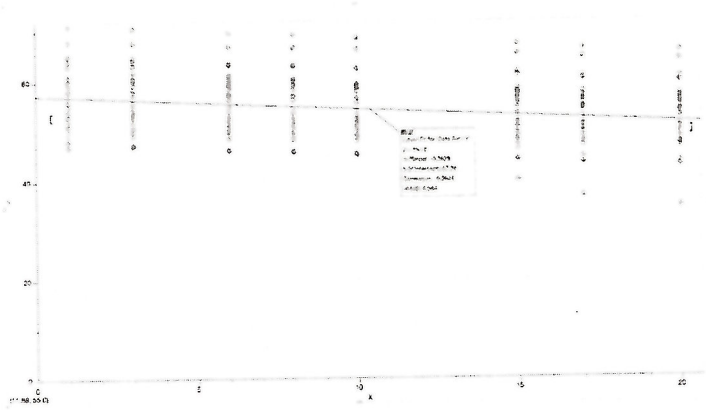
1. W= -0.2829(grams/day)*D+57.26grams

2. After graphing all of the data from the first incubation, I found this model to predict whether an egg will hatch by the amount of grams lost over a certain amount of days. This model tells us that on average, an egg weighs about 57 grams, and that each egg loses on average about -0.28 grams per day during their incubation period. The eggs that lose more than that average per day are less likely to survive and the eggs that lose less than that average per day are also less likely to survive. Of course there are eggs that are perfectly within the measurements that may not survive because of a number of different reasons but the average gives us a prediction on what eggs will hatch or not.



3. Since I used all of the data from the first round, I am very confident but there is always a chance it will not be completely accurate. There will always be a few outliers who will hatch and some who are within the accurate amount of grams lost per batch that will not make it. There is not any perfect formula that will tell you exactly if each egg will hatch or not. There are good predictions and formulas that will estimate almost exactly but never with 100% accuracy.

4. Since no article I found gave a specific model to use in order to figure out what eggs would hatch or not, I decided to go off of the University of Minnesota's information on what they gathered about egg hatching. The information they talk about involves all of the human error possibilities that can arise during the incubation process. I just looked at models of the eggs rather than the whole picture. The first thing they talk about that I did not think about in my predictions is the location of the incubator, placing it near a window where it can be exposed to direct sunlight can change the temperature inside the incubator which can cause damage to the eggs since there needs to be at a very specific temperature; between 99 and 102 degrees Fahrenheit at all times. Since we were never part of that process of getting the incubator ready, handling the eggs and rotating them, it never crossed my mind that it would be a reason the eggs did not hatch. The article discusses humidity and temperature control, which I vaguely remember talking about but not as specific numbers as they state. The last part of the article I was surprised to read about was about turning the eggs, they state they should be turned at least three times a day except for the last three days of incubation, again, since we were not part of that process, it was not possible for me to even have that in my mind as being a reason for why the eggs did not hatch but if it is crucial and missed a couple days such as on the weekends or days when there isn't anybody in the room with the incubator, it can be a contributing factor as to why the eggs that were within the gram loss margins did not hatch.

5. I was rather confused after reading the articles on egg incubation and looking at our data next to my model. It seems that there are many factors involved in having a successful incubation. Looking at our data from the second batch, I notice that many of the eggs changes within the 16 days are on average between 2 grams and 3 grams. There were only three eggs that fell well above a 3-gram loss and none of those eggs hatched. While on our first batch of eggs, on average, the eggs that did hatch had lost between 2.5-5.5 grams over the 20 days, of course with a few between those margins that did not hatch. After reading the articles, it was more clear to me that there are many human error possibilities as to why the eggs within the predicted margins of gram loss did not hatch. There are very specific instructions as to where the incubators must be placed, the temperature and humidity of the incubators at all times and the egg rotation. Of course there are other factors but these were the ones that stuck out to me that would be cause of human error. The second batch of eggs had substantially more eggs not hatch than hatch especially when looking at the first batch. I believe this is because of the incubation process that second time. Looking at 10 different eggs from the second batch, in particular, the first 10- 40-49, four of those ten did not hatch. One had already lost 8.5 grams within 16 days, which gives a good indication that it will not hatch. But the other three were right in-between the gram loss margin I talked about earlier, they were at 3.17, 3.51 and 3.31, this is where I don't understand why they did not hatch since the other six eggs that did hatch were in-between the margins of 2.3-3.5 grams lost over the course of 16 days. My model above would state that 9 out of the 10 eggs should have hatched rather than 6 out of the 10.

