueness of social components; (4) the size of the sociopolitical system; and (5) the heterogeneity of institutional mechanisms that facilitate the coordination of collective activities and the persistence of the sociopolitical organization. Consequently, Tainter proposed that social heterogeneity is an essential component of sociopolitical complexity. For the author, heterogeneity is related to the number, uniqueness, and distribution of individuals across the various parts constituting a society. Through this lens, a population organized unequally across an array of social roles is considered to be heterogeneously distributed and thus evidences a greater level of sociopolitical complexity relative to more homogenous and simpler societies.

Tainter also argued that inequality evidenced the level of complexity of a sociopolitical structure, understanding this construct as reflecting the degree of unequal access to goods and services, as evidenced by the presence of a ranking system. Although the author acknowledged that heterogeneity and inequality coevolved in multiple human societies, these sociopolitical phenomena are not positively associated under certain circumstances. According to Tainter, early states featured low levels of heterogeneity and high inequality. As sociopolitical evolution proceeded, these organizations experienced a decline in inequality and a concomitant increase in heterogeneity, a shift in part attributable to the rise of institutions characterized by their division of labor. Even though previous publications have distinguished between simple small-scale societies and complex large-scale organizations, current macrohistorical and cross-cultural research strongly suggests the presence of a general sociopolitical complexity continuum (Turchin et al., 2018). These results indicate that the complexity of human societies differs in degree rather than in kind. This theoretical and empirical stance is consistent with Tainter's (1988) view, wherein complexity and decline are described as continuous rather than as categorical variables. Nevertheless, Tainter (1988) and other authors (Fried, 1967; Service, 1962, 1975) classify major points along this continuum of human social complexity, ranging from bands to states.

The band is the simplest form of sociopolitical system and is characterized by an absence of institutionalized hierarchical organization, with resource and effort coordination circumscribed to specific activities and occurring for a limited time. Individuals rely on persuasion to attain specific goals rather than operating via legitimate leadership or coercive power (Fried, 1967; Tainter, 1988). Kinship based on familiarity acts as one of the main pillars sustaining this sociopolitical organization. Bands, ranging in size from dozens to hundreds of individuals, occupy and defend small territories (Turchin, 2016). Ingroup members curtail upstarts' social and political ambitions by employing various social mechanisms ranging from gossip and mockery to expulsion and capital punishment (Boehm, 2009). Rank-based, or tribal, systems retain several of the aforementioned attributes found in bands, including the absence of institutionalized hierarchies. However, prestige, status, and symbolic ornamentation are pervasive social phenomena in tribal societies. In contrast to band organizations (wherein individuals infer their underlying relatedness based on residence patterns and familiarity), inhabitants of tribal societies feature sophisticated kinship structures that orient individuals' cooperation and positive Ingroup biased behaviors (Fried, 1967). Tribal kinship is often represented as families being nested within lineages, which, in turn, are found within clans (Fried, 1967).

The persistently egalitarian nature of tribal societies at the sociopolitical level generally hinders individuals from obtaining and inheriting a position of authority. Instead, prestige and status are either earned or ascribed by other community members; hence, a prestigious individual's offspring cannot inherit their parents’ social recognition (Fried, 1967). While social and political coercion is absent in these societies, individuals compete for status, and this may in turn positively impact their fitness (Escasa et al., 2010; Macfarlan et al., 2014). Although most bands and tribal organizations display multiple social mechanisms destined to enforce egalitarianism, researchers have found that several historical and extant pre-agricultural small-scale societies exhibit various forms of social, political, and microeconomic inequality (Flannery & Marcus, 2012). The transition from tribal societies of chiefdoms has been partly attributed to the rise and persistence of indebted servitude and the crystallization of hierarchical institutions legitimizing the succession of authorities based on genealogical descent (Fried, 1967; Flannery & Marcus, 2012). Even though chiefdoms are characterized by their level of sociopolitical stratification, in contrast to state-level societies they lack a monopoly of the use, or threat of use, of force (Fried, 1967). The evolution of paramount chiefdoms and sociopolitical systems with political, social, and economic influence over smaller chiefdoms provides an evolutionary scaffold for the eventual emergence of states. According to Tainter (1988), states are characterized by: (1) occupying a more extensive territory; (2) having institutions that legitimize the authority of sovereigns, which in turn delegate their power further via hierarchical organizations; (3) displaying a monopoly in the use, or the threat of use, of coercive force; (4) having the ability to recruit, draft, or muster individuals for collective endeavors; (5) producing and enforcing laws; and (6) having an administrative organization that is no longer restricted to kinship, but instead is based on the appointment of individuals to certain sociopolitical offices.

