Understanding the Prehistoric Presence of the Sweet Potato in Polynesia: An Investigation on Seed Floatability and Viability

Research Thesis

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by

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Introduction

Food is the ultimate resource for human survival. Food holds the power to bring forth development, cultivate trade, uproot societies, and begin wars. The power of this resource is felt across the globe and throughout all societies. In Central and South America a staple food crop is the sweet potato (*Ipomoea Batatas)*. It is generally accepted that this sweet potato was domesticated in Central or South America, as its earliest found remains were identified in Peru dating back to 8000 BCE (Engle, 1970). The sweet potato I look at in this investigation has strong lineage to the Americas with its closest living relative, *Ipomea trifada* coming from the Carribean, Central, and South America (Roullier et al., 2013). Despite being a native South American crop the sweet potato is a staple in Polynesia as well. It has cultural and culinary value in Polynesian societies going back hundreds of years; yet, archeological remains indicate that the crop was present on some Polynesian islands 1000 years before any contact with Europeans (Green, 2005; Kirch, 2000). Additionally, newer evidence suggests that I. Batatas may predate human colonization of Oceania entirely (Muñoz- Rodríguez et al., 2018. This leaves us with the question, how did the sweet potato arrive in Polynesia?

There are multiple theories present in literature identifying possible human and natural dispersal mechanisms. In this paper, I will share my findings that aim to test components of the natural dispersal theory of a Trans-Pacific oceanic drift. However, the results from the investigation imply that it is highly unlikely that seed capsules alone could have made this Trans-Pacific drift. The investigation aims to understand if sweet potato seed capsules can maintain buoyancy and how seawater conditions may impact their viability to germinate. I will begin by taking a deeper look into the history of the crop, as it has been found that there are three distinct lines of which the sweet potato can be classified. I will then explain the implications the crop holds for development insofar as its nutrients and durability. Next, I will identify and explain the contending theories that attempt to answer our question as well as evidence supporting these theories. Finally, I will go over my experiment and discuss the results and conclusions that can be made.

History of Sweet Potato Crop

Austin (1988) postulated that the sweet potato was domesticated in the Americas; however, the exact origin of the crop is not as easy to define as there is no consensus agreeing upon a wild ancestor. However, by use of numerical analysis Austin, (1988) was able to hypothesize that the center of origin was likely to be between the Orinoco River in Venezuela and the Yucatán Peninsula in Mexico. Engle (1970) postulates that the sweet potato was likely domesticated in Northern Peru, as its earliest found remains were identified in the Chilca Canyon around 8000 BCE. Most recently, Muñoz- Rodríguez (2018) has looked at phylogenies to understand the origin of the sweet potato. His molecular and phylogenetic analysis suggests that the sweet potato evolved from a single ancestor, *Ipomoea trifida,* which can be traced back to the Americas (Muñoz- Rodríguez et al., 2018). The author's work identified *Ipomoea trifida* as the most probable progenitor for the sweet potato and stated that it likely had a dual role in the origin of the sweet potato (Muñoz- Rodríguez et al., 2018). This analysis could point to the potential likelihood of the sweet potato arriving in Polynesia through long-distance dispersal in pre-human times.

From this biological background, it is useful to look at the three different lines of dispersal of the sweet potato. Linguistic evidence points to three distinct lines in which the sweet potato was dispersed: the *kumara* line, the *batata* line, and the *camote* line (Zhang, 1997). The kumara line, comes from the Quechua name and Polynesian word *kumara*. Dispersal of this line is uncertain but some believe that Polynesian or Peruvian voyagers are responsible for its presence in both South America and Polynesia as it is found in both regions and is a valuable food crop to both cultures. However, this theory of dispersal is has been weakened by recent findings (Muñoz- Rodríguez et al., 2018) and there is growing agreement that non-human long distance drift could be responsible. Next, the batata line dates back to the voyages of Columbus in 1492, this resulted in the introduction of West Indian sweet potatoes in Western Europe (Zhang, 1998). Here, Portuguese explorers dispersed sweet potatoes that were grown in the Mediterranean to Africa and Asia around the 16th century, with evidence of records of the plant in China in 1594 and Japan in 1698 (Zhang, 1998). Finally, the camote line, was transferred between Acapulco, Mexico, and Manila, Philippines around the 16th century. These were Mexican sweet potatoes dispersed by the Spanish.

Today, the sweet potato is the seventh most produced food crop in the world (CIP) Notable is that 80% of the sweet potato's produced come from Asia, 15% from Africa, and 5% in the rest of the world, it is stated that around 98% of the production comes from developing countries (CIP). The sweet potato can grow in tropical, subtropical, and warm climates and is highly adaptable to marginal land (Zhang, 1998). This not only makes it a vital crop for many cultures and cuisines but also important to the economic development in the global south. Additionally, the sweet potato is highly nutritious and is ranked as one of the healthiest vegetables due to its high concentrations of Vitamins A and C, iron, potassium, and fiber (CIP). Sweet potato also contains Beta carotene, a pigment found in orange varieties of sweet potatoes. This pigment is very important to human nutrition, particularly children who suffer from vitamin A deficiencies, a common deficiency of those living in less developed regions (CIP). Because of the sweet potato's extreme durability and nutrition it can be assumed that the crop has potential for preventing malnutrition and food insecurity in the developing world.

