ASSESSING PATTERNS OF MOISTURE CONTENT IN DECOMPOSING, DESICCATED, AND MUMMIFIED TISSUE: A BASELINE STUDY

by

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I. INTRODUCTION

Desiccation and mummification are relatively unstudied decompositional processes, especially with reference to potential postmortem interval applications in forensic contexts. The focus of this research is natural mummification, and the sequence and rate at which it occurs. This research will aid in a more comprehensive understanding of late-stage decomposition, providing the groundwork for more accurate estimates of time since death in investigative settings. Specifically, this research aims to quantify desiccation in the decomposition process and examine broad trends in mummification of human remains.

MUMMIFICATION PRACTICES

Optimal factors necessary for desiccation and eventual mummification are generally accepted as a hot and dry climate, preferably with a significant amount of airflow (Schotsman et al. 2011, Galloway 1996, El-Najjar 1998, Campobasso et al. 2009). However, mummification can also occur in cold and dry environments, as well as hot and humid ones (Carter and Tibbet 2008; Micozzi 1991; Schotsman et al. 2011), and mummification can occur as a result of natural or intentional causes.

Mummification is common at archaeological sites in parts of the Southwestern United States. In Arizona, for example, partially mummified remains of a five- to six-year-old child (“Mummy 5”) were recovered from Ventana Cave. The remains have been attributed to the Hohokam culture and likely date to between 1000 and 1450 AD (Reinhard & Hevly 1991). This cave is located in the Sonoran Desert, which is categorized by its high temperatures and low humidity (Galloway 1996). In the case of Mummy 5, much of the internal tissue was mummified, allowing for researchers to examine internal coprolites in order to draw conclusions about parasitological and dietary practices of the Hohokam people (Reinhard & Hevly 1991).

One example of natural mummification in a cold environment is the Tyrolean Iceman, or Ötzi. Analysis of bacterial DNA in skin and muscle samples suggest that shortly after death (estimated between 3350 and 3100 BC), the Iceman's corpse was covered in ice, and much later (possibly during Roman times) the ice surrounding the body thawed and Ötzi was covered in water that had collected in the depression that had formed (Rollo et al. 2000). During this relatively brief warming period, decompositional effects such as loss of the epidermis and adipocere formation took place, followed by desiccation through sublimation (Rollo et al. 2000). Sublimation, or "freeze-drying", occurs when water in the frozen soft tissue trapped within glacial ice sublimates into the air bubbles, thereby slowly desiccating the body (Aufderheide 2003).

Intentional mummification can take many forms and is often performed as part of a ritualized practice. The Chinchorro people inhabited areas along the Pacific coast of southern Peru and northern Chile from approximately 7020 to 1110 BC (Arriaza 1995). Sites associated with the Chinchorro have yielded both naturally and intentionally mummified remains. The intentionally mummified remains take many forms such as: *Black Mummies* which were eviscerated and disarticulated then dried using hot ashes or coals, and then the skin was covered and molded with a white paste that was later painted black with manganese; *Red Mummies* which were treated similarly to Black Mummies, however they were most often not disarticulated, thus not exhibiting incisions and sutures; *Bandage Mummies* which are a variation of the Red Mummy but have head-to-toe skin wrappings; and *Mud-Coated Mummies* which are smoked and dried with hot coals, then covered with mud that would harden to a cement-like substance (Arriaza 1995).

Egyptian mummies, such as those excavated from Ismant el-Kharab, are preserved using two typical methods: evisceration and resin application. In some cases, the resin had been put onto linen straps to hold wrappings in position, in others the resin had been painted onto the surface of the skin (Aufderheide et al. 1999). In Pharaonic Egypt, once eviscerated, corpses were enveloped in a layer of natron. Due to the highly hydrophilic nature of natron, this method of mummification by desiccation was highly effective for long-term soft tissue preservation (Aufderheide 2003).

FORENSIC CONTEXT

In forensic anthropological contexts, estimating the postmortem interval (PMI) via an estimation of time since death is a critical component of investigation. Many methods of scoring decomposition follow a general five-stage model laid out by Galloway et al. (1989). The first stage is fresh, typically characterized by a lack of discoloration and insect activity; followed by early decomposition, which includes skin slippage, marbling, and the beginning stages of bloat; advanced decomposition is described as showing purging of decomposition fluids, sagging of tissue, mummification, and an increase in maggot activity. The last two stages, skeletonization and skeletal erosion, are not dependent on tissue status, but instead on status of bone. Remains have reached the skeletonization stage when more than half of the body has exposed bone, and skeletal erosion is seen through bleaching of bone and its fragmentation (Galloway, et al. 1989).

Megyesi's scoring method expands on this descriptive model by attempting to isolate quantifiable stages and adding the use of accumulated degree days (ADD) (Megyesi et al. 2005). While Megyesi's method of total body scoring has become widely used, (e.g. the University of Tennessee), there are problems with scoring decomposition in the later stages. One of these problems is that mummification is considered one of the last stages of decomposition, implying that every other stage of the decomposition process was sequential and has already occurred.

In fact, preservation as a result of mummification can last years, meaning that a body may never reach the last stages of decomposition. Further, Parsons (2009) argues that the ADD model does not take the state of mummification into account, since the body is unlikely to progress to skeletonization despite the continued accumulation of degree-days, given that mummification is a state of halted decomposition (Parsons 2009). Additionally, mummified tissue can become rehydrated if exposed to events such as rainfall, which can further skew decomposition scoring (Suckling 2011). Because of this, current PMI estimations that involve advanced decomposition are hindered by the lack of knowledge about the sequence and timing of desiccation and mummification.

Despite often being used interchangeably, desiccation refers to moisture loss in tissue, while mummification refers to the point at which decomposition and decay are suspended (Schotsmans, et al. 2011). As used in this study, desiccation is a process, while mummification is a decompositional state. As stated above, the typical conditions needed for desiccation and mummification are a hot and dry environment, but there are also documented examples of mummification occurring in cold or humid environments (Carter & Tibbet 2008; Micozzi 1991; Schotsman et al. 2011). The climate in Central Texas is considered subtropical, meaning that it is particularly humid during the summer months, and human remains at the Forensic Anthropology Research Facility (FARF) at Texas State University has still regularly show varying degrees of desiccation and mummification.

While desiccation can occur in all soft tissue, external desiccation is the focus of this study. Schotsman et al. (2011) explain that desiccation of internal organs is highly variable and they are most often the last parts of the body to desiccate. Based on previous studies at FARF, internal desiccation is not anticipated, primarily because of the continuation of insect activity. One reason for this is that insects such as flies will lay eggs within crevices and orifices of the body, providing maggots with an advantage to break down muscle tissue, thereby breaking down the body from the inside out.

This research builds from studies already completed in Central Texas, such as that of Parks (2011), and Suckling (2011), and more general studies about decomposition such as those performed by Megyesi et. al (2005). During the course of her examination of an individual decomposition in Central Texas region, Parks determined that mummification occurred at day twelve of the donor's exposure (Parks 2011). This correlates to the study by Schotsman and colleagues (2011) who determined mummification occurs between days ten and thirty (Schotsman, et al. 2011). This varies slightly from the explanation given by Campobasso and colleagues (2009) in the case study of an 86 year-old man who was found preserved in his apartment for seven years, where they state that while natural mummification can occur within the first two weeks postmortem, twelve weeks is the more standard and accurate estimation (Campobasso, et al. 2009).

The literature surrounding contemporary natural desiccation and mummification is composed primarily of single case studies and small reference-style paragraphs that provide little more than working definitions. There is no research that examines whether desiccation follows a sequential, predictable pattern, nor is there data available to establish when tissue has reached the point of mummification. This research works to remedy this gap in the literature by working to determine if desiccation follows a predictable and consistent pattern and rate, both in terms of symmetry within an individual, and between individuals. Additionally, the research will examine correlations between temperature, humidity, and solar radiation in order to determine how desiccation and mummification can occur in environments that are not hot and arid.

RESEARCH QUESTIONS

1. Is there an observable pattern to the order that the body desiccates?

1a. Is there a difference in timing of the desiccation of upper and lower limbs?

2. Does desiccation follow a constant rate?
3. Is there a quantifiable point of mummification?
4. Is there a stronger correlation of moisture content to humidity, temperature, or solar radiation?
5. How does precipitation affect the rate of desiccation?
6. Can state of desiccation be tied to PMI?

These questions will be addressed by taking a series of moisture readings from 20 sites on donor bodies on a daily basis, in order to establish a sequence and rate of moisture loss. This study will aid in the understanding of desiccation as a process, which in turn will offer more accurate estimations of postmortem interval in cases of advanced decomposition.

II. MATERIALS

DONATIONS

Five donor bodies were used in this research. All of the individuals were acquired through the Texas State Willed Body Donation program. Through this program, the Texas State Forensic Anthropology Center picks up willed remains from within 200 miles of San Marcos, Texas to be brought back to the Forensic Anthropology Research Facility (FARF) at Freeman Ranch for research on processes of decomposition and skeletal biology (FACTS 2017). During the time between death and placement at FARF, a variety of postmortem actions may have affected the body. For example, remains may have been refrigerated, as well as possibly having been autopsied. Once a donation is picked up from a funeral home, hospital, or medical examiner's office, it is brought to Texas State's Osteological Research and Processing Laboratory (ORPL). Upon arrival, a suite of information is collected, including: height, weight, inventory of personal effects, blood, nail samples, hair samples, photographs of body and identifying marks such as tattoos and scars. The donor is then placed outdoors at FARF, with documentation taken from the moment of placement until the remains are picked up for processing (usually after a year or so).

Of the five specific individuals that were used in this study, two of them were autopsied, four were male, and one was female. The donors ranged in age from 55 to 84, in height from 167cm to 188cm, and in weight from 128lb to 303lb. Biological information for each individual is displayed in Table 1. None of the donors were clothed at placement, however the hands of D32-2017 were placed in gloves, as was standard practice prior to the start of this research. Every donation was covered by a metal and chicken wire cage in an attempt to prevent terrestrial or aerial scavenging. Finally, due to the nature of transport and arrival to the Willed Body Donation program, there was a gap between day of death and day of placement for every individual.

Table 1: Biological Information for Donors

Donor	Sex	Age	Height (cm.)	Weight (lb.)	Autopsied?	Health Conditions
D32-2017	F	71	167	303	Yes	Diabetic
D35-2017	M	70	188.5	201	Yes	Diabetic
D37-2017	M	84	178	176	No	
D40-2017	M	78	173	168	No	Possible colon cancer
D42-2017	M	55	178	128	No	Undergoing chemotherapy

SITE/ENVIRONMENT

The Forensic Anthropology Research Center is located on Freeman Ranch in San Marcos, Texas. Central Texas experiences a wide variety of climatic condition, ranging from periods of drought to flash flooding; the region is classified as a subtropical subhumid environment (Larkin 1983). All weather data were collected at the FARF on-site weather station, which records hourly temperatures, precipitation, humidity, and solar radiation levels (Daniel Wescott, personal communication 2017). During the course of this study, May – August 2017 the highest recorded temperature was 42.06°C with 344.66mm of rainfall.

EQUIPMENT

A Delmhorst RDM3 Moisture Meter with type 26-E electrodes was used for this study (Figure 1). The 26-E electrodes are insulated along the sides in order to reduce the likelihood that moisture readings will be influenced by ambient moisture. The RDM3 meter is manufactured for the examination of wood, this particular model having the widest range of readings possible; since there are no moisture meters intended for use on human tissue this was determined to be best suited for this study based on the wide moisture range that can be measured (Tom Laurenzi, Personal Communication 2017). Being a pin-based moisture meter, the device measures the amount of electrical resistance between the two electrodes, and then converts it to a percent-saturation level (Laurenzi 2017). Given that the moisture meter is designed and calibrated to measure moisture content in wood and not human tissue, the readings are not able to be utilized as standalone data, rather as relative data. Daily photos were taken with a Nikon D40 camera with an 18mm-55mm lens.

Figure 1: RDM3 Moisture Meter with 26-E Electrodes, photo by author

III. METHODS

OBSERVATIONS

The first cadaver was placed on June 6, 2017, after which photos were taken of the head and face (from above, left side, and right side), the torso (from right and left sides), both arms, both legs, and of the body overall. Additionally, moisture readings were taken from a total of twenty sites: nose, lip, right and left ears, right and left armpits, right and left arms (around the elbow), right and left first finger, right and left fifth finger, torso, groin, right and left thighs, right and left first toe, and right and left fifth toe (Figure 2) and recorded in the Data Collection Form (Appendix 1). This process was repeated daily for every cadaver placed (except in the event of heavy rainfall, when data were not collected) starting the day of individual placement and ending at the termination of study on August 29, 2017.

