Climactic Change and the Return of the Living Dead

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Abstract

Following the hypothesis of last year's paper: (**Climactic Change and the "Survival of the Living Dead")**, experiments were conducted to test the stratospheric effects on Triops eggs and their development after hatching. With the documentation of the full lifespans, hatch rates, and developments of the test Triops and their control groups, evidence suggests that UV exposure may directly correlate with the increase of Triops hatch-rates and lifespans. By narrowing down which factor UV benefits the Triops development, this experiment can refine understanding of future space travel, its effects on organism development, and yield larger crop harvest through improved agricultural practices.

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Introduction

With climactic change occurring to some degree or another across the globe, one must wonder how this change will affect humanity. While this experiment will not be looking into its effects on human health directly, it will focus on an unlikely ally to our ecosystems, our crops and our overall health, in the form of a tiny crustacean– *Triops longicaudatus*. However, as former experiments have proven, these organisms could be an excellent candidate for long-term space travel as well. This experiment is a continuation of research done the year prior to see what is consistent with the data collected (See **Climactic Change and the "Survival of the Living Dead"**). In this study, three 200ct samples of *T. longicaudatus* eggs were exposed to stratospheric conditions, with comparisons made to three control groups of the species. This paper will cover the process of the experiment from start to finish, any difficulties that were encountered throughout the process, and what the results of the experiment suggest. Each section will be broken down into two subsections, the processes leading up to the demo-satellite launch (See flight sections), and the development of the crustaceans thereafter (See Triops Sections).

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Materials

The materials section will be broken down into two subsections; for everything leading up to and during the Demo Satellite portion of the experiment refer to the *flight* section, and for everything post Demo satellite launch refer to the *Triops* section

Flight

The following table will show the complete list of materials utilized during the flight section of the experiment

Material	Supplier	Cost
Arduino Uno	(Recycled)	N/A
Poster board	(Recycled)	N/A
Pressure Sensor	(Recycled)	N/A

Accelerometer	(Recycled)	N/A
Temperature/Humidity Sensor	(Recycled)	N/A
Data Log	(Recycled)	N/A
Insulation Foam	(Donated)	N/A
Hot Glue	Donated/ (Recycled)	N/A
Tape	Donated/ (Recycled)	N/A
Thumbtacks	Donated/ (Recycled)	N/A
Clear Acrylic	Donated/ (Recycled)	N/A
DemoSat Kit	CU Boulder	N/A

Triops

The following table will show the complete list of materials utilized during the Triops portion of the experiment

Material	Supplier	Cost
60-gallon Aquarium	Recycled	N/A
Aquarium Gravel	Recycled	N/A
Aquarium Sand	Recycled	N/A
Distilled/Spring Water	Donated	N/A
6 Aquarium Bubblers	Donated/Recycled	N/A
6 Aquarium Heat Pads	Donated/Recycled	N/A
6 Thermostats	Donated/Recycled	N/A
Six 200ct Triops eggs	Green Water Farms	N/A
Aquatic Plants	Donated	N/A
Bladder/Trumpet Snails	Donated	N/A
Algae Eaters	Donated	N/A
Fish/Shrimp Pellets	Recycled	N/A
Compound Microscope	Donated	N/A
Pipets	Donated	N/A
Tap Water Conditioner	Recycled	N/A
6 Aquarium Air Pumps	Recycled	N/A
Grow Light	Recycled	N/A

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Methods

The following methods section will be broken down into two sections; for all information leading up to the Demo Satellite launch see the *Flight* section of the paper, for all information regarding the growth and development of the crustaceans see the *Triops* section of the paper.

Flight

The following subsection describes the methods and procedures used in the UFO team's demo satellite launch, all information regarding the development of the experiment from the initial start date through to the launch and retrieval of the Demo Satellite. For information regarding the growth and development of the shrimp see the *Triops* section of the *Methods* section.

