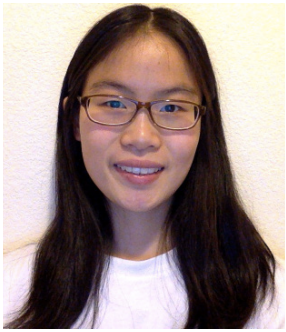
All Because of a Cup of *Qahwah*

Elizabeth Chan



Writers' Comment: Though famous for its much-loved "Crop of the Day," Dr. Gepts' Evolution of Crop Plants course comes at a bargain: free food for the price of a grudgingly long term paper on the origin of any crop plant. Our assignment was to choose a crop and unravel its domestication, using the various types of evidence presented in class. Although hardly an avid coffee drinker myself, I chose to write on coffee because of all the controversy that surrounds the beverage. By evaluating and connecting historical, archaeological, linguistic, botanical and genetic evidences, my paper traces back the origin of Coffea arabica *to the mystical rainforests of southwestern Ethiopia. Taking Dr. Gepts' class and writing this paper has taught me the importance of crop domestication and evolution in maintaining genetic diversity in crops, especially in the light of an ever-increasing human population and global climate change. The writing process for "All Because of a Cup of Qahwah" proved to be a very rewarding experience, so I am very grateful to Dr. Gepts for assigning and assisting me with this project. Note: please enjoy with a cup of coffee!*

Instructor's Comment: PLB143, Evolution of Crop Plants, studies the origins of agriculture and the process of crop domestication. There are many reasons why this 10,000-year old process still matters today. The transition from hunting-gathering to agriculture is one of the milestones of human evolution and a condition for the development of human civilizations. Understanding where agriculture originated is also crucial for biodiversity conservation efforts and to use this biodiversity to develop new crop varieties that are better able to serve

our societies, for example in the mitigation of global climate change. Each student in the class develops a term paper discussing the origin and evolution of a crop of their choice. Elizabeth Chan's paper on the origin of coffee in its native Ethiopia and subsequent spread around the world is a fine example of such a paper. She combines botanical, genetic, historic , and linguistic data to help us understand why terms such as moka, java, bourbon, and arabica have come to be associated with this important beverage, many of us enjoy on a daily basis.

– Paul Gepts, Department of Plant Sciences

Abstract

Coffee is one of the most valued agricultural commodities in the world. Due to its rising popularity, demand for coffee seeds has rapidly increased, leading to the cultivation of the crop in various countries. Among the *Coffea* species, *Coffea arabica* L. is the most prized, grown and cultivated worldwide. Previously, scientists have relied on historical evidence to trace the Ethiopian origin of *C. arabica*; today, genetic tools can be employed to determine a more precise region of origin. Genetic markers such as microsatellites or simple sequence repeats (SSR) are particularly useful in determining the genetic distance between individuals or populations, an important piece of information that can eventually be used to trace back the evolution of an individual or species. To assess polymorphism between modern day cultivars and wild C. arabica accessions, amplified fragment length polymorphism (AFLP) analysis and SSRs have been used. In addition to confirming the Ethiopian origin of *C. arabica*, AFLP results have narrowed the crop's center of origin to southwestern Ethiopia. Although southwestern Ethiopia may be the center of origin of *C. arabica*, it is not necessarily the center of dispersal for cultivated *C. arabica*. Rather, evidences at all levels, including linguistic and archaeological evidence, point to Yemen as the source of cultivated *C. arabica* produced worldwide.

Introduction

The *Coffea* genus of the Rubiaceae family includes about 100 species (Specialty Coffee Association of America 2016), native to Africa, Madagascar, the Mascarene Islands, and Indomalaysia (Meyer 1965). The seeds, or "coffee beans," of these small shrubs or trees are roasted, ground, and brewed to make coffee beverages and products (Specialty Coffee Association of America 2016). Two slippery seeds are typically found inside each drupe, commonly called a cherry, the fruit produced by the *Coffea* tree. Trees reach up to 7m tall, with fragrant white flowers that have both male and female sex organs (Specialty Coffee Association of America 2016). Of all *Coffea* species, only *Coffea arabica* L. (*C. arabica*) is tetraploid and self-fertile (Charrier and Berthaud 1985). Coffee trees grow best in areas with rich soil, mild temperatures, frequent rain, and shaded sun (National Coffee Association USA 2016). About five years of growth after planting is needed to reach full fruit production and trees can live up to 100 years, although they are most productive between the ages of 7 to 20 years old. The average coffee tree produces around 10 pounds of coffee cherries per year, equivalent to 2 pounds of green coffee beans (National Coffee Association USA 2016).