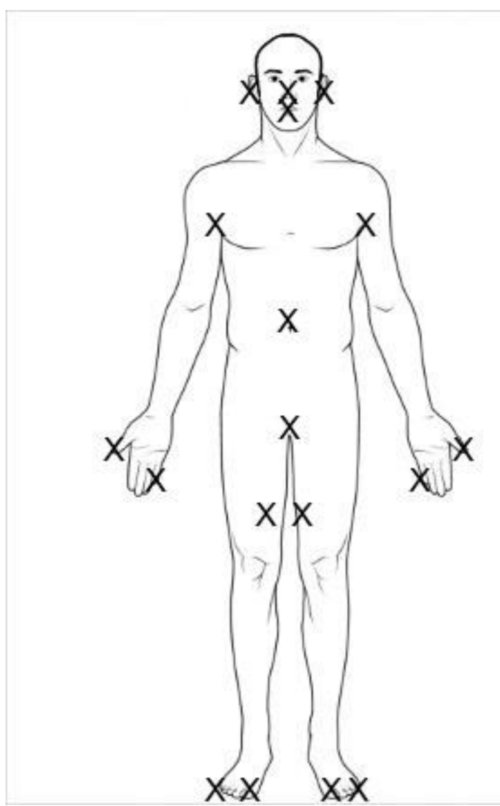

Figure 2: Diagram of data points, adapted from template.com

The RDM3 moisture meter has two read-settings: trigger and continuous. The trigger setting will take a reading every time the “select” button (Figure 3) is pressed, while the continuous setting will take readings from the time the “select” button is pressed to start until it is pressed again to stop. The continuous setting was utilized for this project, and it was determined that once the pins were in contact with the tissue, the measurements would begin, and the value would be recorded once the displayed values stabilized.

Figure 3: RDM3 controls and display, photo by author

Moisture content data were minimized by grouping data into four categories: extremities, head, torso, and limbs. For the extremity group, values from first toes, fifth toes, first fingers, and fifth fingers from each side were averaged. To compose the limb group, measurements from the arms and legs on both sides were averaged. Torso measurements were created from groin, torso, and armpit measurements, and the head measurement group was comprised of both ears, nose, and lip measurements. Additionally, upper and lower limb and extremity values were averaged in order to evaluate symmetry between upper and lower limb desiccation. Desiccation observations for each body are published in Appendix 2. These data are compared to temperature, humidity, and solar radiation and precipitation.

Temperature data is measured via the FARF weather station in degrees Celsius. Data were collected every half hour, minimum and maximum values were extracted and averaged for each day of data collection. Using these data, each average was added to the averages from all days previous, resulting in Accumulated Degree Days that act to standardize time analysis of the study. The weather station also recorded humidity data as a percentage of relative humidity at the same frequency as temperature, solar radiation data were collected in units of W/m^2, and precipitation was recorded in mm. These weather data were kept in their raw form as opposed to being accumulated to provide more robust statistical analysis. Weather data for the data collection period is presented in Appendix 3.

STATISTICAL ANALYSIS

In order to assess the degree to which moisture content measurements are correlated between individuals, an Intraclass Correlation Coefficient (ICC) was calculated for each region. ICC is a measure of the proportion of dependent variable variation that occurs between individuals against the total variation that is present (Russell Weaver, personal communication 2018). These values suggest a significant (non-zero) correlation among moisture content measures. A multilevel, mixed effect model would be the most appropriate method to account for the inherent error and variance between individuals, because as an ICC increases in value it becomes more necessary to employ multilevel modeling strategies (Finch et al. 2014).

Analysis began by specifying unconditional, or null, models for each region-specific dependent variable. The purpose of these models is to understand how variation in moisture content is distributed between variation within individuals and variation between individuals (Russell Weaver, personal communication 2018). Adding independent variables allowed the model to evaluate the extent to which the models' goodness of fit improve as a result of these variables; more simply put, adding the independent variables after running the models with only dependent variables made it possible to determine which independent variables are significant. Independent variables are treated as "fixed effects" because the relationship between moisture content and the weather variables are fixed across individuals.

Moisture content was then graphically represented in a scatterplot utilizing ADD, due to precedent of using ADD as a standard time-scale. A LOESS (Locally Weighted

Scatterplot Smoothing) curve was added to the scatter plot to more accurately capture the curve of moisture loss.

Pseudo R^2 values were also calculated for each region, both marginal and conditional, in order to assess the goodness of fit for each model. The marginal values display the amount of variation in moisture loss that is explained by the fixed effects (temperature, humidity, solar radiation, rain). Conditional values consider these fixed effects, but also accounts for individual variation between donors (random effects).

Drawing on Megyesi et al., the ADD data were transformed to increase goodness of fit in the modeling process. With the given data, the relationship between ADD and moisture content is not linear, and exploratory transformations revealed that a logarithmic transformation produced the best fit (Megyesi et al. 2005). Using logADD, a mixed effects model was conducted on each measurement region. The model takes the following general form:

$$\text{Moisture} = f(\text{logADD, AvgHumidity, AvgSR, Precip})$$

where moisture content is a function of the log-transformed ADD, average humidity rates, average rates of solar radiation, and the amount of precipitation on a given day.

Additionally, following common practice in multilevel modeling, and the high amount of correlation between fixed effects, the independent variables (other than logADD and precipitation) were centered about their means to reduce collinearity (Finch et al. 2014).

Finally, predicted values of the region-specific moisture content variables were measured for each individual. These values were obtained by holding each fixed effect constant at its mean (Russell Weaver, personal communication 2018), with the exception of ADD, in order to visualize patterns of predicted moisture levels and patterns based on temperature.

IV. RESULTS

HEAD OBSERVATIONS

The ICC for the minimized head measurements was 0.353, high enough to justify a multilevel model. The marginal pseudo R^2 value for the head is 0.554 while the conditional value is 0.6495521. These values are displayed in Table 2.

Table 2: ICC and R^2 Values

	ICC value	**R^2 M value**	**R^2 C value**
Head	0.353	0.554	0.650
Torso	0.224	0.528	0.578
Limbs	0.136	0.514	0.524
Extremities	0.179	0.508	0.523

The results from the head measurements multilevel mixed effects model are presented in Table 3. The effect coefficient of temperature is determined to be -10.735, humidity is 0.244, solar radiation is 0.013, and precipitation is 0.262. These fixed effects are presented in Table 3. Moisture content was plotted against ADD with a LOESS smoothing curve added to assess broad patterns of desiccation (Figure 4).

Table 3: Fixed Effects Coefficients for Each Region, >0.05 are significant

	logADD	Humidity	Precipitation	Solar Radiation
Head	-10.735	0.244	0.262	0.013
Torso	-8.794	0.496	0.095	0.013
Limbs	-8.436	0.434	-0.014	0.012
Extremities	-8.227	0.447	0.213	0.016
Average	**-9.048**	**0.405**	**0.139**	0.014

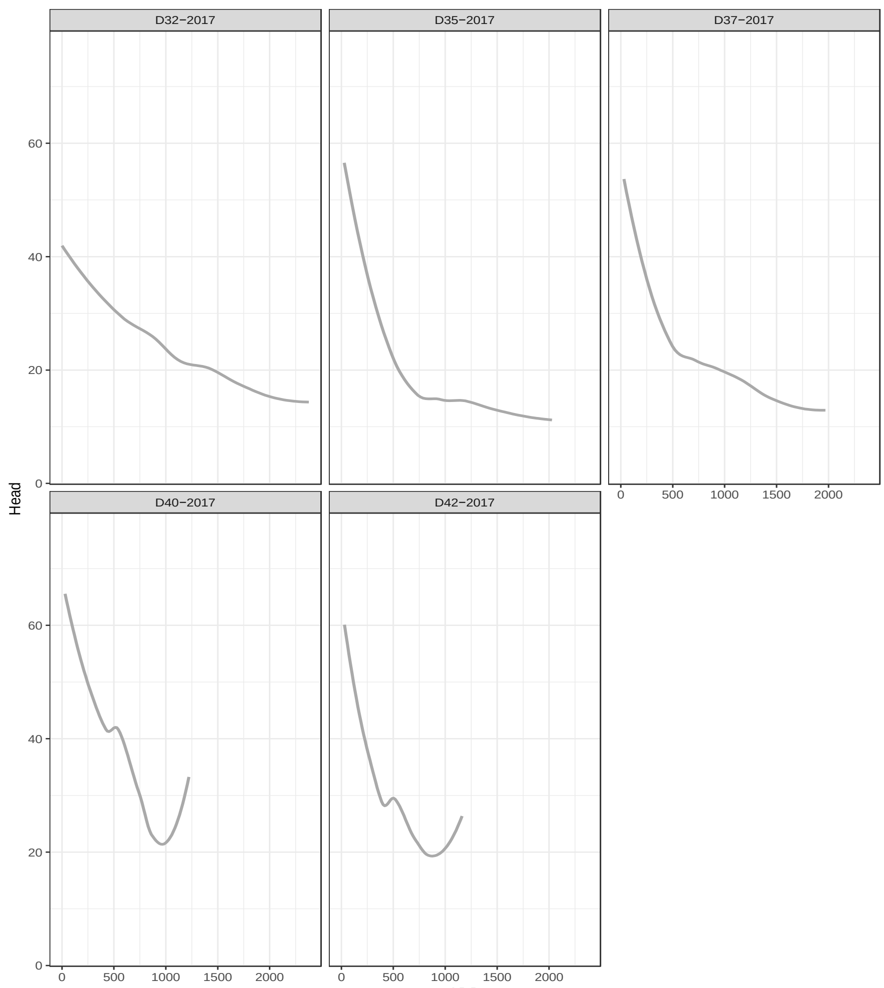

Figure 4: Scatterplot with LOESS curve of head measurements, the Y-axis represents moisture content, while the X-axis represents ADD. The shaded area represents the statistically smoothed data.

TORSO OBSERVATIONS

The ICC Coefficient for the minimized torso measurements was 0.224. The R^2 M value for the torso is 0.528 while the R^2 C value is 0.578 (Table 2). The mixed effects coefficient of temperature is -8.794, humidity is 0.496, solar radiation is 0.013, and precipitation is 0.095 (Table 3). The scatterplot with LOESS smoothing curve of the moisture content of the torso is presented in Figure 5.

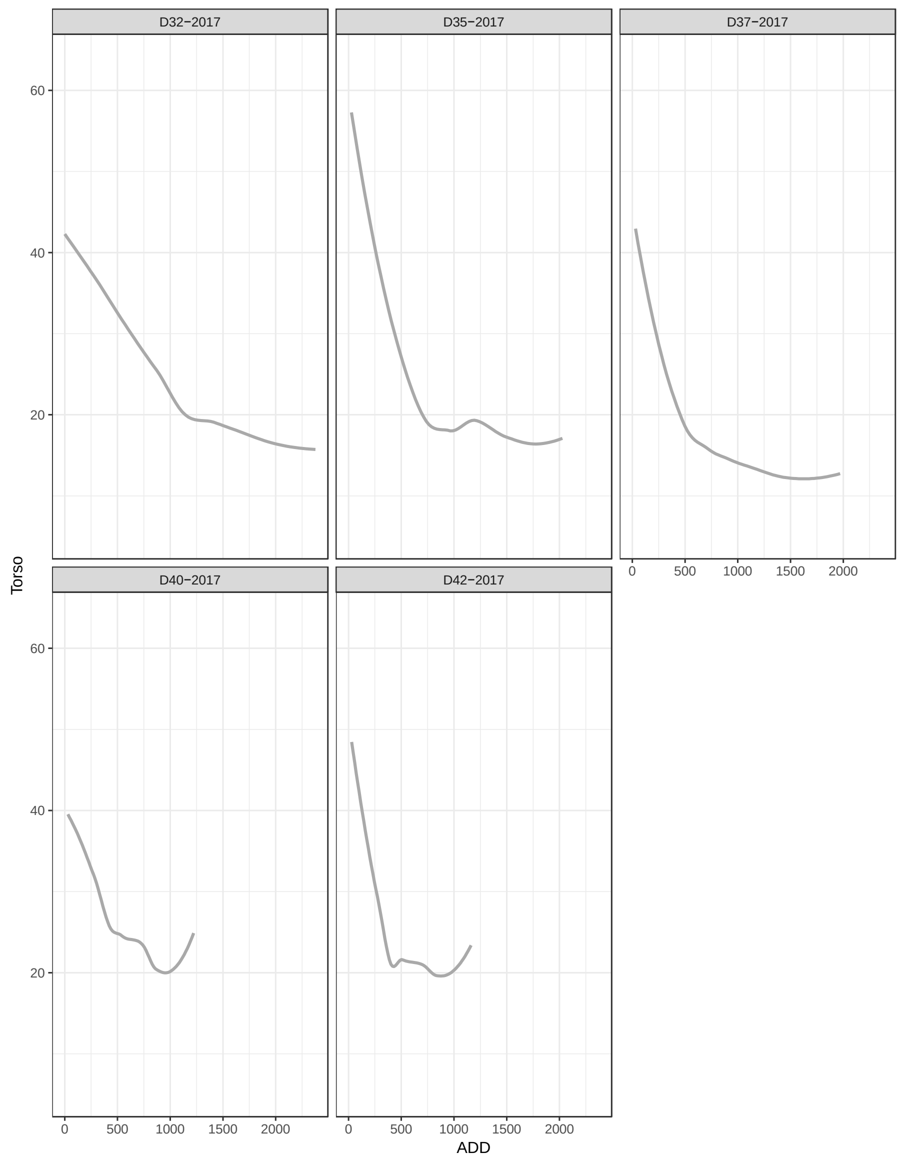

Figure 5: Scatterplot with LOESS curve of torso measurements, the Y-axis represents moisture content, while the X-axis represents ADD. The shaded area represents the statistically smoothed data.

