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Marissa Cuda

University of New Hampshire - Main Campus, mev269@wildcats.unh.edu

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Will the exploratory behavior of lobsters decrease as they become familiar with their environment?

Marissa Cuda

Thesis advisor: Winsor H. Watson III

Zoology Department

University of New Hampshire

Durham, NH 03824

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Abstract

Previous studies have shown that most lobsters have a home range in which they reside on a daily basis. The tendency for lobsters to reside in a particular area suggests that they have the ability to learn the characteristics of an area using exploratory behavior. We hypothesize that the exploratory behavior of juvenile lobsters will decrease as time spent in a novel environment increases; specifically exploratory behavior will decrease as the lobsters continuously learn the environment. Exploratory activity of juvenile lobsters was monitored in six lobsters using two separate maze complexities. Lobsters were video recorded and activity was measured based on the distance traveled each day. Lobsters were kept in the maze for ten days; three lobsters were tested in the simple maze and three were tested in the complex maze. A lobster tested in the simple maze followed our hypothesis and showed a continuous decline in activity for several days (activity decreased from 260.55 cms/day to 45.8 cms/day by Day 7) before reaching a constant baseline level. Another lobster tested in the simple maze was only active during the night and showed a steady decline in nighttime activity. Only one of the lobsters tested in the complex maze showed any decline in activity. Overall, these results suggest that lobsters are able to learn at least some features of a simple maze within seven days and that lobsters need far more than ten days to learn the environment of a more complex maze environment.

Introduction

Being able to navigate the environment is essential for mobile animals; they often leave their home or shelter multiple times a day in search of food or mates. The ability to move efficiently through an environment reduces time and energy which are two key elements to survival. Spatial learning is what allows animals to remember features of their environment in order that they may properly navigate while moving from one location to another (Tierney 2011.) Tierney (2011) found that crayfish can learn how to correctly exit a t-maze using spatial cues and that they will remember the correct exit path up to a week later. A similar study in which toads were tested in a t-maze yielded comparable results; the toads were able to learn which turn to take to reach water based on the spatial cues in the maze (Daneri et al. 2011.) Animals must gather spatial information from the environment in order to explore, navigate, and return home.

Previous studies have shown that lobsters have a tendency to reside in a given area for a duration of time; this area is considered their home range. While looking closely at small scale movements of the American lobster, *Homarus americanus*, Scopel et al. (2009) found that although lobsters have the ability to remain in a single home range and continuously return to a single shelter, they tend to change home ranges rather frequently. Lobsters may change home ranges as frequently as every week (Scopel et al. 2009.) Scopel et al. (2009) also predicted that smaller lobsters may change home ranges even more frequently because their shelters are taken over by larger lobsters.

A study performed on the European lobster, the sister species to the American lobster, found that lobsters remained in the same or similar home ranges for close to a year (Moland et al. 2011.) Home range size for both European and American lobsters does not seem to be dependent on the size or sex of the lobsters (Moland et al. 2011; Scopel et al. 2009.)

Even a non-migratory lobster species, *Panulirus guttatus*, the Spotted spiny lobster has demonstrated the use of a home range (Lozano-Álvarez et al. 2002.) *P. guttatus* has also demonstrated the ability to return to its home range after being physically removed from it, a skill used by various species called homing (Lozano-Álvarez et al. 2002.)

The ability to return to a home shelter has also been demonstrated in the laboratory with European lobsters. In a maze-like environment with two available shelters all lobsters chose one shelter to reside in; researchers considered that their “home” shelter (Mehrtens et al. 2005.) Mehrtens et al. (2005) also found that compared to the larger lobsters, the smaller lobsters spent more time in the shelter and returned to the shelter more frequently while in the maze.

The ability and seemingly frequent occurrence of various lobster species to reside in and return to a home range provides evidence that lobsters have a strong understanding of their

environment. Lobsters that frequently change home ranges must have the ability to quickly learn a new environment using exploratory behavior. The purpose of this study was to determine if juvenile lobsters could learn a maze environment using exploratory behavior. We hypothesized that the exploratory behavior of juvenile lobsters will decrease as time spent in a novel environment increases and they learn their environment. In addition, activity should decrease more rapidly in a simple environment compared to a complex environment.

