CAPTIVE REARING STUDY OF THE *THERMONECTUS MARMORATUS*

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INTRODUCTION

Thermonectus marmoratus, commonly referred to as the Sunburst Diving Beetle are vividly colored diving beetles that are active swimmers and make for a dynamic public exhibit. For the sixteen years that the St. Louis Zoo's Insectarium has been open, we have displayed the *T. marmoratus* on a continual basis. As the population dwindled, we would purchase or personally collect additional individuals from the wild.

This paper will review the methods and results of a study done at the St. Louis Zoo to reproduce the *T. marmoratus* in a systematic manner in order to produce the most successful and consistent results.

PURPOSE

The inception of this study came about due to a number of factors. One was that for several months prior to this study we were not having a lot of success in completing the reproductive cycle of the *T. marmoratus*. We were getting larvae, that would go through their three instars and migrate onto land, but very few of these pupated into adults. We had not changed our husbandry from the times when we were having success and we had introduced new animals into our population to increase our genetic diversity. The answer to our problem eluded us and we wanted a more comprehensive husbandry protocol for these animals.

Another factor was reports coming back from the IECC conference that *T. marmoratus* were becoming harder to find in the streams and ephemeral ponds in the surrounding areas where the beetles had normally been found. To my knowledge, no study has been done on the population of the *T. marmoratus,* but the ongoing collection of these beetles could very well be taking its toll on the wild population.

A third factor was the added stress on the wild population of the *T. marmoratus* with the ongoing and historical drought that the southwest United States has been dealing with for over a decade.

As Gigi Owen from the University of Arizona stated in her publication, Drought and the Environment; "With drought bringing so many changes to the Southwest ecosystems, wildlife is sure to feel the impacts. Animals will face a reduction in available drinking water, habitat and

food (both vegetation and prey). Mortality rates could increase for the most vulnerable animal species, especially regional endangered species. Lack of water, food and habitat protection may also cause decreased reproductive success and survivorship". (Owen 2008).

The last factor for conducting this study was that the CEO of the St. Louis Zoo asked all animal departments at the zoo to focus more of the zoo's conservation efforts into the sustainability of our living collection.

Though there is no documented evidence that the *T. marmoratus* is threatened, the fact that they are a popular display invertebrate and that it is well within our capability to help its population endure the stresses that man and nature are putting on it, the Insectarium staff felt that this effort fell well within this edict.

With the impact that all these factors may have on the *T. marmoratus*, the staff at the St. Louis Zoo's Insectarium decided to direct its efforts into a more intense and comprehensive husbandry program for the *T. marmoratus*.

GOALS:

Our goals from the beginning of this study were fourfold; 1) to determine an effective and efficient method in getting the *T. marmoratus* to reproduce in captivity; 2) To share this information with other institutions and individuals; 3) to encourage a transferring of individual beetles between institutions and individuals to keep the genetic diversity of the captive population at a healthy level and 4) to reduce our footprint from the *T. marmoratus* natural population.

HISTORY

The St. Louis Zoo's Insectarium has displayed *T. marmoratus* since its opening in May, 2000. They are maintained in a 122cm X 76cm X 86cm aquarium with a water level of approximately 15cm.

The substrate is a layer of river gravel at a depth of approximately 2.5cm and a large root ball adorns the display for aesthetics and places of refuge.

Over the years, along with the *T. marmoratus*, we have housed *Ranatra fusca, Lethocerus americanus, Abedus herberti*, *Gerris remiges, Dytiscus marginalis, Dineutus emarginatus* and *Hydrophilus triangularus,* as well as a variety of other aquatic invertebrates that we would collect from the zoos' lakes. The only long term, successful cohabitants with the *T. marmoratus* have been the *A. herberti*, H. *triangularus* and the *D. marginalis.* The other species were either preyed upon or were removed due to them preying upon the other animals.

Initially, this was a nonfiltered environment and water changes were done on a weekly basis with a siphon and fill system. We used a bubbler for aeration and water temperature was determinant on the incoming tap water and the air temperature of the building.

After several years we installed a canister filter below the tank to improve the water quality. Weekly water changes continue to be the normal routine, although at the time of the water change, the water quality is still at an acceptable level. We still use an aerator stone and have included a water heater that maintains the water temperature at the desired level of 24°C – 26°C.