LIMB OBSERVATIONS

The ICC for the minimized limb measurements was 0.136. The R^2 M value for the limbs is 0.514 while the R^2 C value is 0.524 (Table 2). The mixed effects coefficient of temperature is -8.436, humidity is 0.434, solar radiation is 0.012, and precipitation is 0.014 (Table 3). The scatterplot with LOESS smoothing curve of the moisture content of the limbs is presented in Figure 6.

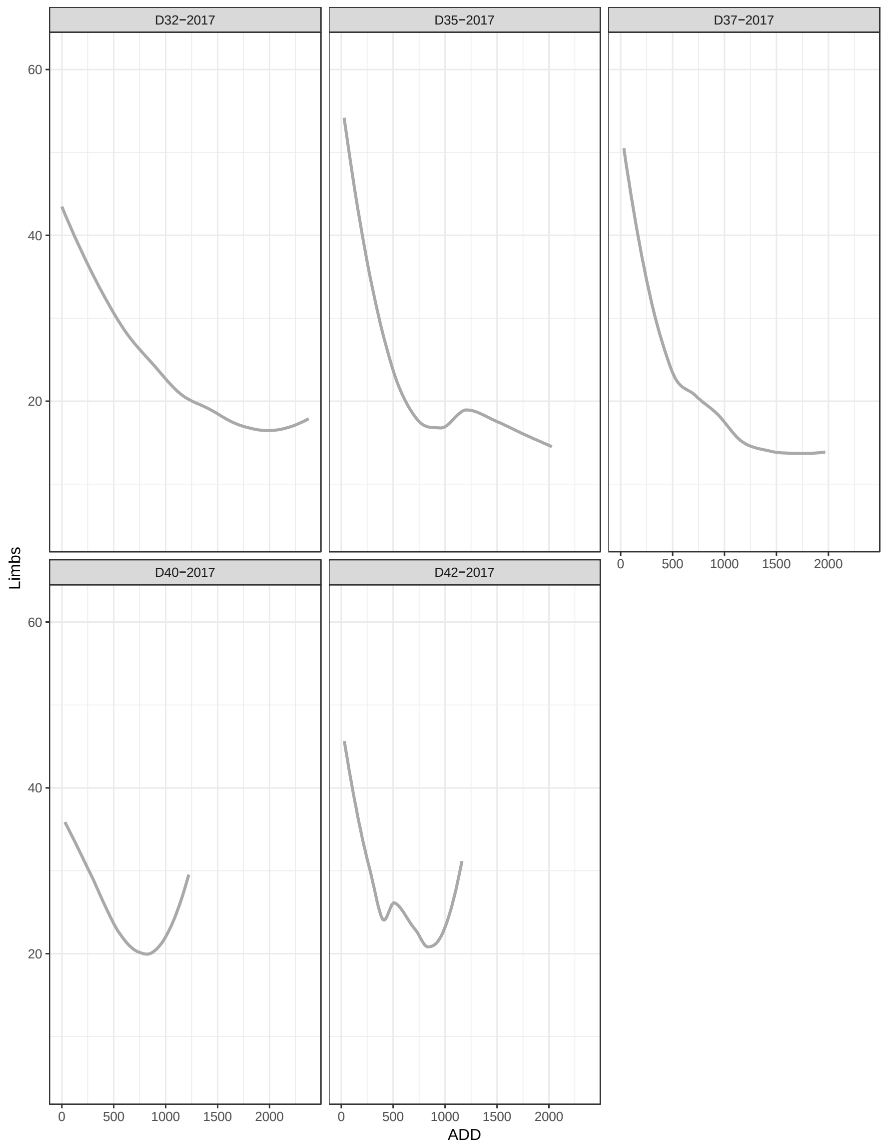

Figure 6: Scatterplot with LOESS curve of limb measurements, the Y-axis represents moisture content, while the X-axis represents ADD. The shaded area represents the statistically smoothed data.

EXTREMITY OBSERVATIONS

The ICC for the extremity measurements was 0.179. The R^2 M value for the extremities is 0.508 while the R^2 C value is 0.523 (Table 2). The mixed effects coefficient of temperature is -8.227, humidity is 0.447, solar radiation is 0.016, and precipitation is 0.213 (Table 3). The scatterplot with LOESS smoothing curve of the moisture content of the extremities is presented in Figure 7.

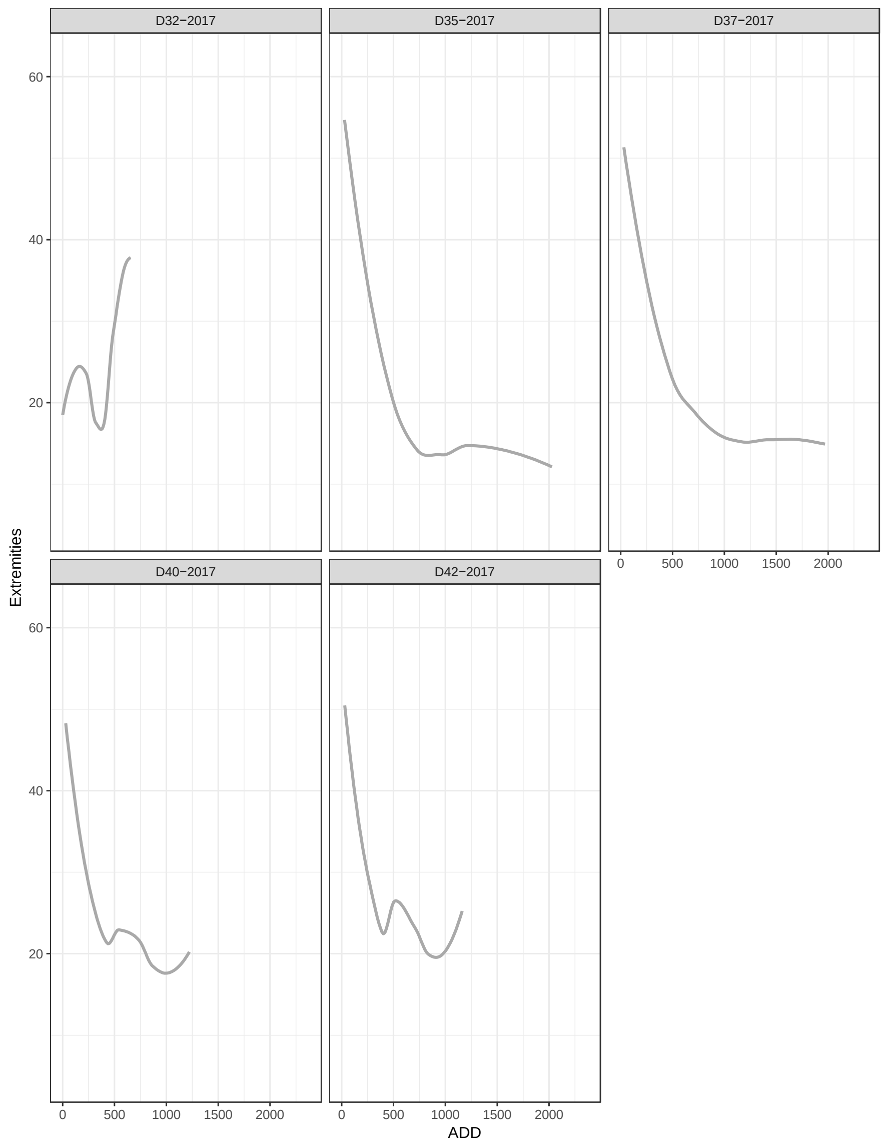

Figure 7: Scatterplot with LOESS curve of extremity measurements, the Y-axis represents moisture content, while the X-axis represents ADD. The shaded area represents the statistically smoothed data.

UPPER AND LOWER LIMB OBSERVATIONS

Upper and lower limbs were only analyzed for differences in broad patterns, and were plotted against ADD in scatterplots with LOESS smoothing curves. These are presented in Figures 8 and 9.

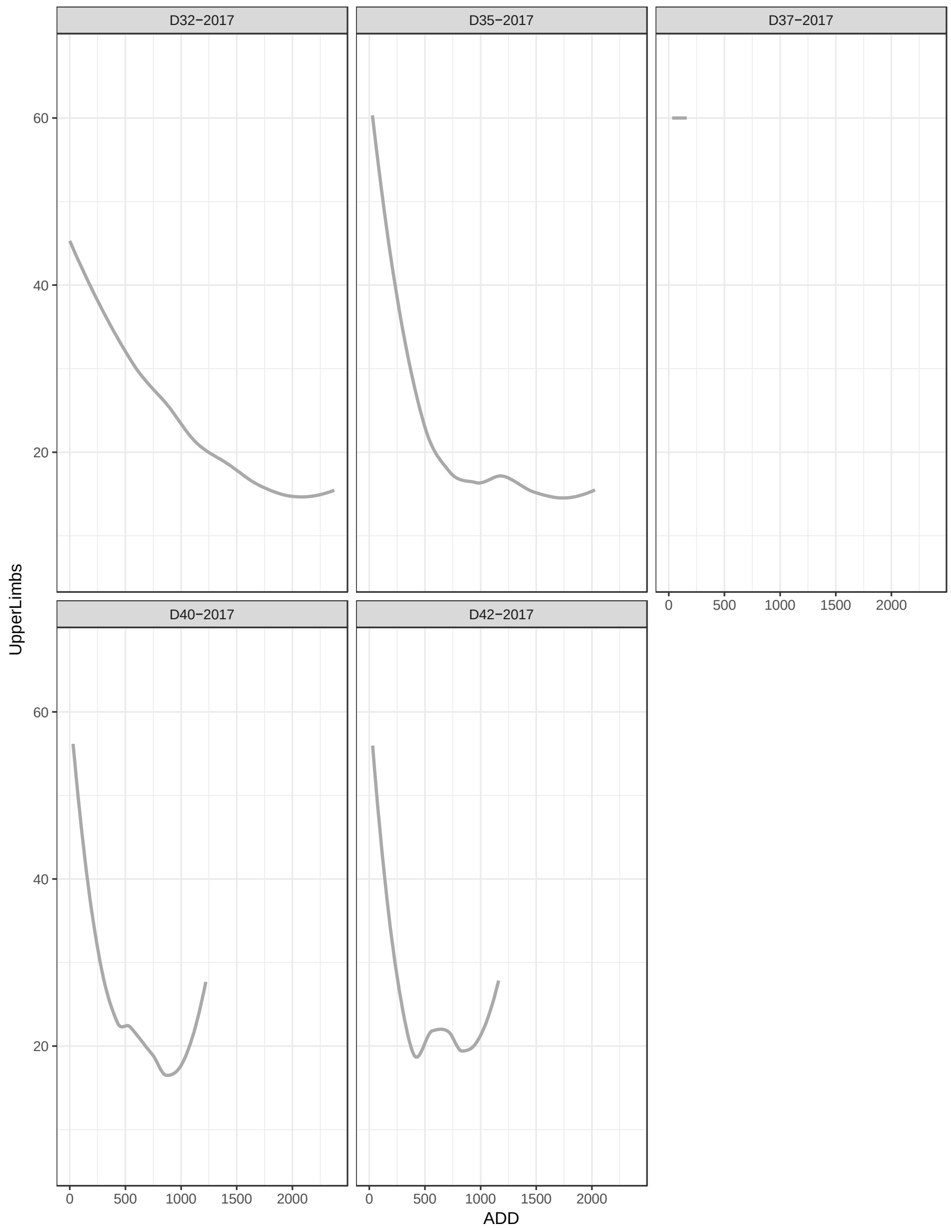

Figure 8: Scatterplot with LOESS curve of upper limb measurements, the Y-axis represents moisture content, while the X-axis represents ADD. The shaded area represents the statistically smoothed data.

