NOTES ON THE CAPTIVE REARING OF THE MONTANE GIANT TIGER BEETLE, *AMBLYCHEILA BARONI* RIVERS, 1890 (COLEOPTERA: CICINDELIDAE).

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INTRODUCTION

Many species of tiger beetles have been successfully reared in captivity. These captive rearing initiatives are important for tiger beetles because many are important bioindicators, whose population numbers can signal the presence of a pristine habitat or can warn of major ecological breakdowns within a system. These insects are able to act as bioindicators due to their need for very specific types of habitat (Pearson, *et al*. 2006). Because of this habitat specificity, many tiger beetles are imperiled, and programs like this and other efforts to rear Cicindelidae in captivity will act as a safe guard if these species numbers ever do start to decline. Answering questions like preferred substrates, ideal substrate depth, larval diets, and others will aid in the effort to sustain these tiny tigers for many years to come. This study outlines the steps taken in the captive rearing efforts for the mysterious Montane Giant tiger beetle, *Amblycheila baroni*.

A. baroni is a large (20-25mm), black, flightless, tiger beetle that inhabits the pinyon-oak-juniper habitats of Southern Arizona and Western Texas. This species, like other members of the Cicindelidae, are predatory in both the larval and adult stages. The natural history and distribution of *A. baroni* is largely a mystery due to their crepuscular to nocturnal lifestyle, and adult activity being limited to very specific habitats for a short period every year (Pearson, *et al.* 2006). Not much information is yet available on this species, and to date there has been only one record of the captive production of this species, by the Toronto Zoo in the late 1990's and early 2000's (Attard pers. com. 2015; Arizona Game and Fish Department 2001; Pearson, *et al.* 2006).

This paper outlines an attempt to breed and rear *A. baroni* in captivity, and makes note to the methods used by the Toronto Zoo, in the only other recorded captive rearing of this species. The goal of this rearing attempt was to gain a better understanding of these secretive beetles, and as an attempt to raise interest in *A. baroni,* and other large flightless tiger beetles as educational and display animals in institutions.

METHODS

Adult Collection, Care and Oviposition: Two males and one female *A. baroni* were collected on the 28th of July, 2014. These three *A. baroni*, were collected in the rough, pinyon-oak-juniper habitat on the Carrie National Mine Trail at an elevation of 1645m above sea level. The beetles

were placed inside of an 11.35 liter Sterilite® container with paper towels as substrate and brought into captivity. A breeding box was set up for the beetles using a 15 liter Sterilite® container that was filled with four centimeters of a substrate that consisted of a mixture of 50% sand and 50% loess, by weight. This substrate was made by sifting sand and loess separately, through a #30 soil sieve and then mixing the two components together to form a homogenous mixture.

The substrate was then moistened with reverse osmosis water until all of the substrate appeared moist and the water could be seen forming small puddles on the bottom of the container. Once the substrate was sufficiently moistened, two rocks each with a diameter of around 10cm were placed inside of the container. These rocks were not solely for decoration but were placed in such a way that the adult beetles could retreat under the rocks during the day. The rocks were also placed in the container because an unpublished abstract from the Arizona Game and Fish Department (2001) and Pearson, *et al*. (2006) note the larvae as "being found under flat rocks and around the bases of large rocks and boulders." This lead to the assumption, on the part of the author that large rocks may be necessary for oviposition and the overall well-being of the larvae. The adult *A. baroni* were fed pre-killed adult *Acheta domesticus* (Orthoptera: Gryllidae), pre-killed *Camponotus pennsylvanicus* workers (Hymenoptera: Formicidae), pre-killed *Galleria mellonella* larvae (Lepidoptera: Pyralidae), pre-killed *Tenebrio molitor* larvae (Coleoptera: Tenebrionidae) and adults of *Calliphora* sp. and *Lucilia* sp. (Diptera: Calliphoridae) that had one wing excised. Food was always available to the adult beetles, and the container was kept at temperatures that ranged from 18.33ºC and 26.66ºC.

