Tunneling Ants: Not Just Your Average Classroom Pets

Abstract

Animals make regular appearances in the classroom setting and are known to motivate learning and promote students' social development while still adhering to certain science and math standards. Despite their prominence in the environment, ants are typically underutilized as "pets" and teaching tools in the classroom. This article presents a guided inquiry lesson for fourth and/or fifth teachers to use with their students which investigates how varying amounts of artificial light affects ant colony behavior. Three artificial ant habitats were observed over a two week period. One habitat (A) was exposed to artificial light for 24h/day while another (B) was kept in complete darkness for 24h/day. A third habitat (C) was rotated between artificial light and complete darkness every 12h to simulate the light conditions of a typical day. During this period students collect observations on nest development, general activity levels, and note any fatalities. Student results show that habitat A had the largest area of tunnel excavation (3280.24 mm^2, 27.3%) and the habitat B had the least (2186.57 mm^2, 18.2%). Habitat C fell in between with 3098.60 mm^2 or 25.8% area excavated.

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Ants are everywhere. They thrive in forests, fields, deserts, and cities all over the Earth and are one of the most dominant groups of insects. In some ecosystems ants can form 10-25% of the entire animal biomass (Schultz, 2000). How are ants so successful? Like humans, ants are social organisms; they live in colonies in which workers cooperate and unite toward the common purposes of survival, growth, and to raise subsequent generations of the queen's offspring. Many young children have a natural curiosity about animals, and ants are no exception. But for such a prominent group of animals, ants are usually underutilized as a teaching tool for elementary-aged students.

Animals have been used in a classroom setting for years. From guppies and goldfish to hedge hogs and snakes, teachers agree that animals serve as natural motivators in a classroom setting because animals are important to young people. To date, research investigating the benefits of pets in classrooms has focused mainly on the social development of young children. These topics include how relationships with animals facilitate social interactions with peers and adults, develop and enhance self-esteem and self-worth, and help develop empathy awareness. Other studies have shown a positive correlation between owning a pet during childhood and later concern about the welfare of wild animals (Prokop & Tunnicliffe, 2010). With such benefits, why are animals only found in a quarter of all classrooms? School policy and legal concerns, as well as student allergies, and extra work are often cited, but so is the concern that lessons do not fit into curriculum (Rud & Beck, 2003).

Incorporating classroom animals into curricula is simpler than it seems. They make excellent subjects for student-led inquiry projects, especially with regards to comparative behavioral studies. These investigations are interdisciplinary, bringing math, language, and technology together to provide a complete picture as to how to answer a question. Some of the best animals for behavioral studies require little maintenance or extra effort for the teacher. The Western Harvester ant, the most readily available tunneling ant for ant farm use, is one such animal. Small, yet large enough to easily examine anatomy, the Western Harvester ant is an example of how structure influences function. Extending from the front of the head, strong, large pinchers serve to carry seeds, aid in tunneling, and help defend the colony.

In the wild, Western Harvester ants are found throughout the Great Plains, southwest, and Rocky Mountain regions of the United States. Harvester ants influence plant species composition near their nests as a result of their varied seed diet and the favorable soil conditions they create through their digging (MacMahon, Mull, Crist, Mu, & Grist, 2000). Previous investigations of Western Harvester ants' responses to environmental factors in the wild indicates influence in establishing colony operating parameters and periods of daily and seasonal activities. For example, colonies often contain an asymmetrical cone shape in order to catch and store the rising sun's rays as well as warming chambers near the Earth's surface to aid in thermoregulation (Romey, 2002).

In an indoor setting, Western Harvester ants also exhibit behavioral influences from biotic and abiotic factors. While multiple variables could be examined as the focus of an inquiry-based lesson, the purpose of the following lesson is to examine how varying amounts of artificial light affect Western Harvester ant colony behavior, specifically, tunneling. The lesson and experiment below were designed to comply with national and state-based standards including introduction and understanding of the structure and function of living systems (5-ESS3-1, 5-LS2-1, 4-LS1-1), as well as formulating questions that can be addressed with data and collect, organize, and display relevant data to answer them (5.NBT, 5.G, 5.MD). The lesson could also serve to introduce ant species native to Ohio and their importance in the ecosystem.