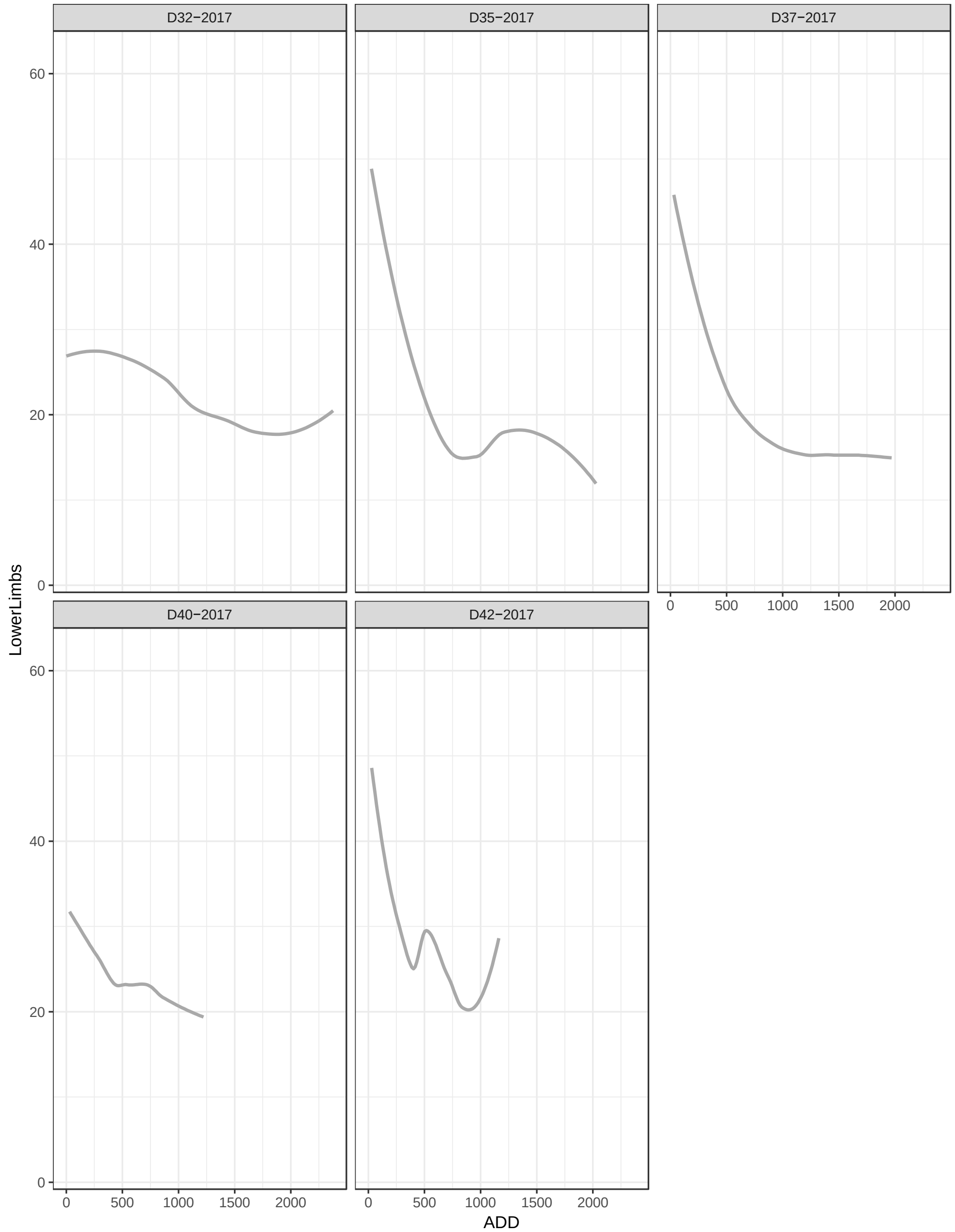

Figure 9: Scatterplot with LOESS curve of lower limb measurements, the Y-axis represents moisture content, while the X-axis represents ADD. The shaded area represents the statistically smoothed data.

PREDICTIVE MODELS

The following models were created by keeping the fixed effects constant and predicting moisture content for various ADD values. These models can be used to estimate moisture content by ADD, or vice versa, in order to draw conclusions about PMI.

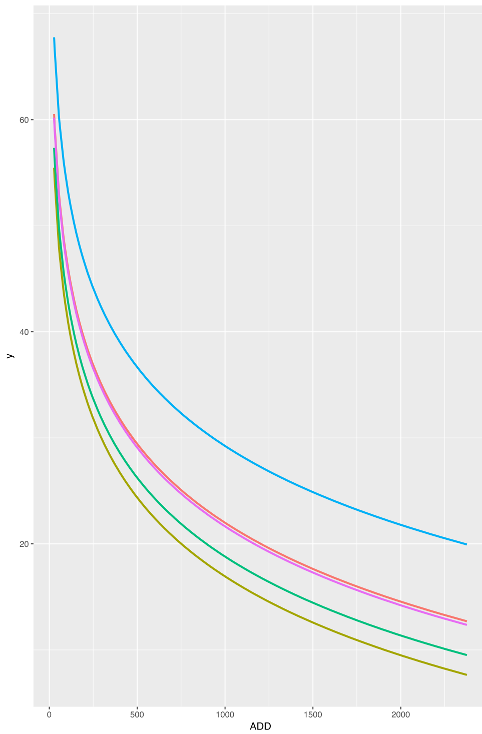

Figure 10: Predictive model for head measurements

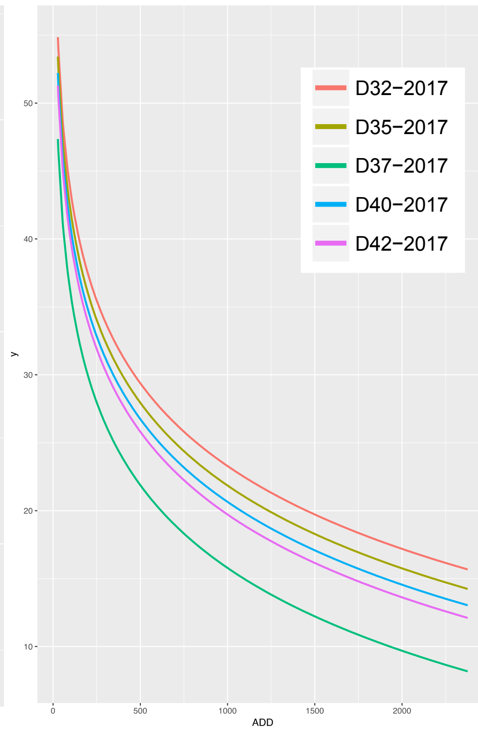

Figure 11: Predictive model for torso measurements

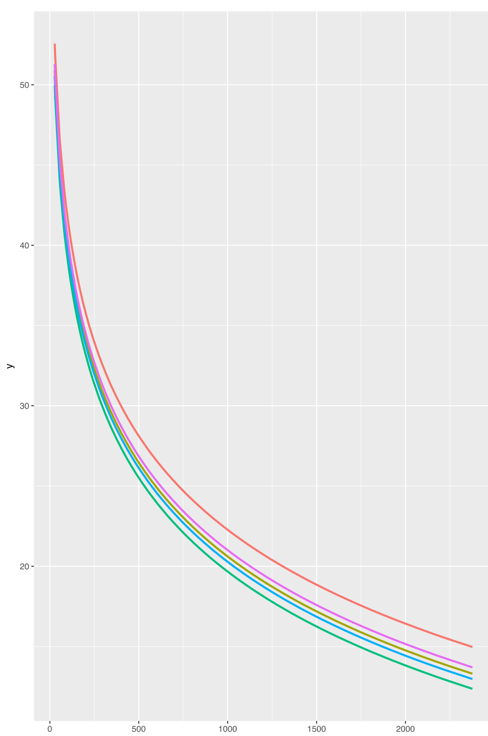

Figure 12: Predictive model for limb measurements

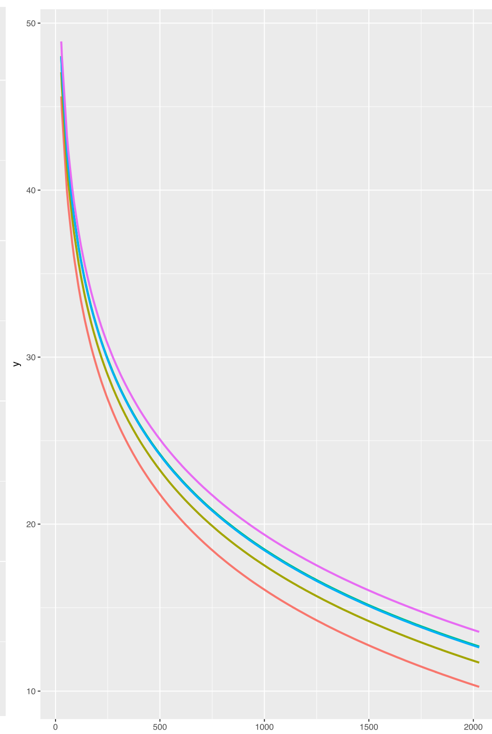

Figure 13: Predictive model for extremity measurements

V. DISCUSSION

BROAD PATTERNS OF DESICCATION

Moisture content of a living individual was determined to be within the 40 to 50% moisture content range. However, the moisture content for the individuals at placement leaned toward the upper threshold of 60%. An explanation for this is the diffusion of water through skin after death. Berenson and Burch (1951) found that at a temperature of 95°F, water is diffused through tissue at a rate of between 2 and 4.5 $mg/5cm^2/hr$. The time between death and placement of donors used in this study, as well as the time between placement and measurement, could account for these differences between epidermal moisture content percentages in living versus deceased individuals.

Overall, body region for each donor followed similar patterns of desiccation. Measurements from the head (Figure 4) exhibit a general exponential decline from the upper threshold of 60% moisture content while D32-2017 and D35-2017 show a nearly asymptotic approach to 10%, however at different rates. D37-2017 shows a similar pattern, however there is little evidence of an asymptote, due to the cessation of data collection prior to ADD 2000. D40-2017 and D42-2017 do not exhibit patterns similar to the other three donors, which is most likely a result of their later placement not reaching ADD 1500.

Torso measurements (Figure 5) follow the pattern of head measurements, every individual except D40-2017 had measurements reaching the upper moisture threshold that gradually decline to between 10 to 20% moisture content. Measurements from D40-2017 started between 40 and 50% moisture content and ended around 20%.

D40-2017 was undergoing chemotherapy prior to death, which may have had an effect on the moisture content of the skin. Chemotherapy is known to affect the skin, such as through formation of rashes and general dryness (de Boer-Dennert et al. 1997, Pernambuco-Holsten 2013), however more in-depth studies about chemotherapy's effect on moisture content of skin could not be found. Large upticks in moisture content with the last data point for each individual correspond to large amounts of rainfall owing to Hurricane Harvey that passed through Central Texas in late August 2017.

Limb measurements (Figure 6) of D32-2017, D35-2017, and D37-2017 followed patterns of desiccation that correspond to head and torso measurements. Limb measurements for D37-2017 are based exclusively on lower limb measurements after ADD 190 due to the skeletonization of the upper limbs. As discussed previously, measurements for D40-2017 and D42-2017 do not display the same curve shape, most likely owing to the cessation of the data collection period. Extremity measurements (Figure 7) for D35-2017 and D37-2017 display what has come to be the expected pattern of desiccation, while D40-2017 and D42-2017 show larger fluctuations of desiccation, most likely because of the data collection period termination, as well as the effects of precipitation from Hurricane Harvey as discussed above. Extremity measurements for D32-2017 do not follow any pattern. This is due to the hands of the donor being placed in gloves, in compliance with FACTS protocols prior to the start of this research, as well as the skeletonization of the toes around ADD 700.

In general, after death, water is diffused through the skin tissue and appears to cause an increase in moisture content from that of a living individual. The pattern of desiccation resembles an exponential decline, until the rate of desiccation decreases sharply between ADD 750 and 1000, and moisture content appears to "plateau" or approach a point between 10 and 20% asymptotically, often around ADD 1000 or 1500.

Due to the extenuating circumstances surrounding most of the donors, the data could not be compared one-to-one. D32-2017 and D35-2017 were the only two autopsied individuals, the hands D32-2017 were gloved which impeded data collection, D37-2017 experienced rapid skeletonization of the posterior portion of the body, and D42-2017 was undergoing chemotherapy prior to death, which may have had an effect on the living moisture content of the individual. Despite this, broad trends could still be evaluated and show significant results.

DIFFERENCES IN UPPER AND LOWER LIMBS

Upper and lower limb desiccation observations are presented in Figures 8 and 9. D32-2017 exhibited lower moisture content in the lower limbs from the time of placement. The upper limbs began with a moisture content of between 40 and 60% while the lower limbs began with a moisture content of between 20 and 40%. The reason for this discrepancy is not known, however it may be correlated with the amount of time between death and placement. D35-2017 showed nearly identical curves for upper and lower limbs, implying that there is not a difference between upper and lower limbs. D37-2017 only has data for lower limbs and is therefore not useful for this analysis. D40-2017 showed a similar pattern to D32-2017 in that the upper limbs began at or around 60% moisture content, while the lower limbs' starting moisture content was between 15 and 40%. Despite this, they both appeared to cluster around 20% before the termination of data collection. D42-2017 does not have a clear curve, likely due to the relatively small amount of data collection days, however both the upper and lower limbs start at or around 60% and then decline sharply to between 20 and 30% around ADD 500. A larger sample, as well as a longer data collection period is necessary in order to draw conclusions about differences in desiccation rate of upper and lower limbs, however based on the data collected in this study, there is not a significant difference between desiccation of upper and lower limbs.

MUMMIFICATION POINT

Mummification refers to the point at which the tissue is no longer losing moisture or continuing to decompose. This study shows that a moisture content approaching 10% is indicative of desiccation to the point of mummification. Once the moisture content reaches this level, it effectively bottoms out and fluctuates only slightly. Longer data collection periods would be necessary to conclude if this is where desiccation stops in the long term, therefore resulting in mummification, or if it continues to desiccate at a rate too slow to be seen over the course of this pilot study. The lowest moisture value that was recorded throughout the study was 5.8%, an extremity measure of D32-2017, but this was not sustainable and the next data collection period approximately 24 hours later showed a value of 11.1%. Moisture content measurement for individuals D58-2016, D46-2016, and D59-2016 that had been exposed for approximately seven months, respectively, were between 7% and 14%. These measurements further support that mummification occurs around 10%.