Our husbandry from the beginning was based on Randy Morgan's paper in the1992 SASI Proceedings (Morgan, R 1992)" *T. MARMORATUS, THERMONECTUS MARMORATUS,* BIOLOGY, HUSBANDRY AND DISPLAY. 1992

We maintained multiple larvae in 38 liter aquariums and once they were in their third instar we would transfer them to a pupation tank that was designed from a 38 liter aquarium with one end walled off with a stiff plastic board and filled with a mixture of sand and potting soil. A ramp led up to the pupation area to allow easy access for the larvae.

Our past success in reproducing the *T. marmoratus* has varied from not having any larvae hatch out for long periods of time, to a four year period were we had nearly 400 adults emerge. No apparent change in husbandry occurred during these wide variances of success.

We have and continue to feed all of our aquatic insects frozen crickets.

METHODOLOGY

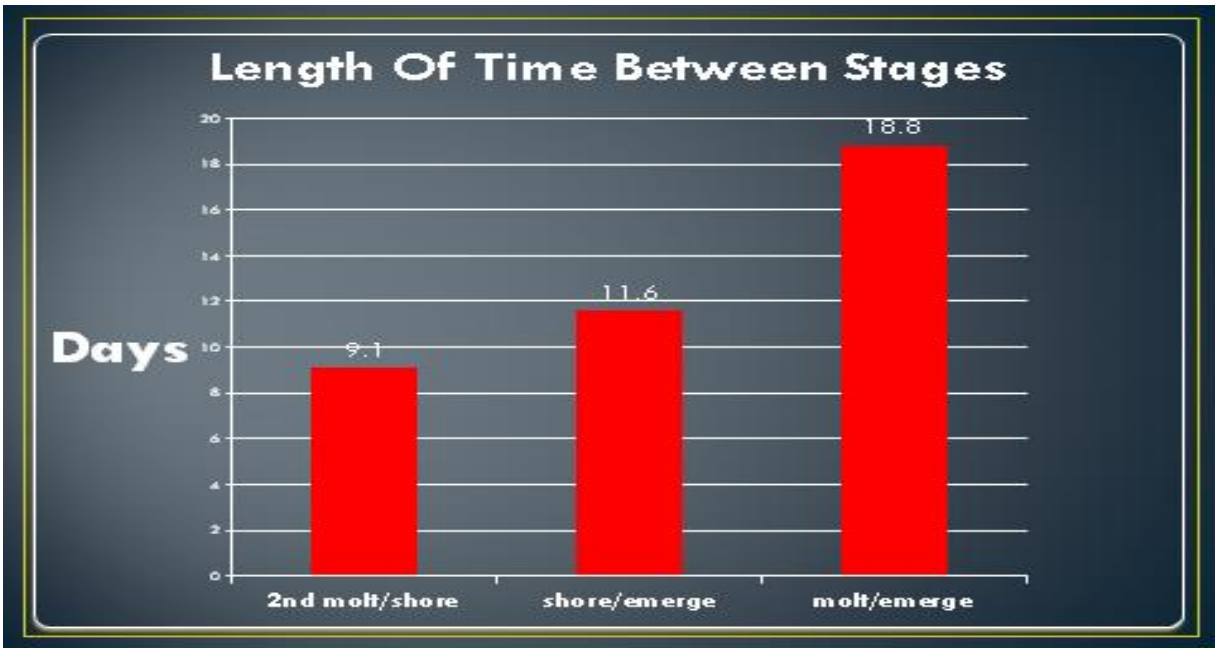
As previously stated, the purpose of this study was to determine an efficient and effective method in getting the *T. marmoratus* to reproduce in captivity - not only for ourselves but for other institutions and individuals. The St. Louis Zoo's Insectarium containment area is a spacious room measuring 12m X 7.5m and manned by four full time keepers, two year round part-timers and two summer seasonal keepers. For those institutions and individuals that do not have this much work force or work space, we wanted to see if there was a way of minimizing the space and time required to reproduce this species and maximize the results.

Our first stage was to determine the length of time it took the third instar larvae to go from their second molt to going ashore to pupate.