Instructional Plan

Step 1: Assembling your Ant Farms

Three commercially available ant habitat kits with observation windows measuring 8 ½” x 5 ½” x ¼” (WxHxD), were purchased and prepared per company instructions. Each of the habitats were filled with sand (provided), and the sand was made damp by adding water. Units sat for several hours in order to allow water to properly diffuse through the sand. A tunnel measuring 1cm was started by inserting a plastic stick (supplied) through the opening in the plastic and into the tunneling sand. Dark paper was taped onto the habitats to cover the area containing sand in order to mimic being underground.

Step 2: Inoculation and Maintenance of the Ant Farm Habitat

Western Harvester ants were obtained commercially. All ants received were female, nonbreeding, worker ants. In preparation for inoculation, ants were kept in a refrigerator for 5 minutes in order to reduce ant activity. Twenty-five ants were transferred into each ant habitat through an opening in the top frame of the enclosure. The cap was then replaced and ant farms were moved to their respective experimental location. Location 1 consisted of exposure to artificial white light, and location 2, the inside of a cabinet, was completely free from light. The third habitat was used as a diurnal control unit and was moved from location 1 to location 2 and vice versus every 12 hours to simulate natural lighting conditions. Both habitat locations 1 and 2 were within the same room, therefore holding the same temperature. Ants in all habitats were fed a piece of apple, approximately the size of a popcorn kernel, once a week and given two drops of water every three days.

Step 3: Introduce Unit to Students

Ant Cities, by Arthur Dorros, was read out loud to the students to introduce ants and ant tunneling behavior to the students. Children's ideas about ants were then elicited through an ideas discussion using the prompt, "Based on this book, what do you know about ants? Did you learn anything?" Next, *What's it Like to be an Ant?*, by Jinny Johnson, was read out loud. Taking cues from this book, students were then led in discussion regarding the anatomy of an ant. Students described properties of a particular structure (e.g. head, antennae, and pinchers) and then listed the function. On a broader scale, students were introduced to the importance of ants in the ecosystem. Following this discussion, the experiment and testable question were introduced to students as a guided inquiry. Students made predictions regarding which habitat they thought would show the most tunneling activity and were assigned experimental roles (e.g. student leader, data collector, and photographer). In order to provide students the opportunity to participate in each experimental role, student responsibilities were rotated each day.

Step 4: Observations and Data collection

Observations were collected over a 2 week period. Observational data points varied, and ranged from 4 hours to 24 hours apart depending on the rate of nest development. At each timepoint, students made general observations on ant activity, if food position or size had changed, and also noted if any fatalities had occurred. Nest development progress was tracked by taking photographs using a digital camera. To ensure consistency throughout the experiment, the camera and ant colonies should always be placed in the same positions at each timepoint before taking a photograph; positions can be determined beforehand and marked with masking tape. Images were uploaded on to a computer, and prepared for analysis by cropping to include the tunneling section of the habitat only.

Step 5: Interpretations and Student Evaluation

Ant tunnels were artificially-colored green using GIMP (GNU image manipulation program) painting software (Sup.Figs. 1A, 2A, 3A). This program calculated the area in pixels that was colored in green (tunnels), as well as displayed the total number of pixels in the image. Pixel value was then converted into the area measurement unit of millimeters squared. If this seems too advanced for your students, students can also use printed copies of the tunnel images, string, and a ruler to measure the distance tunneled in each habitat. Students took this data, compiled it, and presented it graphically for the class (line graph and bar graph).

Results

Light exposure and ant behavior are directly related. Results show that the habitat exposed to constant artificial light (A) had the largest area of tunnel excavation (3280.24 mm^2, 27.3%) and the habitat completely withheld from light (B) had the least (2186.57 mm^2, 18.2%). The control habitat (C), cycled between artificial light and darkness fell in between with 3098.60 mm^2 or 25.8% area excavated (Figure1). Rates of nest development occurred in a non-linear fashion: habitat A ranged from a 4.45% area increase per day to 1% area decrease per day, habitat B ranged from 0.46% area increase per day to 7.87% area increase per day , and habitat C ranged from 6.34% area increase per day to a 1.27% area increase per day (Figure 2).