Contending Theories of Dispersal

The predominant discourse of this topic acknowledges both human and natural dispersal theories. Human dispersal would happen in one of two ways: two-way trip conducted by sailors from Polynesia or South America. These voyages could have intentionally or unintentionally spread the crop. These will be explained further in the following section. There are also theories of natural dispersal that have been discussed as well. These include the ocean drift hypothesis and the migratory bird hypothesis. In this paper, I will be testing certain aspects of the ocean drift hypothesis and sharing my findings.

Human Dispersal

South American Voyages

As our knowledge regarding Polynesia and South America grows the consensus that humans mediated interactions between South America and Polynesia at some point dwindles. With technological advancements and the findings from Muñoz-Rodríguez (2018), Pereira (2020), and John Temmen[1], the consensus seems to be weakened. Specifically, in the case of Muñoz-Rodríguez' findings it appears that the introduction of this specific crop is highly unlikely to be brought about by humans. Nonetheless, there are several theories that attribute the spread of the sweet potatoes to humans.

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[1] These findings will be discussed further in the section regarding natural dispersal

Thor Heyerdahl made quite a spectacle of the question- who colonized Oceania?- in the 1950s. Heyerdahl was a Norwegian explorer who embarked on a 101 day journey with a crew of five men and a traditional Peruvian balsa wood raft. He gathered materials from the Andes and used only that to craft the most accurate depiction of what native people would have used during the ancient Incan empire during the 13th century (Heyerdahl et al., 1956). On his successful journey, Heyerdahl was able to put some questions to rest that caused so many to disapprove his journey. For example, while riding on a balsa wood raft many feared that access to food would be difficult given the technologies of the Peruvian people at the time; however, because of the lack of a motor Heyerdahl and his crew were able to successfully spearfish from the boat and eat flying fish that landed on the boat during the night (Kon-Tiki, 1951). Many also feared that the ocean drift and sail would be unable to land the raft in Polynesia but after 101 days the Kon-Tiki made landfall at the Tuamotu Archipelago (Heyerdahl et al., 1956). This is all to say that the people of this region may be capable to make this journey but the experiment itself is flawed with confounding variables and flimsy design. Additionally, Heyerdahl made no attempt to sail back to South America which makes the likelihood of this journey dispersing only seeds more unlikely. This said, our ever increasing knowledge regarding sweet potato dispersal have allowed us to move on to 'newer' and more historically accurate theories than that of the Norwegian explorer.

Upon modeling vessel drifts coming from Northern Chile and Peru, Montenegro (2008) found that there was a relatively high probability that vessels could make it to the Marquesas and Tuamotu. However, it is notable that survival of humans would not necessarily be required if this were the case. The vessel carrying the seeds could have made landfall on an inhabited island and natives could have planted the seeds themselves (O'Brien, 1972). The ability to sail this duration is attributed in part to the trade winds that exists during normal ocean conditions, trade winds blow west and take warm water from South America to Asia (NOAA, 2009). However, the El Nino-Southern Oscillation (ENSO) cycle known as El Niño and La Niña are opposing climate patterns that cycle break these normal conditions (NOAA,2009). El Niño and La Niña are thought to occur every 2-7 years on average but are not documented to occur on a regular schedule. For the purpose of the investigation it will be useful to note that El Niño years cause trade winds to weaken and push warm water back towards the America's while La Niña years have an opposite effect in which trade winds are stronger and push much more warm water towards Asia (NOAA, 2009). All theories of dispersal could therefore be impacted by the ENSO cycle and trade winds.

Polynesian Agency

Before I introduce the theory of Polynesian agency it is useful to understand a brief history of colonization in Polynesia. Our current knowledge of Polynesian settlement indicates that it occurred as a series of increment and rapid expansions interspersed by "long pauses" (Montenegro et al 2007). The arrival of humans in Oceania occurred during a period in which sea levels were much lower and the land masses of Australia, New Guinea, and Tasmania were connected forming a continent called the Sahul, around 60,000- 40,000 years before present cal BP (Stringer, 2000). Notable is that the Sahul was not connected to East Asia in this time period so settlers are likely to have been decent seafarers with at least basic maritime technology (Montenegro et al, 2007). Next, the Bismarck archipelago, a series of islands on the North-Eastern side of New Guinea and separate from the Sahul were reached by humans around 35,000 cal BP (Kirch, 2000). The Solomon islands are believed to have been reached in the Pleistocene as well (Montenegro et al. 2007). Lastly, the Santa Cruz and Vanuatu island groups as well as the remainder of Oceania were not settled until much later, around 3,200 cal BP (Montenegro et al. 2007). Around 3,500 cal BP, a new culture appeared in Oceania in the Bismarck archipelago: the Lapita culture (Kirch, 2000). The Lapitas, believed to have come from Taiwan, rapidly expanded through remote areas of Oceania and established settlements in the Santa Cruz Islands, Vanuatu, New Caledonia, and the Loyalty Islands (Sand, 2000). Following the expansion and settlement of the Lapitas there was a long pause of their expansion which lasted between 500-1,700 years (Irwin, 1998); however, newer evidence implies that this pause could have lasted longer (Hunt and Lipo 2006).