Materials and Methods

General Procedure

Six juvenile American lobsters, *Homarus americanus*, with a carapace of approximately 2.5 cm were used in the experiment. Lobsters were obtained from the New England Aquarium in Boston, MA. Lobsters were stored in a larger tank when not being tested in the maze. Lobsters were tested one at a time and were kept in the maze for ten consecutive days; three lobsters were tested in the simple maze (Lobsters A, B, and C) and three in the complex (Lobsters D, E, and F.) Activity was continuously monitored using a digital time lapse recording system that allowed me to visualize their behavior both during the day and the night. Lobsters were fed shrimp every other day while in the maze.

Apparatuses

Two different plexiglass mazes were constructed specifically for this experiment: a simple maze (Fig. 1) and a complex maze (Fig. 2.) Both mazes were 57 x 40 cm and were made inside a frame that had Velcro flooring so that the walls could be removed and repositioned. All of the walls were spray painted black and there was a shelter placed against one wall in both mazes. The side walls of the maze had mesh windows in order that cooled salt water could

constantly flow through the maze. The maze was kept in a room where lighting was controlled by a timer so that a 14:10 light:dark cycle could be maintained. A red light remained on in the experiment room so that videos could be recorded throughout the night.

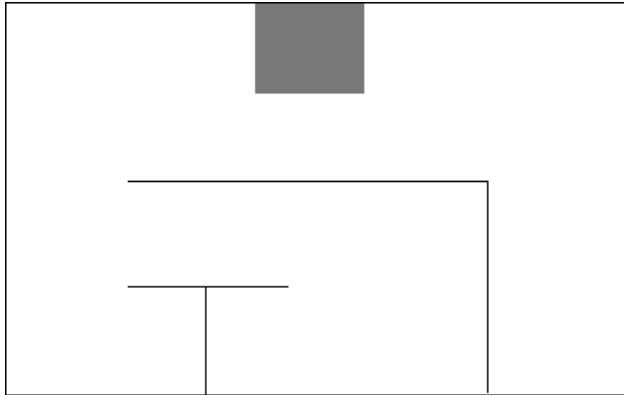


Figure 1: Simple maze apparatus. Grey box indicates shelter. Dimensions: 57 x 40 cm.

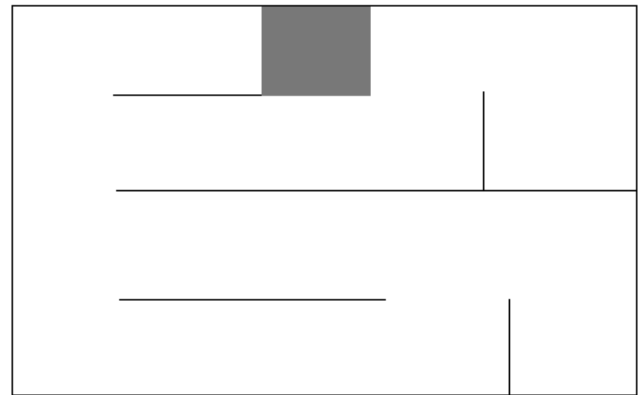


Figure 2: Complex maze apparatus. Grey box indicates shelter. Dimensions: 57 x 40 cm.

