Evaluating the Reproductive Rate of *Aphys gossypii* (Glover) (Hemiptera:Aphididae) on a Cucurbit Squash (*Cucurbita spp.*)

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Abstract: *Aphys gossypii*, commonly known as the melon aphid, is a widespread hemipteran pest of many important agricultural crops. It can be found distributed throughout the world and can cause significant economic damages for farmers and growers. There is a lack of information in the scientific literature about the actual rate of reproduction for these aphids, information which could be very valuable in protecting against losses caused by them. In this experiment, a colony of *A. gossypii* was monitored for a week in order to establish a baseline population growth rate in a controlled setting. The results showed that the aphids increased along a logarithmic function rather than the predicted exponential one. Overall, the experiment demonstrated that the most population growth occurred in the early days of the monitoring period.

Keywords: Aphys gossypii, *melon, cotton, reproductive rate, aphid, cucurbit*

Aphys gossypii is a prevalent species of pest aphid in the insect order Hemiptera. *A. gossypii's* origins are unknown, but it is currently widely distributed throughout the world. It can be found inhabiting at least part of every continent barring Antarctica (Afonin et al., 2008). *A. gossypii* populations are generally mostly female, with members preferring to reproduce parthogenetically.

The female aphids can be found in two forms: wingless and winged. Wingless aphids have an oval-shaped body with an average length of two millimeters that can be one of various shades of green. This form also has yellow legs and antennae that average about three quarters of the aphid's body length. Black coloration is present on the apical tips of the tibia, tarsi, and femora. The winged female form possesses a fusiform body with a black-colored head and thorax. Winged females have a greenish-yellow abdomen with black spots on the sides, and generally possess longer antennae than the wingless forms. (Afonin et al., 2008; Roy et al., 2020)

A. gossypii is an important pest species around the world. It is a polyphagous generalist sap feeder that has significant impact on its host plant (Goff & Tissot, 1932). The aphids themselves are generally present in sufficient numbers to starve plant leaves and stems of their necessary nutrients through the aphids' feeding, causing chlorotic and prematurely dead foliage. *A. gossypii* feeding also results in curled leaves and similar malformations that reduce the photosynthetic efficiency of the host plant (Roy et al., 2020).

In addition to direct impacts, *A. gossypii* affects hosts indirectly through multiple means. The honeydew produced by this species encourages various sooty molds to grow on produce, marring the amount and quality of the crop. The aphids themselves can vector several major plant pathogens

such as crinkle, mosaic, citrus tristeza virus, and similar viral diseases (Afonin et al., 2008; Kosov & Polyakov, 1958).

A. gossypii impacts many common crops such as melons, cucumbers, strawberries, and citrus, and thus poses many issues for farmers and growers around the world (Ullah et al., 2020). During a review of the available literature, it was noted that little work had been published regarding the actual rates of reproduction of this particular pest species. Thus, an experiment was designed to establish a baseline for *A. gossypii* population growth rates. It was originally hypothesized that given an optimal laboratory setting with plentiful food and no chance of predation, the aphids would reproduce at a nearly exponential rate.

Materials and Methods

Preparation

Seven melon aphids (*Aphys gossypii*) from a lab-raised colony managed by Dr. Anjel Helms were placed onto one of the leaves of a cucurbit squash plant (*Cucurbita spp.*). A small mesh bag (Kiefer, Bloomington, IL) was placed over the leaf and aphids to secure them. The aphids were maintained in an approximately 21°C environment (general lab room temperature) with a 14:10 L:D photoperiod for one week, during which time they were permitted to feed and reproduce freely.

Monitoring

Every other day, the mesh bag was removed from the leaf and a digital picture was taken of both the underside and top side of the leaf using an iPhone 7 (Apple, Cupertino, CA). The camera had a resolution of 12 megapixels. The mesh bag was then replaced and the aphids left undisturbed until the next monitoring point. The host plant was watered once during the monitoring period.

Data collection and analysis

After the conclusion of the monitoring period, the total population of the aphids at each monitoring point was counted from the pictures. Given the nature and small scale of this experiment, no statistical analyses were able to be performed on the results. The conclusions of this experiment are drawn from a scatter plot of the raw data generated in Microsoft Excel 2008 (See Figure 1).

Results

The aphid population did increase greatly over the course of the monitoring period. The initial population was 7 individual *A. gossypii*, and the final population was 68 individual *A. gossypii*, a 9.7-fold increase in population. Figure 1 below displays a visual representation of this data.