Two-way voyaging expeditions have been well documented in many island nations as the drive to expand and explore has been ever-present and the stories that followed have been passed down through oral traditions (Harburg, 2013). Polynesia is made up of many distinct island nations and each hold their own myths explaining their arrival in the Pacific. In many of these stories it is common to hear of daring sailors. Perhaps, these daring sailors could have been responsible for facilitating trade with South Americans. The Maori, which brought the sweet potato with them during their migration to New Zealand in the 13^{th} century mention the crop in some of their traditions and myths; however, aside from them there is very little mention of the sweet potato in Polynesian cultural practice (Harburg, 2013). There is also no known oral or historical evidence that indicates a meeting with South Americans or if a great journey across the Pacific even existed (Harburg, 2013). However, it is possible that Polynesians were responsible for the eventual spread of the sweet potato throughout the Pacific.

Evidence Supporting Theories of Human Dispersal

There is linguistic evidence that supports the theory of human facilitated dispersal. The word meaning sweet potato is remarkably similar in some Polynesian languages and a regional dialect of the Peruvian originated language Quechua. In Quechua the word for sweet potato is Cumal or Cumar, in Samoan it is Umala, in the Marquesas it is Kuma'a, in Hawaiian it is Uala, and lastly, in Maori it is Kumara (Harburg, 2013). It is almost undeniable that all of these words sound and look similar. It is as though these words are all cognates or 'loanwords' for sweet potato.

Loanwords are coined when a culture encounters something new and are in need of a name for it. It is common for these cultures to loan or take a part of an existing word from another culture to come up with their own new term- Cumal to Kumara. Because the Marquesas and Maori word for sweet potato are closest to the Quechua word it could be presumed that the peoples may have had contact (Harburg, 2013). All of this aside, there is one culture who has deified the sweet potato to the extent that it is a part of oral traditions and mythology.

The Maori people settled in the Pacific in 1250 CE when they arrived in Aotearoa (Fischer, 2002). They are the only known people of Oceania to bring the sweet potato into their mythology which has some compelling implications for the project of understanding the sweet potato in Polynesia. The Maori-maintained website from Maori.org.nz describes the myth of the sweet potato. The Maori see that the god Rongo was the original parent and guardian of the sweet potato or Kumara, this being expressed in the saying, *"Ko Rongo-marae-roa te putake o te kai, o nga hua o te whenua."* (Rongo-marae-roa was the origin of food, of the fruits of the earth) (Maori.org.nz). The myth goes on to explain that Rongo was given the kumara from his brother

Whanui, or the name of the star known as Vega which is connected to the harvest of the sweet potato. Later, Rongo's wife Pani gave birth to the kumara in the river.

As time passed the sweet potato still has great tribal importance in Maori culture. They still have a god dedicated to the Kumara and have short proverbs that encourage humbleness and leadership related to the sweet potato (Harburg, 2013).

Natural Dispersal

Birds

Insofar as natural dispersal mechanisms, the theory that birds could have potentially spread the sweet potato to the Pacific Islands is not well documented. Birds can be held responsible for the dispersal and introduction of many seed crops in Polynesia. However, there are some reasons that indicate this would have been highly unlikely in the case of the sweet potato.

When a bird ingests a plant it is common for it to consume and digest the seeds as well. The likelihood of germination of the seed increases during a process that happens in the birds stomach called scarification[2] (Roland B Dixson, 1932). Because of this, it is likely that birds are responsible for the dispersal of sweet potatoes within and around Central and South America (Harburg, 2013). This would explain the phenomenon of different groups of people and civilizations cultivating the crop further. However, due to the enormous distance between South America and Polynesia it is unlikely that this theory would apply.

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[2] Sweet potato capsules require scarification in order to germinate and are otherwise viable for over 20 years (Pereira, 2020). However, it is notable that the process of scarification does not need to occur within the digestive system of a bird but just means the scratching of the outer layer of the capsule. This can be done in lab or through any other natural means of scratching.

There are many birds that have migration patterns taking them to and from Polynesia, including Pacific Golden-Plovers, Bristle-thighed Curlews, Ruddy Turnstones, and Wandering Tattlers (Montenegro, 2008). It would be possible for these birds to make non-stop migrations that span this distance but to do so without defecating would be extremely unlikely and perhaps impossible. Another reason this is theory falters is due to the simple fact that other seeded plants native to south America do not show up in archeological record as well (Harburg, 2013).