The original design utilized all sensors included in the payload kit provided by Colorado Space Grant Edge of Space. The first complication arose in the soldering of our Arduino board: once all sensors were properly soldered, all extruding pins were clipped from the back, even the plugging pins that communicate from the motherboard to the computer. This act rendered the Arduino board useless. This was before the group's first review, and with the hopes of using a back-up Arduino board, our first design review was to include 6 Triops egg capsules, an acrylic window to allow UV radiation to reach 2 of our 3 test groups, rechargeable lithium batteries to power the Arduino board, and the Arduino board itself with all included sensors.

An Arduino board from last year's demo satellite project was available, per the back-up plan, although upon programming the prebuilt board, the code we implemented was incompatible with the board and continuously sent error messages when compiling. This problem continued until a second backup plan was implemented: the sensor-less demo satellite.

The second design began with an acrylic window allowing light to shine through the payload, a battery powered humidity temperature sensor, a no *power source* UV card that displays UV exposure with no *programming required*, and 6 trips egg capsules.

Payload Dimensions in inches: 3”x 7”, 7x7”. acrylic window: 4.6”x 2”.

The payload was built using posterboard for the outside structure, insulation foam as the lining, hot glue for holding the structure and insulation foam together, a tube placed through the center of the payload (also fastened with hot glue), and finally, the eggs and uv card that were both held down using tape, glue, and thumb tacks. Once all components were fastened and secured, the outer seams of the box were taped with aluminum foil and a paper clip was poked through the tubing of our payload to attach to the weather balloon.

The Go-Pro was fastened with a foam holster attached with hot glue, snug between the box and the closed lid. The Go-Pro camera was positioned to capture the display of the UV cards and the Humidity Temp. Sensor, along with the horizon showing through the 4.6x2” acrylic window. Plan B was completed and put through all 4 pre-flight tests with the following supplies: UV sensor cards, Humidity/Temperature sensor, a GoPro, an acrylic window, and the 6 triops egg capsules.

This design proved to be too heavy, even with minimal equipment, weighing 300 grams. Upon testing, the weight of the Go-Pro caused it to dislodge even after several attempts at refastening. Outside of dislodgement, the Go-Pro did survive all tests, between the freeze test, the lasso-whip test, the roll test, and the drop test.

Upon the group's final design, the authors opted to remove all programmable software and implement non-electric sensors instead. This limited the team to UV radiation cards that absorb light, displaying the UV exposure, and the Triops egg capsules themselves. The advantage to this design is cutting the design’s overall weight budget down to 188 grams, which is 112 grams lighter than our previous design’s weight budget.

During the groups 3 mandatory Space Grant reviews (our original concept design review, critical design review, and our flight readiness review), the design had gone through 3 major

changes, between using the original sensors supplied with the demo sat kit, the Go-Pro and sensor-less recording, and the electricity-free design. With the final sensor-less design, we had a weight budget of 188 grams which includes a payload made of posterboard and insulation foam, Two Ultraviolet Radiation cards, tubing, an acrylic window, and three capsules of Triops eggs.

Final Design Pre-Flight Testing included;

FREEZE test

Lasso Test

Drop test

Roll Test

(Damage=1 corner)

UV Radiation Card

UV card tests: Two UV cards, one inside, one outside of a car window tested the card functionality and the cloud cover variable.

Upon the final flight readiness review, our payload was granted ready for flight from the Space Grant Consortium student project manager Veronica Corral Florez, PhD. On the day of the flight, the Payload was the lightest of any groups, weighing 200 grams with the added aluminum tape.

Triops

The following subsection will include all information regarding the development of the *Triops'* from the start of the egg's introduction into the aquariums through to the death of the very last surviving *Triops'*. This experiment would encompass a large sample size of *Triops longicaudatus* eggs to ensure a certain hatch rate among each group and a consistency of the available data **(Knezevich & Kikani 2024),** six groups of 200ct eggs were utilized throughout

this experiment, three 200ct Test groups and three 200ct Control groups of eggs. Each tank was set up as an 8-gallon tank complete with a constant temperature control achieved via individual thermostats, an air pump, and accompanying organisms to replicate the natural environment (vernal pools) of the Triops'.