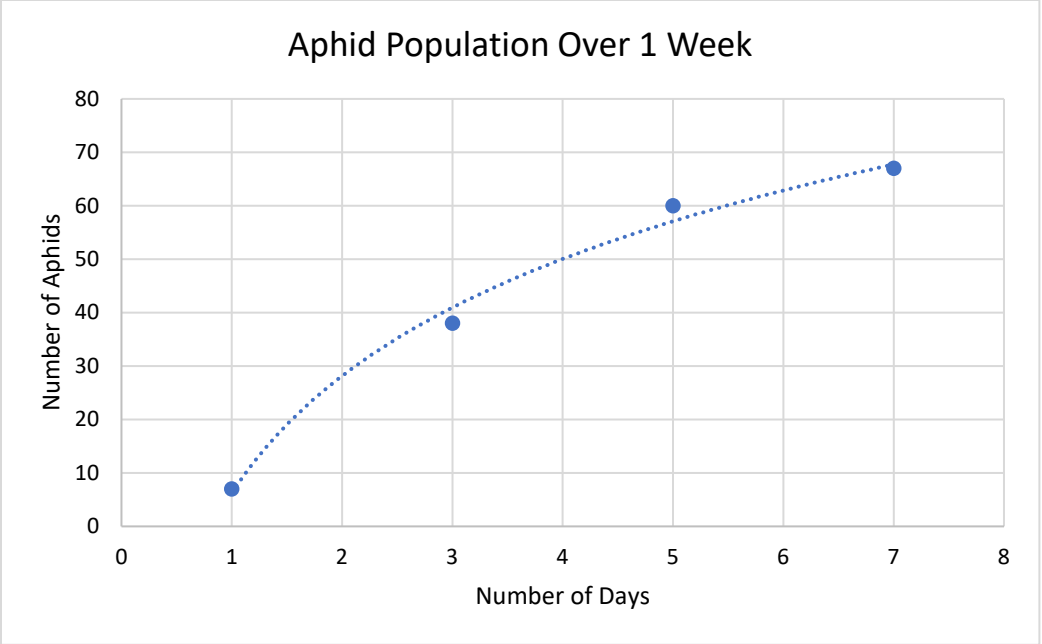

Figure 1. A visual representation of the increasing aphid population over the weeklong monitoring period. The graph shows a strong logarithmic trend (R^2 = 0.9916), running counter to the original hypothesis.

The resulting population curve best fits a logarithmic equation. As for the individual censuses, the largest population increase between periods was between day 1 and day 3, with an increase of 31 aphids. The second largest was between days 3 and 5, an increase of 23 aphids, and the least increase was between days 5 and 7 with only seven new aphids being born. Table 1 below shows these results.

Table 1. The raw data gathered from the four censuses, with analysis of the net and percent change between each monitoring period.

Day:	Population:	Net Change:	% Change:
1	7	N/A	N/A
3	38	+31	+442.7%
5	61	+23	+74.19%
7	68	+7	+11.48%

Discussion

During the monitoring period, the aphids reproduced and their population increased. It was hypothesized that this population increase would be following an approximately exponential population growth model due to aphid fecundity and parthenogenetic reproduction (Kieckhefer

& Gellner, 1988). The aphids in this experiment reproduced quickly, but their growth rate began to stall towards the end of the monitoring period. This result is abnormal compared to similar studies. Van Veen et al. (2001) established a much more exponential growth rate for pea aphids (*Acyrthosiphon pisum* [Harris, 1776]), and similarly, Lopez et al. (2014) found a nearly exponential growth rate for their control group of *A. gossypii* in a study on entomopathogenic fungi.

A. gossypii is a generalist herbivore, and has been documented feeding successfully on cucurbit squashes (Ebert & Cartwright, 1997). Since the aphid population did increase by several times, it is clear that the growth rate discrepancy observed in this experiment was not due to dietary incompatibility. The aphids were maintained at a warm enough temperature to maintain normal function, and a standard photoperiod of 10:14 L:D, similar to what they would experience in their natural habitat.

With all of these factors ruled out, the most likely explanation for the lower-than expected growth rate was simply due to a small sample size. Only one population of aphids was able to be examined, making the chance of inaccurate representation much higher. In order to more accurately model the growth rates of *A. gossypii*, a larger-scope experiment should certainly be conducted.