1.4 The Present Study

The main question we take up in the present study is how the coevolution of human niche-constructed SPAs relates to the emergence of elevated levels of human sociopolitical complexity. We review two major alternative hypotheses regarding the relative timing of these two evolutionary milestones: (1) the “conventional”, or *kalliergogenic*[5]*,* view that the Neolithic Revolution in farming and animal husbandry temporally preceded, and was indeed causal to, humans starting to live in larger, settled communities, giving rise to the increasing complexity of human "civilization"; and (2) the "contemporary", or *anthropogenic*[6], view that the emergence of human sociopolitical complexity greatly preceded any significant amount of animal or plant domestication and was instead a behaviorally necessary preadaptation for the coevolutionary dynamic leading to the human niche-constructed SPAs. We support the latter view by reviewing how increased human sociopolitical complexity was promoted by a self-reinforcing autocatalytic process of social selection (e.g., Peñaherrera-Aguirre et al., 2023) rather than the gradual transition to a settled, agricultural existence.

Although there is a growing literature on the archaeology and evolutionary history of nonhuman animal and plant domestication (e.g., Francis, 2015), little is currently understood about the details of the coevolutionary mechanisms underlying this process. Some multiple-pathway theories (Larson & Burger, 2013; Larson & Fuller, 2014) have been proposed, but at this point they remain mostly in the domain of logical inference and reasoned conjecture and little empirical evidence has been brought forth to attempt to either support or disconfirm them. The timing of these coevolutionary events has also not been fully understood, given that in spite of the broad span of human evolutionary history (as much as the past 300 *kya,* or thousand years ago, for anatomically modern humans), most plant and animal domestications have occurred since no earlier than the Mesolithic[7] (within 30 *kya*, meaning more recently by about one full order of magnitude).

The purpose of the present study is, therefore, to perform a more detailed examination of the major alternative hypotheses regarding the origins and evolutionary histories of SPAs in light of the growing corpus of recent evidence that can be brought to bear on these questions.

CHAPTER 2.0

ALTERNATIVE HYPOTHESIS 1: THE "CONVENTIONAL" (*KALLIERGOGENIC*) VIEW

2.0 Conventional Theories of Human Civilizational Complexity

The conventional view is that human sociopolitical complexity evolved as a direct result of the settled farming lifestyles that arose during the Neolithic. In this view, human civilizations sprang up in several major river valleys when horticulture and then agriculture required that humans settle down in permanent communities. This was followed by greater division of labor, social stratification, the need for armies to defend high-density resources, and finally, kingships to coordinate the new city-states. We first examine the empirical evidence in favor of this conventional theory.

2.1 Predomestication Foraging and Climate Change

There is some evidence of wild rye (13 *kya*, meaning thousand years ago) and squash growing on the banks of the Yangtze River 11 kya, though there is no evidence that horticulture and husbandry were common until some few thousand years later (Pringle, 1998). Also, as early as 11 kya, there is predomestication evidence of humans having used and stored grains in the Jordan Valley (Kuijt & Finlayson, 2009); but again, true farming emerged at least a millennium later, and even then it diffused slowly over several thousand years. Stable and semi-sedentary Natufian populations residing in the Levant and parts of modern Syria, subsisted on wild grains, as indicated by microscopic differences between wild and cultivated cereal grains, and between brittle and non-brittle varieties (Mithen, 2003). The decline of larger ungulates, as well as the exhaustion of wild nuts and cereals, seems to have resulted in declining health in Late Natufian societies, as established by physical growth and dental health. Cultivating brittle varieties before they were ripe seems to have supported large populations 12 kya, but this Natufian way of life fell victim to its demographic success; it seems to have supported initial growth but not sustained or sustainable growth. Burgeoning populations facing declining food supplies resulted in malnutrition and dispersal. These factors were complicated by climate change, as the Younger Dryas[8] brought more than a thousand years of aridity and cold. Within the space of 500 years, there was a return to harshness not seen since the last glacial maximum.