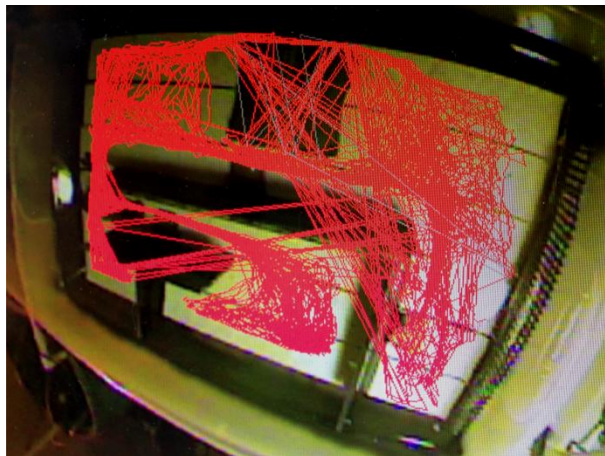


Image 1: Representation of how Ethovision tracks lobster activity. This example is from Lobster A tested in the simple maze.

Analyses

Videos were analyzed to determine distance traveled using EthoVision XT (Image 1.)

This computer program tracks the animal's activity and exports the raw data into an Excel

spreadsheet. From the raw data I was able to calculate the animal's total distance traveled per day in centimeters. Statistical analyses were performed using InStat. A paired t-test was performed to compare day vs. night values. For those lobsters that were significantly more active during the night, an ANOVA was performed comparing the average distance traveled per night for each lobster.

Results

Overall, the lobsters tested in the simple maze showed greater evidence, compared to the lobsters tested in the complex maze, that they learned the maze environment based on a decrease in exploratory behavior. Also, two of the three lobsters tested in the simple maze were significantly more active during the night compared to the day ($p=0.0080$; $p=0.0041$, t-test), whereas none of the lobsters tested in the complex maze showed a significant difference in day vs. night activity.

Lobster A: Lobster A was tested in the simple maze and was active both during the day and night. Lobster A showed a steady decrease in exploratory behavior for days 1 through 7 and then activity levels stabilized at approximately 50 cm per day (Figure 3.) This suggests that it took Lobster A 7 days to learn the simple maze. Lobster A's final activity level, that is the distance it traveled after the maze was learned, was approximately 50 cm each day.

Lobster B: Lobster B was tested in the simple maze and showed a significant difference in day vs. night activity ($p=0.0080$, t-test) (Figure 4.) The amount of exploratory activity performed during the night showed a steady decrease whereas the amount of exploratory behavior performed during the day remained relatively constant (Figure 5.) These results are

expected considering Lobster B was never very active during the day. The nighttime activity for Lobster B decreased to approximately 100 cm per day towards the end of the experiment.

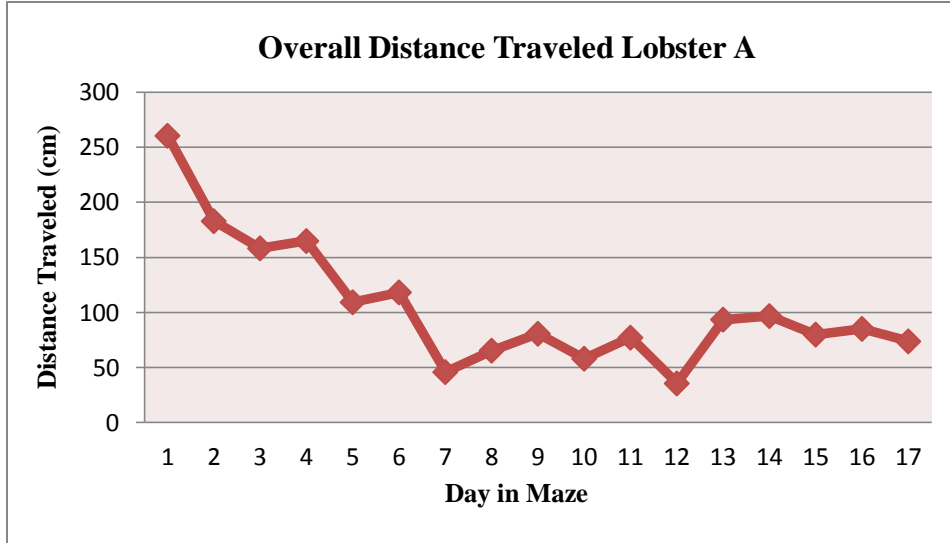


Figure 3: Overall distance traveled each day for Lobster A in the simple maze. Distance traveled was measured in centimeters. Lobster A showed a steady decrease in activity for 7 days after which activity levels stabilized.

