Scalesia’s Migration and Adaptation to the
Galapagos Islands: A Focus on Scalesia
pendunculata, a Uniquely Adapted and
Divergent Species

By: Analisa Shields-Estrada

Biology Major
Stanford University
Professor Bill Durham
The peculiarity of the Galapagos Islands, and the flora and fauna that it holds, manifests itself today in such a wide array of ways that it seems almost fantastical to predict its causes. Yet two simple long spanning events, geographical isolation and human isolation have acted as the major causes of the unparalleled uniqueness of the Galapagos Islands. My paper will focus not on the uniqueness of the islands themselves, but on the uniqueness of those species whom survived the journey to these islands, and subsequently found a suitable niche that allowed for their long term survival. Broken into two parts, I will begin by examining a particular genus’ migration to the Galapagos, discussing the particular possible methods of transportation and hypothesizing as to which actually occurred. Secondly, I will examine unique characteristics of that particular genus and a species within that genus, searching for adaptations formed to the Galapagos Islands themselves. I will focus on two specialized characteristics and hypothesize as to their origin, determining whether they are adaptations, exaptations, or homologies. Again, I will use data and experimental results two test these hypotheses.

Introduction:

Unlike many islands, the Galapagos did not arise due to a landmass breaking off from mainland South America. Instead, the Galapagos arose from volcanic origins. Rising hundreds of miles off the coast of Ecuador, the tectonic plate upon which they lie, is only moving the islands further from the coast of South America. Today they sit approximately 600 miles off the coast of Ecuador. Therefore, the islands were never part of the mainland; indeed there was never even a land bridge that connected the mainland to the Galapagos. Furthermore, there are no populations of people considered native to the islands. The volcanic
origins of the islands did not allow for any original human populations. However, even after humans did reach the islands, every early human attempt to build a settlement, failed. It was not until the 1950’s that a successful community was built and maintained. Therefore, what we consider to be a natural introduction, or those organisms we consider to be native, traveled hundreds of miles through the wind and/or ocean from the Ecuadorian Coast to the Galapagos Islands. This gives us a very eclectic group of species that survived the journey and were able to successfully find a sustainable and viable niche on the islands.

A peculiar genius, *Scalesia*, native and endemic to the Galapagos Islands, and a particular species within this genus, *Scalesia pendunculata*, will be the focus of this paper. This genus was among the few survivors from this eclectic group discussed above. Belonging to the *Asteraceae* family, more commonly known as the “Aster,” “Sunflower,” or “Daisy,” which widely populates the South American coast of Ecuador and Columbia, *Scalesia* is believed to have its origins along the same coasts. The *Scalesia* genus is made up of 15 species, inhabiting 11 different islands, with very different niches, plant types, climates, and leaf sizes, as demonstrated in Figure 1. *Scalesia pendunculata*, a forest dwelling sunflower tree species, lives on four Galapagos Islands alone; Santiago, Santa Cruz, Floreana, and San Cristobal. Furthermore, the *Asteraceae* family tends to encompass herbaceous species and species that prefer arid and semi-arid regions. Yet the members of the *Scalesia* genus prefer both arid and moist climates and only a handful are herbaceous. We will explore the unique divergence of *Scalesia*, and in particular, *Scalesia pendunculata*, in the sections to come.
Figure 1. *Scalesia*’s 15 species Galapagos Islands geographical distribution & leaf size

*Scalesia*’s Migration to the Galapagos Islands

**Question & Procedure**

Here we focus on the intricacies of *Scalesia*’s successful migration to the Galapagos Islands. The question I pose to determine their method of travel is the following: What characteristics allowed *Scalesia* to withstand the journey to the Galapagos Islands, and subsequently, by what means did it survive this journey? This question allows us to delve into three aspects of migration. The procedure will be as follows.

First we will look into the special characteristics of *Scalesia* seeds that allowed them to survive the journey. Understanding these characteristics, we can postulate as to their compatibility with different “hosts,” thereby allowing speculation as to which species or
element brought them from the mainland to the islands. In turn, we will look into the particular characteristics of these species or elements that allow for seed dispersal. Along with the seed characteristics investigated previously, we will again use compatibility to ponder which method of seed survival the host chose. Yet before attempting to answer this question and proceed with the procedure, we must outline each of these three steps.