This episode of abrupt climate change might have been triggered by one or more low-altitude bolide airbursts and impacts of cometary fragments (Sweatman, 2021), as evidenced by microspherules, shock-fractured quartz, and meltglass in the lower Younger Dryas boundary layer (Moore et al., 2024). The microspherules were also found to contain "high-temperature melted chromferide, zircon, quartz, titanomagnetite, ulvöspinel, magnetite, native iron, and PGEs[9] with equilibrium melting points (~1,250° to 3,053°C) that rule out anthropogenic origins" (Moore et al., 2024, p. 2). Such impacts of extraterrestrial origins and the subsequent climate change have been hypothesized to have been at least partially responsible for the extinction of much of the terrestrial megafauna that existed prior to this catastrophe (Stewart et al., 2021). After these megafaunal extinctions, humans are believed to have turned to hunting smaller prey animals, such as many of those that were subsequently domesticated (goats, sheep, pigs, cows, etc.)

The coincidence of population pressure and climate change reversed emerging signs of sedentary living, promising technologies, novel social organizations, more productive patterns of land use, and increasingly complex dwellings, among other Natufian cultural achievements (Mithen, 2003).

Within a short space, perhaps no more than a decade, temperature increases of seven degrees Celsius are reported at the close of the Younger

Dryas (Mithen, 2003). Waters acceded to former levels, more heat energy and carbon became available, pollen levels spiked, and those progenitors of domesticated plants that had been used 10 to 11 kya began producing higher yields (Mithen, 2003). It is at this point that Neolithic structures emerge in Jericho and *Netiv Hagdud* and *Gilgal* and *Mureybet*. From these precipitating climatic factors (Weisdorf, 2005), foraging gave way to farming, in what is known as the *Neolithic Revolution.* The name comes from the time, with this revolution taking place after the Paleolithic[10] Age (which is generally dated from 2.5 mya, before humans diverged as a species, and ended circa 12 kya, with the start of the Neolithic Age). Unlike political revolutions that can be dated, this Neolithic Revolution emerged over more than a thousand years (Simmons, 2011). Pringle (1998) cites pollen cores and cereal shape as data points within a larger trove of evidence that pushes back the date of both animal husbandry and plant domestication, further lengthening the time over which these cultural innovations spread.

The leading edge of change was evident in the Near East and the Nile River Valley. The literature, of course, speaks of the *Fertile Crescent,* beginning in the headwaters of the Nile, traveling up to its Delta, hugging the Westward coastline of the Mediterranean, and then reaching south into Mesopotamia along the Tigris and Euphrates Rivers. Cultivated wheat and barley, as well as domesticated sheep and goats, emerged between 9 kya and 11 kya in the Fertile Crescent (Bell, 1987). Beginning as early as 8 kya in the Fertile Crescent, genetic analyses suggest that farming then propagated West through Eurasia and into Anatolia (Feldman et al., 2019; Baird et al., 2018). Shifting patterns of tooth wear place farming as having spread through the Levant between 10.3 kya and 7 kya (Eshed, Gopher, & Hershkovitz, 2006). Archaeobotanical remains place emmer wheat in Iraq and Iran about 10 kya (Riehl, Zeidi, & Conard, 2013). There is rice cultivation and pig domestication in China’s Middle and Lower Yangtze Valley beginning around 10 kya (Chi & Hung, 2010), and domestication of maize in central Mexico dated to 9 kya (Mithen, 2003). Increased carbon emissions are suggestive of human farming activity around the same time (Ruddiman, 2003), which broadly coincides with radioactive carbon dating evidence (Vander Linden et al., 2014).

2.2 From Small-Scale Horticulture to Intensive Plow Agriculture

Farming is thought to have begun with small-scale *horticulture*, or *hoe farming*, and the word *agriculture* is mostly reserved for the intensive cultivation of larger fields using the plow. Rudimentary wooden plows date back, at most, to 10 kya (Lal, Reicosky, & Hanson, 2007). The *Ard,* antecedent to the Roman plow, was a wooden plow present 8 kya in Mesopotamia. This invention scratched the soil rather than truly turning it over, though it may have been more effective and efficient than hoes, antlers, and digging sticks (Hooke, 2000; Erinç & Tunçdilek, 1952). Beyond the shortcomings of early plows, prior to the domestication events of the Neolithic Revolution, there seems to have been a relative absence of suitable domesticated animals that could be effectively harnessed to a plow (Huntington, 1927).

