INCREASED FECUNDITY AND LARVAL GROWTH RATE OF AFRICAN FRUIT CHAFER, (*PACHNODA SINUATA FLAVIVENTRIS*) IN A NOVEL, FERMENTED SUBSTRATE.

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INTRODUCTION

Scarab beetles are a commonly displayed insect in zoos, insectariums and butterfly houses around the country. Prized for their color, size, and showiness, many scarab beetles are a staple of live collections, but the husbandry of many species has not been perfected. As a result, captive bred individuals of many species are not widely available, and insect zoo displays still rely heavily on animals collected from the wild. This study outlines the steps taken to create a better substrate for breeding scarab beetles, using the African Fruit Chafer, *Pachnoda sinuata flaviventris* as a model organism.

Like all beetles, *P. sinuata flaviventris* has four life stages: egg, larva (grub), pupa and adult. Native to tropical Africa, the larvae of this beetle is often found in compost heaps and the adults feed on flowers and rotting fruit. In many areas in the wild it is common enough to be considered a garden pest. In captivity at the Butterfly House we have managed to maintain a slowly growing population over many years, but were unable to replicate the fast population growth you would expect with an animal common enough in the wild to be an agricultural pest.

This paper outlines an attempt to increase fecundity and growth rate of our beetle colony by making changes to the makeup and treatment of the substrate used to house and feed all stages of the beetle. The goal of the study is to add a new tool to beetle husbandry that may apply to other species beyond *P. sinuata flaviventris.*

METHODS

The Butterfly House has long maintained a colony of *P. sinuata flaviventris* in captivity for display purposes. The original stock was captive bred and obtained from another institution. The traditional husbandry methodology we have followed for maintaining these beetles, referred hereon as our “Control group” is as follows:

Control group: "Forest Fines" a premixed locally available mulch product comprising70% triple ground hardwood mulch and 30% compost (composed itself of 50/50 green waste and food waste), has been used with success as food for the larval stage and a suitable substrate for adults. Approximately 3-6 inches of substrate is kept lightly damp in 50 quart plastic Rubbermaid tanks, with additional water being added approximately once a week to avoid desiccation. Adults and larvae both live together in the breeding tanks. Bananas and occasional other soft fruits are offered daily to feed adults, and larvae are often observed feeding on them as well. Adults willingly lay eggs in the substrate which hatch into larvae. The larvae progress through three larval stages, L1, L2, and L3 before forming a claylike, egg-shaped puparium in which they form a pupa and eventually turn into an adult beetle.

The media is turned over approximately twice a month and any L2 or L3 larvae are moved to larval growth tanks to complete their growth. As the larvae consume the Forest Fines media it is converted into frass. After four to six weeks frass reaches a high level in the breeding tanks and it is moved to a larval growth tank housing L2 and L3 larvae. New media is then added to the breeding tanks and larval tanks. Because eggs of this species are small, media is not disposed of until it has sat without adults in a larval growth tank for a period of at least 3 weeks to ensure all eggs have hatched. Once larvae form pupariums in the larval growth tanks they are removed and placed in a container with a damp paper towel. When adults emerge from the puparia they are placed back into a breeding box and the cycle repeats.

Experimental group: The husbandry for the experimental group was exactly the same as the control group, with the exception that a different media was used as substrate. The procedure for creating the new media was adapted from an online website NaturalWorlds.org[i]. The experimental media was created by mixing 10 parts Forest Fines mulch with 1 part King Arthur Whole Wheat Flour and 1 part water. The media was placed in a Rubbermaid garbage can in our facility's basement where ambient heat is approximately 85 degrees. The media is stirred daily for approximately 3 weeks. It gives off a very strong odor similar to spoiled bread dough for the first two weeks as the substrate ferments. As the fermentation stops, the smell changes to an earthy smell, and after another week is ready for beetles.

At this point the color of the Forest Fines media has changed from the light brown starting color to a dark, almost black color.

Experimental procedure: Identical 50 quart plastic totes are filled with experimental or control media. Each tote was filled with 3.5 inches of media weighing approximately 20 pounds. 50% of each lid was cut away and replaced with mesh for ventilation. 10 male and 10 female beetles were placed in each tub. Because the starting beetles were chosen at random and their age was unknown, for the first three weeks any dead beetles were replaced with another beetle of the same sex to ensure an adequately sized starting colony. The beetles were sexed based on the

presence of a ventral groove dissecting the abdominal sternites on males, with females lacking indentation on their sternites.

The beetles were housed in the Butterfly House laboratory which is kept at 80 degrees Fahrenheit. The adult beetles were offered fresh fruit daily. Banana was most commonly given, but papaya, melon, apple and other soft fruits were sometimes offered. The specific fruit and the portion size sometimes varied day to day, but identical portions were given to both tanks each day.