Despite its shortcomings, this experiment does have useful applications. *A. gossypii* is a major pest and also a plant disease vector, causing significant damages to cotton in Sub-Saharan Africa (Celini & Vaillant, 2004). Establishing a model for how quickly this species can colonize a crop would allow for easier prediction and treatment of infestations in agricultural areas.

The original hypothesis was not supported by the experiment, but this is believed to be due to an issue in sample size rather than design. This experiment's results for *A. gossypii* population growth were not comparable to other work with aphid population growth. However, due to the prevalence of *A gossypii* as a pest, more research into this should be conducted, preferably with larger sample size and perhaps a longer monitoring period.

References

Kieckhefer, R. W., Gellner, J. L. 1988. Influence of Plant Growth Stage on Cereal Aphid Reproduction. *Crop Science* 28(4) 688-690

Van Veen, F. J. F, Rajkumar, A., Muller, C. B., Godfray, H. C. J. 2001. Increased reproduction be pea aphids in the presence of secondary parasitoids. *Ecological Entomology* 26(4), 425-429

Lopez, D. C., Zhu-Salzman, K., Ek-Ramos, M. J., Sword, G. A. 2014. The Entomopathogenic Fungal Endophytes Purpureocillium lilacinum (Formerly Paecilomyces lilacinus) and Beauveria bassiana Negatively Affect Cotton Aphid Reproduction under Both Greenhouse and Field Conditions. *PLoS ONE* 9(8) e103891

Ebert, T. A., Cartwright, B. 1997. Biology and ecology of *Aphys gossypii* (Glover) (Homoptera: Aphididae). *Southwestern Entomologist* 22(1) 116-153

Celini, L., Vaillant, J. 2004. A model of temporal distribution of *Aphis gossypii* (Glover) (Hem: Aphididae) on cotton. *Journal of Applied Entomology* 128(2) 133-139

Afonin, A. N., Greene, S. L., Dzyubenko N. i., Frolov A. N. (eds.). 2008. Interactive Agricultural Ecological Atlas of Russia and Neighboring Countries. Economic Plants and their Diseases, Pests and Weeds. [Online]

Roy, D., Alderman, D., Anastasiu, P., Arianoutsou, M., Augustin, S., Bacher, S., Başnou, C., Beisel, J., Bertolino, S., Bonesi, L., Bretagnolle, F., Chapuis, J. L., Chauvel, B., Chiron, F., Clergeau, P., Cooper, J., Cunha, T., Delipetrou, P., Desprez-Loustau, M., Détaint, M., Devin, S., Didžiulis, V., Essl, F., Galil, B. S., Genovesi, P., Gherardi, F., Gollasch, S., Hejda, M., Hulme, P. E., Josefsson, M., Kark, S., Kauhala, K., Kenis, M., Klotz, S., Kobelt, M., Kühn, I., Lambdon, P. W., Larsson, T., Lopez-Vaamonde, C., Lorvelec, O., Marchante, H., Minchin, D., Nentwig, W., Occhipinti-Ambrogi, A., Olenin, S., Olenina, I., Ovcharenko, I., Panov, V. E., Pascal, M., Pergl, J., Perglová, I., Pino, J., Pyšek, P., Rabitsch, W., Rasplus, J., Rathod, B., Roques, A., Roy, H., Sauvard, D., Scalera, R., Shiganova, T. A., Shirley, S., Shwartz, A., Solarz, W., Vilà, M., Winter, M., Yésou, P., Zaiko, A., Adriaens, T., Desmet, P., Reyserhove, L. 2020. DAISIE - Inventory of alien invasive species in Europe. *Version 1.7. Research Institute for Nature and Forest (INBO)*

Goff C. C., Tissot A. N. 1932. The melon aphid, *Aphis gossypii* (Glover). *Florida Agricultural Experiment Station Bulletin* 252-275

Kosov V. V., Polyakov I. Y. 1958. Forecasting and registration of pests and diseases on agricultural crops. *Moscow: Agricultural Department.* 1-341

Polyakov I.Ya., ed. 1989. Forecasting of pests and diseases on agricultural crops for 1989. *Moscow: VIZR.* 128-132

Ullah, F., Gul, H., Tariq, K., Desneux, N., Gao, X., Song, D. 2020. Fitness costs in clothianidin-resistant population of the melon aphid, *Aphis gossypii*. *PLoS ONE* 15(9): e0238707. https://doi.org/10.1371/journal.pone.0238707