Commercial coffee production relies mainly on the two species *Coffea arabica* L. (Arabica) and *Coffea canephora* Pierre ex Froehner (Robusta), with *C. arabica* boasting the better cup quality. In regards to the world supply of coffee, the Arabica coffee plant makes up 75% while the Robusta plant contributes 25% (Meyer 1965). Global coffee production in the 2015-16 year was estimated to be a staggering 143.4 million (60 kg) bags (International Coffee Organization 2016). In 2015, Arabica coffee plants contributed 84.3 million bags while Robustas contributed 59.1 million bags. Following the increased demand and production of coffee is the swift consumption of the beverage; global coffee consumption reached up to 150.2 million bags in the 2014 calendar year (International Coffee Organization 2016). According to FAOSTAT (2013), the top five producers of coffee were Brazil (3 million tons, MT), Vietnam (1.5 MT), Indonesia (699 KT), Columbia (653 KT), and India (318 KT), with Ethiopia at seventh place (270 KT). Though coffee is grown in more than 70 countries, the top four producers of coffee supply over 60% of the world's coffee (Fairtrade Foundation 2016). These coffee producing countries only consume 30% of the world's coffee while

the remaining 70% is traded internationally. The United States is the highest coffee importing country, followed by Germany and Italy. Even more impressive is the number of people who depend on coffee for their livelihoods; around 25 million smallholder farmers produce 80% of the world's coffee (Fairtrade Foundation 2016) and some 125 million human beings rely on it for their living (Pendergrast 2010).

Besides providing your daily brew, the coffee tree and its beans have a myriad of other uses. Before coffee existed, the Ethiopians brewed the leaves and cherries in boiled water to make a tea infusion (Pendergrast 2010). Beans could be ground up, mixed with animal fat, and formed into a ball to make an energy rich snack. Wine could be made from the fermented fruit. Some more modern uses of coffee include it as a flavoring in foods and liqueurs (Duke 1983). The mesocarp (pulp) and endocarp (parchment) have been used in manures and mulches. Wood from coffee trees is hard, durable, and dense, making it suitable for furniture. Surprisingly, coffee beans can also be used to make a type of plastic, called coffelite (Duke 1983).

Though most famous for caffeine (a natural stimulant), coffee actually has a very complex chemical profile, reported to contain more than a thousand different chemicals including carbohydrates, lipids, nitrogenous compounds, vitamins, minerals, alkaloids and phenolic compounds (Spiller 1998). As a result, much research has been conducted to assess the health profile of coffee and analyze the effects of coffee consumption (Higdon and Frei 2006). So far, moderate coffee consumption has been associated with reduced risk of several diseases such as Parkinson's disease (Ascherio *et al* 2001), liver disease (La Vecchia 2005), Type 2 diabetes (Van Dam 2005), and Alzheimer's disease (Lindsay *et al* 2002). At the same time, excessive coffee consumption is not recommended, as increased caffeine intake can have negative side effects.

Results and Discussion

Historical evidence

While the true origin of coffee drinking and the coffee plant remains obscure, most texts, stories, and legends tie the origin of the beverage to Yemen and the discovery of the plant back to Ethiopia. The

first written mention of coffee was by a 10th century Arabian physician named Rhazes, who described the nature and effects of a plant named *bunn* and the beverage, *buncham*, made from it (Weinberg and Bealer 2001, Smith 1985). Reference to coffee drinking or knowledge of the coffee tree can be traced back no earlier than the 15th century, in the Sufi monasteries of Yemen in southern Arabia (Weinberg and Bealer 2001). The myth of Kaldi, related by Antoine Faustus Nairon, describes how the Ethiopian goatherd discovered coffee after noticing the energizing effects the coffee beans had on his flock. However, the authenticity of this account is questionable, considering its lack of reference in earlier Arabic sources. Another origin story, often told in Arabian tradition, highlights the role of the African civet cat in dispersing the seeds of the coffee plant from central Africa to the Ethiopian mountains (Krapf 1860). The plant was cultivated by the Galla warriors and then brought to Arabia by a merchant. Both of these stories attribute the Ethiopians with being the first to discover the stimulating effects of the coffee plant.

