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HISTORICAL NOTE

From forest to plantation: a brief history of the rubber tree

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Abstract

This article describes how the rubber tree (*Hevea brasiliensis*) (Willd. ex A. Juss.) (Müll. Arg., family–Euphorbiaceae) which grows wildly in the Amazon forests, came under global focus due to industrial revolution. From 1860 to 1913, since the tree was found only in the Amazon forest, the entire world depended on a few business magnates of that region for rubber. These rubber barons enslaved many local people to extract rubber from the wildly growing trees in the forest since the efforts to grow rubber as plantations failed mainly due to a devastating fungal disease. The rubber slaves recruited to collect rubber latex from the wildly growing trees in the forest went through untold misery. The economy of towns in the Amazonas such as Manaus and Belém, which were located strategically for exporting the extracted rubber by ships, boomed. This monopoly of Amazon's rubber trade crashed due to the British which itself is an intriguing story. The 'travel' of the rubber tree from the Amazon forest to the then Southeast British colonies to be grown as plantations encompasses many fields including biology, sociology, industry, economics and environment.

Keywords Amazonia · Charles goodyear · *Hevea brasiliensis* · Henry Wickham · South American leaf blight disease

1 Introduction

The natural rubber is a polymer of isoprene molecules; although rubber is produced in the form of latex by many plants belonging to different families, only one plant viz. the rubber tree is commercially exploited worldwide for rubber production because of its ability to produce the latex in large quantity. With its coagulating ability, the rubber latex protects the tree against insect pests (Sharples, 1918). The rubber latex is sticky and glues the mouth parts of borer insects and seals the wounds in leaf and bark to prevent further damage by pests or pathogens. The rubber tree (*Hevea brasiliensis*, family-Euphorbiaceae), is native to the rainforests of the Amazon which includes Brazil, Venezuela, Peru, and Bolivia. It grows to about 40 m in height and has latex vessels in its bark. When the bark of a mature tree is cut, a milky latex of rubber oozes out which is collected for commercial purposes. In *Hevea brasiliensis*, about one-third of the volume of latex is made of rubber (Tang et al., 2016). Long before the European explorers encountered rubber, the Native Americans have been using the latex of *H. brasiliensis,* which they called *ca-hu-chu* or 'the crying tree'. More than 3500 years ago, the Aztecs and Maya civilizations of the current Mexico and parts of Central America had made balls out of rubber plant latex for use in games for over 100 of years (Tarkanian & Hosler, 2011; Blomster & Salazar Chávez, 2020).

In 1770, Edward Nairne, an English engineer, accidentally discovered the efficiency of rubber to erase pencil markings on paper and sold erasers made of natural rubber at high price. Joseph Priestley (1733–1804), a well-known English Chemist, described the relevance of 'rubber' as: "I have seen a substance excellently adapted to the purpose of wiping from paper the mark of black-lead-pencil. ... It is sold by Mr. Nairne, Mathematical Instrument-Maker, opposite the Royal-Exchange (Priestley, 1770, p. xv)". Following this, the term *rubber* is used universally. Natural rubber is waterproof. In 1823, the British chemist Charles Macintosh (1766–1843) produced rainproof jackets and panchos using rubber in Glasgow, Scotland. A dispute occurs here; it is felt that Mackintosh stole the work of a surgeon James Syme. Syme's method

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of creating the solvent from coal tar was published in *Annals of Philosophy* in 1818 (Syme, 1818); this paper also describes the dissolution of natural rubber in naphtha. However, all materials made out of natural rubber turn brittle in temperatures < 10 °C and stick together in temperatures > 50 °C. Several methods including exposure to nitric acid were tried to improve rubber's weather proof capacity, but they only ended up worsening the quality of rubber (Princi, 2019).

2 Making industrially fit rubber

After several years of continuous experimentation to make usable-form of rubber, Charles Goodyear (1800–1860), a merchant from Philadelphia, in 1839 accidentally discovered that heating rubber at 120–140 °C with sulphur made it to withstand heat and cold, improved its elasticity, waterproofing ability, and resistance to many organic solvents, electricity, and oxidation. Termed vulcanization, this process enabled cross linking of rubber molecules with sulphur atoms, thus enhancing the industrial quality of rubber (Somma, 2014). The vulcanized rubber was then used for making vehicle tyres, tubes, shoes, conveyor belts, shock absorbers and insulators, rain jackets, car springs, rubber seals that enhanced the efficiency of steam engines by reducing the any leakage (Bellis, 2020; Raman & Narayanan, 2017). Goodyear did not lead a comfortable life during his investigations to make rubber more worthy. He was jailed for debt, was in poor health and his friends who initially supported his experiments, lost interest in his work. But he continued with his experiments—in and out of jail—despite being discouraged by his family and friends. His serendipitous discovery of vulcanisation is summarised by Morris in his book *Heroes of Progress in America* (1906) as follows:

> One day in 1839, a mass of gum (rubber) and sulphur he had mixed happened to touch a red-hot stove. To his surprise and delight, its character was changed by the heat and it would not melt. He tried and tested it in every way he could think of, and always with the same result. He had penetrated the mystery. The great secret was his! All that was needed was to mix the gum with sulphur and expose it to great heat. It would afterwards stand both heat and cold (Morris, 1906).