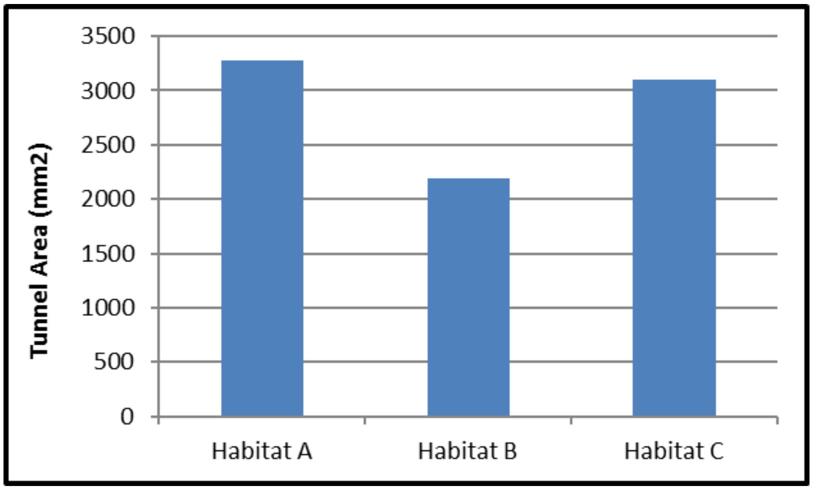

Figure 1 Area of day 14 tunnel excavation. An example of the comparison of experimental endpoint tunnel areas in 100% artificial light (habitat A), 100% darkness (habitat B), and 50% artificial light and 50% darkness (habitat C).

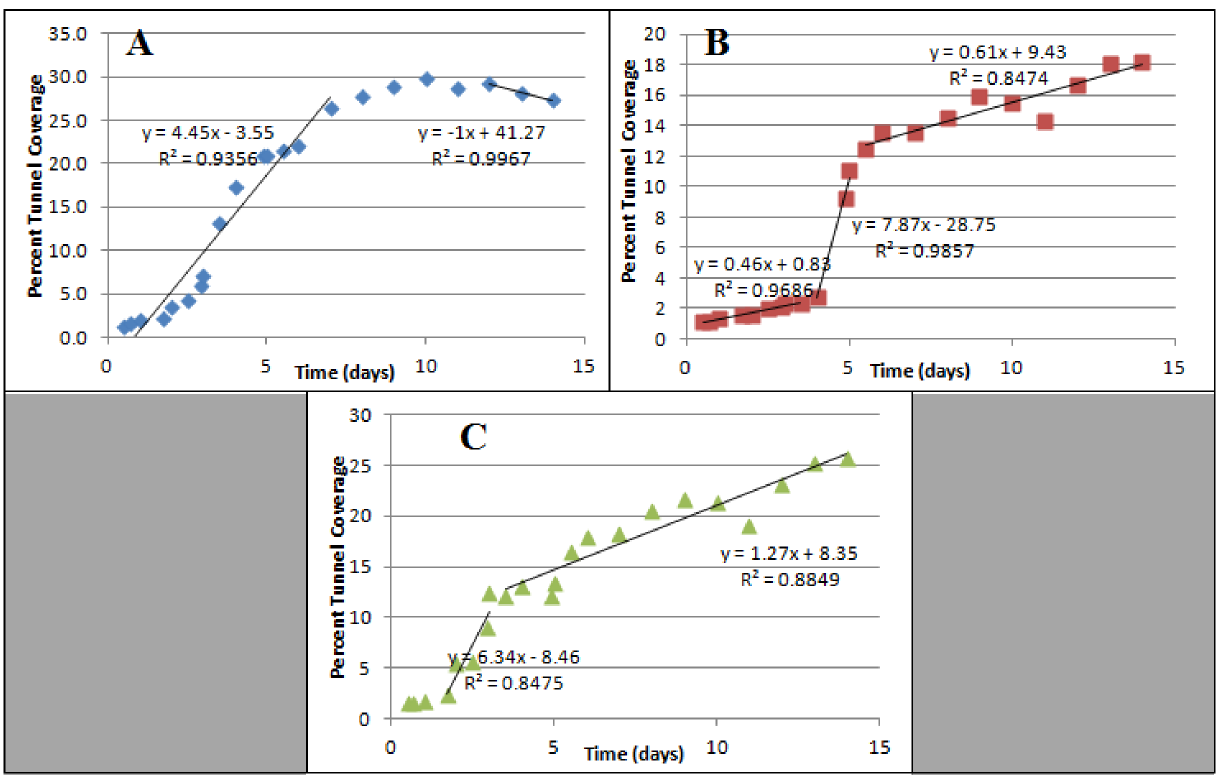

Figure 2 Rate of nest development. An example of the rate of nest progression throughout all three habitats.