Observations were made on the adult beetles once a day at 2100 hours, and their behaviors were recorded. While no mate guarding or ovipositing was ever recorded during observations, several oviposition holes were observed in the container, and two elliptical cream colored, 3mm eggs were found on the surface of the soil. Forty-three days after the oviposition holes had first been observed, the first instar burrows of *A. baroni* were recorded. As soon as the first instar burrows were seen, the adult *A. baroni* were pulled from the breeding box and placed into another identical container to the original breeding box. Unfortunately, shortly after the adult beetles were moved, they died before any eggs could be laid. The adults were preserved on #2 insect pins and labeled for future reference.

Larval Care: The first larval burrow was recorded 43 days after the oviposition holes were observed in the container. The first instar burrows of *A. baroni* are large, with a diameter of about 3mm. These first instar larvae could be observed waiting for prey at the entrance of the burrow but were quick to retreat when the container was disturbed.

The first instar larvae were offered food on a daily basis. The larvae were fed 5mm *Ac. domesticus* nymphs, and adult *C. pennsylvanicus* workers, that were pre-killed by crushing the head capsules. The abdomen of the pre-killed prey was then inserted into the opening of the burrow, and the presence or absence of the prey was recorded the next day. The container was checked every day and the prey would be pulled if not consumed.

One month after the female had been removed from the breeding box, the substrate was carefully removed from the container and picked through with a #4 paint brush to tally the total number of

larvae produced. In total, 41 larvae were removed from the substrate. Interestingly, 22 of the 41 larvae were found in capsules in the substrate and had not yet constructed a burrow. The reasons for this behavior are unknown and future studies may be needed in order to determine why these first instar larva encapsulated themselves instead of constructing a burrow.

Due to the high number of larvae found in the substrate and lack of suitable housing for such large numbers, 20 larvae were donated to Steve Spomer, at the University of Nebraska-Lincoln, and the 21 remaining larvae were retained. The substrate was replaced inside of the Sterilite® container and the larvae were introduced into 1cm deep holes, poked into the substrate with the handle of the #4 paintbrush. The first instar larvae reconstructed their burrows, remained active, and continued to be feed after the census was taken.

The first instar larvae were kept at temperatures that ranged from 18.33ºC and 26.66ºC and were fed at least three times a week until they plugged their burrows and went into an inactive state for four straight days. This first occurred in all but two of the remaining 21 first instar larvae five months after the original burrow had opened. Eleven days after the first instar burrows were sealed, second instar burrows, 4.5mm in diameter, began to open. Once these burrows opened, they were offered a steady diet of live 5mm *Ac. domesticus* nymphs three times a week. This diet was supplemented periodically with wild caught *Iridopsis obliquaria* (Lepidoptera: Geometridae), *Calliphora* sp. (Diptera: Callaphoridae), and *Tipula* sp. (Diptera, Tipulidae). The second instar larvae are voracious predators and ate consistently for two months before sealing up their burrows in April of 2015.

During the time period that the larvae were sealed in their second instar burrows, the substrate was allowed to dry out to the point where the surface began to crack. The substrate was then moistened with 300-950ml of tap water every other day for a week until the substrate became saturated to the point where small pools of water could be seen forming on the bottom of the container. The third instar burrows opened up in May 2015, 43 days after the second instar burrows were plugged, and the opening of the burrows did seem to correspond to the "Monsoon like" saturation of the substrate. The Toronto Zoo also used similar methods while rearing *A. baroni*.

The third instar larvae were fed 5-7mm *Ac. domesticus* nymphs, at least three times per week and there diet was supplemented with various species of wild caught insects. The third instar larvae readily accepted many different species of adult moths (wings excised), and nymphs of the short-horned grasshoppers (Orhtoptera: Acrididae). The larvae did however, reject any pre killed *Pogonomyrmex* sp, and *Veromessor* sp. ants (Hymenoptera: Formicidae) that they were offered.

RESULTS

Adult Collection, Care and Oviposition: In observations made on the adult beetles, no oviposition or mate guarding was observed between 2100 and 2200 hours. While these observations are of just three beetles, it might be safe to hypothesize that mating and oviposition behaviors occur under the cover of the stones or perhaps these behaviors occur later in the night than the specified observation times.