[redacted] good

There are many models that can be used to predict which eggs will hatch and which will not. One method is that there is a higher chance eggs with a mass that changes more from day 1 to day 17 will not hatch. More specifically, eggs with a change in mass over six grams have a much lower chance of hatching. This is true according to the data from the first incubation. Out of the five eggs with a mass change over six grams between day one and day 20, four did not hatch. This means that, according to the data, 80 percent of the eggs fitting the criteria did not hatch. Therefore, the model is correct 80 percent of the time for incubation one. ✓

This prediction does have a high rate of accuracy; however, it is not helpful in discovering all of the eggs that will not hatch. In other words, the model is not inclusive of all the data. It only is true for eggs with a mass change of over 6 grams from day one to day 20. There are eight eggs that did not hatch in incubation one, but have a mass change of less than six grams from day one to day 20. It is possible that four of these eight eggs may not be helpful in determining a model. There is a potential that these eggs were impacted by egg three, which is dented. They are all in close proximity to the dented egg, and the fact that so many around egg 3 did not hatch suggests the dented egg may have had an impact of the eggs around it. This model may be useful, but only for certain eggs within the data. ~ Interesting Idea!

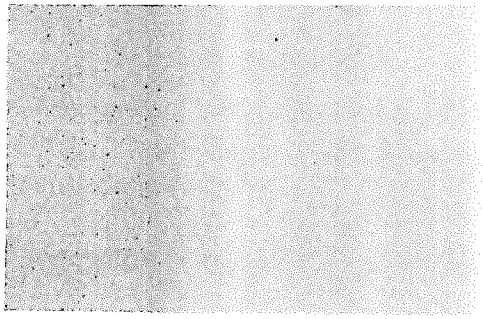
Although he data from incubation one suggests that eggs with a higher mass tend to not hatch, there are some studies that conflict with this idea. In a Selcuk University study of initial mass and mass change in incubation of Rock Partridge eggs, the data indicated that eggs with a low weight loss were less likely to hatch.

The study was conducted on Rock Partridges but is similar to other domesticated poultry (Kirikçi 383). This study can lead to questioning not only the validity of the model, but also the data of incubation one. It is possible the data may have been incorrect, or the interpretation of the data into the previously discussed model may be inaccurate. Another possibility for the confliction between the model and the study could be that the chicken eggs are not similar to Rock Partridge eggs. As Chicken eggs were not specifically mentioned in the report, they might not be included in the statement that "rock partridge eggs are similar to that of other domesticated species of poultry" (Kirikçi 380).

Even if the model is not always accurate method of determining which eggs will or will not hatch, it could at times be useful. Testing the model is one way to discover its degree of accuracy and can be accomplished by applying the model to the data from incubation two. For this prediction, the 12 eggs with the highest mass loss from day one to day sixteen will be used. The sample used is 12 instead of 10 because three eggs were of the same change in mass. The model will be applied to eggs 40, 42, 43,44,45, 47,51,53,63,65, 68, and 69. According to the model eggs 40 and 53 will not hatch, because their change in mass was greater than 6 grams between day one and day 16. The specific model does not include the other eggs, but they do fall into the broad idea that eggs with a higher change in mass are less likely to hatch. Overall, this model seems to be true, but not particularly helpful to determining which eggs will hatch.

Works Cited

Kirikçi, K., D.C Deeming, and A. Gunlu. "Effects of Egg Mass and Percentage Mass Loss During Incubation On Hatchability of Eggs of the Rock Partridge (Alectoris Graeca)." *British Poultry Science* 45.3 (2004): 380-384.



Nice work!
5/5

Based on the data that was collected after the first incubation, I think weight loss plays a large roll in whether an egg will hatch or not. As time passed over the first incubation period, we notice the weight of the eggs decrease. Changes in egg weight during incubation are due entirely to the loss of water from the egg (Aviagen). **I believe that if an egg loses between 12-15% of its weight over the 21-day incubation period then** it will **hatch.**

One of the first things I noticed when observing the egg data was the change in weight from the first day that the eggs were weighed, to the last day. During the first incubation, all of the eggs lost weight. However, some eggs lost 3g, while others lost 20g. There were about 12 eggs that did not hatch from the first incubation. Since there were fewer eggs that did not hatch than eggs that did, it is easier to reason why the eggs did not hatch than to reason why they did. Based on the classroom data sets, the eggs that did not hatch had weight loss percentages that were either less than 10% or more than 16%. There was one exception to this rule and that was with egg #32. Egg #32 had a weight loss percentage of 12% and it still did not hatch. If I were to change my prediction statement to -"**If an egg loses 13-15% of its weight over the 21-day incubation period, then it will hatch**"- based on this data set, my prediction was accurate. → to what end?