Ocean Drift

The final theory of natural dispersal employs the current of the ocean and the circulation patterns that might have been able to link South America and Polynesia. The coconut was spread through similar mechanisms, though shorter distances, but it could be posited that the sweet potato could drift via ocean current (Harburg, 2013). The sweet potato's seed is held within a pod or capsule that has a durable exterior. Each capsule holds around 1-3 seeds and are able to maintain buoyancy. Because of this, Purseglove (1965) theorized that the seed could have drifted to Polynesia via ocean current. However, Sauer (1993) argues that this would be unlikely. The journey from Western South America, Peru or Chile to the closet Polynesian island would take around 120 days (Montenegro, 2008). Montenegro (2008) found that the minimum journey for seed pods to cross the Pacific and land in Polynesia would be 120 days. This near the maximum amount of time coconuts are able to remain viable in seawater like conditions (Montenegro, 2008). Prior to and during my experiment, there has been no tests to see if the capsules could remain buoyant for this duration or if seawater would impact the seeds viability to germinate. However, Pereira et al recently published work attempting to show how sweater exposure may impact sweet potato seed viability. Despite this, it could have also been possible that the seed pod or tuber attach itself to a natural mat or floating debris.

Evidence Supporting Theories of Natural Dispersal

As technology improves the evidence pointing towards the plausibility of natural dispersal has increased considerably. In the past 3 years alone the work of Muñoz-Rodríguez et al. (2018), Pereira et al. (2020), and John Temmen (2020) have given much greater insight into the origin of the sweet potato and its viability after a long-distance trans-pacific drift. Muñoz-Rodríguez et al. (2018) published research regarding the genetic origins of the sweet potato which contradict many theories relating to human dispersal. The authors use nuclear data that estimates a divergence time between sweet potato lineages which indicate that I. batatas was present in the region at least 111,500 years ago, predating human colonization of Oceania; thus, refuting all theories of human mediated dispersal (Muñoz-Rodríguez et al., 2018).

Next, we can look to the recently published work of Pereira et al. (2020), which investigates the viability of sweet potato seeds after incremental immersions in seawater conditions. The authors immersed and tested four groups of seeds for their viability to germinate: no immersion (control), 30-day immersion, 75-day immersion, and 120-day immersion in seawater (Pereira et al., 2020). John Temmen's model has shown that the minimum drift time for seed capsules to make it from South America to Polynesia would be around 82 days (Temmen, 2020); therefore, Pereira et al.'s work is useful in testing viability after this duration of drift. Their results indicate that throughout a 12 day germination period 100% of the seeds (from control and immersion groups) germinated. Hence, supporting the sea drift natural dispersal theory.

Experiment

The experiment that will be described in this essay attempts to test the theory of natural drift dispersal in which seed pods could have potentially drifted via ocean circulation and landed in Polynesia. This investigation occurred in partnership with the numerical drift modeling investigation by John Temmen. Temmen ran numerical drift modeling to identify the number of days required to make landfall, determine the likelihood of landfall occurring, and locate where the landfall may be the most probable.[3] In order to run the experiment there was a two part investigation on floatability and viability after being exposed to seawater conditions. The float test aimed to answer: how long could sweet potato seed capsules remain afloat in water. As stated in the previous section, it is known that the capsules are capable for buoyancy but duration was still unknown. Second, a viability test, which would further our understanding of the impact that seawater may have on the seeds viability and potential to germinate.

Methods and Materials

The goal for the physical experiment was to closely replicate the surface oceanic conditions of the Pacific. In preparing for this experiment various items were needed. First, sweet potato seeds were received from the USDA's Seed Repository in Griffin, GA and seed capsules from Louisiana State University's (LSU) Sweet Potato Research Station. To contain the experiment, clear, polycarbonate, food grade containers (13.5 liters) were used to hold the seawater. Next, using a long clear PVC pipe 8 cylinders were cut to hold each set of seed pods creating eight experimental units (see figure 1). A water heater was set to mimic ocean

[3] I will be sharing the results of Temmen's numerical drift models as they are directly relevant but I give full credit to him for this component of the investigation.

temperatures of the Pacific (~30° C).[4] Because of low seasonality across the study area a consistent temperature was acceptable. Additionally, a water filter[5] was set to keep the water flowing so each cylinder experienced the same environmental conditions by circulating water temperature, aeration and maintaining cleanliness. Once the experimental setup was complete, a dye test was run to ensure desired circulation was present (see figure 1).