The observations did however, reveal that the adult *A. baroni* tended to retreat under the stones in their enclosure when exposed to white light, but were less apt to retreat when observed with red light. This could be a useful piece of knowledge when conducting observation on this species in the future, and may help in display designs for these insects. These observations also supports the idea that *A. baroni* prefers to oviposit close to large rocks because most of the initial oviposition holes were within 1cm of the two large stones in their container (pers. obs. 2014).

When offered several prey items at the same time adult *A. baroni* seemed to prefer larvae of *Achroia grisella*, and *C. pennsylvanicus* adult workers to all other, by eating those species first over 90% of the time (pers. obs. 2015). These findings may suggest that wild adult *A. baroni*, might prey upon soft bodied Lepidoptera larvae and species of ants as a large part of their diet. However, further studies will have to be conducted to confirm this hypothesis.

A. baroni is documented as living two to three years in captivity (Attard pers. com. 2015; Arizona Game and Fish Department 2001). Having collected wild individuals, there was no way to know how old the original beetles were, and therefore there is no way to know why they all suddenly died in a short time frame. If this study is able to produce adult *A. baroni*, then a better understanding of the longevity and fecundity of this species can be gained.

Larval Care: The average length of *A. baroni* first instar larvae was 4mm. The larvae were active when removed from their burrows but did not perform escape behaviors, such as flips or forming into a wheel, like the larvae of the Common tiger beetles, *Cicindela* sp. No measurements were taken on second instar larvae, in order to reduce the stress on the individual larvae. It will be a priority in future rearing efforts of *A. baroni* to record the measurements of larvae at each larval stage.

The most important results derived from the rearing of the larvae are the time that it takes the eggs to hatch into first instar larvae after being oviposited. In this first attempt, the eggs took approximately 43 days to hatch after being laid. In future studies, the oviposition holes should somehow be marked in order to further understand the incubation time for *A. baroni* eggs. The time it takes between instars and the amount of time the burrows are closed in order to molt (2-5 weeks), are also some important results that can be collected from this captive rearing venture. The approximate time from one instar to the next is said to vary greatly according to the report by the Arizona Game and Fish Department (2001). This will have to be a focus of rearing when and if future generations are produced. However, the current set of *A. baroni* larvae do seem to be progressing at about the same rate, with 18 of the 21 larvae reaching second instar within a week of each other and all but one of these second instars closing their burrow entrances on the same day, presumably to molt into third instar. Two larvae remained in the first instar for six months before molting into second instar, despite the same number of feedings, and identical environmental conditions. These larvae did however progress through the second instar rapidly and reached third instar within a week of those larvae that developed into second instars earlier.

Experiments on the ideal depth of soil for these larvae and the types of substrate that *A. baroni* is able to survive in also need to be investigated upon the successful eclosion of this first generation of larvae. This species reportedly prefers sandy to rocky soils (Pearson, *et al.* 2006), but the

Toronto Zoo reports successful oviposition in a substrate that consisted of 15cm to 20cm of a mixture of sand, peat moss and composted cow manure that contained wood mulch, and managed to keep their colony going for several years without the addition of new bloodlines (Attard, pers. com. 2015). This may indicate that this species is not very selective about substrate needed for oviposition, as are other species of tiger beetle.

DISCUSSION

The lack of literature on this species and the fact that besides this attempt, *A. baroni* has only ever been recorded to be produced at the Toronto Zoo (Arizona Game and Fish Department, 2001), makes this effort to rear *A. baroni* an important step in the captive husbandry of *Amblycheila* sp. tiger beetles.

However, this study is far from over and with every new instar comes more questions that will need to be investigated in the future. The short list of questions that will hopefully be answered or confirmed from the one other study available on this species are, what is the total time for the *A. baroni* to complete its immature stages? Can sustainable populations of this species be kept in captivity, for educational or display purposes? What other substrates can be used to by this species for oviposition? What is the preferred adult and larval diet? And can the methods listed above be used to produce other species of *Amblycheila* in captivity?

This species is a fascinating animal that still has many secrets to reveal. This is the reason that working with *A. baroni* and other tiger beetles in captivity is such an exciting and rewarding endeavor.

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