Approximately 3 kya, metal and traction came together. Figurines showing yoked oxen suggest plowing in the Early Bronze Age Aegean (Pullen, 1992). By 2.5 kya, at the outset of the Iron Age, iron shares were fitted to wooden plows; thereafter came solid iron plows (Hooke, 2000). Primitive plows made some contribution early in the Neolithic Revolution, though their effects were not truly revolutionary until they became capable of turning soil over, as could the heavy plows of medieval Europe (Andersen, Jensen, & Skovsgaard, 2016), and the Mouldboard Plow modified by Thomas Jefferson (Clagett, 2009). This was especially true of soils like the six foot high cogon grass, such as that found in Southeast Asia and Southern Europe (Huntington, 1927), and tall grasses of the African Savannah (Huntington & Cushing, 1922; p. 272).

Following the works of Cavalli-Sforza, a wave of immigrant farmers was envisioned as entering Europe, largely replacing those hunter-gatherers around 7 kya, though mitochondrial DNA analysis of extant humans moderates this claim, finding that the mitochondria of Mesolithic hunter-gatherers preponderate in modern European populations. The hunter-gatherer lifestyle, however, was largely abandoned by 6 kya, save for parts of Northern Europe where it persisted to 3 kya (Mithen, 2003; pp. 194-195). Thereafter came increased sedentism and resultant population expansion (Cole, 1959; Bradley, 2005). Simmons (2011) warns of variation among the accounts of different scholars, but speaks of two characteristics that define the Neolithic Revolution, the domestication of food sources and permanent settlement. The former necessitated the latter. Before, there were a few examples of sedentary living, as there were a few examples of domesticated plants; yet it was only in the Neolithic Revolution that the two became commonly paired. The Neolithic Revolution was at once technical and social, leaving artifacts and permanent structures assembled into villages.

2.3 The Neolithic Demographic Transition

After the adoption and intensification of farming came the *Neolithic Demographic Transition* (Bocquet-Appel, 2008). A demographic surge came from an altered caloric regime. This altered caloric regime contained several interrelated components: (1) *locomotion,* (2) *early weaning,* and (3) the amplification of *alloparental care*[11]. These three factors combined to significantly shorten interbirth intervals, leading to the aforementioned Neolithic Demographic Transition, wherein higher birth rates were attained.

First, Bocquet-Appel (2008, p. 5) states that there was “a major shift in the maternal energetics of farming communities relative to mobile foragers” that involved higher caloric foods coinciding with reduced calorie expenditure in foraging, locomotion, and child transport. Intensive agriculture enabled sedentism, which freed up maternal energy that might have otherwise been spent in ranging widely for food while carrying children. The agricultural products that increased fertility simultaneously allowed sedentism, or sedentary living. *Archaeobotanical* evidence finds some opportunistic use of wild grasses that suggests purposeful use, if not cultivation, though sedentism is classically correlated with cultivation (Savard, Nesbitt, & Jones, 2006). Staying in one place has manifold consequences. One can point to food stores, possessions, and technologies; and when sedentism is combined with demographic surges and specialism, civilizational complexity can result, as it did in the American Midwest (Brown, 1985), Mexico (Rosenswig, 2006), and West Africa (Anquandah, 2014).

Second, horticulture, and thereafter agriculture, facilitated the cultivation, processing, and cooking of weaning foods. Prior to the use of weaning foods, some poor supplements seem to have sometimes been used, such as armadillo fat, grubs, and regurgitated foodstuffs. These did not reduce interbirth intervals reliably or in a manner that safeguarded mothers and infants; “babies born at shorter intervals might destabilize a mother’s precarious juggling, contributing to her demise and/or their own” (Hrdy, 1999, p. 197). The costs to mothers of lactation are underscored by Hrdy (1999, p. 140): “Each offspring that survives past weaning would have extracted enormous somatic investment from the mother, not to mention the opportunity costs—time out of her life spent nursing offspring she already has instead of making more.” It follows that restricting lactation time reduces somatic investment in one offspring, so it can be invested in another. “Early weaning and better nutrition for the mother,” Hrdy (2009, p. 43) states, “translate into a shorter interval between the last birth and the next conception”. Hrdy then extrapolates from the individual birth, to lifetime reproductive fitness for the mother, to reproductive success for the lineage.