Daily rhythms have been observed in a wide variety of animals, plants, and microorganisms. Nuptial flights of various ants occur at species-characteristic times of the day and workers of some species are active during only a certain part of the day. These rhythms can be constant, or shift, and seem to have been analyzed very little under controlled conditions. Often, such rhythms are thought to occur endogenously (McCluskey, 1963) and are influenced based on temperature and exposure to light; the Western Harvester ant appears to be influenced by both.

When compared to the control habitat, ants within the habitat constantly exposed to light appeared to be hyperactive. While the initial excavation rate was not as high as the control, maximum tunnel area (29.8%, day 10) was greater than the control's maximum achieved (25.8%, day 14). The rate of excavation was also more linear throughout the course of the experiment. Should this experiment have had the opportunity to progress, it would be predicted that the individuals within this habitat would not live as long due to their constant activity; they would simply "wear out."

Challenges and Potential Solutions

While habitats were assembled as similarly as possible, it is likely that the tunneling sand was not evenly compacted between habitats. Also of note, the habitats were filled upside down and then returned to their upright position; over time, the tunneling sand could settle towards the bottom due to gravity. It was observed that the area of tunnels excavated did not always appear to correlate with the amount of tunneling sand that was excavated about the "surface". If the sand was looser in some areas than others, tunnel excavation could be achieved at a faster rate. Such results are believed to have been observed experimentally within habitat B. The sharp increase in tunnel area was observed when a tunnel suddenly appeared across the entire viewing window, yet little sand appeared to have been excavated.

It was noted that tunnels could be excavated in areas that were not easily visible by eye and not able to be recorded digitally. In both habitats A and C, tunnels on the far left and right as well as bottom were excavated; they were first observed when ants could be seen running across the bottom of the habitat. These areas could not be included in the tunnel area calculations or subsequent rate of tunnel development calculations. This is especially problematic when calculating rate of tunnel development; in habitat C, it appeared that excavation stalled on multiple occasions. It is more likely that excavation did not stall, merely it occurred in an area in which it could not be recorded.

Conclusion

Ants are fascinating and highly beneficial insects. Because of their complex colony-level behaviors, ants serve as model organisms for the highly visible disciplines of behavioral ecology and sociobiology, particularly in studies focused on the dynamics of kin selection, within colony conflicts of interest, caste differentiation, and division of labor (Schutlz, 2000). It is key to educate today's young minds on the importance of these small creatures; should they disappear, the big gap they leave within the ecosystem may be difficult to fill.