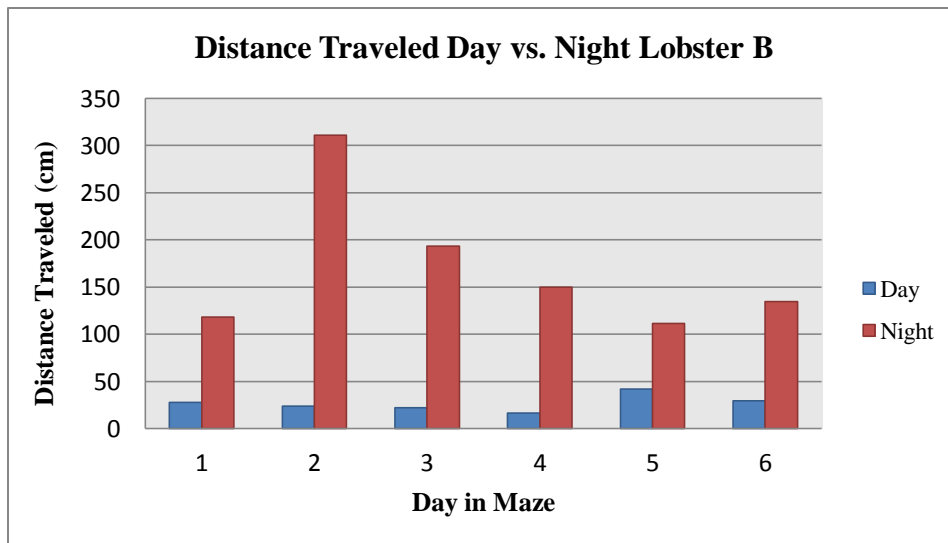


Figure 4: Day vs. night distance traveled each day for Lobster B in the simple maze. Distance traveled was measured in centimeters. Lobster B was visibly more active during the night.

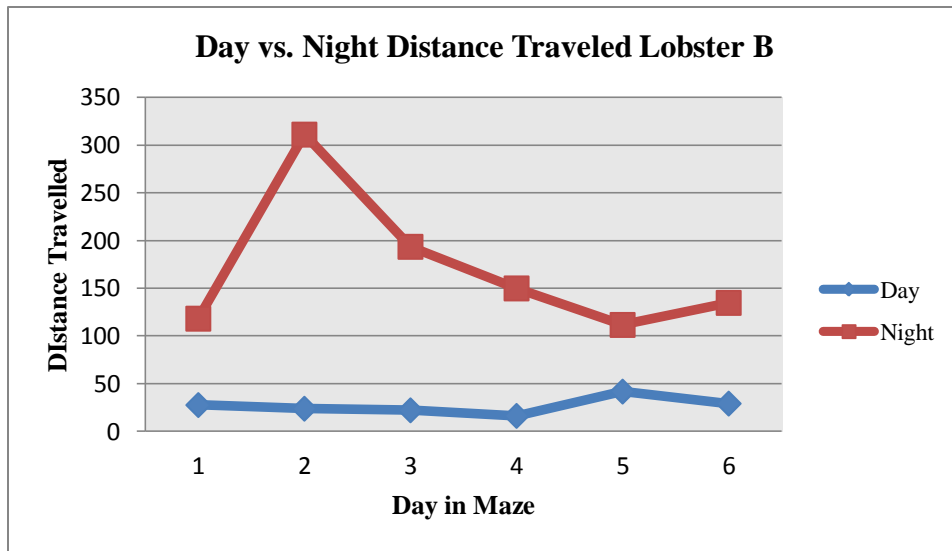


Figure 5: Total distance traveled day vs. night for Lobster B in the simple maze. Distance traveled was measured in centimeters. Lobster B showed a steady decrease in night activity whereas day activity remained constant.