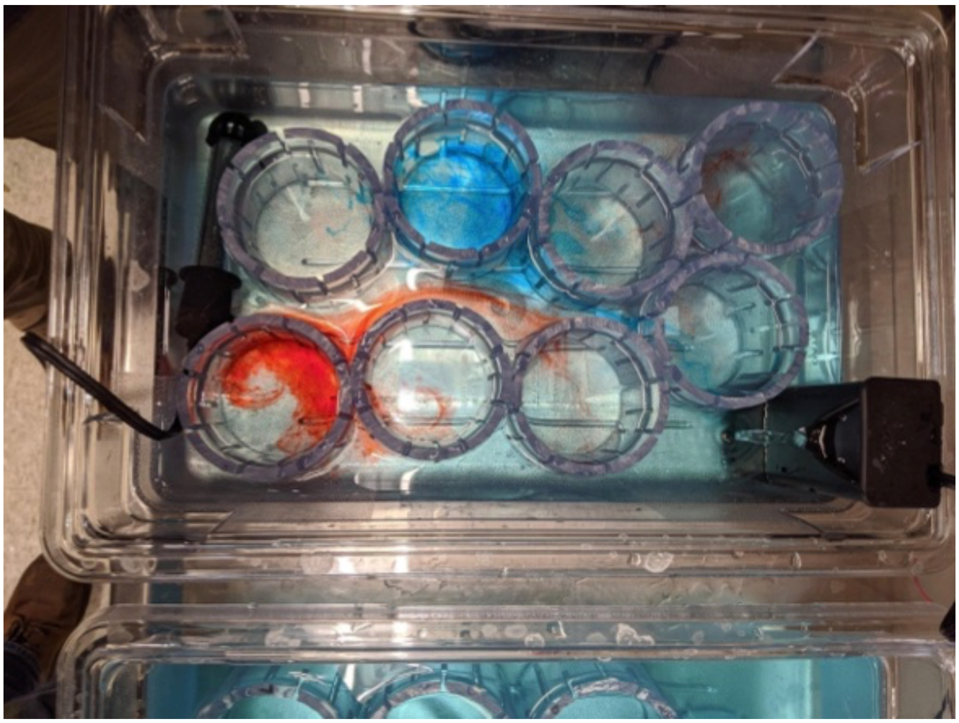

Figure 1: Red and blue dye placed at opposite ends of container in order to visually inspect water circulation.

After the desired circulation was met the environment was manipulated to match the ocean surface conditions as closely as possible. The equipment was first removed and cleaned well with distilled water. Next, a 1000 ml beaker was mixed with Instant Ocean aquarium sea

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[4] The heater used was a 50-Watt Aqueon aquarium heater that had a preset temperature of ~25.6° C, the submerged heater used a sensor that monitored the water temperature to assure that temperature was constant
[5] The water filter used was an Aqueon Quiet Flow E Internal Power Filter for 3 gallon aquariums.

salt to closely match the salinity of ocean water. 3.45 g of Instant Ocean was measured with an electronic scale and thoroughly mixed with 100 ml of water to achieve a salinity of 34%-35.5% which reflects the average sea surface salinity from Di Lorenzo et al. (2015). The concentrated salt solution was then added to the container to ensure desired salinity was present in the experimental container. The salinity was measured daily to ensure standard conditions throughout the experiment. In addition, grow lamps were used to mimic the natural sunlight of the ocean and were set for a 12 hour on and off cycle.

Once the capsules were in the water the number of capsules remaining afloat, water salinity, pH, and temperature were record daily, at around the same hour (9-10 am). Two methods were adopted for the temperature measurements, a mercury thermometer and a thermistor, with the former used for measurements inside each cylinder. Containers were replenished with freshwater, as needed, to account for evaporation and maintain a consistent salinity. The experimental unites (cylinders) were rotated by position to account for any variabilities between different regions in the tank. In logging for our records, the capsules were to be recorded as floating, sunk, or neutral buoyancy which occurred if the capsule was completely submerged but not touching the bottom of the container. Once a capsule had sunk completely it was removed and placed in a petri dish which corresponded to the specific experimental unit it had come from. The experiment continued until the final seed pod sunk at T=40 days.