ENVIRONMENTAL EFFECTS

Based on the R^2 values, variation in the fixed (environmental) effects accounted for between approximately 50 and 55% of the variation in moisture content while individual variation accounted for between 1 and 10% of moisture content variation (Table 2). The fixed effects coefficients presented in Table 3 provide estimates for the influence that each environmental factor has on moisture content; for analysis, values for each region are averaged. Given that the data is centered, the coefficients are to be interpreted as the change in moisture content given an increase in 1 unit of the fixed effect. Temperature has the greatest effect on moisture content, -9.048, meaning that for every degree Celsius increase, moisture content should decrease by 9%. Humidity had the next largest effect on moisture content, however in the opposite way. With a coefficient of 0.405, for every percent increase of relative humidity, there was an increase of 0.4% in moisture content. Precipitation was less influential, only raising moisture content by 0.14% for each millimeter of rain. Solar radiation was found to have a surprisingly low impact on moisture content. The coefficient for solar radiation was 0.014, an increase in 1 W/m^2 would increase moisture content by just over 0.01%.

Temperature having the greatest influence over moisture content was an expected outcome. Likewise, precipitation and humidity were anticipated to have an additive effect on moisture content given that they are sources additional moisture to the environment. Solar radiation was the most surprising result. Possible explanations include collinearity, given that solar radiation and temperature may be so closely linked; or perhaps that the weather station from which the environmental measurements were taken is in an area of full sun exposure, unlike the individuals, and therefore conditions measured at the weather station did not mirror those experienced by the individuals. Given the layout of FARF, none of the individuals were placed in areas completely free of tree coverage. Based on these values, solar radiation is the only documented environmental variable that does not have a significant impact on moisture content.

PMI ESTIMATION

In order to provide estimations of PMI, predictive models were created holding all fixed effects but temperature constant (Figures 10, 11, 12, and 13). Based on these models, the limbs and extremities would be the most consistent indicators of PMI, showing the smallest amount of individual variation. These models would potentially be helpful in both early and late stage decomposition estimations, however a long-term study would be more helpful in late stage decomposition studies to determine how mummified tissue is influenced by the environment over months or years. This pilot study shows potential for developing a PMI estimation method, however more data would need to be collected to refine this approach.

SIGNIFICANCE

Studies of mummification and desiccation are helpful beyond PMI estimation considerations. In a forensic context, greater understanding of mummified tissue can allow for rehydration under laboratory conditions to obtain fingerprints or help estimate ancestry (Schmidt et al. 2000). In a bioarchaeological context, understanding tissue's response to environmental conditions can allow for greater understanding of local and climatic conditions that result in mummified remains, including the environmental factors that were the focus of this study as well as other factors such as ancient bacteria (Rollo et al. 2000).

FURTHER RESEARCH

The constraints of this research, primarily in terms of sample size and length of data collection period, limit the number of research questions that could be addressed. Utilizing this study as a baseline, the researcher would like to address differences in desiccation rates based on clothing, seasonality, soil type, and sun exposure exploring the use of surface temperature of the tissue as a more reliable indicator than solar radiation. Further, the equipment used is not intended for use on human tissue and therefore can not be utilized as standalone data. Continued research with various instruments would be necessary to demonstrate the applicability of these values on estimations of PMI. A greater understanding of desiccatory processes could also aid in bioarchaeological endeavors such as improving rehydration techniques and conservation techniques.

VI. CONCLUSION

This study examined broad patterns of desiccation in cases of naturally decomposing human remains. By measuring the amount of moisture in a given region of the body daily, it was possible to draw conclusions about which regions of the body demonstrate more significant desiccation, as well as the relative rates of desiccation among these regions. In general, after death there is a small, but measureable increase in moisture content, followed by a steady decrease in moisture content that eventually plateaus, thus signifying mummification. There does not appear to be a significant difference between desiccation of the upper and lower limbs, as earlier research in the discipline had suggested.

Based on the predictive models created from the data (Figures 10-13), limb measurements may be the strongest indicator of desiccation and its connection to PMI, which should be explored through future research. Utilizing this as a pilot study, it is clear that there is still much to be gained from further examination of moisture and its effects on the decomposition sequence of the human body. Potential applications in medicolegal investigations and bioarchaeological research of this data include postmortem interval estimation, understanding taphonomic events, environmental and climate reconstruction, and purposeful versus natural mummification.

APPENDIX SECTION

APPENDIX A: SAMPLE MOISUTRE READING DATA COLLECTION FORM

Donor: ______________________ Date:____________

Weather: ____________________________ Time: ________________

Moisture Readings:

Nose		**Thumb (left)**	
Lip		**Thumb (right)**	
Ear (left)		**Torso**	
Ear (right)		**Groin**	
Armpit (left)		**Mid-thigh (left)**	
Armpit (right)		**Mid-thigh (right)**	
Arm (left)		**1st toe (left)**	
Arm (right)		**1st toe (right)**	
5th finger (left)		**5th toe (left)**	
5th finger (right)		**5th toe (right)**	

Notes: ____

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Visual Notes:

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APPENDIX B: DESICCATION OBSERVATIONS

Date	ID	Head	Torso	Limbs	Extremities	Upper Limbs	Lower Limbs	ADD	AHD	ASRD
6/8/17	D32-2017	47.9	23.65	29.05	18.675	29.5	21.98333333	0	0	0
6/9/17	D32-2017	39.5	40.85	41.5	20.825	40.6	28.01666667	27.5955	72.25	263.75
6/10/17	D32-2017	44.8	52.625	50.075	19.925	55.95	28.01666667	58.7235	146.9	871.25
6/11/17	D32-2017	45.025	46.675	54.625	19.875	50.6	32.8	84.9705	214.45	1478.75
6/12/17	D32-2017	48.1	57.125	51.125	32.05	60	35.45	112.5115	284.85	2117.5
6/13/17	D32-2017	27.2	29.25	31.025	22.8	38.7	22.98333333	141.847	356.6	2739.35
6/14/17	D32-2017	28.9	32.45	26.2	22.025	26.95	23.16666667	170.9285	427.65	3378.1
6/15/17	D32-2017	39.125	53.75	46.625	24.25	44.9	32.28333333	200.75	496.85	3978.7
6/16/17	D32-2017	35.075	49.65	43.025	25.425	42.95	31.31666667	230.456	565.6	4601.8
6/17/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	260.5895	634.35	5150.55
6/18/17	D32-2017	26.9	15.75	21.85	16.275	23.35	17.63333333	290.8507	701.3	5684.3
6/19/17	D32-2017	37.975	47.275	43.425	21.575	49.05	26.98333333	319.2462	775.25	6046.8
6/20/17	D32-	38.6	43.05	49.7	25.8	47.2	34.6	348.2347	842.45	6629.3

	2017									
6/21/17	D32-2017	17.075	12.55	16.95	9.65	15.6	12.53333333	376.3412	903.6	7184.9
6/22/17	D32-2017	15.75	13.75	15.625	12.85	18.5	12.81666667	405.9357	961.85	7801.75
6/23/17	D32-2017	16.475	15.15	15.875	13.475	14.35	14.78333333	436.4847	1028.3	8336.75
6/24/17	D32-2017	37.4	38.8	38.8	24.5	43.15	27.81666667	460.8342	1086.4635	8653.6
6/25/17	D32-2017	26.95	21.25	18.45	23.95	14.55	23.41666667	486.0392	1165.3635	9292.35
6/26/17	D32-2017	43.4	60	46.125	50.325	50.6	47.43333333	513.8612	1238.5135	9931.1
6/27/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	540.6747	1316.2635	10521.7
6/28/17	D32-2017	55.625	54.125	56.15	51.15	52.3	54.1	567.0602	1391.6135	11160.45
6/29/17	D32-2017	39.375	45.15	37.25	38.75	44.3	35.9	595.8147	1465.9135	11755.45
6/30/17	D32-2017	27.8	33.15	28.575	31.475	32.9	29.06666667	626.3332	1536.1635	12302.3
7/1/17	D32-2017	30.225	43.325	27.525	31.475	29.95	29.35	656.1857	1606.3135	12831.05
7/2/17	D32-2017	15.4	14.625	13.425	No Data	14.1	12.75	686.1817	1678.0135	13406.65
7/3/17	D32-2017	31.125	27.875	25.15	No Data	26.15	24.15	715.7707	1748.8135	14020.4

7/4/17	D32-2017	28.75	24.65	26.25	No Data	28.95	23.55	745.8817	1817.2135	14596.65
7/5/17	D32-2017	27.575	29.2	22.375	No Data	22.2	22.55	776.3712	1879.8135	15147.25
7/6/17	D32-2017	26.5	22.25	23.95	No Data	23.15	24.75	806.0947	1948.6135	15738.5
7/7/17	D32-2017	29.35	22.675	26.075	No Data	24.45	27.7	834.5202	2017.1635	16358.5
7/8/17	D32-2017	23.725	21.55	25.5	No Data	24.2	26.8	863.0667	2082.5635	16895.35
7/9/17	D32-2017	11.3	17.625	12.625	No Data	12.65	12.6	892.2482	2145.5635	17453.45
7/10/17	D32-2017	21.95	21.74	22.4	No Data	23.2	21.5	920.2737	2210.5135	17986.55
7/11/17	D32-2017	28.925	27.325	27.425	No Data	26	28.85	950.1052	2276.7635	18550.9
7/12/17	D32-2017	27	21.225	27.95	No Data	35.05	20.85	979.5457	2344.2635	19160.25
7/13/17	D32-2017	26.05	23.475	25.625	No Data	28	23.25	1008.7717	2411.4135	19792.75
7/14/17	D32-2017	26.15	27.55	25.4	No Data	25.75	25.05	1038.2062	2476.3135	20357.75
7/15/17	D32-2017	14.85	16.65	17	No Data	20.9	13.1	1067.8977	2539.7635	20964
7/16/17	D32-2017	23.45	24.225	23.4	No Data	24.6	22.2	1095.7597	2608.0135	21505.85
7/17/17	D32-	22.575	18.2	19.65	No Data	19.8	19.5	1125.2057	2674.4635	22082.1

	2017									
7/18/17	D32-2017	23	21.3	22.35	No Data	22.35	22.35	1153.7932	2743.5635	22673.35
7/19/17	D32-2017	11.85	12.875	13.25	No Data	14.45	12.05	1183.6707	2809.9635	23274.6
7/20/17	D32-2017	24.425	21.5	25.075	No Data	26.95	23.2	1214.4427	2874.7135	23806.45
7/21/17	D32-2017	24.45	21.2	22.25	No Data	19.1	25.4	1244.1817	2937.8135	24339.55
7/22/17	D32-2017	26.8	22.475	26.425	No Data	25.55	27.3	1274.6887	3002.4135	24905.15
7/23/17	D32-2017	13.275	15.61666667	13.2	No Data	12.85	13.55	1305.5807	3069.7635	25432.65
7/24/17	D32-2017	21.075	20.45	18.3	No Data	17.2	19.4	1336.0992	3131.4135	25957
7/25/17	D32-2017	21.5	21.2	20.425	No Data	18.95	21.9	1367.5852	3195.4635	26543.25
7/26/17	D32-2017	25.025	23.35	24.125	No Data	21.45	26.8	1398.3472	3260.7635	27080.1
7/27/17	D32-2017	23.45	20.925	20.925	No Data	19.15	22.7	1427.4492	3325.1635	27611.95
7/28/17	D32-2017	25.575	23.25	24.875	No Data	20.4	29.35	1457.7667	3385.5635	28150.7
7/29/17	D32-2017	10.375	12.025	10.875	No Data	10.75	11	1489.4187	3445.3135	28702.55
7/30/17	D32-2017	14.5	14.4	13.875	No Data	13.2	14.55	1521.2032	3502.4635	29310.05

7/31/17	D32-2017	12.7	13.075	11.925	No Data	11.3	12.55	1551.4862	3551.7635	29932.55
8/1/17	D32-2017	10.775	10.75	10.275	No Data	10.35	10.2	1580.0067	3609.1135	30525.65
8/2/17	D32-2017	11.875	12.35	11.475	No Data	11.25	11.7	1607.4967	3682.7635	30783.15
8/3/17	D32-2017	29.95	26.05	23.4	No Data	26.25	20.55	1635.8317	3757.1135	31235
8/4/17	D32-2017	40.35	31.35	31.05	No Data	30.9	31.2	1665.3152	3822.1635	31838.75
8/5/17	D32-2017	13.5	14.975	17.025	No Data	21.1	12.95	1695.2707	3889.2135	32412.5
8/6/17	D32-2017	20.95	17.875	16.575	No Data	15.1	18.05	1726.0567	3956.8135	33051.25
8/7/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	1751.8437	4040.1635	33473.75
8/8/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	1779.1712	4116.0635	33984.35
8/9/17	D32-2017	20.2	26.75	21.9	No Data	20.95	22.85	1807.6112	4184.9135	34562.45
8/10/17	D32-2017	18.5	19.26666667	22.5	No Data	14.55	22.5	1836.4697	4255.4135	35167.45
8/11/17	D32-2017	10.45	15.075	11.85	No Data	10.95	12.75	1865.6547	4323.9635	35736.8
8/12/17	D32-2017	11.2	14.1	11.65	No Data	12.05	11.25	1895.7717	4392.7635	36267.4
8/13/17	D32-	15.25	17.25	17.325	No Data	14.5	20.15	1925.7782	4460.8135	36794.25