If I were to look at just the eggs that did not hatch, I would be fairly confident in my prediction. Unfortunately, when I calculate the weight loss for the eggs that

did hatch, I came up with similar percentages to the eggs that did not. This makes me believe that my prediction is only correct for certain eggs. Either way, I still believe that the eggs weight loss percentage has something to do with whether or not it will hatch. For instance, egg # 1 had a dent in it from the very beginning. This egg lost 38% of its mass over the 16 day period and did not hatch. Due to the dent, I think more moisture could escape from the shell, and that is why it lost so much weight.

The arbor acres website discussed how to measure egg water loss and why this information is pertinent to the hatching process. As stated earlier, they clarify that changes in egg weight during incubation are due entirely to the loss of water from the egg. They explain that when incubated correctly, eggs lose on average 11-12% of their egg weight between setting and transfer at 18 days. This means that about .5% of water is lost from the egg each week of storage. The incubator humidity plays a large roll in the amount of water that is loss throughout the process. Arbor acres validates that controlling incubator humidity can ensure that egg weight loss is in the optimal range and will maximize hatch and chick quality. They say that the best way to determine if incubator humidity is correct is to monitor the egg water loss on a routine basis. The website backyard chickens also refers to the fact that eggs need to lose 13% moisture over 21 days.

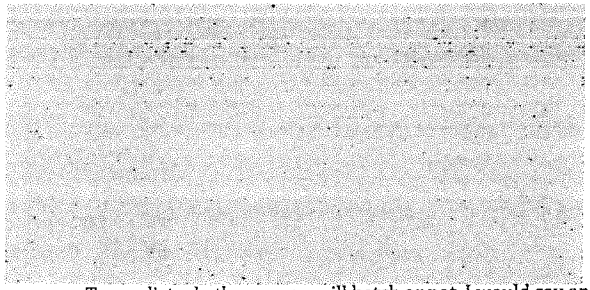
I will now apply my prediction theory to the 2nd incubation data set and determine whether or not an egg will hatch. It is harder to compare the 2nd data set to the first because in the 2nd incubation the eggs were only massed over a 16-day period rather than a 21 day period. Applying my prediction theory, after examining the

first 10 eggs (egg #[illegible]), [illegible] eggs will hatch. 9/10 of the eggs have lost between 4-6% [illegible] egg lost 14% of its weight. I need to remember tho[illegible] th[illegible] s[illegible] ch states that each egg must lose 13% of it's weight in order to hatch, re[illegible] y collection of data rather than a 16-day collection.

Resources

http://www.ba[illegible] hatching-eggs-101

http://www.avi[illegible] Center/BP_Resources_Tools/AA_How_Tos/AAHowto[illegible]



To predict whether an egg will hatch or not, I would say an accurate indicator would be by looking at how much the egg has lost in mass over the 20 days. Most of the eggs that lost between 2 and 4 grams were more likely to hatch because most eggs in that range hatched according to the data. Also, within the data, it shows that other outside factors such as the egg colored brown doesn't change the likelihood of the egg hatching or not. In the first egg incubation there were only 5 eggs that were brown and two of those eggs didn't hatch. In the attached file of the graph I made in Logger Pro of the "Eggs That Didn't Hatch" I found some data. I could not find an exact fit for the "Linear Fit" or "Curve Fit", because one of the eggs lost 21.44 grams in mass over the 30 days and this bizarre egg changed the data. The other egg grams were mainly between 3.2 grams and 7 grams. Looking through the data and trying to find an exact answer and fit for the prediction, helped me come to the realization that there is no 100% accurate representation or answer for the math model of the eggs hatching vs. not hatching.

good test + test fails approach.

I decided to look at the article titled, "Hatching and Brooding Small Numbers of Chicks" from the University of Minnesota's scholarly website, which brought to my attention that many other factors can change whether and egg could hatch or not, such as the humidity, temperature, turning the eggs and ventilation. Since I was not the one in charge of all of these different factors for the incubator, I am not sure if these factors were changing throughout the eggs time in the incubator. Maybe not all of the eggs were turned like they were supposed to be, which could affect the outcome of the egg. Plus other groups, including my own may have not placed the eggs the right way when putting them back in the incubator.