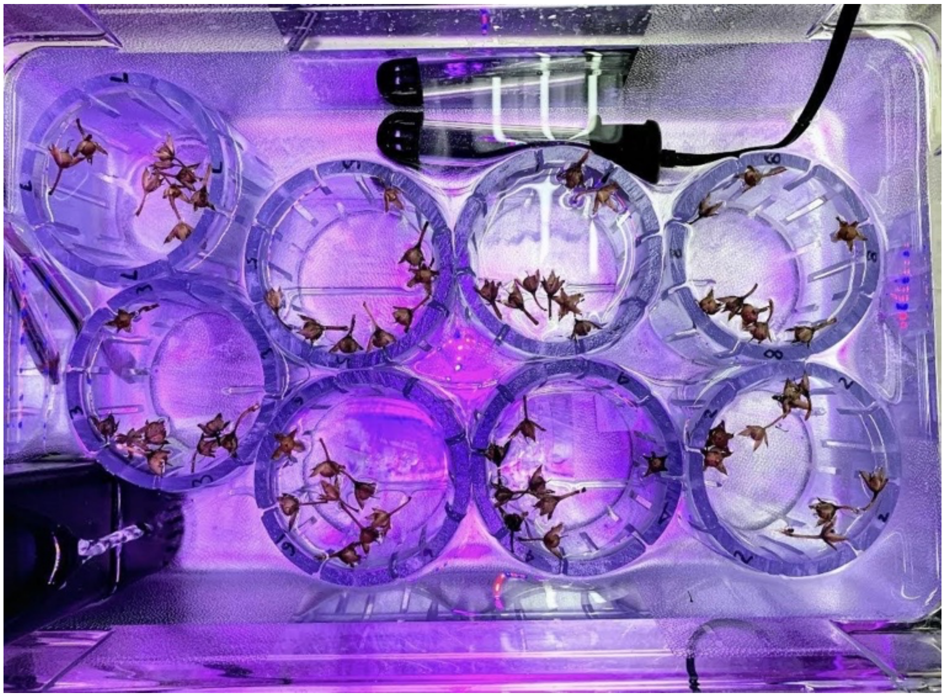

Figure 2: Photo of the experimental design. Eight quadrants each holding eight pods.

Following the initial buoyancy experiments were the sweater exposure experiments. Because it was determined that the capsules could not maintain buoyancy after 40 days, in order to prolong seawater exposure makeshift vegetative mats were used to assist floatability. There were three experiments run in order to test saltwater exposure, two of which were conducted on the seeds from the LSU Sweet Potato Research Station and one trial on the seeds provided by the USDA.

For this experiment, natural sponges were used to mimic a vegetation mat; in order to ensure the seeds did not get stuck in the sponges they were wrapped in gauze[6] and then placed on top of the sponge. This design allowed seeds to maintain contact with both the saltwater and the surrounding air (see figure 3). Environmental conditions were monitored in the same fashion as

[6] The gauze used was 5x5 cm medical grade cotton gauze

the buoyancy experiment. Due to the COVID-19 pandemic, checks were done every 2-3 days and the gauze was changed (as needed) around 3 times or every 40 days throughout the experiment. After 121 days, 256 seeds were removed from gauze, left to dry, and sent to undergo viability testing at the Montana State Seed Testing Lab.

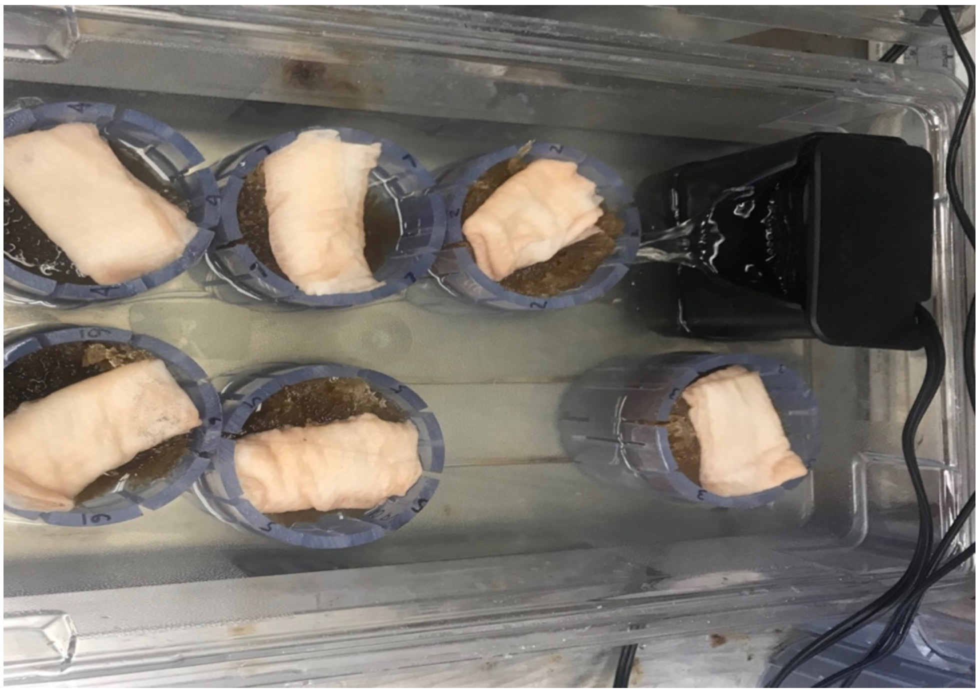

Figure 3: Saltwater exposure experiment shown with natural sponge and gauze

The next component of the investigation was viability testing. This was done through the use of Tetrazolium Chloride (TZ) tests. In order to test our seed viability we contacted Montana State Seed Testing Lab in Bozeman, Montana. A total of 256 seeds underwent Tetrazolium Chloride (TZ) tests. Tetrazolium Chloride (TZ) tests consisted of the seeds being sliced and injected with Tetrazolium Chloride. Depending on how the seed reacts to the solution indicates if the seed is viable for plant growth. Results are indicated by a pink-ish color change (shown in figure 4).

Figure 4: Preliminary results from TZ tests showing color change of viable seeds.