Goodyear had sixty patents to his credit before he died on July 1, 1860. Later in 1887, John Dunlop, a Scottish-born inventor and veterinary surgeon, popularised pneumatic rubber tyres. Vulcanisation and pneumatic rubber tyres were the two milestones in vastly increasing the demand for rubber in the early 1900s.

3 Rubber barons and rubber slaves

Between 1870 and 1910, the use of bicycles and automobiles increased greatly in Europe and America leading to a great demand for rubber for manufacturing tyres for these transport modes. By 1900, the annual requirement of rubber rose to ≥ 40,000 tons—most of which was imported from the Amazonas (the largest state of Brazil), where rubber tree was available wildly in the rain forests.

In 1860–1913, the Amazon forest was the only source of rubber for the world and the economies of the cities Belém and Manaus in Brazil and Iquitos in Peru boomed (Resor, 1977). In 1909, rubber, equivalent to today's value of > US $2 billion, was exported from the Amazons (Barham & Coomes, 1996). Since attempts to raise rubber tree plantations failed, the rubber tappers had to go deep in to the forests to locate wildly growing trees and tap them for the latex. Furthermore, the trees could be tapped for latex only in August–January. These restrictions for rubber extraction in the wild were a gruelling task for the tappers. Hence, as the global demand for rubber increased, 1000s of native tribes of the Amazons were enslaved by the rich European traders-the rubber barons—for tapping rubber. The rubber tappers (*seringgueiros*) were either unpaid or paid meagre for their hard labour, treated cruelly, and even killed when they failed to meet their employer's demands in collecting and transporting rubber from the forest to the riverfront (Hardenburg, 1913). Roger Casement, a British consul who travelled through the Putumayo region of Peru from 1910 to 1911 stated, '"The crimes charged against many men now in the employment of the Peruvian Amazon Company are of the most atrocious kind, including murder, violation, and constant flogging" (Hardenburg, 1913). Many indigenous rubber tappers died either due to malaria or yellow fever and were replaced by the many tribal people captured from other parts of the Amazonas (Griffing et al., 2015).

Manaus, a town in the middle of the Brazilian forest, topped rubber export due to its slightly lower export tax. Moreover, it was close to the merging point of the tributaries Negro and Solimões of the Amazon River thus making it cheaper for rubber export. With the rubber boom, the social and economic status of Manaus underwent a drastic change. The rubber barons of Manaus made much money during the rubber boom (Furneaux, 1969). Manaus was supplied with electricity before many European cities and led the world in the purchase of diamonds during the rubber boom. The hallmark of the luxurious life of rubber barons was the Amazon Theatre (Teatro Amazonas). Steel walls and gates for constructing the theatre were imported from England, glass from Bohemia, and marble from Italy. Hollow vibrating columns of Scottish cast iron in strategic locations in the hall improved the acoustics. The main road in front of the theatre was lined with rubber to defuse the sound of traffic so that the patrons could enjoy the performance without disturbance.

4 The crash of rubber hedonism

All this hedonism of the rubber barons and untold sufferings of the native people were due to just one plant and its restricted distribution. In the year 1876, Henry Alexander Wickham (1846–1948), an English adventurer and planter smuggled 70,000 seeds of rubber tree from Santarém in Brazil to the Royal Botanic Gardens, England (Grandin, 2009) and presented them to its then Director, Joseph Dalton Hooker. Although the rules were not strict in those days to get an export permission, it is said that Wickham declared to the Brazilian authorities that he was exporting 'exceedingly delicate botanical specimens specially designated for delivery to Her Britannic Majesty's (Queen Victoria 1819–1901) own Royal Gardens of Kew' (Gollin, 2008). Many consider this act of Wickham as biopiracy, but a few suggest that Wickham used this expression to convince the authorities since the Brazilian regulations existing then did not prevent the dispatch of seed (Lane, 2008). Of the 70,000 seeds exported by Wickham, only nearly 2000 germinated in the Royal Botanic Gardens, Kew. The British sent them to tropical South-east Asian colonies of Britain for cultivation. Although this effort of Wickham was funded by the India Office in London, the seeds were not sent to India (Raman & Narayanan, 2017). Later, the plantations spread to many British colonies including British Borneo (Borneo), Burma (Myanmar), and India. The rubber tree which could not be raised in plantations in its place of origin, thrived successfully in plantations in these British colonies. A few years later, rubber plantations in these colonies began to supply more than the 90% of the global requirement of rubber (Jackson, 2008). Thus, the rubber monopoly of Brazil collapsed in 1914 (Lawrence, 1931) and ended totally by 1940 by this act of biopiracy by Wickham.