	2017									
8/14/17	D32-2017	13.45	17.275	17.75	No Data	16.95	18.55	1955.7647	4528.6135	37316.75
8/15/17	D32-2017	13.65	15.75	15.275	No Data	12.95	17.6	1985.9332	4596.5635	37909.25
8/16/17	D32-2017	14.4	16.3	14.375	No Data	12.95	15.8	2016.7967	4665.4135	38513.6
8/17/17	D32-2017	14.475	15.675	16.75	No Data	16.4	17.1	2048.3937	4730.4635	39031.1
8/18/17	D32-2017	13.55	17.3	16.65	No Data	15.35	17.95	2079.2712	4795.8135	39551.7
8/19/17	D32-2017	9.6	10.45	9.75	No Data	9	10.5	2108.8962	4861.7135	40077.95
8/20/17	D32-2017	13.925	13.25	19.725	No Data	15.25	24.2	2138.4902	4927.8135	40631.7
8/21/17	D32-2017	12.15	14.175	14.35	No Data	11.6	17.1	2168.1227	4986.384	41177.95
8/22/17	D32-2017	11.175	13.575	17.275	No Data	14.3	20.25	2196.7967	5051.234	41711.05
8/23/17	D32-2017	12.625	14.375	16.25	No Data	12.5	20	2225.7212	5116.084	42250.4
8/24/17	D32-2017	11.8	12	12.875	No Data	10.65	15.1	2254.9772	5183.384	42850.4
8/25/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	2281.1692	5259.584	43168.5
8/26/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	2304.3917	5352.784	43291.6

8/27/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	2325.8547	5452.584	43435.35
8/28/17	D32-2017	No Data	No Data	No Data	No Data	No Data	No Data	2349.9507	5533.784	43817.2
8/29/17	D32-2017	27.375	25.175	25.05	No Data	24.55	25.55	2376.1362	5603.934	44359.05
6/21/17	D35-2017	56.975	45.1	45.95	43.3125	55.65	32.73333333	28.1065	61.15	555.6
6/22/17	D35-2017	51.775	44.85	36.2	48.55	55.81666667	33.05	57.701	119.4	1172.45
6/23/17	D35-2017	27.725	50.475	53.525	47.925	58.85	40.73333333	88.25	185.85	1707.45
6/24/17	D35-2017	60	60	59.325	57.4	59.46	56.96666667	112.5995	244.0135	2024.3
6/25/17	D35-2017	60	53.75	53.05	51.75	53.85	50.51666667	137.8045	322.9135	2663.05
6/26/17	D35-2017	53.03333333	57.2	57.4	60	59.68333333	58.3	165.6265	396.0635	3301.8
6/27/17	D35-2017	No Data	No Data	No Data	No Data	No Data	No Data	192.44	473.8135	3892.4
6/28/17	D35-2017	54.4	55.75	48.325	37.1	47.4	41.76666667	218.8255	549.1635	4531.15
6/29/17	D35-2017	37.93333333	48.675	39.55	45.55	24.66666667	58.43333333	247.58	623.4635	5126.15
6/30/17	D35-2017	27.56666667	39.075	31.025	25.75	32.9	25.63333333	278.0985	693.7135	5673
7/1/17	D35-	29.1	39.95	24.6	21.15	23.26666667	23.63333333	307.951	763.8635	6201.75

	2017									
7/2/17	D35-2017	10.7	16.975	15.275	8.8	11.96666667	14.26666667	337.947	835.5635	6777.35
7/3/17	D35-2017	26.7	31.15	26.325	19.8	25.83333333	22.46666667	367.536	906.3635	7391.1
7/4/17	D35-2017	23.16666667	35.075	26.95	23.8	28.23333333	23.56666667	397.647	974.7635	7967.35
7/5/17	D35-2017	24.93333333	28.225	21.8	20.45	22.4	20.3	428.1365	1037.3635	8517.95
7/6/17	D35-2017	22.06666667	30.725	27.65	18.2	28.73333333	20.26666667	457.86	1106.1635	9109.2
7/7/17	D35-2017	23.7	26.9	24.35	21.45	24.66666667	22.1	486.2855	1174.7135	9729.2
7/8/17	D35-2017	21.73333333	25.225	22.625	19.65	22.33333333	20.93333333	514.832	1240.1135	10266.05
7/9/17	D35-2017	9.266666667	11.625	11.55	14.05	10.53333333	14.23333333	544.0135	1303.1135	10824.15
7/10/17	D35-2017	17.76666667	20.575	20.75	16.75	20.26666667	18.56666667	572.039	1368.0635	11357.25
7/11/17	D35-2017	20.93333333	24.15	23.7	18.95	24.76666667	19.46666667	601.8705	1434.3135	11921.6
7/12/17	D35-2017	21.7	26.025	21.875	20	22.63333333	19.86666667	631.311	1501.8135	12530.95
7/13/17	D35-2017	19.36666667	23.05	20.675	14.35	20.03333333	17.1	660.537	1568.9635	13163.45
7/14/17	D35-2017	21.1	23.225	21.75	19.25	21.73333333	20.1	689.9715	1633.8635	13728.45

7/15/17	D35-2017	12.06666667	16.2	16	10.3	13.7	14.5	719.663	1697.3135	14334.7
7/16/17	D35-2017	18.4	20.675	19.925	16.45	19.8	17.73333333	747.525	1765.5635	14876.55
7/17/17	D35-2017	15.36666667	18.1	15.875	14.8	15.96666667	15.06666667	776.971	1832.0135	15452.8
7/18/17	D35-2017	15.6	22.05	22.3	16.15	20.96666667	19.53333333	805.5585	1901.1135	16044.05
7/19/17	D35-2017	9.3	13.275	10.475	8.45	9.9	9.7	835.436	1967.5135	16645.3
7/20/17	D35-2017	17.1	21.875	19.2	16.8	20.1	16.7	866.208	2032.2635	17177.15
7/21/17	D35-2017	17	20.525	18.4	16.25	19.46666667	15.9	895.947	2095.3635	17710.25
7/22/17	D35-2017	18.03333333	20.75	20.35	15.9	20.4	17.33333333	926.454	2159.9635	18275.85
7/23/17	D35-2017	10.33333333	13.225	12.65	9.25	11.63333333	11.4	957.346	2227.3135	18803.35
7/24/17	D35-2017	15.63333333	19.7	20.025	14.65	17.33333333	19.13333333	987.8645	2288.9635	19327.7
7/25/17	D35-2017	15.7	19.075	18.15	14.95	16.66666667	17.5	1019.3505	2353.0135	19913.95
7/26/17	D35-2017	17.8	21.55	20.3	16.1	18.96666667	18.83333333	1050.1125	2418.3135	20450.8
7/27/17	D35-2017	16.5	20.1	19.5	14.7	18	17.8	1079.2145	2482.7135	20982.65
7/28/17	D35-	18.36666667	20.475	20.125	15.45	19.5	17.63333333	1109.532	2543.1135	21521.4

	2017									
7/29/17	D35-2017	9	11.275	9.625	7.6	9.166666667	8.733333333	1141.184	2602.8635	22073.25
7/30/17	D35-2017	10.26666667	12.7	12.425	11.05	11.8	12.13333333	1172.9685	2660.0135	22680.75
7/31/17	D35-2017	9.866666667	12	11.45	9.7	10.86666667	10.86666667	1203.2515	2709.3135	23303.25
8/1/17	D35-2017	7.566666667	11.05	10.825	7.5	9.7	9.733333333	1231.772	2766.6635	23896.35
8/2/17	D35-2017	9.166666667	11.375	11.05	9.15	9.866666667	10.96666667	1259.262	2840.3135	24153.85
8/3/17	D35-2017	25.3	36.65	21.175	26.3	24.23333333	21.53333333	1287.597	2914.6635	24605.7
8/4/17	D35-2017	30.3	42.475	46.775	32.75	46.1	38.1	1317.0805	2979.7135	25209.45
8/5/17	D35-2017	10.46666667	13.6	16.025	10.65	11.66666667	16.8	1347.036	3046.7635	25783.2
8/6/17	D35-2017	13.06666667	19.7	18.775	17.35	15.66666667	20.93333333	1377.822	3114.3635	26421.95
8/7/17	D35-2017	No Data	No Data	No Data	No Data	No Data	No Data	1403.609	3197.7135	26844.45
8/8/17	D35-2017	No Data	No Data	No Data	No Data	No Data	No Data	1430.9365	3273.6135	27355.05
8/9/17	D35-2017	17.06666667	27.125	47.05	20.6	29.23333333	47.23333333	1459.3765	3342.4635	27933.15
8/10/17	D35-2017	14.03333333	23.55	21.45	20.15	17.16666667	24.86666667	1488.235	3412.9635	28538.15

8/11/17	D35-2017	8.7	11.325	10.575	8	9.233333333	10.2	1517.42	3481.5135	29107.5
8/12/17	D35-2017	8.8	10.825	10.5	7.55	9.1	9.933333333	1547.537	3550.3135	29638.1
8/13/17	D35-2017	12.23333333	14.925	15.2	15.1	13.5	16.83333333	1577.5435	3618.3635	30164.95
8/14/17	D35-2017	11.5	15.275	13.775	13.7	12.43333333	15.06666667	1607.53	3686.1635	30687.45
8/15/17	D35-2017	11.7	13.85	13.25	13.8	11.93333333	14.93333333	1637.6985	3754.1135	31279.95
8/16/17	D35-2017	11.43333333	14.025	13.775	12.85	11.9	15.03333333	1668.562	3822.9635	31884.3
8/17/17	D35-2017	11.43333333	13.925	12.875	13.4	12.36666667	13.73333333	1700.159	3888.0135	32401.8
8/18/17	D35-2017	11.56666667	13.825	13.65	13.7	12.96666667	14.36666667	1731.0365	3953.3635	32922.4
8/19/17	D35-2017	8.133333333	9.875	8.95	6.7	8.366666667	8.033333333	1760.6615	4019.2635	33448.65
8/20/17	D35-2017	12.53333333	15.875	14.725	13.85	14.86666667	14	1790.2555	4085.3635	34002.4
8/21/17	D35-2017	11.1	13.775	11.65	12.45	11.46666667	12.36666667	1819.888	4143.934	34548.65
8/22/17	D35-2017	13.23333333	15.125	14.75	14.8	14	15.53333333	1848.562	4208.784	35081.75
8/23/17	D35-2017	11.96666667	13.775	14.375	12.8	13.23333333	14.46666667	1877.4865	4273.634	35621.1
8/24/17	D35-	9.966666667	12.425	11.8	11.15	11.1	12.06666667	1906.7425	4340.934	36221.1

	2017									
8/25/17	D35-2017	No Data	No Data	No Data	No Data	No Data	No Data	1932.9345	4417.134	36539.2
8/26/17	D35-2017	No Data	No Data	No Data	No Data	No Data	No Data	1956.157	4510.334	36662.3
8/27/17	D35-2017	No Data	No Data	No Data	No Data	No Data	No Data	1977.62	4610.134	36806.05
8/28/17	D35-2017	No Data	No Data	No Data	No Data	No Data	No Data	2001.716	4691.334	37187.9
8/29/17	D35-2017	14	31.225	27.55	16.1	27.5	19.96666667	2027.9015	4761.484	37729.75
6/23/17	D37-2017	60	25.5	41.25	46.9125	60	30.05	30.549	66.45	535
6/24/17	D37-2017	53.43333333	47	56.725	51.45	60	43.125	54.8985	124.6135	851.85
6/25/17	D37-2017	47.53333333	50.175	46.625	50.55	60	38.48333333	80.1035	203.5135	1490.6
6/26/17	D37-2017	60	60	57.63333333	55.9	60	56.12	107.9255	276.6635	2129.35
6/27/17	D37-2017	No Data	No Data	No Data	No Data	No Data	No Data	134.739	354.4135	2719.95
6/28/17	D37-2017	#REF!	#REF!	#REF!	#REF!	60	56.61666667	161.1245	429.7635	3358.7
6/29/17	D37-2017	45.85	33.4	60	42.2	No Data	49.32	189.879	504.0635	3953.7
6/30/17	D37-2017	33.76666667	22.85	36.6	43.75	No Data	37.5	220.3975	574.3135	4500.55

7/1/17	D37-2017	26.45	24.05	25.9	31.025	No Data	29.31666667	250.25	644.4635	5029.3
7/2/17	D37-2017	12.65	8.9	8.05	11.225	No Data	12.3875	280.246	716.1635	5604.9
7/3/17	D37-2017	25.9	24.9	19.05	28.425	No Data	25.3	309.835	786.9635	6218.65
7/4/17	D37-2017	32.8	25.15	27.15	28.85	No Data	27.6	339.946	855.3635	6794.9
7/5/17	D37-2017	27.7	21.05	25.55	26.3	No Data	26.05	370.4355	917.9635	7345.5
7/6/17	D37-2017	24.55	20.35	25.6	26.3	No Data	26.5	400.159	986.7635	7936.75
7/7/17	D37-2017	29.2	22.85	27.8	27.775	No Data	27.78333333	428.5845	1055.3135	8556.75
7/8/17	D37-2017	25.2	20.35	26.5	21.775	No Data	19.6125	457.131	1120.7135	9093.6
7/9/17	D37-2017	8.7	7.4	8.4	9.225	No Data	8.95	486.3125	1183.7135	9651.7
7/10/17	D37-2017	22.9	14.55	22.75	21.25	No Data	23.2125	514.338	1248.6635	10184.8
7/11/17	D37-2017	25.4	16.65	27.6	23.25	No Data	24.7	544.1695	1314.9135	10749.15
7/12/17	D37-2017	22.7	19.7	21	23.75	No Data	23.6625	573.61	1382.4135	11358.5
7/13/17	D37-2017	28.25	21.95	26.15	24.25	No Data	24.88333333	602.836	1449.5635	11991
7/14/17	D37-	27.35	20.65	25.7	23.925	No Data	21.375	632.2705	1514.4635	12556