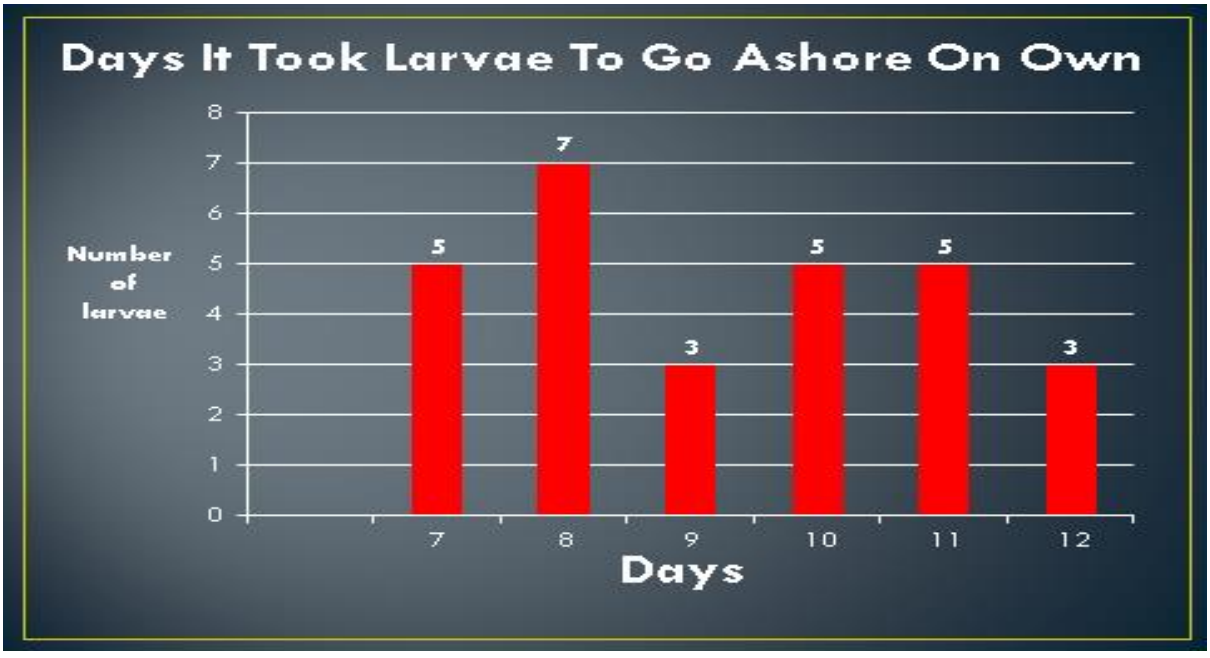
To maximize the number of larva for this stage of the study we housed the newly hatched larvae in separate containers measuring 10cm X 10cm X 7.5cm.

On the day of their 2nd molt we transferred them to small pupation tanks that measured 20cm X 10cm X 10cm and counted the days until they went ashore to pupate.

The information gleaned from this stage is that it took an average of 9.1 days from their 2nd molt to crawling ashore, 11.6 days from going ashore to emerging as adults and 18.8 days from their 2nd molt to adulthood.



Out of the 28 larvae that survived to go ashore; 5 took 7 days, 7 larvae took 8 days, 3 took 9 days, 5 took 10 days, 5 took 11 days and 3 took 12 days. So these results gave us a starting point on when to remove the 3rd instar larvae out of the water and force into pupation.



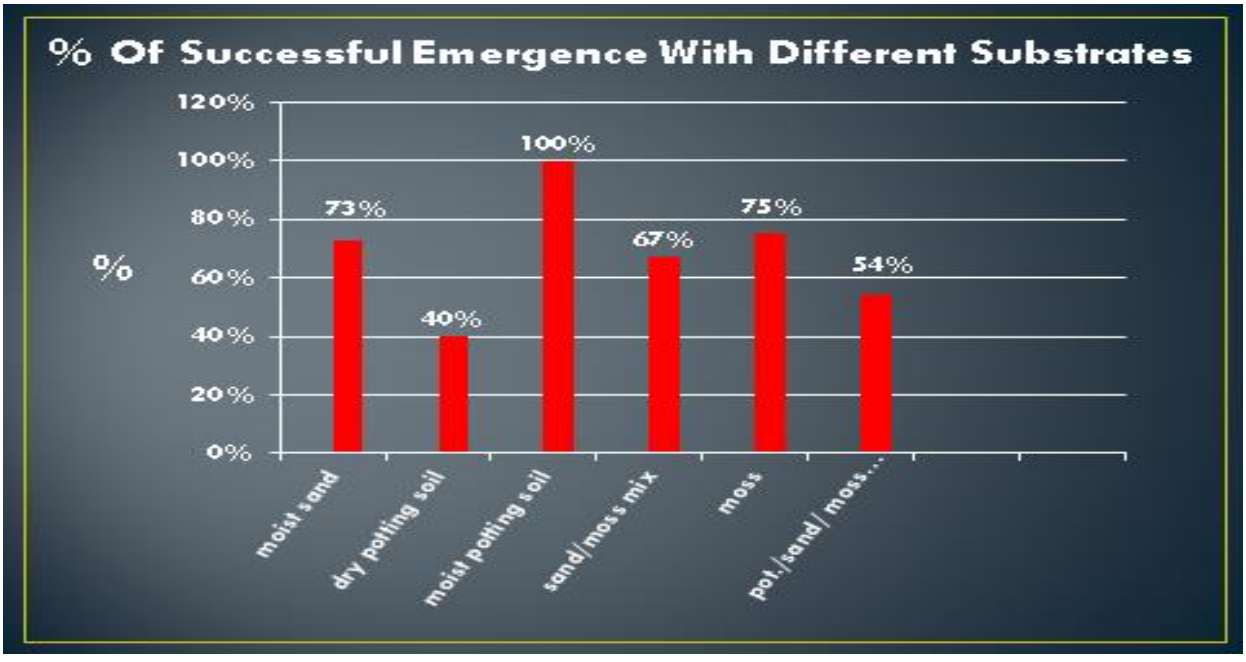
We incorporated this data into our next stage of the study which was to try to determine if there is a better substrate to use in order to get the larvae to pupate and survive until emergence. We used a variety of substrates that included sand, potting soil and sphagnum moss. We used them individually and mixed and matched them with each other. Most were moistened to varying degrees and a couple were left dry.