Soon after the Ethiopians discovered coffee, the beans traveled to Yemen via trade across the Red Sea (Pendergrast 2010). Adopted first by the Sufi Muslims as a drink to keep them awake during midnight prayers, coffee eventually became a casual beverage. By the end of the 15th century, the drink spread throughout the Islamic world (Persia, Egypt, Turkey, and North Africa). When the Ottoman Turks occupied Yemen in 1536, the coffee bean became an important export, cultivated and shipped from the port of Mocha until the late 19th century. As a result, coffee from that region became known as Mocha. Having acquired such a valuable export, the Turks became protective of their trees in Yemen, not allowing any berries capable of germination to leave the country (Pendergrast 2010). For this reason, coffee smuggling arose, with the first case attributed to Baba Budan, a pilgrim from India (Smith 1985). Supposedly, Budan strapped seven coffee seeds from Mecca to his belly, and successfully cultivated them in Mysore. Soon enough the Dutch caught on, and in 1616, they transported a tree from Aden, a port city in Yemen, to Holland (Pendergrast 2010). From that tree's offspring, cultivation of coffee in Ceylon (now Sri Lanka) was born. Later in 1699, another Dutchman transplanted trees from Malabar to Java, followed by the cultivation of trees in the East Indies.

Coffee was first brought to Europe by travelers in a region known as Levant (Ukers 1935). The first European to mention coffee in writing

was the German physician and botanist, Leonard Rauwolf (Ukers 1935). Served *chaube* in Aleppo, Syria, he noted the "very good drink" was "as black as ink" and "very good in illness." Once introduced, coffee spread like wildfire among the European countries, followed by the establishment of coffee houses. By the early 18th century, there were over two thousand coffee houses in London, which became centers for social, political, literary and commercial life (Smith 1985). Coffee was becoming a mainstay in Europe, and the controversial drink even inspired Johann Sebastian Bach to write his famous *Coffee Cantata* in 1735 (Open Culture 2014). The secular cantata tells of a young Aria who loves coffee, but her strict father is wholly against it. As for the rest of the world, European colonization was largely responsible for the dissemination of coffee to South America, Africa, the Caribbean, South and Southeast Asia (Slate 2014). European missionaries, merchants, and ambassadors introduced both the word and the drink to East Asian countries.

Archaeological evidence

Coffee cups, either made of porcelain or clay, are the primary archaeological evidence for coffee consumption (Bouzigard 2010). The tiny cups that were used to drink coffee (Pendergrast 2010, Weinberg and Bealer 2001) were typically made out of porcelain and distinct from other cups in that they had no handles (Bouzigard 2010). Referred to as *fenjeyn* (Baram 1999), these porcelain cups were first imported to the Middle East from China in the 16th century (Brosh 2002, cited by Bouzigard 2010). The cups imported from China had distinct Chinese styles, an important component used in identifying the shift in coffee usage. As coffee spread to Europe, Chinese porcelain cups were gradually replaced by Western styles and products, as evidenced by large finds of coffee cups recovered from shipwrecks within the Red Sea and excavations throughout the Middle East (Watson 2004 and Ward 2001, cited by Bouzigard 2010). As a result, the shift in material culture appropriately reflected the spread of coffee from the Ottoman Empire to Central and Western Europe (Baram 1999).

Linguistic evidence

Many cognates, words that share the same root and develop from a common ancestor, for coffee can be found in the several hundreds of languages rooted in Indo-European language family. For example, compare the Italian *caffè*, the French *café*, the German *kaffee*, the Danish and Swedish *kaffe*, the English *coffee*, and the Dutch *koffie*. Not only do these cognates sound remarkably similar to each other, but they also resemble the Finnish *kahvi*. Yet Finnish and English grew on entirely separate language family trees—Finnish is Uralic and English is Indo-European. This indicates that *coffee* is a loan word, a word borrowed from another language (Slate 2014, Haspelmath 2008). Most likely this is an indication that cultures that borrowed the word for coffee adopted the crop fairly recently. *Coffee*, being a new commodity, bounced from one language to another, just as the beverage was picked up from one place to another. The word *coffee* found its way into the European languages from the Turkish *kahveh*, which in turn was derived from the Arabic word *qahwah* (OED 2016). However, the origin of qahwah, which means "wine" in Arabic, is obscure. Some say the word *qahwah* refers to the Kaffa province of southwestern Ethiopia, where coffee is grown today (Weinberg and Bealer 2001). This etymology has been disputed though, since the Oromo people of Ethiopia refer to the coffee berries as *bun*. Instead, many argue that the Kaffa province was named for the bean. Other possible derivations for qahwah include *quwwa* (the Arabic word for "power"), and *kafta*, the drink made from the khat plant (Pendergrast 2010).