Lobster C: Lobster C was tested in the simple maze and was significantly more active during the night compared to the day ($p=0.0041$, t-test) (Figure 6.) Lobster C also showed somewhat of a decrease in night activity while daytime activity remained relatively constant (Figure 7.) The nighttime activity for Lobster C decreased to approximately 50 cm on the final day of the experiment.

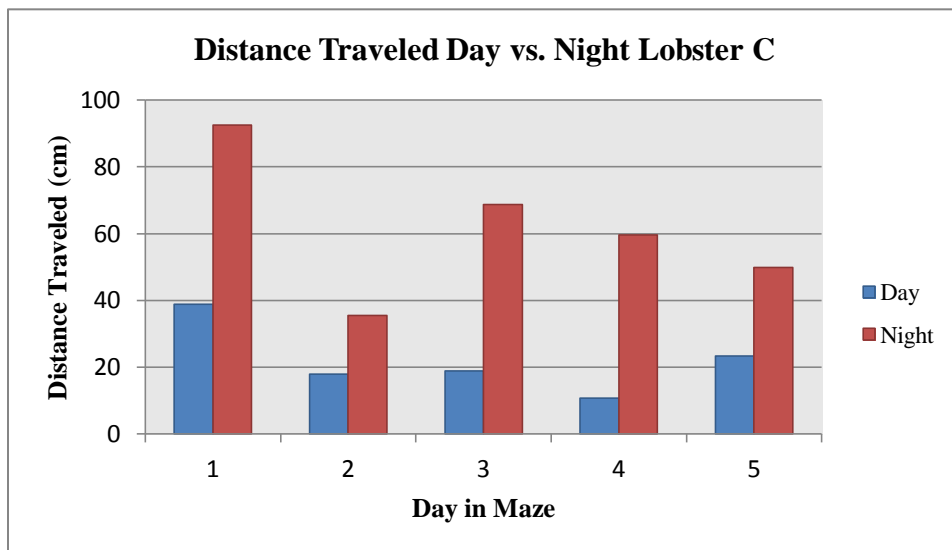


Figure 6: Day vs. night distance traveled each day for Lobster C in the simple maze. Distance traveled was measured in centimeters. Lobster C was visibly more active during the night.

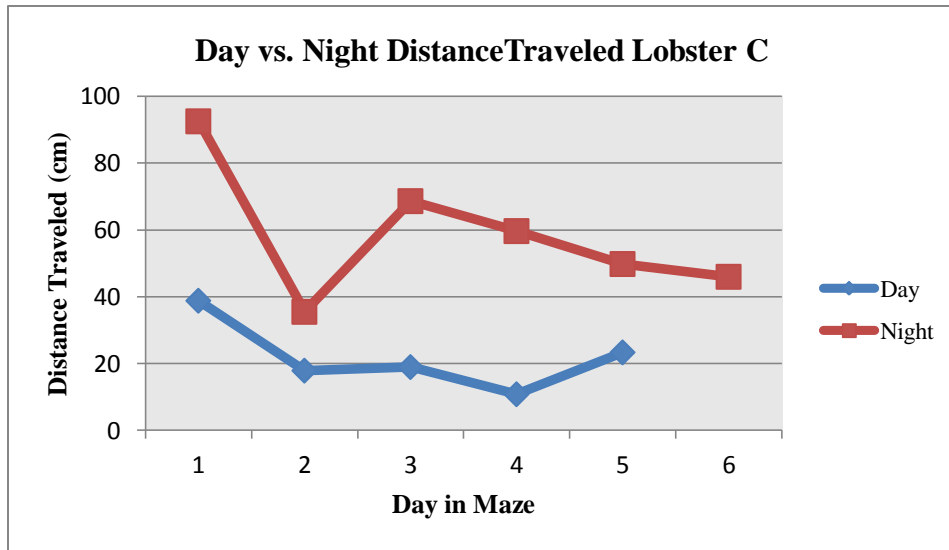


Figure 7: Total distance traveled day vs. night for Lobster C in the simple maze. Distance traveled was measured in centimeters. Lobster C showed somewhat of a decrease in night activity whereas day activity remained constant.