Our hope was to use an equal number of same-aged, 3rd instar larvae for each age group ranging from 7 to 12 days. This was not possible due to the number of larvae available during this stage. We decided to eliminate the 7, 11 and 12 day portion of this stage and focus on using 8, 9 and 10 day old 3rd instar larvae.

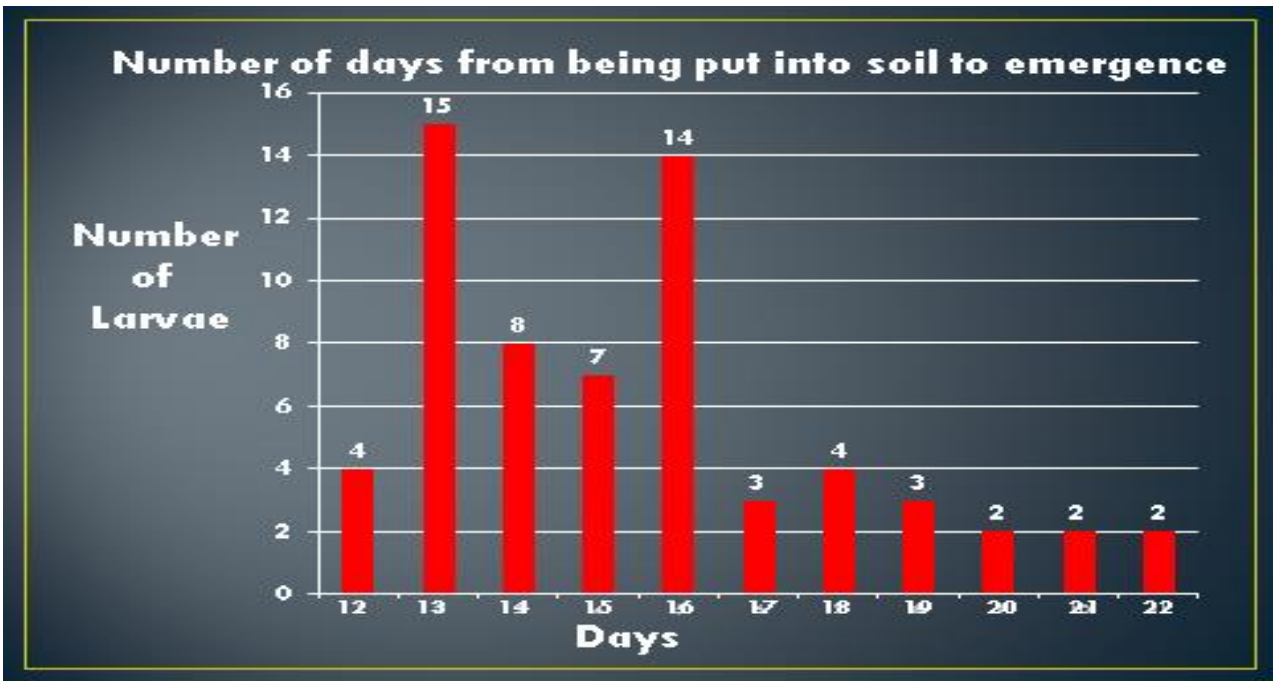
All newly hatched larvae were again put into the individual containers. We changed the water daily with tap water and they were fed 3mm frozen crickets and live house fly maggots. On the day that their second molt was observed, we dated that container and that larva stayed with that container until they were put into the substrate. For consistency, we calculated day one as the day we observed the larvae had molted for the second time and the final day as the day we took them out of the water and placed them into the substrate.