	2017									
7/15/17	D37-2017	15.95	12.75	11.95	13.35	No Data	12.88333333	661.962	1577.9135	13162.25
7/16/17	D37-2017	24.3	19.75	24.7	21.225	No Data	21.9	689.824	1646.1635	13704.1
7/17/17	D37-2017	23.35	14.25	20.45	20.15	No Data	20.25	719.27	1712.6135	14280.35
7/18/17	D37-2017	26.4	16.9	24.25	20.575	No Data	18.3125	747.8575	1781.7135	14871.6
7/19/17	D37-2017	9.85	7.45	7.85	9.425	No Data	8.9	777.735	1848.1135	15472.85
7/20/17	D37-2017	24.3	17.7	24.7	21.1	No Data	22.3	808.507	1912.8635	16004.7
7/21/17	D37-2017	23.85	15	22.3	19.75	No Data	20.6	838.246	1975.9635	16537.8
7/22/17	D37-2017	25.55	17.65	26.05	21.725	No Data	19.8375	868.753	2040.5635	17103.4
7/23/17	D37-2017	12.45	10.45	9.85	10.975	No Data	10.6	899.645	2107.9135	17630.9
7/24/17	D37-2017	22.9	17	21.4	19.175	No Data	20.325	930.1635	2169.5635	18155.25
7/25/17	D37-2017	23.6	17.6	21.55	18.325	No Data	19.4	961.6495	2233.6135	18741.5
7/26/17	D37-2017	23.7	18.45	22.95	19.825	No Data	21.6625	992.4115	2298.9135	19278.35
7/27/17	D37-2017	23.55	16.9	24.05	18.725	No Data	20.5	1021.5135	2363.3135	19810.2

7/28/17	D37-2017	24.15	16.75	24.15	18.8	No Data	17.25	1051.831	2423.7135	20348.95
7/29/17	D37-2017	8.2	7.15	7.25	7.65	No Data	7.516666667	1083.483	2483.4635	20900.8
7/30/17	D37-2017	14.8	10.4	12.55	10.8	No Data	11.075	1115.2675	2540.6135	21508.3
7/31/17	D37-2017	11	8.8	10.15	10.35	No Data	10.28333333	1145.5505	2589.9135	22130.8
8/1/17	D37-2017	6.85	7.2	5.65	6.45	No Data	6.875	1174.071	2647.2635	22723.9
8/2/17	D37-2017	11.55	7.5	8.95	10.15	No Data	9.75	1201.561	2720.9135	22981.4
8/3/17	D37-2017	25.15	17.1	12.8	14.325	No Data	17.3375	1229.896	2795.2635	23433.25
8/4/17	D37-2017	44.35	24.9	27.9	29.475	No Data	28.95	1259.3795	2860.3135	24037
8/5/17	D37-2017	9.4	8.55	7.5	9.175	No Data	10.9	1289.335	2927.3635	24610.75
8/6/17	D37-2017	21.6	19.15	17.75	21.775	No Data	20.43333333	1320.121	2994.9635	25249.5
8/7/17	D37-2017	No Data	No Data	No Data	No Data	No Data	No Data	1345.908	3078.3135	25672
8/8/17	D37-2017	No Data	No Data	No Data	No Data	No Data	No Data	1373.2355	3154.2135	26182.6
8/9/17	D37-2017	16.75	15.4	16.3	23.65	No Data	20.975	1401.6755	3223.0635	26760.7
8/10/17	D37-	16.75	13.75	20.3	24.5	No Data	23.1	1430.534	3293.5635	27365.7

	2017									
8/11/17	D37-2017	8.15	7.5	7.5	9.575	No Data	8.425	1459.719	3362.1135	27935.05
8/12/17	D37-2017	7.5	7.05	7.05	7.775	No Data	7.533333333	1489.836	3430.9135	28465.65
8/13/17	D37-2017	14.55	12.95	18.4	19.45	No Data	18.4875	1519.8425	3498.9635	28992.5
8/14/17	D37-2017	13.8	12.05	16.65	15.725	No Data	16.03333333	1549.829	3566.7635	29515
8/15/17	D37-2017	13.3	12.1	16.75	17.525	No Data	16.8875	1579.9975	3634.7135	30107.5
8/16/17	D37-2017	13.75	11.45	15.75	15.825	No Data	15.8	1610.861	3703.5635	30711.85
8/17/17	D37-2017	13.7	13.15	14.95	17.05	No Data	16.35	1642.458	3768.6135	31229.35
8/18/17	D37-2017	13.15	12.5	16.35	17.025	No Data	16.8	1673.3355	3833.9635	31749.95
8/19/17	D37-2017	7.55	7	6.95	7.225	No Data	9.7375	1702.9605	3899.8635	32276.2
8/20/17	D37-2017	15.75	16.75	17.55	16.975	No Data	17.16666667	1732.5545	3965.9635	32829.95
8/21/17	D37-2017	13.2	11.8	15.15	15.675	No Data	16.225	1762.187	4024.534	33376.2
8/22/17	D37-2017	15.7	14.65	18.4	17.525	No Data	17.81666667	1790.861	4089.384	33909.3
8/23/17	D37-2017	14.3	12.35	10.8	16.35	No Data	14.0875	1819.7855	4154.234	34448.65

8/24/17	D37-2017	12.45	10.35	12.85	14.9	No Data	14.21666667	1849.0415	4221.534	35048.65
8/25/17	D37-2017	No Data	No Data	No Data	No Data	No Data	No Data	1875.2335	4297.734	35366.75
8/26/17	D37-2017	No Data	No Data	No Data	No Data	No Data	No Data	1898.456	4390.934	35489.85
8/27/17	D37-2017	No Data	No Data	No Data	No Data	No Data	No Data	1919.919	4490.734	35633.6
8/28/17	D37-2017	No Data	No Data	No Data	No Data	No Data	No Data	1944.015	4571.934	36015.45
8/29/17	D37-2017	13.75	13.15	10.6	13.4	No Data	13.7875	1970.2005	4642.084	36557.3
7/19/17	D40-2017	60	25.025	38.875	45.2375	60	26.23333333	29.8775	69.1	601.25
7/20/17	D40-2017	60	42.875	34.65	38.8625	48	26.91666667	60.6495	135.5	1133.1
7/21/17	D40-2017	60	39.875	30.625	43.075	43.65	34.2	90.3885	200.25	1666.2
7/22/17	D40-2017	60	44.575	27.525	42.3875	44.25	30.61666667	120.8955	263.35	2231.8
7/23/17	D40-2017	60	29.05	29.625	34.7875	38.43333333	27.7	151.7875	327.95	2759.3
7/24/17	D40-2017	60	46.575	31.1	40.8875	44.61666667	30.63333333	182.306	395.3	3283.65
7/25/17	D40-2017	60	42.45	46.8	39.7125	41.93333333	42.21666667	213.792	456.95	3869.9
7/26/17	D40-	60	43.625	34.325	30.1	32.01666667	31	244.554	521	4406.75

	2017									
7/27/17	D40-2017	39.425	31.45	30.45	31.6	32.3	30.13333333	273.656	586.3	4938.6
7/28/17	D40-2017	60	35.425	35.15	25.85	27.86666667	30.03333333	303.9735	650.7	5477.35
7/29/17	D40-2017	22.125	14.75	24.1	11.8375	13.06666667	18.78333333	335.6255	711.1	6029.2
7/30/17	D40-2017	45.325	28.35	21.175	16.275	18.88333333	16.93333333	367.41	770.85	6636.7
7/31/17	D40-2017	36.375	19.2	19.825	12.975	17.51666667	13	397.693	828	7259.2
8/1/17	D40-2017	34.25	15.2	21.525	12.35	13.16666667	17.65	426.2135	877.3	7852.3
8/2/17	D40-2017	28.725	18.65	18.7	14.8125	16.18333333	16.03333333	453.7035	934.65	8109.8
8/3/17	D40-2017	50.575	36.6	28.175	36.975	40.98333333	27.1	482.0385	1008.3	8561.65
8/4/17	D40-2017	56.775	42.425	41.075	43.725	38.46666667	47.21666667	511.522	1082.65	9165.4
8/5/17	D40-2017	38.975	17.375	15.225	15.9	16.58333333	14.76666667	541.4775	1147.7	9739.15
8/6/17	D40-2017	46.475	26.2	25.075	23.375	23.23333333	24.65	572.2635	1214.75	10377.9
8/7/17	D40-2017	No Data	No Data	No Data	No Data	No Data	No Data	598.0505	1282.35	10800.4
8/8/17	D40-2017	No Data	No Data	No Data	No Data	No Data	No Data	625.378	1365.7	11311

8/9/17	D40-2017	52.325	26.875	22.4	29.775	23.56666667	31.06666667	653.818	1441.6	11889.1
8/10/17	D40-2017	41.825	32.225	23.925	27.65	25.13333333	27.68333333	682.6765	1510.45	12494.1
8/11/17	D40-2017	24.15	15.4	16	11.925	10.71666667	15.85	711.8615	1580.95	13063.45
8/12/17	D40-2017	18.125	13.225	11.425	12.475	10	14.25	741.9785	1649.5	13594.05
8/13/17	D40-2017	24.525	21.6	23	21.875	21.13333333	23.36666667	771.985	1718.3	14120.9
8/14/17	D40-2017	22.575	22.9	19.825	20.475	18.3	22.21666667	801.9715	1786.35	14643.4
8/15/17	D40-2017	22.375	31.375	23.725	21.9625	18.98333333	26.11666667	832.14	1854.15	15235.9
8/16/17	D40-2017	24.525	21.5	17.3	20.1875	17.55	20.9	863.0035	1922.1	15840.25
8/17/17	D40-2017	22.8	20.85	22	18.35	18.15	20.98333333	894.6005	1990.95	16357.75
8/18/17	D40-2017	19.4275	22.175	23.05	19.725	18.98333333	22.68333333	925.478	2056	16878.35
8/19/17	D40-2017	14.65	7.65	9.95	10.35	9.366666667	11.06666667	955.103	2121.35	17404.6
8/20/17	D40-2017	22.575	17.9	32	17.75	17.51666667	27.48333333	984.697	2187.25	17958.35
8/21/17	D40-2017	22.6	20.1	21.25	17.575	18.85	18.75	1014.3295	2253.35	18504.6
8/22/17	D40-	21.775	19.4	27.725	17.775	17.93333333	23.68333333	1043.0035	2311.9205	19037.7

	2017									
8/23/17	D40-2017	20.55	21.125	19.775	15.825	18.23333333	23.95	1071.928	2376.7705	19577.05
8/24/17	D40-2017	20.55	21.125	19.775	15.825	15.76666667	18.51666667	1101.184	2441.6205	20177.05
8/25/17	D40-2017	No Data	No Data	No Data	No Data	No Data	No Data	1127.376	2508.9205	20495.15
8/26/17	D40-2017	No Data	No Data	No Data	No Data	No Data	No Data	1150.5985	2585.1205	20618.25
8/27/17	D40-2017	No Data	No Data	No Data	No Data	No Data	No Data	1172.0615	2678.3205	20762
8/28/17	D40-2017	No Data	No Data	No Data	No Data	No Data	No Data	1196.1575	2778.1205	21143.85
8/29/17	D40-2017	37.45	27.825	29.975	22.5125	32.3	17.7	1222.343	2859.3205	21685.7
7/21/17	D42-2017	48.4	33.5	25.225	30.6	47.91666667	29.7	29.739	63.1	533.1
7/22/17	D42-2017	56.125	38.6	39.525	54.125	47.91666667	50.6	60.246	127.7	1098.7
7/23/17	D42-2017	47.15	46.75	54.55	41.125	53.73333333	38.58333333	91.138	195.05	1626.2
7/24/17	D42-2017	60	60	56.975	54.35	53.73333333	56.71666667	121.6565	256.7	2150.55
7/25/17	D42-2017	60	44	50.7	50.2875	37.45	52.91666667	153.1425	320.75	2736.8
7/26/17	D42-2017	51.725	53	37.475	48.125	37.45	51.7	183.9045	386.05	3273.65