To achieve this naturalistic set up, the tanks were stocked with organisms that help to not only maintain the aquarium's upkeep but also serve as a symbiotic relationship to the Triops'. Since the Triops are an animal that inhabits a seasonally large rain puddle, the authors opted to achieve a similar ph to a rain puddle. This was achieved by creating a concentration of distilled water, spring water, and purified waters for each individual aquarium. With the water parameters being consistent with their natural habitat the authors then opted to include beneficial organisms to live alongside the Triops'. Each tank housed plants (Java moss, Guppy Grass & Anubias), these plants would serve multiple purposes by offering the Triops hiding place, serving as an additional food source, and by better oxygenating the water. Each tank was also stocked with Algae Eaters (Sucker Fish), two kinds of aquatic snails (Bladder & Malaysian Trumpet Snails), and detritus worms. Both the fish & snails served as complementary species that would help keep the tanks clean, and the detritus worms served as a food source to the Triops'.

The eggs of each group were placed into smaller nursery tanks that were housed inside the larger main tanks. The use of the nursery tanks ensured that the Triops populations were easier to count during the earliest stages of their life cycles when they are much smaller in size. By keeping the nursery tanks inside of the main tanks, the Triops would be consistently acclimated to the parameters of the primary tanks. Once the Triops had reached a size that would be easier to locate more immediately they would be moved into the primary tanks for the remainder of their lifespan.

A visual count was made of the various Triops populations each weekday throughout the course of their lifespan. The populations for each tank were recorded into an accompanying notebook that was kept adjacent to the aquariums. This information was then consolidated into the graphs available in the **Results** section of this paper.

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Results

The following Results section will be broken down into two subsections, for all information regarding the demo satellite data see the **Flight** section, for everything regarding the lifespan of the shrimp see the **Triops** section.

Flight

The payload box was fashioned with the following methods;

- With paperclips through plastic tubing, which did not have to turn on sensors, upon retrieval, the box was opened and photographed the UV card's results, then resealed.

Release of the box

At 6:40 AM, the payload was attached to the middle of the weather balloon cable between all other team's payloads. The UV card had no reading due to the timeframe, the sun had not risen, so no prior documentation was required before launch. The elected team member stood in line with all other team's payload holder, ensuring the weather balloon went straight up with no complications.

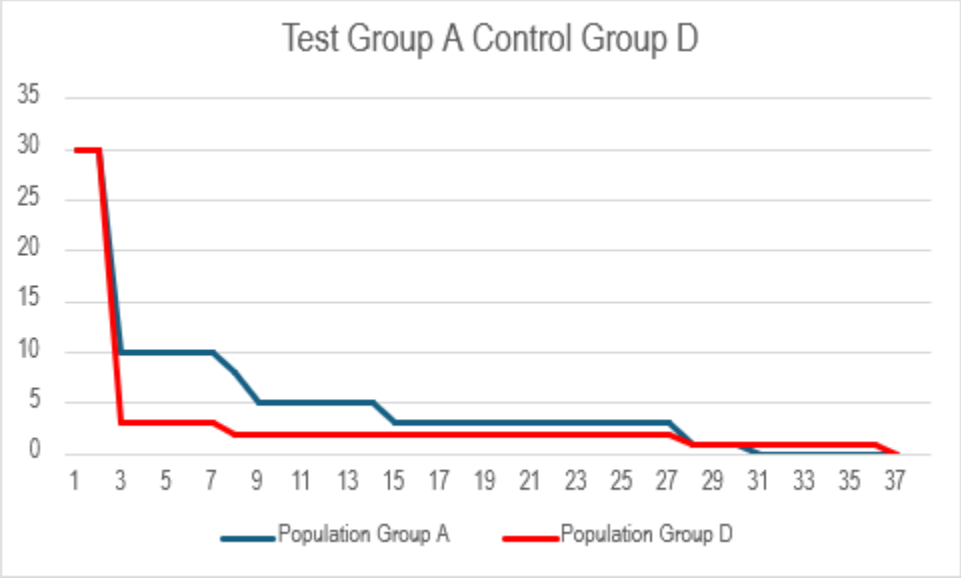
The flight lasted 2-hours and landed west of the Kansas border at 7:38 AM, between Straton and Burlington CO. Jacob Farmer (the Space Grant Affiliate director) retrieved the box, cut the aluminum foil tape to open the payload, photographed the UV cards results and resealed the box. The payload was brought to campus and reopened the following Monday,

