Antlion Herding Patterns with Interrupted Communication Pathways

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Rationale:
The bottom-up organizational methods that antlion larvae use can be generalized to other fields and possibly duplicated in artificial structures where components have low computational power. Nanomachines would require low-intelligence algorithms, as their hardware cannot harness the energy required for complex computers, and these algorithms can be designed to mimic the response-observation loop of antlions. The distribution behavior of antlions also compares to other organisms, which will illuminate genealogical study.

Essential Question:
How do antlion spatial patterns, such as pit depth, width, and nearest neighbor, as well as group behavior, vary with spatial constraints and interruptions in possible communication pathways?

Hypothesis:
Antlions likely lack an intelligent mode of communication, so interruptions in the environment (removal of trails, introduction of physical obstacles, fictional pits) will not impact their ability to form nesting patterns, except insofar as they cannot nest immediately adjacent to the obstacles because the primary regulating method is cannibalism.

1. 24 16oz deli containers were acquired and 1 antlion was placed in each
2. The sand (100lbs) was uniformly spread into a 24" × 24" plastic container
3. Marks were made on the box so the pits locations could be observed.
4. Each trial was started by introducing a constant number of antlions, at the same time
5. After the first and second days of each two-day trial, the coordinate locations, diameters, and depths of each antlion pit were recorded for analysis.
6. After each trial, all living antlions were restored to their pits and dead antlions disposed of.
7. Further trials repeated these same protocols except with space restrictions of 24" × 24" and 12" × 12" and three disruption methods:
   a. "Trail erasure" included brushing away old trails in the sand that antlions have dugout, in an effort to determine if the antlions are reliant upon the presence of trials or pheromones when distributing.
   b. "Fake pits" were introduced to mimic an antlion pit, in order to determine if antlions were dependent on the presence of surrounding pits.
   c. "Artificial obstacles" included the introduction of rocks to determine if antlions are aware of the shape of their settlement region and use that to organize the group.

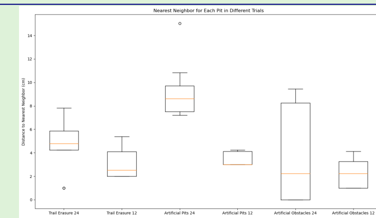

Fig 1: This boxplot illustrates the nearest neighbor metric on different trial sizes and interventions. The artificial pits trials showed the largest impact on the metric, indicating antlions choose settlement based on surrounding pits.

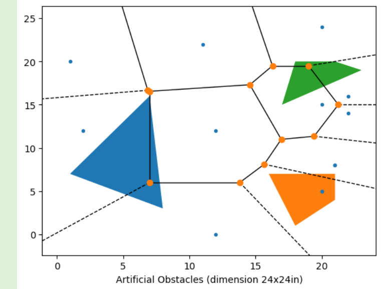

Fig 2: Voronoi diagrams show territory that is nearest to a given pit. Blue dots represent pits, and colored shapes represent obstructions.

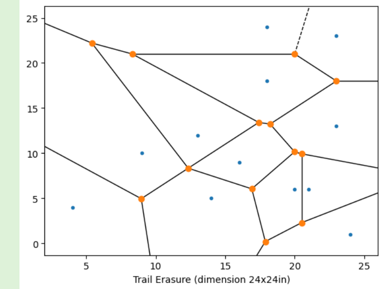

Fig 3: Trail erasure did not interrupt, and may have reinforced, the regularized pattern antlions make. Food-catching regions are well-distributed between pits in all trials.

Size	Interruption	Reclusive	Dead	Pits formed	Nearest Neighbor (avg)	Width (avg)	Depth (avg)
24 × 24	Trail Erasure	1	2	12	4.69in	2.17cm	2.00cm
12 × 12	Trail Erasure	2	3	10	3.17in	2.70cm	1.60cm
24 × 24	Artificial Pits	1	7	7	9.33in	3.57cm	2.14cm
12 × 12	Artificial Pits	4	4	7	3.50in	2.71cm	1.86cm
24 × 24	Artificial Obstacles	0	4	13	4.45in	3.54cm	2.08cm
12 × 12	Artificial Obstacles	3	0	10	2.26in	3.00cm	1.60cm

Fig 4: Pit depths and widths remained fairly constant between trials. The nearest-neighbor metric also remained constant, but only within trial sizes. This indicates antlions respond to their environmental restrictions.

This experiment investigated how antlions make individual settlement choices, and how those choices create group patterns. Environmental factors, in terms of other pits, trails, and environment shape were investigated. Antlion larvae were shown to regularly, rather than randomly, distribute themselves, indicating they avoid other pits and respond to environmental structure. As also observed in the previous study, antlions use behaviors like this, cannibalism, and reclusivity as mechanisms to limit intra-species competition. These behaviors increase species fitness and therefore are an evolutionary advantage. Avoidance mechanisms can be extended to the analysis of other animals and engineering applications. Bottom-up organization often relies on a hierarchical image of its members, like a hexagonal or rectangular grid, but individuals don't require strict communication pathways for efficient, semi-regular distributions such as an antlion's. The distribution patterns of the antlions can also be expanded to understand similar organisms, such as termites, ant, bees, and wasps, as these animals also distribute as groups. Similar behaviors may be used to draw conclusions regarding the evolutionary history of these organisms.