Nevertheless, *qahwah* was the word that spread to the four corners of the earth. Because it was the Arabic word for coffee that spread, this supported the hypothesis that Yemen was the origin of coffee drinking and, as we'll see later, the center of dispersal for cultivated coffee. As coffee spread to numerous countries and different languages, the word and pronunciation was slightly adapted to better suit the natural sounds of those languages (Slate 2014). As a result, no matter where you travel, you can almost always know when someone is offering you a cup of *coffee*.

Botanical and Genetic evidence

Even before the advent of DNA sequencing, it was well known that the southwestern highlands of Ethiopia were the home of wild *C. arabica* (Vavilov 1992, Meyer 1965). Today, studies both at the phenotypic (Montagnon and Bouharmont 1996) and genotypic levels (Lashermes et al 1996, Anthony *et al* 2002) have established southwestern Ethiopia as the primary center of origin and diversity for wild *C. arabica*.

Just as the Persians are called the first coffee brewers, Meyer (1965) regarded Yemen as the primary dispersal center of cultivated *C. arabica*. He noted that *C. arabica* cultivated in Latin America, Kenya, India, Java, and other areas was originally derived from Yemen, due to early introduction of *C. arabica* from Ethiopia (See Figure 1). As a result, Ethiopia was designated the dispersal center of wild *C. arabica*. From his documentations of wild *C. arabica* collected in the rainforests of Illubabor and Kaffa, Meyer concluded that the Arabica coffee plant was abundant and spontaneous in rainforest areas between 3000 and 6000 ft. altitude, indicating great diversity in these districts. In addition, he observed that coffee rust fungus (*Hemileia vastatrix*) and *C. arabica* coexist harmoniously in the rainforests of Ethiopia, an observation that follows Vavilov's statement of how "the center of origin of a cultivated plant is often correlated with the center of origin of associated pathogens" (Vavilov 1926).

Around 1715, coffee trees were introduced from Mocha to Bourbon Island (now Réunion), giving rise to the cultivar *C. arabica* var. *bourbon* (B. Rodr.) Choussy (Bourbon) (Haarer 1956). Along with Bourbon, another Arabica cultivar is grown worldwide: C. arabica var. arabica (usually called *C. arabica* var. typica Cramer). The Typica variety is said to have originated from a single plant from Indonesia, subsequently cultivated in Amsterdam in the early 18th century (Chevalier and Dagron 1928, cited by Anthony *et al* 2002). To identify the origin of these cultivated varieties, Anthony *et al* (2002) used amplified fragment length polymorphism (AFLP) and simple sequence repeats (SSR) to assess the polymorphism between the Typica- and Bourbon-derived accessions and accessions derived from subspontaneous trees (coffee trees collected in forests and farms of Ethiopia). They found less genetic diversity and polymorphism (Figure 2) in the cultivated accessions compared to the subspontaneous-derived accessions, supporting the fact that dissemination of coffee

and selection has reduced the genetic diversity otherwise present in subspontaneous coffee of Ethiopia. Ethiopian origin of the Typica and Bourbon genetic bases was further substantiated by the fact that all AFLP markers in the cultivated accessions, except for one, were also found in the subspontaneous-derived accessions.

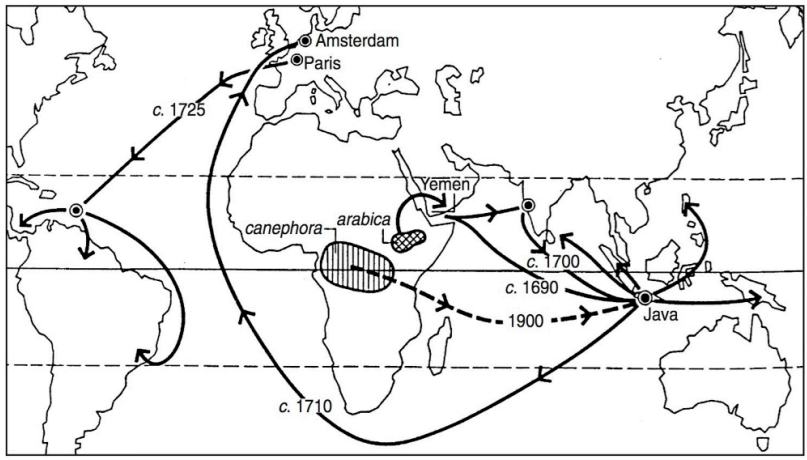


Figure 1. A map showing the distribution routes of cultivated *C. arabica* (continuous lines) and cultivated *C. canephora* (dotted lines) with the approximate years of introduction (Ferwerda 1976 cited by Gole *et al* 2001)

