Ecological Analysis of Mango Pollination: the Impact of Arthropods on Pollination and Fruit Set of Keitt Mangoes

Upon anthesis, wind and insects play an important role in the pollination of mangoes. The exact species of insects, however, is unexplored, and there is no connection between specific insects and the amount of pollen being transported. Minimal pollen deposition rates and differences in environmental conditions leads to differentiating insect importance. In response to these issues, three different experiments were constructed to highlight key insect families and species and the extent to which excluding arthropods affect mango pollination. The experiments dealt with signifying the most frequent visitors, determining the duration and interaction of insects with the flower structures, and excluding arthropods through mesh bagging. Through these experiments, we expect to provide a better understanding of the insects involved with Keitt mango production in the Miami-Dade area and their importance in fruit set production.

The overall objective of this research is to gain further insight into the different arthropods that pollinate Mangifera indica (Keitt) and there impact on fruit set that have not previously been looked at to improve mango production in the Miami-Dade area. Specific objectives are as listed:

1. Determine most frequent visitors: Identify arthropods visiting mango flowers at three separate mango groves over eight weeks
2. Determine the behavior of most common arthropods during flower visitation. Duration and interaction with flowers and flower structures and how much pollen they are transporting
3. Importance of arthropods to pollination and fruit set (production). Exclude arthropod access to flowers through bagging.

Origin, Distribution, and Importance of Mangifera indica

Mangifera indica is a major fruit crop of worldwide tropics and subtropics, originating in eastern India and southern Asia. The majority of Mangifera species are amassed throughout the various sections of the Malay Peninsula, the Indonesian archipelago, Thailand, Indochina, and the Philippines (Litz, 1997). There are two select types of Mangifera indica, which are distinguished by their mode of reproduction and generalized location amongst the tropics. This includes the monoembryonic seed, an Indian type found in the subtropics and the tropical polyembryonic seed of South-east Asia (Litz, 1997). A monoembryonic seed contains only a single embryo as the name suggest, and thus does not produce clones of the parents as it would in

polyembryonic seeds. For this reason grafting is often sought after and is one of the cultural methods practiced with Keitt mangoes this research focuses on.Through the European voyages of the 15th and 16th centuries, mango began to spread globally and be cultivated outside of its original area of domestication (Litz, 1997).

Due to mango seeds being unorthodox seeds with the inability to survive freezing or drying, mango transportation had to occur as ripe fruit, seedlings, or grafted plants (Litz, 1997). This lead to an understanding that the Portuguese were responsible for introducing the mango from their Indian colonies to those of Africa. It is also theorized that the mango made it's way to Africa through Persia and Arabia around the 10th century from Arab traders (Litz, 1997). Brazil became the next destination from Portuguese living on west and east coasts of Angola and Mozambique (Litz, 1997). Over time the polyembryonic mango varieties were brought through the pacific trading ports of Mexico and Panama into the New World colonies (Litz, 1997). From there the mango landed in the West Indies around the later half of the 18th century and the first introduction into Florida ensued in 1861 (Litz, 1997). This involved the "No. 11" polyembryonic seedling derived from Cuba and although many of the early introduced mangoes did not find success in being cultivated, this lead the ground work for future production.The Florida variety Haden stemmed from a seedling "Mulgoba", which was first introduced to Florida in 1910 (Litz, 1997).

The Haden cultivar was an important addition to the production of mango in Florida due to its wide genetic base. Over time this gene pool diversity increased and by the 20th century there was mango germplasm arriving from Cambodia, the Philippines, and other areas in South-East Asia which is believed to have lead to a second center of diversity of mangoes species (Litz, 1997). Despite the vast amount of diversity amongst Florida mangoes, it is estimated that all Florida species are descended from four monoembryonic Indian mango cultivars and one polyembryonic from the West Indies (Schnell et al., 1995). This includes monoembryonic cultivars Amini, Sandersha, Mulgoba, and Bombay and polyembryonic Turpentine. The success of mango cultivars is due in part to their adaptability to growing in new agroecological areas in contrast to the Indian cultivars, which seem to perform inadequately outside of their origin of domestication (Litz, 1997).

The genetic diversity paired with varieties resistant to diseases like anthracnose has helped Florida be a major supplier of mangoes worldwide. Florida cultivars are amongst the most prevalent mangoes in many countries such as Mexico, Australia, South Africa, and Israel (Dag et al., 1997). In addition to genetic diversity and disease resistance, the mango season in the United States extends over quite a long period of time, up to 6 months from early May to October ("Mangos" – AGMRC, 2016). Mangoes groves in the United States are found in select states such as California, Florida, Hawaii, and Puerto Rice ("Mangos" – AGMRC, 2016). Despite having many influential cultivars, the United States is no major exporter of mangoes

unlike India, which accounted for 38.6% of world production between 2003 and 2005 and is the largest producer (Evans, 2008). During those 2 years, India, China, and Thailand averaged 10.79, 3.61, and 1.71 million metric tons respectively, where as the United States sits at merely 3,000 metric tons annually (Evans, 2008). The United States is however the top importer of fresh mangoes, bringing in 32.7% of total imports from 2003 to 2005 (Evans, 2008).

In 2006 the total volume was 298,088 metric tons where as in 2017 according to USDA market news the total volume in pounds was 1,105,241,561, which equates to 501,329 metric tons. This annual increase in mangoes can be attributed to several factors, such as an influx of immigration from Asian and Latin American countries, in addition to consumption knowledge and interest in different fruits and healthy lifestyles ("Mangos" – AGMRC, 2016). Another facet for increase consumption includes year-round availability at an affordable cost (Evans, 2008) and the curiosity in different cultivars and their uses in the kitchen. As production increases in the United States, the amount imported will decrease, thus lowering prices and allowing greater availability for the average consumer to include mango in their diet. Since 1998 to 2006, imports from 5 major countries of Brazil, Ecuador, Haiti, Peru, and Mexico have all declined significantly.