Making one additional extrapolation, we can see the demographic consequences for those erstwhile foragers who became farmers during the Neolithic Revolution. Some of the earliest known pottery specimens almost invariably include small containers thought to be used in the cooking of grains and other suitable mashes made into weaning foods; and with sufficient availability of even these rudimentary pottery technologies and year round grains, weaning could take place even before the first year (Hrdy, 1999).

Third, male provisioning, which is a species of alloparental care, supplements gestation and lactation to the end of shortening interbirth intervals (Thornhill & Gangestad, 2008). Alloparental care, care provided by any conspecific other than the mother (Solomon and French, 1997; Muller & Thompson, 2012), is “extreme in South American marmosets and tamarins,” and broadly common among primates relative to other animal orders (Tardif, 1997; p, 11). Alloparental care is critical in reducing human interbirth intervals from six or more years, common among other apes, to three to four years, common to humans in hunter-gatherer societies (Hrdy, 2009). While alloparental care can shorten interbirth intervals, it generally cannot do so before a child is weaned; and if weaning still takes place in the fourth year of life, conception is often deferred as long. However, weaning foods amplify the effects of alloparental care. A grandmother can thereby feed a weaned two year old, leaving her daughter to conceive another child twice as quickly. Weaning foods may also play a critical role in the survival of orphaned young. With the death of a mother, offspring mortality increases, but this effect is strong only up until the age of two (Hrdy, 2009), which may mark the age after which young children can be feasibly transitioned to weaning foods in horticultural societies. Lactating females within a family or band may contribute at times, such as just after parturition before milk let down, to nursing infants of other mothers, as happens among the Efe and Aka (Hrdy, 2009). And, of course, there is the alternative of employing a wet nurse. However, nursing restricts the feasibility of lactation and the range of others that can act as alloparents. With weaning, not only males, but non-lactating, prepubescent and postmenopausal women can contribute directly to feeding orphaned young.

As Hrdy, Paine, and Hawkes (2006; p, 10) discuss, the use of highly processed foods allows humans to supplement children's caloric intake and, thereafter, wean them earlier in comparison with other apes. Paine and Hawkes further contextualize shortened interbirth intervals within a life history framework, within which this shortening of interbirth intervals can be appreciated. As presented by Paine and Hawkes in table 2.1 on pages 22 and 23 of *The Evolution of Human Life History,* there is a general logic across human life history variables with correlations being in the expected direction; for example, relative to other primates, humans have larger brains, longer lives, and later pubescence. However, humans wean early, between two and three years. Many apes wean when infant body size becomes a third of that of their mothers. If humans did this, they would nurse until the child was six. Most interesting is the fact that, in comparison to other apes, weaning is faster even while most other life history traits are slower (Robson, van Schaik, & Hawkes, 2006). This uncoupling of interbirth intervals from the broader family of human life history traits is by no means an exclusive consequence of post-Neolithic

Revolution energetics, but it is a trend accelerated by the growing and processing of weaning foods in the last 12,000 years. Demography is supportive of this theory. For example, to further investigate post-Neolithic Age population expansion, Gignoux, Henn, and Mountain (2011) estimated human numbers from distributions of mitochondrial genomes, supporting classic assumptions; and furthermore showing that lineages that took up farming grew fivefold faster than hunter-gatherers. Similar conclusions are drawn from analyses of Neolithic Age cemeteries and from probability distributions of summed calibrated radiocarbon dates (Downey et al., 2014). This does not mean that growth was always sustained or that early farmers were always fertile and healthy, but such seems to be the overall trend when collapsing across sites and larger swaths of time. Page and colleagues (2016), for example, find early agriculturalists to have increased morbidity and mortality, with these effects being overtaken by increased fertility.

2.4 Farming as a Source of Between-Groups Competition

Plants are just like other resources in that their concentration augurs competition. Whether it is land, a herd, or a field of crops, all such resources critical to survival and reproduction cannot be stored up, concentrated, and used for one’s benefit without attracting rivals, poachers, and competitors.