On days 38, 84, 155, and 232 of the experiment a survey was taken, and all larvae, adults and pupae were counted. Eggs were frequently encountered but not counted.

On day 84, additional new media was added to each tank. On day 155 the larval growth tanks were set up, and all L2 and L3 larvae along with old media were removed from the breeding tanks and placed in their corresponding larval tanks. New media was then added to all tanks. On day 232 new media was added to all tanks, and larvae moved to growth tanks.

Puparіums were removed from the media after forming, and placed on a damp paper towel in a plastic kitchen container that corresponded to each media type. When adult beetles emerged they were weighed using an "EZ Digital Pocket Scale, Model EZ-500G" and weight recorded to the tenth of a gram. Adults were then placed back into their corresponding breeding box.

RESULTS

Population: A complete census of each group's population was taken 4 times during the experiment:

	Day	Adults	Pupa	L1 larva	L2 larva	L3 larva	Total
Experimental	1	20	0	0	0	0	20
Control	1	20	0	0	0	0	20
Experimental	38	15	0	38	18	0	71
Control	38	10	0	26	1	0	37
Experimental	84	2	3	41	41	81	168
Control	84	0	1	8	34	52	95
Experimental	155	53	17	0	3	83	156
Control	155	19	18	0	0	39	76
Experimental	232	42	16	237	173	51	519
Control	232	25	8	11	33	51	128

The experimental tank produced its first eclosed adult after 94 days, and the control after 105 days. In total the experimental media produced 122 adults, and the control media produced 64

adults. Including larvae, pupae and adults on day 232 the experimental population had increased by 499 and the control by 108.

Weight: The mean weight of the control group was determined to be 1.231 gm, and the experimental group was 1.026 gm. An unpaired t-test was performed to determine if the groups were statistically different from each other in weight.

t-test results

	Experimental	Control
Mean	1.026	1.231
SD	0.255	0.271
SEM	0.023	0.034
Number	122	64

The t-test determined the two-tailed P value to be less than 0.0001, indicating that by conventional criteria, this difference in weight between the experimental group and the control is considered to be extremely statistically significant.

The average adult weight of both groups dropped during the experiment:

Weight change between first 33% and final 67% of each group

	Average weight first 33%	Average weight final 67%	Change in average weight	Change
Experimental	1.198 g	.933 g	-.265 g	-22.10%
Control	1.493 g	1.012 g	-.481 g	-32.50%

DISCUSSION

It is clear from the experiment that there is room for improvement in the husbandry of *Pachnoda sinuata flaviventris* from traditional methods. These beetles responded well to the change in substrate, producing over four times more offspring in the experimental media than the control.

Of note however, is the weight discrepancy that existed between the two groups. The average weight of the experimental group was 16.7% lower than the control. One possible cause for the

weight difference is overcrowding, as Rueda and Axtell (1996), found that adult beetles raised in mealworm cultures of high larval population density weighed significantly less than beetles raised in uncrowded conditions[ii].

A surprising result was the decrease in average weight of each group as the experiment progressed. This change is likely a direct result of the animal husbandry methodology that recycled a high percentage of the media when moved from the breeding tanks to the larval rearing tanks. At the start of the experiment each tank was 100% new media with 0% frass/recycled media. As the experiment continued the media developed a higher level of previously used media, with noticeable buildup of frass. Though the concentration of frass was not scientifically monitored, there was a clearly noticeable correlation between the increase in the concentration on frass and recycled material and the decrease in adult weight as the experiment progressed.

It is necessary to save all media that is removed from the breeding tanks to ensure that eggs and small, freshly hatched larvae are not accidentally discarded. However, it is our belief that a third 'hatching' tank be used that houses only recycled media from the breeding tank only, and as soon as sufficient time has passed to ensure all viable eggs have hatched the larvae will be sorted out and the old media disposed of. Breeding and larval rearing tanks will be composed of near 100% new media, with small amounts of frass and recycled media added to preserve any gut microbes that may be passed on between generations. It is our belief that this will lead to the heaviest, and presumably healthiest, adult beetles.

With the apparent success of the experimental media with *Pachnoda sinuata flaviventris,* the next step will be to attempt to raise other scarab beetles on it including *Chalcosoma, Dicronorrhina,* and *Megasoma* species.

References:

[i] 1. The Breeding/Rearing of *Prosopocoilus giraffa keisukei - Yasuhiko Kasahara* - http://www.naturalworlds.org/scarabaeidae/manual/giraffa/Prosopocoilus_giraffa_breeding_4.htm

[ii] 2. Rueda, L.M., Axtell, R.C., (1996) Temperature-dependent development and survival of the lesser mealworm, *Alphitobius diaperinus. Medical and Veterinary Entomology*, 10, 80-86.