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Supplemental Figures

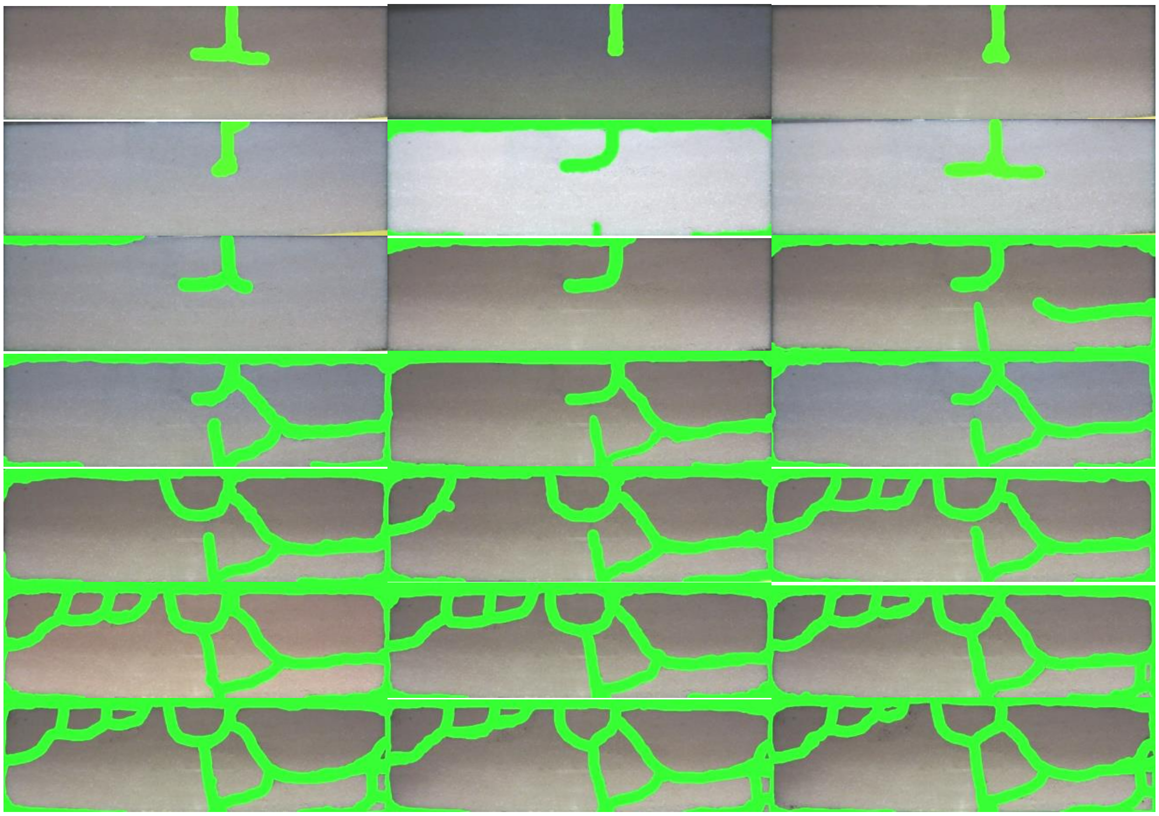

Figure 1 GIMP false coloration of habitat A. Nest development of habitat exposed to artificial light 100% of experimental time. Timepoints are arranged in order, left to right, top to bottom as follows: 16h, 25h, 36h, 48h, 60h, 67h, 72h, 84h, 96h, 107h, 5d, 5.5d, 6d, 7d, 8d, 9d, 10d, 11d, 12d, 13d, 14d.