Early farmers were sometimes targeted by hunter-gatherer societies over possession of the land, as they were, in a specific instance, described by Alt and colleagues (2020). At the site of *El Trocs* in the Spanish Pyrenees, “farmers and indigenous hunter-gatherers collided violently around 5300 BCE” (p. 1). The result was a “massacre” (p. 1) deemed an “overkill reaction” (p. 1) by these authors. Yet, farmers were perpetrators, as well as victims, of violence. Fibiger and colleagues published a study of archaeologically documented violence in Northern Europe, concentrating on peoples identified as *early farmers*. While this does not preclude herding, the emphasis on farming suggests that cultivars served both as a predominant source of calories and as a correspondingly predominant source of conflict. Far from peaceful, these early farming societies experienced intensive violence. As Fibiger and coauthors (2023) conclude, "it becomes apparent that violence was endemic in Neolithic Europe, sometimes reaching levels of intergroup hostilities that ended in the utter destruction of entire communities" (p. 4). In addition to merely reporting that violence was high among these farming societies, these authors more directly impute a causal relationship, noting that conflict and competition were linked and burgeoning populations fueled violent competition for arable lands.

In the period and place of study, in the Early Neolithic Age within Central Europe, evidence of violent death increased, and this seems to support the emergence of more widespread and coordinated violence that is recognizably like modern warfare. There is ample evidence of intragroup violence, smaller-scale blood feuds, and raiding among hunter-gatherer bands (Keeley, 1996). However, there is evidence of "mass violence" (p. 7) between groups within Fibiger and colleagues' review of the archaeological record, which brought a qualitative difference in "scale, frequency, and tactics" (p. 7). This expansion in scope, as well as its within-group coordination against rival outgroups, is directly related to Neolithic domestication, as seen below in a passage worthy of extended quotation (Fibiger et al., 2023, p. 7):

> Prior to domestication, episodes of massed violence as indicated by multiple burials and attacks on fortified structures during the Neolithic are neither in evidence nor were they possible due to the small-scale, scattered, and more mobile nature of forager populations. As stated, direct comparisons of the prevalence of violence-related assaults are not currently feasible, although it is salient to note that in regions where the condition of Neolithic skeletal remains is closest to the situation seen among Mesolithic samples, in being generally fragmentary, disarticulated, and poorly preserved, such as Britain, the rates of trauma remain markedly higher postdomestication. The assertion that violence was more frequent among farmers than in earlier periods is therefore argued to be a real distinction rather than simply an artifact of preservation.

Rowthorn and Seabright (2010) extend this argument beyond the principle of defense. As their reasoned argument proceeds, those Early Neolithic Age farmers had to adopt defensive postures to protect the fruits of their labor. This is a claim made by many other authors, but Rowthorn and

Seabright then elaborate on this claim by suggesting that these defensive structures and arrangements did not necessarily remain defensive. Once formed, they could be repurposed for offensive actions. For example, a fortification originally constructed on defensive grounds, might encourage offensive actions. Early farmers could conduct a raid and retreat behind walls. Similarly, an armed cross-section of a population originally formed for defense, could turn to offensive actions. Especially Rowthorn and Seabright’s (2010) latter assumption that weapons and warriors were rarely idle once formed, is reminiscent of modern concerns about standing armies that may be repurposed to threaten the populace they were established to protect. It is from this argument that Rowthorn explains the spread of agriculture. The threat that some agriculturalists posed to non-agriculturalists, induced the spreading adoption of agriculture even against the unfavorable nutritional cost-benefit ratios known to characterize early farmers reliant on cereal crops. Rowthorn and Seabright go on to explain what might be thought of as a paradox; namely that pilfering fostered increased sociality (p. 5):

> Even output that can be produced without the need for transactions as such must still be protected against theft before it can contribute to human welfare. Put like that the point may seem obvious - what is less obvious is that variations in the extent to which output can be protected may have played an important part in the dynamics of growth during prehistory as well as in historical times. Furthermore, increases in the vulnerability of certain kinds of output to theft may not only have led to an increase in the incidence of theft, but more importantly to a diversion of society’s resources away from production and towards both aggressive and defensive investments, with a consequent impact on productive investment and growth.

That possession of an intensively cultivated plot and the food resources it yields, induces defensive violence can be obliquely gleaned by indirect supporting evidence gained through the relationship between population density and violence. This is pertinent because agriculture augments density. For example, Baten and colleagues (2023) reviewed the archaeological record between 12,000 and 400 BC, looking for evidence of violence within modern day Turkey, Iraq, Iran, Syria, Lebanon, Israel, and Jordan. They describe a curvilinear trend, in the middle of which, violence increases. Eliding over much instructive nuance, their explanation of this trend is related to density. Early in this period, there was the beginning of cultivation, but without sufficient population density to cause significant competition and conflict. Later in this period, there were violence-reducing *Leviathans* (Hobbes, 1998); empires of the ancient world monopolizing violence and thereby reducing conflict. However, in between these phases, in the middle of their period of study, stands a time wherein there was a sufficient density of agriculturalists with concentrated resources to increase conflict, but not yet the violence-reducing arbiters of ancient governments.