To begin, we will discuss and investigate seed characteristics. We will look into the size, time of viable seed dispersal, length of viable seed dispersal, and endurance against the elements, of *Scalesia* seeds. We will then investigate four major seed hosts, namely, the wind, the water, reptiles (specifically giant tortoises), and birds (specifically finches). Essentially, the successful journey to the Galapagos of such a mass number of viable seeds to provide for the beginning of an entirely new genus could have only occurred through the movement of an element, or the travel of a seed-dispersing organism, such as the tortoise or finch. Yet the question of how the seed was able to survive the journey using such a host still remains uninvestigated. Therefore in the third step of our investigation we will determine what I coin to be, “the method of survival.” In regards to an element this could be wind or weather currents and in regards to an organism, it could be through the stomach with initial ingestion and subsequent digestion, by seed storing in the mouth without actual ingestion of an organism, or by external storage on the feathers, shell, or skin of an organism. This distinction between one organism (in this case the seeds) living on the exterior of another organism and the seeds living in the interior of an organism is referred to as endozoic vs. epizoic and is also something will attempt to pinpoint.
Hypothesis

With the path for addressing my first question already illuminated, I will lay out the hypothesis I made regarding the three aspects of my question. *Scalesia* seeds survived the journey to the mainland in the beaks or feathers of finches. Their size and short dispersal time make them most compatible with a bird host, specifically a finch.

Results

In regards to results, I began by researching each potential host, the characteristics a seed would need to survive a journey by that host and how the seed would survive on this particular host.

Choosing giant tortoises as my first host, I searched for numerous studies that would enlighten me as to what type or size of seed the tortoises dispersed. Taking into account the hundreds of miles of distance between the mainland and the islands, I also searched for giant tortoise seed dispersal time and length. One study by Sadeghyobi in 2011, attempted to determine the correlation between gut passage time and type/size of seed. By giving the same tortoises placebo seeds of different sizes and real seeds of different sizes and types he came to the conclusion that the gut passage time was surprisingly not dependent on size or type. Instead it was dependent on seasonal changes in weather. Quicker gut passage occurred when the temperature was warmer, and shorter gut passage time was observed as the temperature became cooler. The gut passage time ranged from 6 to 33 days, and we learned in class that 12 days is the minimum number of days it would take an object to float on the oceanic currents from the mainland out to the islands. From this I concluded that the variable gut
passage time made it probable that during a certain season the passage time could have been optimal and the seed could have successfully made the journey.

However, the next article I found, lead me to a different conclusion. In a study by Porter in 1983, he found that of the 306 natural introductions of flowering plants, 79% were by birds, 11% were by wind and 9% were by sea. In a different study by Itow, in 2003, he states Porter noted that “based on the morphology of seeds and fruits adaptive to natural agents of introduction such as birds, winds and oceanic drift, (Itow, 2003) ” he was able to come to the conclusion that different types of plants, depending on seed type, size, and resistance to salt water, chose a different natural agent for a certain reason. With all flowering plants, the bird was the best agent in the great majority of the cases, and the giant tortoise failed to be a good agent. Since the Scalesia genus is a flowering plant genus, this eliminates the possibility of a giant tortoise as a host.

Next, I looked at the possibility of wind or sea dispersion. Doing further research I found that Scalesia seeds are not buoyant or salt water resistant, therefore eliminating the possibility of the sea as a host. In regards to wind, in a study by Hamann in 1978, he was able to conclude that “Scalesia are adapted to short distance dispersal in a way similar to that of many other Asteraceae,” stating “my observations indicate that wind plays an important role, and that the dispersal may occur over a relatively long period (Hamann, 1978).” What can we make of this knowing that long distance dispersal must have occurred at some point? The author refers to Scalesia as a present day genus, not the genus it was thousands of years ago when it was in the process of diverging from another genera as it traveled to a new land. Yet it is still clear that to some extent, the wind can carry Scalesia seeds for long periods of time over short distances. Wind, therefore may play some important factor in Scalesia seed
Lastly, I looked at bird dispersion of *Scalesia* seeds. The first study I found by Abbott, 1997, showed that there are currently at least three species of finch feeding on *Scalesia*. The article did not specify their names however one of the Galapagos guides, Carlos, informed me that these three would be the vegetarian finch, the large tree finch, and the small tree finch. Another article by Hamann found that “finches undoubtedly participate in the dispersal of *Scalesia* seeds.” (Hamann, 1978) It is undeniable that yet again, the articles available are studying the present day interaction of *Scalesia* with an element, or in this case, a species. However adaptive radiation occurred in both the finches and the *Scalesia* and both have experienced similar diverse niches and populations. For as long as its size has been recorded, the seed has always been deemed small enough to fit into the beak of any of the modern day finches, which are believed to be not drastically larger than there relatives.

**Conclusion**

It seems to be the most likely conclusion that the finches have been dispersing the *Scalesia* seeds not only throughout both genera’s respective adaptive radiations, but since they migrated to the mainland. The wind may have played a role as well, carrying the seeds for part of their journey before a finch snatched it out of the air, or carrying a seed the rest of the way to the islands once a finch dropped. Both the wind and the finches, modern day *Scalesia* seed dispersers, and viable and logical methods of transportation in the past, seem to be the most likely candidates as hosts for the water sensitive, small, *Scalesia* seeds.
**Scalesia Pendunculata’s Adaptation to the Galapagos Islands**