Classification of the AFLP markers by Anthony *et al* (2002) also confirmed the separation between coffee trees growing east and west of the Great Rift Valley, proposed by Montagnon and Bouharmont (1996). In their 1996 paper, Montagnon and Bouharmont revealed a separation between the southwestern and south- and southeastern trees, based on characterization of phenotypic traits affected by domestication. Anthony *et al* (2001) later verified their results through random amplified polymorphic DNA (RAPD) markers. Seeing that the southern and southeastern coffee trees were little differentiated from the southwestern trees, Anthony *et al* (2001) supported the hypothesis that trees in the south and southeast were introduced from the southwest. This did not, however, preclude the idea that cultivated plants might have been selected from wild-type plants east of the Rift, another hypothesis of *C. arabica* origin suggested by Montagnon and Bouharmont (1996). At the

discovery of this split, Montagnon and Bouharmont (1996) declared that a single center of wild coffee trees in Ethiopia was highly unlikely. Rather, there was a second center east of the Great Rift Valley, which may have been the source of domestication of *C. arabica* in Yemen.

To determine whether the southeastern group gave rise to *C. arabica* in Yemen, Silvestrini et al (2007) compared the genetic diversity and structure of Ethiopian, Yemen and Brazilian *C. arabica* accessions using microsatellite markers (SSR). Their analyses not only showed that accessions from Sidamo, a province in southern Ethiopia, were more closely related to cultivated plants, but also that one accession from Sidamo was grouped within the Yemen group. On top of that, they observed similarity between accessions from Yemen and eastern Ethiopia, leading them to agree with Montagnon and Bouharmont's postulation of a second center in southeastern Ethiopia.

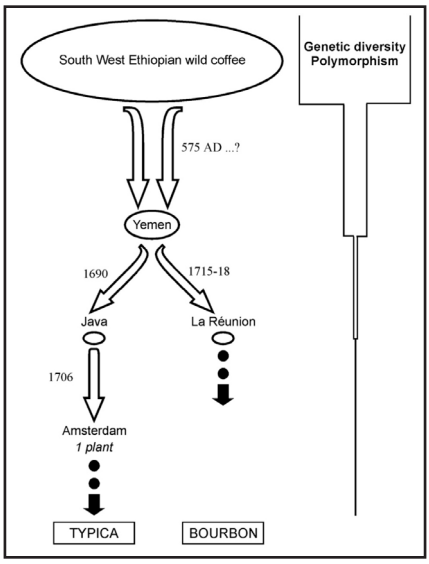


Figure 2. Schematic representation of the main steps in the history of coffee cultivation leading up to the Typica and Bourbon cultivars (Anthony *et al* 2002).

In addition to validating southwestern Ethiopia as a center of origin, the above results have suggested Yemen as one of the centers of domestication of *C. arabica*. If indeed Yemen were a center of

domestication, today's cultivated varieties of *C. arabica* should be genetically similar to Yemen cultivars. As predicted, Anthony *et al* (2002) found a number of AFLP and SSR markers present in Yemen cultivars to be similar in the Typica- and Bourbon-derived accessions. Their results fit accordingly with the historical data—that Typica and Bourbon genetic bases diffused from Ethiopian coffee introduced to Yemen (Figure 2), a center of domestication for *C. arabica* and the primary center of dispersal for coffee (Meyer 1965).

Recommended Future Lines of Research

While multiple types of evidences (historical, archaeological, linguistic, botanical and genetic) have been analyzed to trace the Ethiopian origin of *C. arabica*, archaeological evidence is still lacking. On the one hand, multiple sources affirm the strong linkage between coffee consumption and tiny porcelain/earthenware coffee cups, but on the other hand, recovery of such cups is rare. Not only would the sources of these cups help us trace the dissemination of coffee, but the cups themselves could be dated, confirming important dates in coffee history provided by other types of evidence. In addition to cups, other tools used to prepare coffee, such as a mortar and pestle to grind coffee beans, could carry valuable archaeological data. Promising excavation sites would include villages near the rainforests in southwestern Ethiopia, the Sufi monasteries of Yemen, and the trading ports of Yemen (i.e. Mocha, Aden). Any coffee-related tools found in these areas would provide useful chronological data. Archaeobotanical evidence, such as seeds, pollen, phytoliths, etc., is almost nonexistent for *C. arabica*, which is unfortunate because these remains would prove crucial in verifying conclusions drawn from genetic evidence.

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