In regards to the numerical drift model there are a few components necessary to know in order to understand the results of Temmen's investigation. First, departure points were determined, Temmen (2020) found that 285 departure points, 1 departure every 5 days, from 34 years of data (1979-2012). The oceanic drift models were then conducted on MATLAB. Temmen used Wind Data from ECMWF's ERA interim reanalysis product and Ocean Current Data from ECMWF's Global Ocean Physics Reanalysis ORAP 5.0. He also integrated a drift parameter from Van der Stocken et al. 2013, 2015. Lastly, the drift parameters were on a 0.25° x 0.25° grid with a study area of 160°E, 50°S, 70°W, 30°N.

Results

The results from the floatability experiment are shown in figure 5. The graph below shows the change in number of floating capsules over time. No capsules remained floating beyond 40 days. On average, capsules remained afloat for 19 days and the first capsule to sink did so after 7 days.

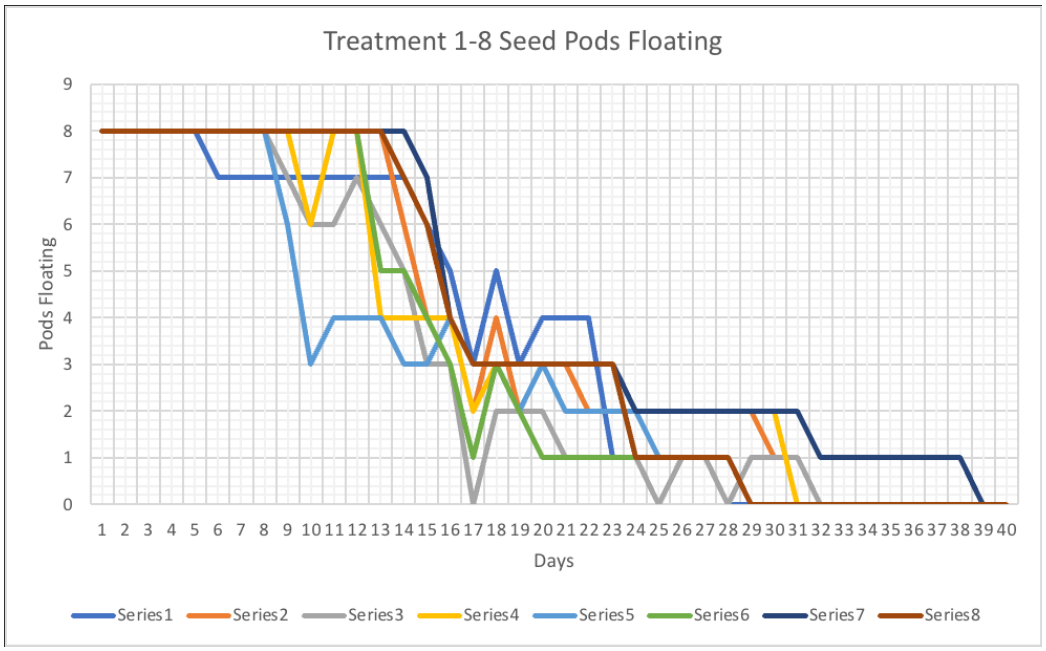

Figure 5: The above graph shows the average rate that each capsule sunk for each sample over a span of 40 days

The results from the Montana State Seed Lab indicated that after 120 days of seawater exposure, the viability was reduced. From the 256 seeds that underwent a TZ test, 59 were deemed viable. This showing that after four months in seawater-like conditions sweet potato seeds experience an average 65% reduction in viability. This data shows a significant reduction in viability after prolonged contact with seawater which contradicts the findings of Pereira et al. However, there were many differences in experimental design between our experiments and both experiments ultimately corroborate the notion that there is some viability intact after seawater exposure.

The results from Temmen's investigation indicate that the minimum voyage from South America to Polynesia would be 82 days with a landfall probability of 19.62% (703440 hits out of 3,585,300 simulated voyages) (Temmen, 2020). The results are shown in figure 6 and 7.

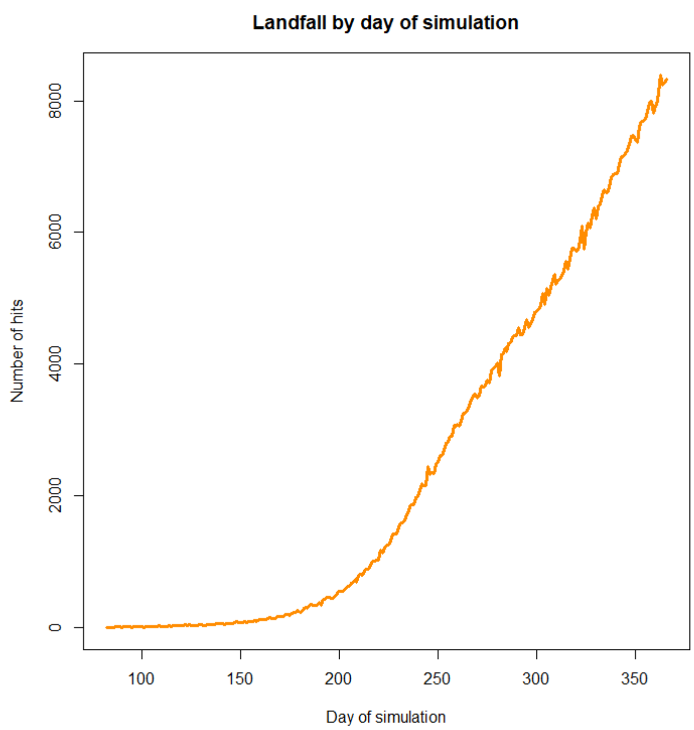

Figure 6: Results of landfall by day simulation (Temmen, 2020)