We used two plastic containers that were divided into 24 separate compartments measuring 5cm X 5cm X 5cm) each. We used six different substrates and filled four compartment areas with each substrate.

The results showed that the *T. marmoratus* larvae will pupate in a variety of substrates with relatively little difference in success rates.

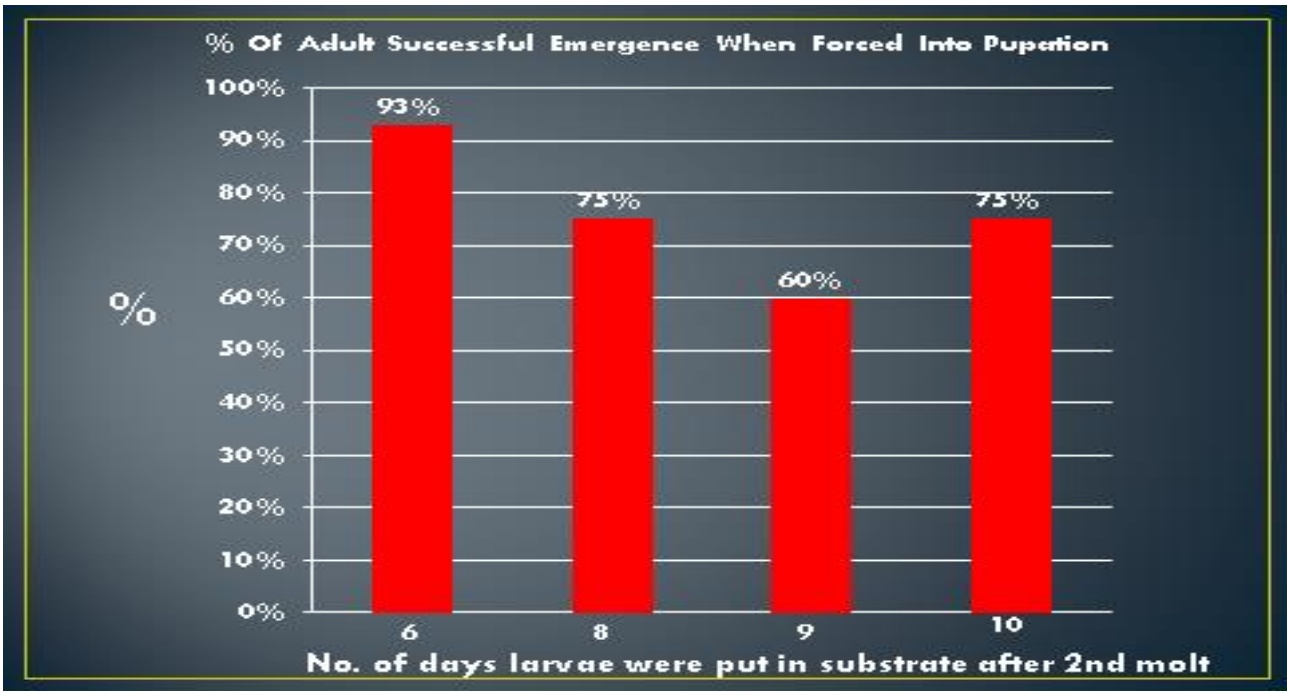


Of the 96 total larvae that were put into the substrates, 64 emerged as adults, giving us a 66 % success rate. The average length of time it took those 64 larvae from being put into the soil and emerging as adults was 15 ½ days; ranging from 12 days up to 22 days. 32 larvae died while in the substrate, but not knowing the exact reason for their deaths, I would not eliminate any substrate you might prefer to use. This stage was to determine if there was one substrate that was better than another and I would determine that there is not, but I would have the substrate moistened.