Jan 3rd. For information regarding the next portion of the experiment see the **Triops** subsection of the **Results** section.

Triops

The following **Triops** section will be dedicated to all information gathered throughout the lifecycle of the various *Triops* populations. Each of the following paragraphs within this section will display a comparison of one test group to one control group, with the final paragraph of this section comparing all groups.

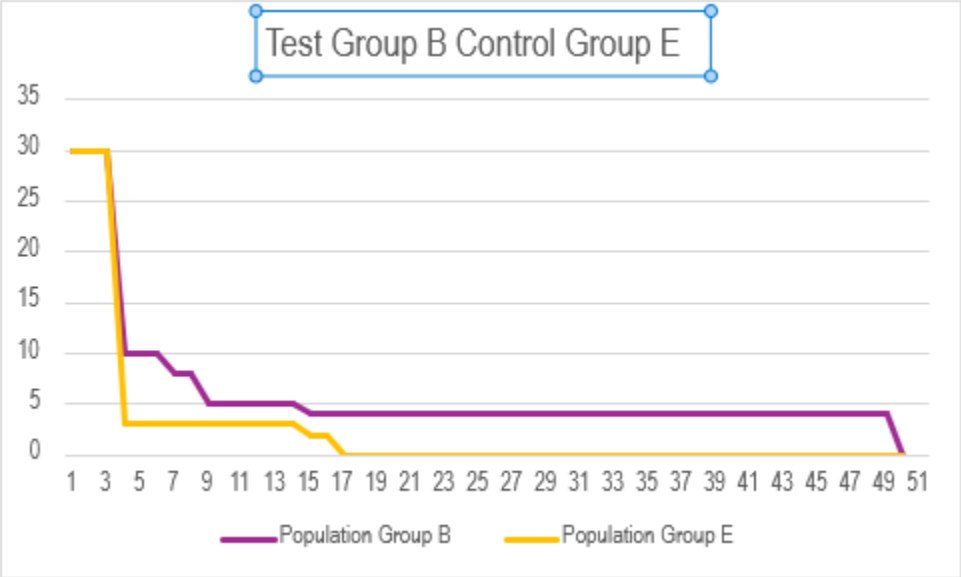
The first two groups were kept under similar conditions to the Triops groups from last year, Test Group A being maintained under the same flight conditions as the previous conditions. Their development was compared against Control Group D with both groups kept under the same aquarium conditions. Under these conditions the control group was consistent with last year's lasting a 30–37-day lifespan, the test group also being consistent topping out at about 30 days overall (see figure A).