Twenty-five 9-year-old 'Keitt' mango trees grafted to 'Turpentine' rootstock will be selected at The University of Florida, Tropical Research and Education Center (TREC) located in Homestead, FL. Trees are growing in Krome very gravely sandy-loam and are under a conventional cultural program, which includes selected pesticides, inorganic and organic fertilizers, and occasional irrigation. When flowering occurs it is affected by inherent genetics, previous and current weather conditions, soil moisture, and cultural practices. Panicle emergence and flowering may begin anytime from late December through April. Determination of most frequent arthropod visitors: time observations.

Five randomly selected inflorescence per tree on twenty-five 'Keitt' mango trees will be observed weekly. The number of visits and identification of the arthropods will be recorded and arthropods will be captured for positive identification. Approximately 10 minutes will be spent per tree, which will take about 4 hours. Observations will be timed with a stop watch. While observing, insects were noted on duration spent per inflorescence and if nectar or pollen was fed on. Insects will be collected by net as they fly away and placed in plastic vials to correctly identify. Data recorded per observation will include: Whether the insect is collecting nectar or pollen?

Temperature of locality (FAWN) Wind Speed (FAWN) Relative humidity (FAWN)

The identity and number of arthropod visitors will be analyzed to determine the most frequent visitors. To gain a better understanding of the diversity of species contributing to the pollination of mango flowers, three different collections will be sampled at different times of the day over

the course of six weeks. The locality of the groves includes the Keitt mango at TREC, (name of other nursery), and (name of other nursery). Should weather conditions allow, data will be collected at 9 am, 12 pm, and 3 pm respectively. If weather is unsuitable, data will be collected the following day or as soon as possible. Data collection will be set to commence every Monday for six weeks. Two transects will take place, one taking place two rows in from the west most side of the grove and the other two rows in from the east most side. The length of the transect will be defined as the length of the row (subject to change in length depending on the grove) and will involve one pass of insect collecting by means of sweep net on mango inflorescence. Collected specimen will be placed in a glass jar. The time for collection at each site will rotate accordingly as shown below. Once both transects are completed at each location, specimen will be brought back to the lab for study.

The one problem I foresee with this is that the collection periods are only taking place during the day, which means there are some potential pollinators we are not encountering. I was wondering if it would be better to add a fourth time, to include a nightly sweep, say 9:30 pm or if we could simply set up three different black light at the different locations and turn them on once a week each Monday night and collect the insects the following morning for identification. Let me know your thoughts.

Correlation of frequency of arthropod visitors and amount of pollen carried; quantifying the pollen. The insects collected from 'Keitt' mangoes inflorescences will be placed into plastic vials. The vials with collected arthropods will be stored in a freezer at (temperature) for later insect and pollen identification and quantification. Insects will be dunked and vortexed in a solution containing 50% ethanol to wash off any pollen. The insect will then be removed and the remaining solution was placed in a centrifuge to further collect the pollen grains ((note: degree of pollen hydration affects external pollen appearance).

Once collected, pollen grains will be added to a acetolysis mixture (glacial acetic acid and concentrated sulphuric acid in a 9:1 ratio). During acetolysis, pollen grains lose their protoplasm and have just the exine remaining. The acetolysis mixture containing the pollen will be heated until boiling, while stirred with a glass rod. After a few minutes, let the solution cool and centrifuge the mixture once again while discarding the supernatant. It is important to then re-suspend the mixture in distilled water, centrifuge, and decant the supernatant once gain. This step should be completed twice through. Prior to observation, stain the pollen to help increase the contrast. Stains such as methyl-green or fuchsin can be applied, however the preferred method is to use Safranin O. This will give the pollen a pinkish-red appearance depending on how much is applied. Transmitted light microscopy or scanning electron microscopy (SEM) are different techniques that can be used for pollen identification. Haemocytometers will be used to count the number of pollen grains. Data from this will then be used to make correlations among arthropod frequency of visits and fruit set. Importance of arthropods to pollination and fruit set

(production) through exclusion.

Three different ‘Kiett’ mango groves will be used to determine the importance of arthropods to fruit set and crop yields. These groves will be located within the Homestead production area. Ten arthropod excluding bags per tree will be placed on each tree. Ten other inflorescences will be tagged but not bagged for comparison. Each bag will be held by a frame in an attempt to limit arthropod excluding screen with the flowers.

Pollination bags are made of sheer nylon

Excludes insects but permits entry of air and light

Semi transparent nylon and have draw strings to secure the bag around the inflorescence rachis (structure that holds all the flowers)

Inflorescence should be positioned as much as possible in the center of the bag so that the mesh does not touch the flower – could lead to self pollination.

To limit self pollination – fix a wire frame around the flower and place the bag over the frame, thus providing structural support to the bag.

Weather resistant tag

The No-Thrips Insect screening allows for air circulation, is lightweight, and disallows small insects from entering. The chicken wire cages will be placed inside the bags, which will be sewed shut at the top and on the sides. The bottom will remain open to allow for the bag and wire cage to be placed over the inflorescence while aiming to not disturb the flowers. The bottom of the bag will be tied around the base of the inflorescence using zip ties. The fruit set and crop yield of bagged and non-bagged inflorescences will be recorded and compared.