5 Rubber in Asia

Although the rubber tree belonged to the Amazon basin, the production of rubber from Asian countries including Thailand, Indonesia, Vietnam, Sri Lanka, and Malaysia, where it was introduced was phenomenal. Establishment of rubber plantations drastically changed Malayan economy and resulted in a huge in flow of migrant workers. The Gross Domestic Product (GDP) per head in 1929 was the highest for British Malaya among other Asian countries (Huff, 2003). The one main reason for this was the availability of a range of plantation methods owing to the diverse cultural practises of the local population (Corey, 2017). In the Amazon forests, no plantations existed and rubber could be tapped only from wild trees which were growing disparately in the rain forest. The failure of creating plantations in the Amazon basin is ascribed mainly to the South American leaf blight (SALB) disease caused by the fungus *Pseudocercospora ulei* (Ascomycota: Capnodiales: Mycosphaerellaceae) (Furtado et al., 2019). SALB was reported for the first time in 1904 on wild rubber trees of Upper Amazon, close to the border of Peru and Brazil (Stahel, 1917). The fungus infects rubber trees of all ages and causes leaf necrosis (death) followed by severe defoliation leading to the death of the trees (Heng & Joo, 2017). Although the pathogen is native to the Amazon Basin, it spread throughout South America wherever rubber plantation was developed, since the climatic conditions of South and Central America were favourable for the development of the disease. Various measures to control SALB including chemical, biological and breeding for resistance have failed; hence, rubber production on a commercial scale in these regions suffered (Lieberei, 2007). An estimate shows that in 2018, 91%, 7% and 2% of natural rubber was produced by Asia–Pacific, Africa and Latin America respectively; such a low output by Latin America was primarily due to SLAB disease (Sterling et al., 2019). Although rubber plantations flourished in Asia, the story of woes of rubber tappers was repeated here also. In the 1880s and 1890s, migrant workers mostly from southern India and Malaya (Malaysia) who were recruited for plantation work in rubber growing Asian countries faced many difficulties. Malaria was a major concern since the migrants especially from southern India were highly susceptible to this scourge. With the poor sanitary conditions existing in the plantations then, the death rate of the migrant workers was about 8% in some plantations (Amrith, 2014). During 1926 and 1927, it was recorded that in 11 of the 20 biggest plantations in various parts of Indochina, the death rate fluctuated between 12 and 47%; in 1927, 17% of young men workers died in plantations of Phú Riềng, (Vietnam) (Panthou, 2014).

6 Environmental concerns

Rubber in Asia has brought in environmental and economic concerns too (Ziegler et al., 2009). Nearly 89% of the world natural rubber production comes from plantations covering more than 10 million ha in Asia (FAO, 2017). All the rubber trees of Asia's plantations have emerged from the few rubber seedlings acquired by Wickham from Brazil. Thus, the genetic base of Asian rubber is limited which has been further reduced by the polarised selection and breeding for productivity as against disease resistance. Years of selective breeding focused mainly on increasing the rubber production from 650 kg/ha during the 1920s to 2500 kg/ha in the 1990s (Tang et al., 2016) has resulted in the partial loss of disease tolerance trait. This is compounded by the fact that an effective and economic control measure for managing SALB disease is still not known. Furthermore, little is known about the epidemiology of the disease (Guyot & Le Guen, 2018). Selective breeding of rubber for resistance to SLAB and concomitant high yield is challenging due to the quick evolution of virulent strains of the pathogen which could infect resistant rubber plants, its ability to survive as resistant spores during unsuitable months and to initiate new epidemic during more suitable climatic conditions (Guyot & Le Guen, 2018). Hence caution is needed to prevent the establishment of SLAB, which if happens would result in an epidemic (Nair, 2010).

With the planting of rubber in non-traditional areas, rubber plantations which covered more that 1 million hectares in 2012 in Cambodia, China, Laos, Myanmar, Thailand, and Vietnam are likely to increase four-fold by 2050. This would result in the loss of forest cover (Fox et al., 2012) and biodiversity. Although some argue that since rubber being a tree crop, it could aid in carbon sequestration, it appears that rubber plantation is not any superior to the traditional cultivation methods which it replaced in many regions (Fox et al., 2014). Plantations represent monocultures of single plant species. Hence, the diversity of life (micro and macro organisms) associated with the plantation crop is bound to be less than that existing in a high plant diversity supporting forest. Thus, the interactions between the plant and its associated microbes in rubber plantations are lesser when compared to tropical forests indicating a decline in environmental quality brought about by the plantations (Singh et al., 2021).

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Data Availability Data will be made available on request.

Declarations

Competing Interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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