Sticking with my own prediction of the eggs hatching losing grams between 2-4, I will give some data as support to my prediction. Throughout the first egg incubator, I counted 13 eggs that hatched with losing mass between 2 and 4. Looking at the second round of eggs that we predicted, the same prediction applies with 18 eggs also having a mass losing from 2-4 grams, which applied more to the prediction. Almost all of the eggs that hatched were a change of mass between 2-4 grams. Using this data of these first 10 eggs in the first egg incubator show that:

Difference Between Day 1 and Day 17	9/14/2015	Difference Between Day 1 and Day 20	Did it Hatch?
2.85	49.78	3.22	No
3	50.63	3.37	No
19.05	34.56	21.44	No
4.69	59.72	5.28	No
3.04	49.56	3.44	No
3.17	52.42	3.58	
3.52	51.09	3.91	No
3.11	47.48	3.52	
9.73	52.81	11.19	
9.2	53.56	10.44	No

The prediction is not true because there is four eggs right away shown that have a mass between 2-4 grams and didn't hatch.

It has been difficult to come up with an exact prediction for the eggs hatching vs. not hatching.

I know that there is not an answer or one math model/math method that can work for determining the eggs hatching. My hypothesis of eggs hatching between 2-4 grams less is not accurate like I had hoped it would be. There must be other determining factors such as the factors I brought up earlier from the article that could have changed the outcome of the eggs.

	Data Set	
	Eggs	Mass (grams)
1	1	3.22
2	2	3.37
3	3	21.44
4	4	5.28
5	5	3.44
6	6	3.91
7	7	4.26
8	8	5.48
9	9	3.2
10	10	7.87
11	11	10.45
12		
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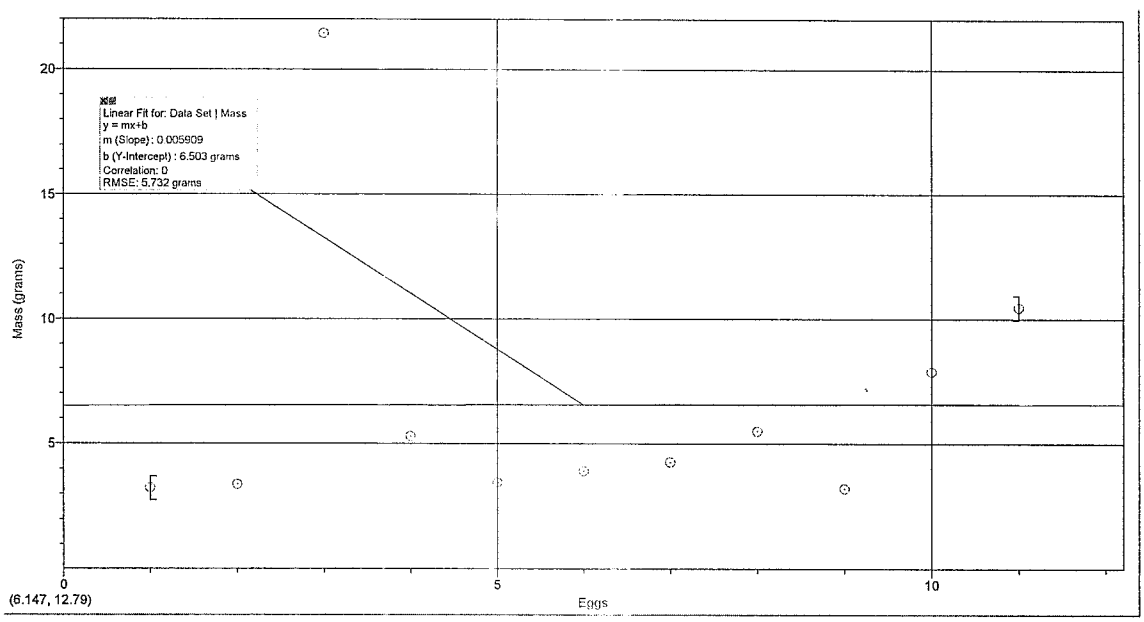


s Wil Hatch?

Based on the data collected from the first incubation we did in class, I have concluded that the egg is more likely to hatch if the total weight loss of the egg over the incubation period is less than six grams. Of the eggs of the first incubation, the eight of the eggs that did not hatch had a total weight difference below six grams. While this is true for all but one of the majority of the eggs that did not hatch, only one egg that had a total weight loss greater than six did end up hatching at the end of the incubation period.

As we saw in the first incubation, it is clear that this is not true 100% of the time. Yet, I am confident that this will be true about 87% of the time. When trying to predict whether the eggs will hatch, there are many variables that we have no control over. Therefore finding a way to predict with 100% accuracy if the egg will hatch or not would be extremely unlikely. ✓

It has been said that the eggs should be moved from side to side about two times a day to prevent the embryo from sticking to the shell. Regarding this, it has been said that the eggs are more likely to hatch. I find this statement interesting because one would think that the movement would not affect the embryo which is the most important factor the hatching.