**Question & Procedure**

Here we focus on the special adaptations and characteristics of *Scalesia pendunculata* that allow it to thrive in such a unique environment. My question is as follows: What special features did *Scalesia pendunculata* already have before coming to the Galapagos and what special adaptations did it form? *Scalesiap Pendunculata* is known as a “sunflower tree.” It dominates a forest niche in a moist, temperate, relatively high altitude environment. Furthermore it is a pioneer species, which prefers to come into an uninhabited niche and take over the landscape to build its own environment. This exactly, is what the once small daisy-like plant did. It has an extremely fast growth and death rate, as understood by Table 1. The trees thin out very fast so there are never a lot of very mature trees for an extended period of time. Within 20 years of the beginning of a new stand each tree has given way to another.
This works perfectly with the El Niño cycle, which quickly wipes out entire populations of *Scalesia pendunculata*. Unlike other plants also wiped about by the El Niño it can regrow extremely quickly and therefore El Niño has little to no long term negative effects on the species. Problems only occur, when El Niño resistant plants invade *Scalesia pendunculata*’s niche. They cannot grow with any sort of canopy cover. Therefore if a real forest species is introduced and provides any sort of shade or canopy the saplings will not be able to grow.

![Self-thinning in S. pedunculata stand](image)

Table 1: *Scalesia Pendunculata* self thinning on the island of Santa Cruz

Another unique characteristic of the *Scalesia* genus as a whole is its specialized capitulum (shown below in Figure 2) that makes several little flowers grouped together look like a single flower. This type of inflorescence is called a psuedanthium, and is special to many *Asteraceae* species. Furthermore, *Scalesia* stores almost all of its energy as inulin, a special form of energy.
Among the many special characteristics of *Scalesia Pendunculata*, I chose to focus on its specialized capitulum and its energy storer, inulin. I will investigate whether they are specialized adaptations to the Galapagos, whether they are exaptation, or whether they are homologous characteristics derived from ancestors and not at all specialized to the Galapagos.

My procedure will be as follows. I will begin by looking into two different aspects of the specialized capitulum. First I will determine how truly different *Scalesia pendunculata*’s specialized capitulum is from other *Scalesia* and even other *Asteraceae*. Then I will explore the existence, or lack of advantages the capitulum provides *Scalesia pendunculata*, and determine whether these advantages are unique to the Galapagos Islands. Next, I will follow a very similar procedure with respect to *Scalesia pendunculata*’s energy storer, inulin, first.
distinguishing its use among the genus and family, and secondly determining how advantageous this is for *Scalesia pendunculata* in the Galapagos.

**Hypothesis**

My hypotheses regarding two special characteristics of the *Scalesia* are as follows: *Scalesia*’s highly specialized capitulum is an adaptation to the Galapagos, however the presence of a high amount of inulin in *Scalesia pendunculata* is simply a characteristic of the Asteraceae family and not a new adaptation to the Galapagos.

**Results**

My search for differences between the typical *Scalesia* or Asteraceae specialized capitulum and *Scalesia pendunculata* lead me to some very interesting conclusions. One particular paper, that of Carlquist in 1982, caught my attention. Here he determined the rays of *Scalesia pendunculata* to be “relatively short and wide, and are richer in procumbent cells than those of the other species (Carlquist, 1982).” There is only one other *Scalesia* species found to have a similarly specialized capitulum. This therefore stood as evidence to show that indeed *Scalesia pendunculata*’s capitulum is perhaps more specialized or specialized differently than other species of its genus or family. Next, I looked into particular advantages the capitulum provided that stood out as uniquely adapted to the Galapagos. In 2002 Neilsen ran a study testing the attractiveness of different flowers to different pollinators and found that with certain pollinators, *Scalesia pendunculata* and a the single other *Scalesia* with a similarly specialized capitulum, the ray floret allowed for more pollination to occur. “Thus, ray floret development proved beneficial in pollinator-restricted localities (Neilsen,
This evidence suggests that not only is *Scalesia pendunculata*’s capitulum specialized differently than others, but that it serves a particular purpose, unique to the Galapagos.

On the other hand, my search for differences between inulin as an energy storer in *Scalesia pendunculata* versus others of its genus or family, showed very little differences. Inulin is shown to have no unique properties that could be considered adaptations to the Galapagos. Its function in the Galapagos is parallel to its function in other *Scalesia* and other *Asteraceae* found elsewhere. Essentially its ability to store almost all energy as inulin is no more specialized nor differently specialized than any other member of the same family or genus.

**Conclusion**

In conclusion, it seems very likely that *Scalesia pendunculata*’s capitulum has formed certain adaptations to the Galapagos Islands that make it so uniquely specialized and give it pollination, and therefore reproductive advantages. In contrast, it is quite likely that inulin is
simply a homology, a trait or characteristic passed down from previous generations, genera, and families. It has no special properties that make it advantageous to the Galapagos.

References

10. Sadeghayobi, E. (2011). The gut passage time in the galapagos giant tortoise (chelonoidis nigra) and its role for seed dispersal. Uppsala University, Sweden