As this stage of the study progressed we were entering the summer months and the sunlight was starting to shine through the skylights in our containment room directly onto the larvae containers. We started experiencing an increase of mortality in the 3rd instar larvae before they were reaching 8 days after their 2nd molt. In order to avoid this increase in mortality, we put the larvae into the soil six days after their 2nd molt. Of the 16 larvae that we put into the pupation container after 6 days, 15 emerged as adults, in an average of 18 days. The larvae that were put in soil at 8, 9, & 10 days after their 2nd molt emerged as adults within the 23 day time span.

The other interesting occurrence was that the larvae that were put into the soil at 6 days after their 2nd molt had a higher success rate in emerging as adults.



Our speculation for the increased mortality was that the sun was warming up their environment and the larvae were reaching the stage where they needed to get out of the water to pupate faster, but being unable to do so, drowned.

Due to this occurrence we added another stage to the study. We wanted to see how much temperature variances affected the life cycle of the larvae and to see if we could quantify that data.

We decided to place newly hatched larvae in three different areas of our containment room. In one area, we set up two groups where they would get direct sunlight. One of these groups was in individual containers and the other was a communal group in a 38 liter aquarium. Another group was kept in a different area of the same room, but out of direct sunlight. The last group was placed in a temperature controlled room and the larvae were put in a small egg incubator that was maintained at 21° C. We kept the water we used for the daily water changes in the incubator to maintain a stable water temperature during water changes.

But as the saying goes; the best-laid plans of mice and men often go awry. Well, that's what happened here. As the weeks went by in accumulating enough larvae for all the different groups, the sun moved to a different angle and no longer directly shone on the counter where the larvae were housed. The temperature of the area and the water stabilized and we experienced no real difference from one group to the next.

The only reason I am including this part of the study into the paper is to make aware that there is antidotal evidence (and common sense) that higher air temperature and therefore higher water temperature may accelerate the larval development. And this needs to be kept in mind especially when removing the larvae from the water and placing it into the substrate.

Mortality is high even when keeping the larvae separate. Death usually happens during the molting process. We did not keep track of all the larvae that hatched out during the entire study, but we did during the temperature control stage. Of the 203 larvae that hatched out, 166 died in the water, 11 died while pupating and 43 emerged as adults. Of the 43 that emerged as adults, it took an average of 40 days from hatching to adulthood.

Needing as many larvae as possible for this study, only once did we have an abundance of larvae to where we were able to do a communal tank. As expected, the mortality was high due to cannibalism and unfortunately the ones that were not preyed on died while molting. Our past experience has shown that you can keep them together and have some reach their 3rd instar.

CONCLUSION

After evaluating the results of the study, we set up a protocol that is as follows;

-We remove the newly hatched larvae from the display tank and place them into individual containers. We chose to house them individually because we have both the room and the man power to care for them in this manner. And by raising them individually, we are capable of producing the most number of beetles.

-Once they molt for the second time, we date that container and maintain that larva with that container until 8 – 10 days pass. Depending on the time of the year and the temperature of the containment room we will adjust the number of days when we remove them from the water. Seldom do we go below 8 days, unless we notice the larva dying before that time, and if so, we will go down to 6 days and still have successful pupation. If the larvae are on the small side and are still eating, we will go up to 10 days.

-We then place the larvae into our compartment box containing moistened sand. It may take two to three days for the larvae to start building their pupation chamber or to molt into pupae, but the majorities do finally pupate. Once they emerge as adults they are left in the compartment box for 24 hours for their elytra to harden and then are placed into our display tank. Since the time we set up this protocol we have placed 127 larvae into the pupation box and have had 109 adults emerge for an 86% success rate.

For the institutions and individuals that do not have the time or space to raise them separately the same basic protocol could be set up in a communal setting. It would just be a matter of removing the 3rd instar larvae on the day of their 2nd molt and raising them individually for the 8 to 10 days and then placing them into the substrate of your choice. Of course the number of larvae reaching the 3rd instar will be greatly reduced due to the cannibalistic nature of this species.

By breaking down the life stages of the *T. marmoratus* and developing a systematic protocol for successfully reproducing this species, the St. Louis Zoo's Insectarium hopes that there will be a renewed interest in captive rearing this species among institutions and individuals and participating in a collaborative effort in maintaining a healthy population of captive bred *T. marmoratu*s.

APPENDIX

Owen, G. (2008). Drought and the Environment. The University of Arizona .

Morgan, R. (1992). *T. marmoratus Thermonectus marmoratus* Biology, Husbandry and Display. Invertebrates in Captivity Conference Proceedings.