Based on this data, I have listed the eggs from our second incubation. I have listed their total weight loss as of the last period (this was the last time the eggs were massed before they started hatching, therefore this may not be completely accurate) and whether or not I believe the egg will hatch.

#40- 60.11 – 51.55 =

Will

#42- 64.86 – 61.51 =

Will

#44- 56.96 – 53.65 =

Will

#46- 50.9 – 48.56 =

Will

#48- 52.83 – 50.06 =

Will

#52- 63.32 – 60.38 =

Will

#54- 57.73 – 55.03 = 2

Will

#56- 61.37 – 58.66 =

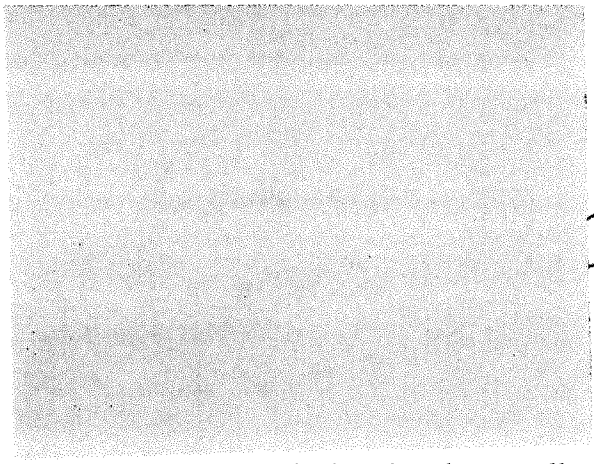
Will

#58- 47.32 – 45.41 =

Will

#60- 66.25 – 63.47 =

Will



In this egg study, I have come to the conclusion that there really is no possible way to tell if an egg will really hatch by recording its mass. The masses of the eggs in Data Set 1 had no correlation to be able to predict which eggs will hatch. However, you can come to a few conclusions about which ones probably *will not* hatch. There are also some solutions as to why some of the eggs that had a possibility to hatch did not hatch.

To start, let's look at the eggs that you can tell probably will not hatch. My theory is that any egg that loses over ten grams during the incubation period will not hatch. This remains constant with those eggs except for one stubborn egg who defies my theory. Observe:

Egg Number.	Amount of Mass Lost. (g)	Did it hatch?
3	21.44	No
9	11.19	Yes
10	10.44	No
35	10.45	No

There was not a superfluous amount of data for eggs over ten grams, so in order to develop this theory more I would have to record another set of data with more eggs so the probability of having eggs that were over ten grams would be greater. As for egg number nine, I have no idea as to why it hatched, maybe sheer luck. Another data set with more eggs would help me see if my theory is entirely wrong.

It is odd that we seem to have three categories here: eggs that will not hatch, eggs that should hatch, and eggs that do not hatch. This last category is the most confusing for me, but with the research I have done I can guess why some of the eggs that had a chance to hatch did not. My first theories are concluded from Melvin L. Hamre's research on the State University extension's services.[1] Hamre discusses the right amount of humidity that the chicks should be kept at. There may have been a problem with how often that humidity remained constant because we cannot keep watch over them at all hours of the day. Another issue he discussed is the fact that the eggs need to be turned. The eggs may not have been turned enough, and if they were turned they may have been turned back when we massed the eggs because we did not realize that how they are situated matters. Another issue on our part may have been the thoroughness of our handwashing. If we were not careful and deliberate on how well we washed our hands, we might have still had oil residing on our fingers which then clogs the airways for the egg. Those are the theories as to why the eggs that could have hatched did not. Now to predict.

[1] Hamre, M. (2013). Hatching and brooding small numbers of chicks. Retrieved October 4, 2015, from http://www.extension.umn.edu/food/small-farms/livestock/poultry/hatching-and-brooding-small-numbers/

Egg Number	Amount of Mass Lost. (g)	Could it Hatch?	Did it Hatch?
40	8.56	Yes	No
41	3.17	Yes	No
42	3.35	Yes	
43	3.51	Yes	No
44	3.31	Yes	
45	3.43	Yes	
46	2.34	Yes	
47	3.31	Yes	No
48	2.77	Yes	
49	3.06	Yes	

I believe that all of these eggs had the possibility to hatch. Unfortunately I was not able to test my theory of eggs more than ten grams. The eggs that did not hatch may have been affected by the humidity and the lack of turning.

In conclusion, there is really no possible way to determine by mass whether an egg will hatch for sure, though there are ways to tell if it will not hatch.