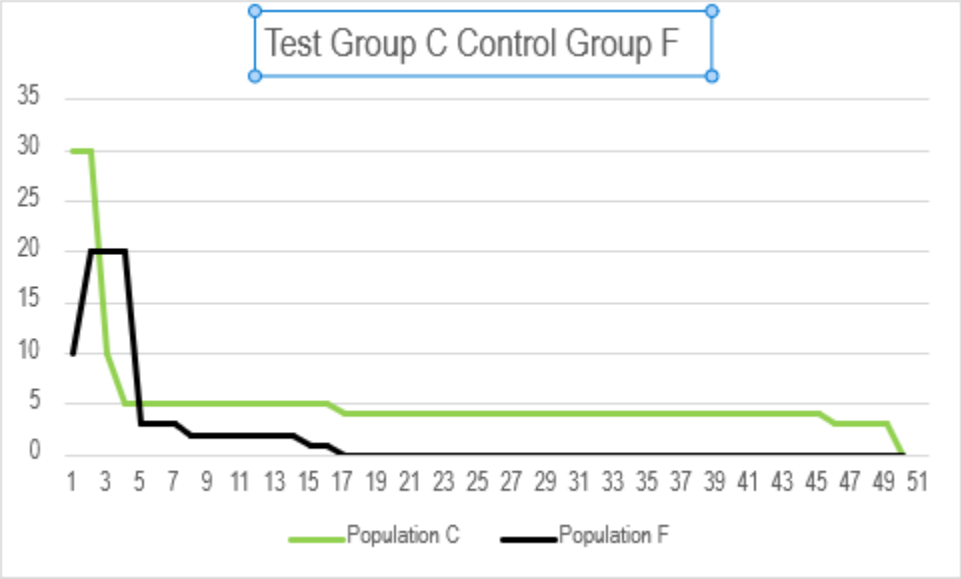
(Figure A)

The next two test groups were kept under new conditions with direct UV exposure through an acrylic window. The results of both being quite extraordinary and unexpected. Both

test groups that were exposed to ultraviolet radiation had populations which lasted 50 days while the respective control groups lasted a mere 17 days (see figures B & C).

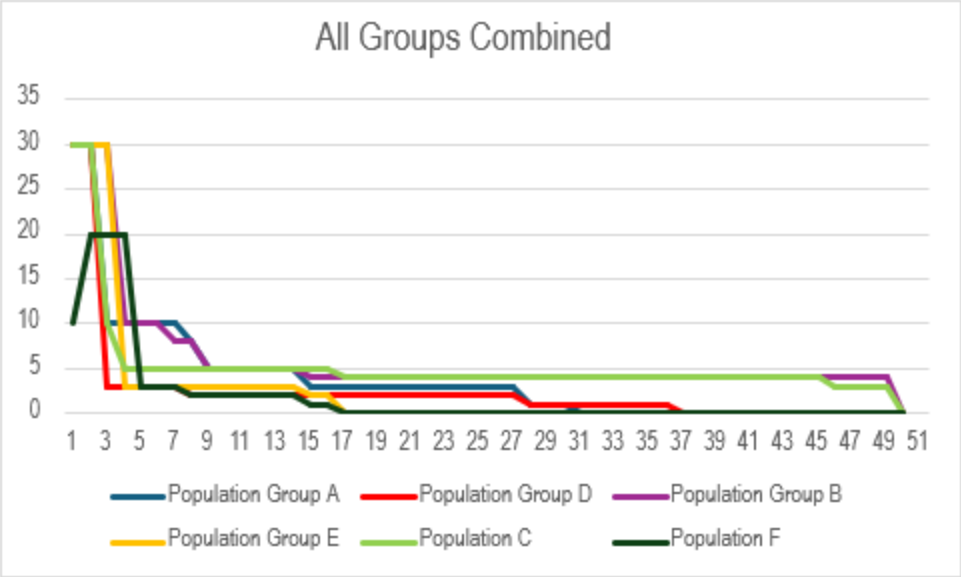


(Figure B)



(Figure C)

The final figure displays the populations of all six groups of Triops' throughout the experiment compiled together.



(Figure D)

Conclusion

This experiment was a continuation of the hypothesis explored the year prior (**Climactic Change and the "Survival of the Living Dead"**). With the addition of an acrylic window to the Balloon payload, this experiment provided new insight into how stratospheric conditions impact the survival & development of Triops. When housed in identically set-up aquariums, the researchers found that those Triops exposed to stratospheric conditions lived nearly three times longer than their respective control groups; suggesting that Triops will be among the organisms best suited to handle climactic change, also suggesting that long-term space travel could be beneficial to these organisms. Further testing would be necessary to determine which factor of stratospheric conditions is beneficial to the development of the Triops, however, since Triops are used in agricultural practices such as rice farming, narrowing down this factor to increase the Triop's lifespan could contribute to larger crop harvests and agriculture overall.

References

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