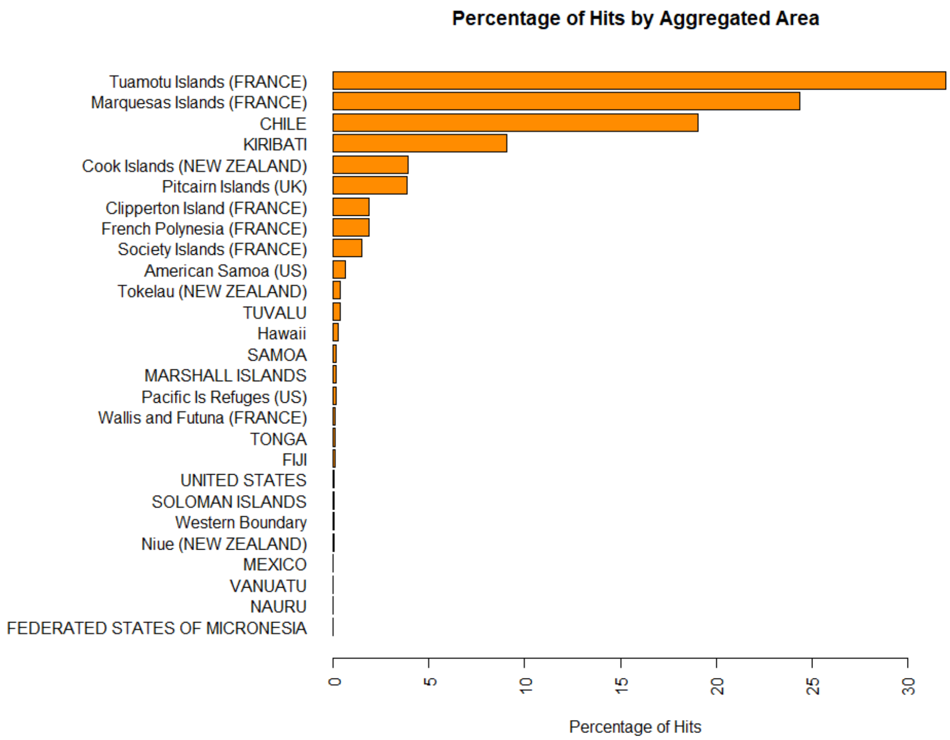

Figure 7: The % of seeds that arrived to specific Polynesian islands (Temmen, 2020).

Conclusion

Before I discuss the findings from these experiments I will address some shortcoming that must be considered. The goal of the buoyancy and exposure experiments was to closely mimic the conditions of the Tropical Pacific as possible. With this being conducted in a basement lab in Ohio we were surely unable to match the conditions perfectly. For example, in Pereira et al's experiment they were able to use natural ocean water whereas we had to use an aquarium blend. Additionally, a water filter in no way mimics the tumultuous nature of the ocean's waves and currents. Because our experiment happened in a lab one of the most notable uncontrollable conditions was that the salinity was nearly always higher than our intended 34%, due to evaporation.

The findings of this investigation indicate a number of implications regarding a theory of long distance natural dispersal. First, the buoyancy experiment allows us to reject that seed capsules could remain buoyant for any period necessary for a trans pacific drift. Temmen's models suggest the minimum amount of time to reach Polynesia would be around 80 days, with all capsules sinking within 40 days it can be posited that capsules alone would be unable to make this journey. Because all of the capsules sunk after 40 days, eventual arrival at Polynesia would have depended on seeds being assisted by some other source of buoyancy, such as a vegetation mat or floating debris. Additionally, the experiment involving natural sponges and viability shows that after the requisite amount of time seawater exposure seems to have negative impacts on seeds ability to germinate. Because our knowledge of sweet potato viability after this amount of seawater contact is so new and only corroborated partially with one other study (Pereira et al., 2020) it would be very useful to continue investigating this further.

By way of conclusion, the possibility that sweet potatoes could have been introduced into Polynesia through natural mechanisms remains. This investigation supports a theory of natural dispersal and furthers the existing literature while corroborating that sweet potato seeds remain viable after seawater exposure. However, I can say with near certainty that it would be highly unlikely and perhaps impossible for sweet potato capsules alone to be able to make this Trans-Pacific journey.

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