Lobsters D and E: Both lobsters D and E were tested in the complex maze and showed no significant difference in day vs. night activity. Neither lobster showed a change in exploratory behavior throughout the experiment; the distance traveled values were relatively constant throughout the ten days (Figure 8.) Lobster D traveled approximately 50 cm per day for the majority of the experiment.

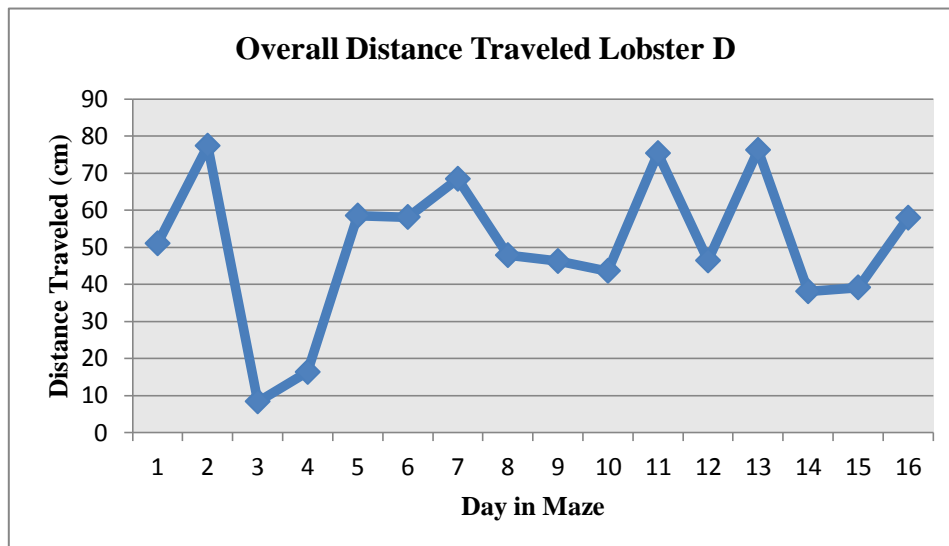


Figure 8: Overall distance traveled each day for Lobster D in the complex maze. Distanced traveled was measured in centimeters. Lobster D showed no change in exploratory behavior throughout the 10 days. Lobster E data was very similar with no visible declining trend.

Lobster F: Lobster F was tested in the complex maze and showed no significant difference between day vs. night activity. Lobster F showed a minimal decline in overall activity but the distance traveled each day never stabilized (Figure 9.) The distance traveled for Lobster F decreased to approximately 50 cm on the final day of the experiment.