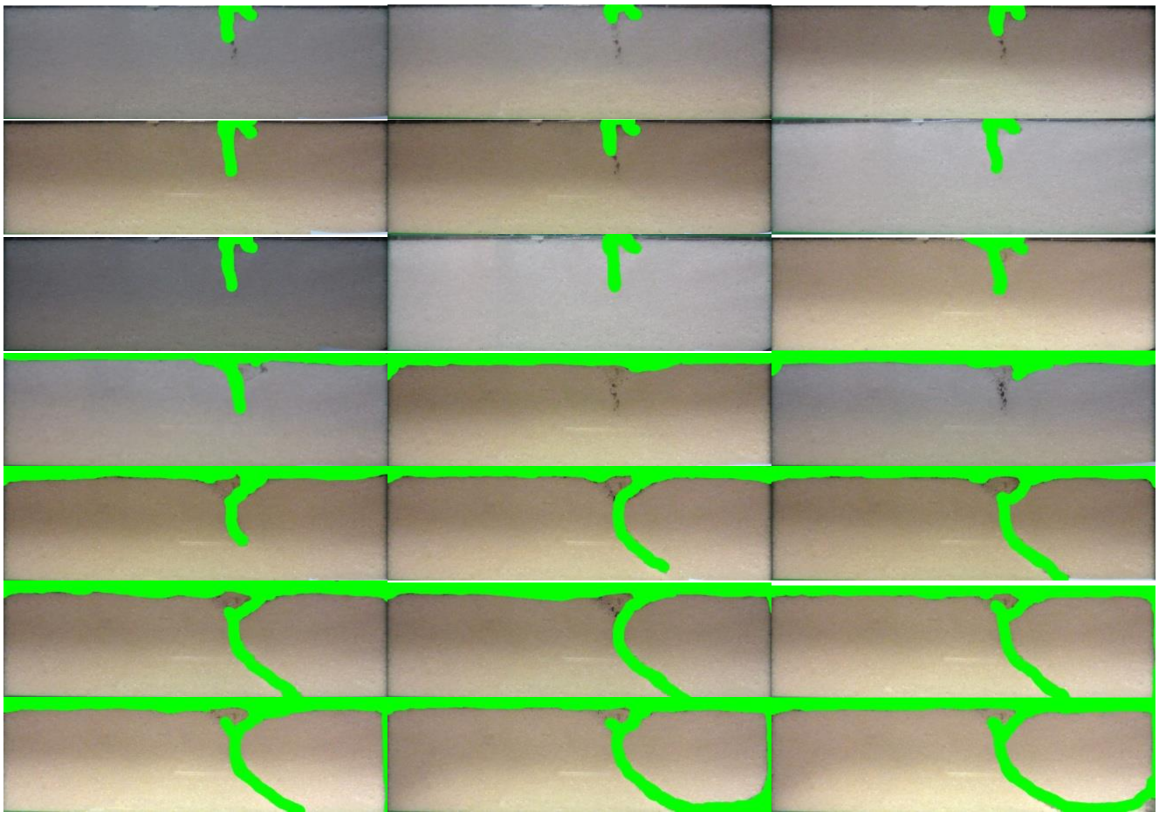

Figure 2 GIMP false coloration of habitat B. Nest development of habitat exposed to no light (complete darkness) 100% of experimental time. Timepoints are arranged in order, left to right, top to bottom as follows: 16h, 25h, 36h, 48h, 60h, 67h, 72h, 84h, 96h, 107h, 5d, 5.5d, 6d, 7d, 8d, 9d, 10d, 11d, 12d, 13d, 14d.

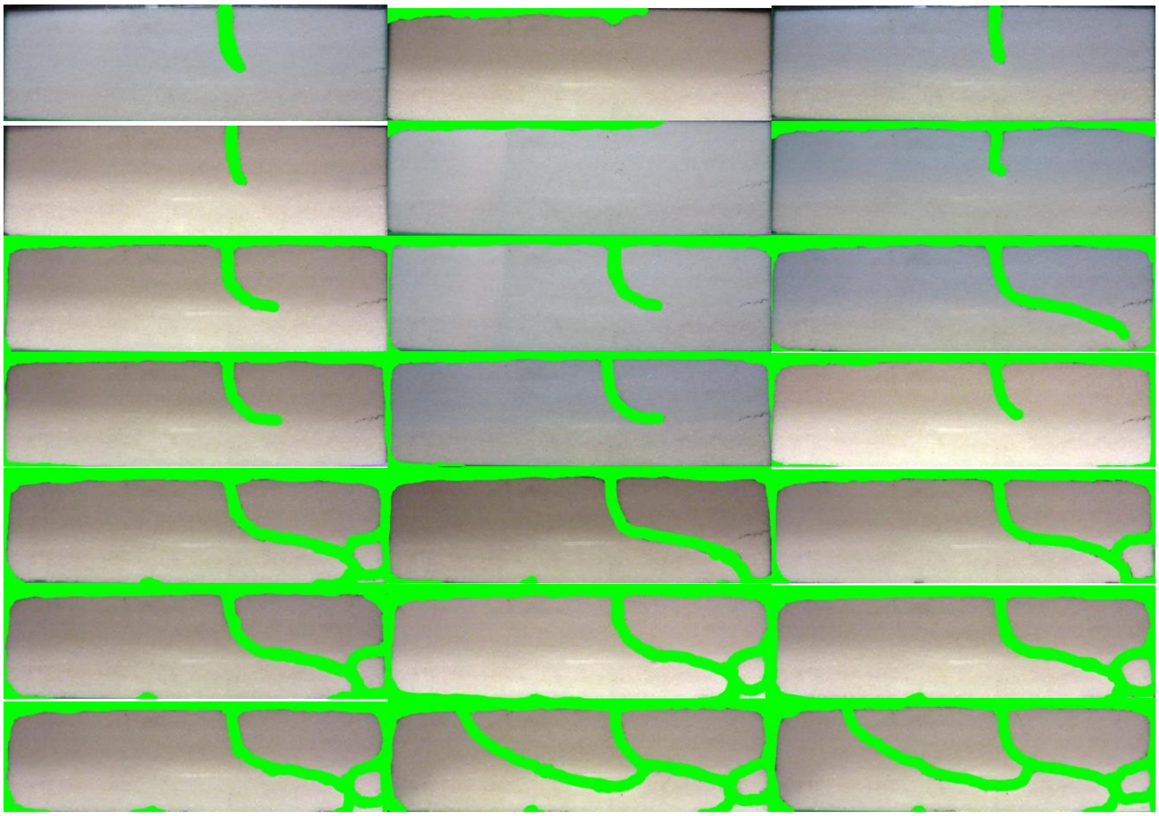

Figure 3 GIMP false coloration of habitat C. Nest development of habitat exposed to artificial light 50% of experimental time and complete darkness 50% of experimental time. Timepoints are arranged in order, left to right, top to bottom as follows: 16h, 25h, 36h, 48h, 60h, 67h, 72h, 84h, 96h, 107h, 5d, 5.5d, 6d, 7d, 8d, 9d, 10d, 11d, 12d, 13d, 14d.