A similar story is evidenced by Müller and his seven coauthors (2024), who studied 23,000 Central European prehistoric graves. Echoing the power of political Leviathans, as described in the previous publication, Müller and coauthors found the signature of violent death to be positively correlated with social equality. Put another way, mounting social inequality reduced violence; or at least is associated with the reduction of violence. Again, the causal force behind what might seem counterintuitive is the early governmental ability to monopolize violence. As noted, this conclusion comes down firmly on the side of Hobbes (1998), the early Enlightenment Era philosopher who assumed, *contra* Rousseau (1755), that the state of nature is replete with violence. It also agrees with Keeley (1997), the anthropologist who did so much to controvert the *myth of the noble savage.*

As had Baten and colleagues (2023), Müller and colleagues (2024) describe a curvilinear trend wherein violence rises from an earlier baseline prior to agriculture, but then declines to theretofore unknown low levels. At the outset of the Neolithic Age, circa 5,500 BC, evidence of violent death increases; there is a further increase to "very high trauma rates" (p. 4) by 4,100 BC, with a slight decrease recognizable circa 3,300 BC. Still, there is another upturn in violence between 2,500 and 2,300 BC. This seems to be a peak value, after which there is a decline to 1,900 BC and levelling off at 1,300 BC. This trend is more variable and contains more fluctuations, but at its broadest, it does show a trend similar to that of Baten and coauthors (2023). In reaction to their data, Müller and colleagues state (2004, p. 11):

> We understand these processes as a monopolization of violence, which in part gains in intensity with the development of non-dual weapons in the Final Neolithic and the Bronze Age. The overall historically reduced rate of violence can therefore be attributed to a stronger structuring of societies.

Again, this does not directly show farming and cultivation to be causally related to violence, but is consistent with a narrative wherein the cultivation of plants during the Neolithic Age induced and augmented violence by concentrating resources that were then violently fought over.

Thus, in this conventional (*kalliergogenic*) view, complex human civilizations sprung up primarily due to the gradual intensification of horticulture, and then agriculture, which demanded that humans settle down in permanent communities of ever-higher population densities, as facilitated by the expanded food production generated by the cultivation of crops. These higher population densities, especially in the emerging urban centers, then purportedly led to the increases in division of labor and social stratification that augmented sociopolitical complexity. It has also been alleged that these increased population densities and increased concentration of defensible food supplies also led to increases in territorial aggression.

On the other hand, this conventional view is directly contradicted by much contemporary archaeological evidence, as we review in the section that follows on the alternative (*anthropogenic*) view, in which we show that the levels of both within-groups and between-groups aggression actually peaked in the Mesolithic, the period that immediately preceded the Neolithic, wherein farming began to predominate and levels of aggression declined.

CHAPTER 3.0

ALTERNATIVE HYPOTHESIS 2: THE "CONTEMPORARY" (*ANTHROPOGENIC*) VIEW

3.0 Pre-Neolithic Civilizational Complexity

Having reviewed the conventional model in the prior chapter, we now delve more deeply into prehistory to review the "contemporary", or *anthropogenic,* view that the emergence of human sociopolitical complexity predates, and is causally independent of, the domestication of most nonhuman animals and plants. In this contrary view, an evolutionary progression of increasing human sociopolitical complexity was a necessary precondition for the coevolution of the human niche-constructed SPAs. Furthermore, although the "conventional" (*kalliergogenic*) view has historically featured climate change as a seemingly likely explanation for the plant and animal domestications of the Neolithic (Hillman, 2000; Hillman et al., 2001), substantial agronomic evidence has been arrayed against climate stability as the precipitating causal factor (Abbo, Lev-Yadun, & Gopher, 2010).

3.1 Upper Paleolithic and the Evolution of Human Modern Behaviors

Human behavioral modernity encompasses an array of phenotypes; d'Errico and Stringer (2011) reviewed such attributes as including: (1) the fabrication of sophisticated stone tools employed in harvesting and food preservation procedures; (2) toolkits used in a variety of novel and extreme environments; (3) groups equal to or larger than those of some contemporary hunter-gatherers; (4) exchange networks; (5) complex