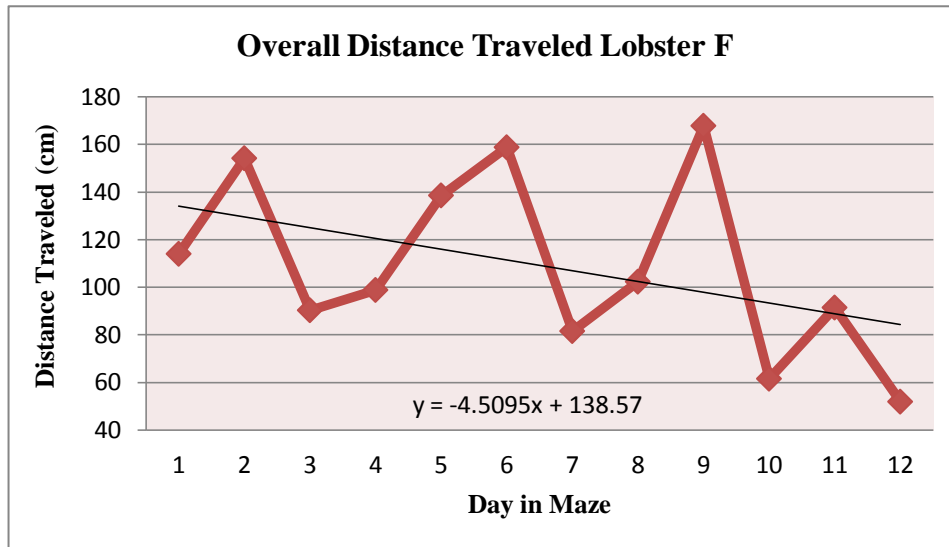


Figure 9: Overall distance traveled each day for Lobster F in the complex maze. Distanced traveled was measured in centimeters. Lobster F showed a decline in activity but stabilization was never reached.

Discussion

Overall, only two of the six lobsters were significantly more active during the night compared to the day; both of these lobsters were tested in the simple maze. Whether lobsters are primarily nocturnal or not has been somewhat debated; the results of some studies have led to the belief that lobsters are mostly nocturnal whereas other studies have provided evidence that lobsters can also be very active during the day (Golet et al. 2006.) Our results do contradict those of Mehrtens et al. (2005) in which European lobsters tested in a laboratory maze were far more active during the night. Whether or not it is important that the two lobsters that showed far more

nighttime activity were tested in the simple maze is uncertain. Perhaps lobsters in the complex maze expressed more exploratory behavior during the day because they were more uncertain of their surroundings.

All three of the lobsters tested in the simple maze showed somewhat of a decline in activity. Lobster A showed the greatest evidence that it learned the maze environment because its activity steadily declined and then stabilized around Day 7 in the maze. After Day 7, its exploratory activity remained minimal for the remainder of the time in the maze. It is likely that the other two lobsters tested in the simple maze, lobsters B and C, did not show a stabilization in activity level because they were significantly less active during the day. Therefore, in a 24 hour period lobsters B and C were only exploring 10 hours whereas lobster A was exploring all 24 hours. Lobster A would therefore have more time to learn the maze environment.

Only one of the lobsters tested in the complex maze showed any decline in activity during the 10 days, and the activity never stabilized. It is possible that 10 days was not a long enough period of time for the lobsters to learn the complex maze environment. These results coincide with the hypothesis that it would take the lobsters in the complex maze longer to learn the environment. We hypothesize that given more time the lobsters would have shown a steady decrease in activity before leveling off, similar to results from lobster A.

Traveling the distance of 50 cm per day appears to be somewhat of a baseline level for the lobsters. Many of the lobsters showed a decline in activity until reaching approximately 50 cm per day. Lobster D did not show a decrease in distance traveled throughout the experiment, but traveled approximately 50 cm each day. This lobster may have been inactive due to sickness or possibly it was preparing to molt. This specific distance may provide evidence of typical

exploratory activity levels for juvenile lobsters in a familiar environment. That is, traveling approximately 50 cm per day may be a common amount of activity for juvenile lobsters in an environment they are familiar with.

Conclusions

Overall we found that the presence of light affects the exploratory activity of some individuals but not others. Also, based on our results we believe that juvenile lobsters can learn at least some features of a simple maze environment within seven days. It is likely that given more time the lobsters tested in the complex maze would have also expressed a decrease in activity level. These results do not contradict the hypothesis because it was expected that lobsters in the complex maze would take longer to learn the environment and thus show a decrease in activity level.

Further Research

A beneficial follow up study could test juvenile lobsters of various sizes in the simple maze. This study tested lobsters that were very close in size, and thus very close in age. Mehrtens et al. (2005) found a distinct change in behavior in juvenile lobsters that were 75-80 mm in length or larger; the lobsters switched from being very defensive to being more offensive. It would be beneficial to determine if that change in behavior could be replicated by means of exploratory behavior. Perhaps larger lobsters would become more offensive, would spend less time in the shelter, and thus would be able to learn the maze environment more quickly. It would also be beneficial to determine if there is a physiological or morphological change that occurs during this change in growth that would ultimately alter behavior.

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