7/27/17	D42-2017	60	33.925	29.325	30.075	30.03333333	26.16666667	213.0065	450.45	3805.5
7/28/17	D42-2017	35.375	32.35	32.525	31.75	30.03333333	33.98333333	243.324	510.85	4344.25
7/29/17	D42-2017	17.925	14.825	14.225	11.0625	20.46666667	11.28333333	274.976	570.6	4896.1
7/30/17	D42-2017	23.85	23.2	25.2	19	20.46666667	21.66666667	306.7605	627.75	5503.6
7/31/17	D42-2017	21.025	21.025	22.75	15.5625	16	16.9	337.0435	677.05	6126.1
8/1/17	D42-2017	14.95	17.325	19.7	12.6375	16	13.98333333	365.564	734.4	6719.2
8/2/17	D42-2017	20.625	18.475	21.35	14.675	25.8	16.18333333	393.054	808.05	6976.7
8/3/17	D42-2017	40.325	24.3	29.35	36.825	25.8	42.86666667	421.389	882.4	7428.55
8/4/17	D42-2017	56.125	32.23333333	42.2	46.0125	17.05	51.63333333	450.8725	947.45	8032.3
8/5/17	D42-2017	20.9	14.275	16.475	16.35	17.05	15.73333333	480.828	1014.5	8606.05
8/6/17	D42-2017	31.625	23.45	29.475	27.025	No Data	30.31666667	511.614	1082.1	9244.8
8/7/17	D42-2017	No Data	No Data	No Data	No Data	No Data	No Data	537.401	1165.45	9667.3
8/8/17	D42-2017	No Data	No Data	No Data	No Data	24.68333333	No Data	564.7285	1241.35	10177.9
8/9/17	D42-	37.675	27.3	24.95	32.95	24.68333333	35.88333333	593.1685	1310.2	10756

	2017									
8/10/17	D42-2017	28.075	28.425	32.575	32.725	16.8	36.08333333	622.027	1380.7	11361
8/11/17	D42-2017	16.25	15.3	18.175	17.5625	16.8	18.73333333	651.212	1449.25	11930.35
8/12/17	D42-2017	11.7	13.875	15.15	13.025	27.03333333	14.4	681.329	1518.05	12460.95
8/13/17	D42-2017	22.675	22.05	29.1	25.5	27.03333333	26.36666667	711.3355	1586.1	12987.8
8/14/17	D42-2017	20.825	20.3	22.125	23.2125	22.5	22.45	741.322	1653.9	13510.3
8/15/17	D42-2017	23.65	21.875	22.525	23.075	22.5	23.28333333	771.4905	1721.85	14102.8
8/16/17	D42-2017	21.425	21.275	20.7	21	21.31666667	21.25	802.354	1790.7	14707.15
8/17/17	D42-2017	21.425	22.325	22.65	21.425	21.31666667	22.35	833.951	1855.75	15224.65
8/18/17	D42-2017	22.2	20.825	23.375	21.8125	12.3	21.88333333	864.8285	1921.1	15745.25
8/19/17	D42-2017	12.125	11.325	13.15	11.35	12.3	11.6	894.4535	1987	16271.5
8/20/17	D42-2017	21.675	22.7	22.875	21.025	17.35	22.38333333	924.0475	2053.1	16825.25
8/21/17	D42-2017	19.6	17.8	19.4	18.125	17.35	19.75	953.68	2111.6705	17371.5
8/22/17	D42-2017	22.325	21.625	23.625	21.0625	20.06666667	22.83333333	982.354	2176.5205	17904.6

8/23/17	D42-2017	21.625	20.575	22	19.2875	20.06666667	20.31666667	1011.2785	2241.3705	18443.95
8/24/17	D42-2017	20.15	17.825	19.775	18.1375	No Data	18.78333333	1040.5345	2308.6705	19043.95
8/25/17	D42-2017	No Data	No Data	No Data	No Data	No Data	No Data	1066.7265	2384.8705	19362.05
8/26/17	D42-2017	No Data	No Data	No Data	No Data	No Data	No Data	1089.949	2478.0705	19485.15
8/27/17	D42-2017	No Data	No Data	No Data	No Data	No Data	No Data	1111.412	2577.8705	19628.9
8/28/17	D42-2017	No Data	No Data	No Data	No Data	29.31666667	No Data	1135.508	2659.0705	20010.75
8/29/17	D42-2017	26.225	25.225	35.425	28.0875	29.31666667	31.75	1161.6935	2729.2205	20552.6

APPENDIX C: WEATHER DATA

Date	Temperature (°C)			Relative Humidity (%)			Solar Radiation (W/m^2)			Rain (mm)
	High	Low	Avg	High	Low	Avg	High	Low	Avg	
6/9/17	32.175	23.016	27.5955	86.3	58.2	72.25	526.9	0.6	263.75	0
6/10/17	31.128	17.355	31.128	94.4	54.9	74.65	1214.4	0.6	607.5	0
6/11/17	31.128	21.366	26.247	94.4	40.7	67.55	1214.4	0.6	607.5	0
6/12/17	34.36	20.722	27.541	96.4	44.4	70.4	1276.9	0.6	638.75	0
6/13/17	35.823	22.848	29.3355	96.4	47.1	71.75	1243.1	0.6	621.85	0
6/14/17	33.365	24.798	29.0815	92	50.1	71.05	1276.9	0.6	638.75	0
6/15/17	35.689	23.954	29.8215	95	43.4	69.2	1200.6	0.6	600.6	0
6/16/17	35.555	23.857	29.706	92.9	44.6	68.75	1245.6	0.6	623.1	0
6/17/17	36.362	23.905	30.1335	93.7	43.8	68.75	1096.9	0.6	548.75	0
6/18/17	36.2554	24.267	30.2612	92.3	41.6	66.95	1066.9	0.6	533.75	0
6/19/17	33.391	23.4	28.3955	95.6	52.3	73.95	724.4	0.6	362.5	0
6/20/17	36.444	21.533	28.9885	92.4	42	67.2	1164.4	0.6	582.5	0
6/21/17	36.039	20.174	28.1065	93.4	28.9	61.15	1110.6	0.6	555.6	0
6/22/17	37.37	21.819	29.5945	81.3	35.2	58.25	1233.1	0.6	616.85	0
6/23/17	38.896	22.202	30.549	95.8	37.1	66.45	1069.4	0.6	535	0
6/24/17	28.072	20.627	24.3495	95.7	20.627	58.1635	633.1	0.6	316.85	1.01
6/25/17	30.95	19.46	25.205	96.2	61.6	78.9	1276.9	0.6	638.75	34.8
6/26/17	33.131	22.513	27.822	96.4	49.9	73.15	1276.9	0.6	638.75	1.01
6/27/17	32.691	20.936	26.8135	99	56.5	77.75	1180.6	0.6	590.6	1.75
6/28/17	33.287	19.484	26.3855	99.2	51.5	75.35	1276.9	0.6	638.75	0.25
6/29/17	35.235	22.274	28.7545	97.4	51.2	74.3	1189.4	0.6	595	0
6/30/17	35.609	25.428	30.5185	90.1	50.4	70.25	1093.1	0.6	546.85	0
7/1/17	34.81	24.895	29.8525	93.5	46.8	70.15	1056.9	0.6	528.75	0
7/2/17	35.315	24.677	29.996	96.1	47.3	71.7	1150.6	0.6	575.6	0

7/3/17	35.128	24.05	29.589	93.9	47.7	70.8	1226.9	0.6	613.75	0
7/4/17	35.931	24.291	30.111	93.7	43.1	68.4	1151.9	0.6	576.25	0
7/5/17	36.471	24.508	30.4895	92.7	32.5	62.6	1100.6	0.6	550.6	0
7/6/17	37.508	21.939	29.7235	95.4	42.2	68.8	1181.9	0.6	591.25	0
7/7/17	36.796	20.055	28.4255	95.8	41.3	68.55	1239.4	0.6	620	0
7/8/17	36.633	20.46	28.5465	94.3	36.5	65.4	1073.1	0.6	536.85	0
7/9/17	36.878	21.485	29.1815	90.2	35.8	63	1115.6	0.6	558.1	0
7/10/17	36.281	19.77	28.0255	94.6	35.3	64.95	1065.6	0.6	533.1	0
7/11/17	36.335	23.328	29.8315	95.5	37	66.25	1128.1	0.6	564.35	0.51
7/12/17	35.985	22.896	29.4405	94.7	40.3	67.5	1218.1	0.6	609.35	0
7/13/17	37.206	21.246	29.226	95.6	38.7	67.15	1264.4	0.6	632.5	0
7/14/17	38.004	20.865	29.4345	95.7	34.1	64.9	1129.4	0.6	565	0
7/15/17	38.756	20.627	29.6915	93.5	33.4	63.45	1211.9	0.6	606.25	0
7/16/17	36.525	19.199	27.862	96.3	40.2	68.25	1083.1	0.6	541.85	0
7/17/17	36.905	21.987	29.446	94.2	38.7	66.45	1151.9	0.6	576.25	0
7/18/17	36.119	21.056	28.5875	95	43.2	69.1	1181.9	0.6	591.25	0
7/19/17	37.673	22.082	29.8775	94.5	38.3	66.4	1201.9	0.6	601.25	0
7/20/17	38.504	23.04	30.772	95	34.5	64.75	1063.1	0.6	531.85	0
7/21/17	37.921	21.557	29.739	93.6	32.6	63.1	1065.6	0.6	533.1	0
7/22/17	38.309	22.705	30.507	95.6	33.6	64.6	1130.6	0.6	565.6	0
7/23/17	38.504	23.28	30.892	95.4	39.3	67.35	1054.4	0.6	527.5	0
7/24/17	38.476	22.561	30.5185	93.3	30	61.65	1048.1	0.6	524.35	0
7/25/17	38.004	24.968	31.486	92.1	36	64.05	1171.9	0.6	586.25	0
7/26/17	38.532	22.992	30.762	96.9	33.7	65.3	1073.1	0.6	536.85	0
7/27/17	37.673	20.531	29.102	93.1	35.7	64.4	1063.1	0.6	531.85	0
7/28/17	38.84	21.795	30.3175	94.8	26	60.4	1076.9	0.6	538.75	0
7/29/17	41.795	21.509	31.652	92.7	26.8	59.75	1103.1	0.6	551.85	0

7/30/17	42.06	21.509	31.7845	87.5	26.8	57.15	1214.4	0.6	607.5	0
7/31/17	37.315	23.251	30.283	68.7	29.9	49.3	1244.4	0.6	622.5	0
8/1/17	37.866	19.175	28.5205	85.6	29.1	57.35	1185.6	0.6	593.1	0
8/2/17	31.868	23.112	27.49	91.1	56.2	73.65	514.4	0.6	257.5	0
8/3/17	33.678	22.992	28.335	95.4	53.3	74.35	903.1	0.6	451.85	12.45
8/4/17	37.673	21.294	29.4835	96.4	33.7	65.05	1206.9	0.6	603.75	0.76
8/5/17	37.206	22.705	29.9555	93.6	40.5	67.05	1146.9	0.6	573.75	0
8/6/17	37.015	24.557	30.786	92.1	43.1	67.6	1276.9	0.6	638.75	0
8/7/17	30.495	21.079	25.787	98.8	67.9	83.35	844.4	0.6	422.5	63.74
8/8/17	33.313	21.342	27.3275	98	53.8	75.9	1020.6	0.6	510.6	0
8/9/17	35.395	21.485	28.44	95.6	42.1	68.85	1155.6	0.6	578.1	0
8/10/17	36.065	21.652	28.8585	95.9	45.1	70.5	1209.4	0.6	605	0
8/11/17	35.689	22.681	29.185	91.2	45.9	68.55	1138.1	0.6	569.35	0
8/12/17	36.039	24.195	30.117	94.7	42.9	68.8	1060.6	0.6	530.6	0
8/13/17	36.661	23.352	30.0065	95.8	40.3	68.05	1053.1	0.6	526.85	0
8/14/17	36.525	23.448	29.9865	95	40.6	67.8	1044.4	0.6	522.5	0
8/15/17	35.877	24.46	30.1685	92.7	43.2	67.95	1184.4	0.6	592.5	0
8/16/17	36.444	25.283	30.8635	93.8	43.9	68.85	1208.1	0.6	604.35	0
8/17/17	36.987	26.207	31.597	90	40.1	65.05	1034.4	0.6	517.5	0
8/18/17	37.343	24.412	30.8775	93.7	37	65.35	1040.6	0.6	520.6	0
8/19/17	36.905	22.345	29.625	95.4	36.4	65.9	1051.9	0.6	526.25	0
8/20/17	36.579	22.609	29.594	94.2	38	66.1	1106.9	0.6	553.75	0
8/21/17	36.824	22.441	29.6325	94.7	22.441	58.5705	1091.9	0.6	546.25	0
8/22/17	36.769	20.579	28.674	94.9	34.8	64.85	1065.6	0.6	533.1	0
8/23/17	37.508	20.341	28.9245	93.9	35.8	64.85	1078.1	0.6	539.35	0
8/24/17	35.448	23.064	29.256	91.2	43.4	67.3	1199.4	0.6	600	0
8/25/17	30.875	21.509	26.192	94.3	58.1	76.2	635.6	0.6	318.1	0

8/26/17	24.171	22.274	23.2225	100	86.4	93.2	245.6	0.6	123.1	146.06
8/27/17	22.633	20.293	21.463	100	99.6	99.8	286.9	0.6	143.75	77.49
8/28/17	28.518	19.674	24.096	99.8	62.6	81.2	763.1	0.6	381.85	4.83
8/29/17	31.816	20.555	26.1855	90.2	50.1	70.15	1083.1	0.6	541.85	0

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