The Effects of Lead Poisoning on Fathead Minnow Reproductive Behaviors
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Abstract

In this experiment, the class studied how constant exposure to lead affects the long-term reproductive health and behavior of the fathead minnow. In doing so, assumptions could then be made regarding the results of lead on human reproduction. To test the hypotheses, two tanks of lead poisoned fish (with males and females) were set up with PVC piping (nesting site) and recorded to determine the number of occurrences of specific sexual actions and features. Likewise, two tanks of unaffected fish were set up and recorded in the same manner. The pooled data illustrates that the unleaded fish had a tendency to remain located near the nesting site, whereas those exposed to lead generally moved in and out of the location. Also, through the use of qualitative data, the group found that the fish exposed to lead generally lacked/ showed poorly defined sexual characteristics. Lastly, even though only two eggs were found in the unaffected tanks, none were found in the nesting site of the leaded tanks. These factors suggest that the fish exposed to lead have a diminished sexual maturity and fertility, and as a result, humans who frequently come in contact with lead will experience the same consequences.

Introduction

Despite the many practical uses of the element, lead can be extraordinarily unhealthy, or even fatal, when ingested. Children and growing fetuses are especially susceptible due to the fact that they haven’t fully developed mentally, and therefore suffer the long-term consequences, such as difficulties learning and socializing with others. Furthermore, it is well known that lead affects more than just humans. In fact, scientists of the USGS National Wildlife Health Center
(2009) found that, due to its use in ammunition, several wild birds (bald eagles, condors, loons, etc.) had suffered premature deaths as a result of lead poisoning.

In order to test the effects of lead on reproductive behavior and fertility, fathead minnows were exposed to lead (20 PPM) and are therefore used as a model organism for humans. The minnow provides an effective representation of humans in that fathead minnows contain many similar sex organs. Subsequently, the results of lead on the fish will have similar results on humans. For this reason, the minnows are vital in determining the consequences of lead on humans and the rest of our ecosystem. When sexually developed, male minnows will show a variety of traits, including tubercles and a head pad (used to prepare the nesting site), banding patterns, and a black dorsal fin spot. However, it was found that a group of lead-exposed fish had ill-defined sexual characteristics in relation to the control group of unexposed fish. Similarly, the lead exposed fish produced fewer eggs between greater intervals, and said eggs developed at a far slower rate (Marine and Freshwater Biomedical Core Center, 1993). In addition, the minnows will exhibit a variety of behavioral traits as they mature sexually, including nest preparation, or rubbing up against the roof of the nesting site in order to set up the location of egg deposition. Also, they may hover or patrol (swimming outside of the nesting site) to protect the deposited eggs. Lastly, males generally swim up to a female, flipping her over to deposit eggs in a process known as spawning. Furthermore, another experiment tested the proteins P450 aromatase and estrogen receptor b (which are also found in humans) within the fish’s ovaries. To study the physiological effects of infertility as caused by lead poisoning, the minnow ovaries were exposed to lead, thereby illustrating that the element was absorbed, causing the tested proteins to decrease significantly (Taupeau et al, 2003). These articles show a strong correlation between lead poisoning and decreased sexual development. For this reason, it was hypothesised that lead
exposed fish will display fewer sexually developed traits and behaviors of the fish in pure water as well as have fewer eggs.

**Materials**

- 4 large fishtanks (labeled A, B, C, D)
- 8 porous partitions (two for each tank)- separates the tank into three sections
- 12 male fathead minnows (6 of which were lead poisoned at 20 ppm)
- Filtered water
- Frozen Brine Shrimp Fish food
- Dechlorinated pipettes
- 12 halves of PVC piping tubes
- 1 Stopwatch

**Procedure**

1. Minnows of the same age were raised until sexually active, some of which were exposed to lead water with a concentration of 20 PPM.

2. Each of the four tanks is set up so that two partitions form three sections, each with one male, one female, and a semi-cylinder PVC pipe (nesting area).

3. We recorded the qualitative data of each tank for 5 minutes each, examining the dorsal fin spot, head pad, side bars, and tubercles.

4. For five minute intervals, each of the three sections were observed for all characteristic traits, including nest preparation, spawning, hovering, not hovering, and patrol (outside chasing and outside not chasing).
5. The data was collected in a graphic organizer for each tank, and each tank was given a total value for each trait recorded.

6. Each group rotated and repeated steps 3-5 for each of the three remaining tanks.

7. Steps 3-6 were repeated in order to collect as much data as possible.

8. After each day, the PVC piping was checked for any eggs on the roof. This number was then recorded.

9. Data from each group was pooled in order to reach a classroom total for each behavior in each tank.

Results

**Occurrences of Minnow Reproductive Behaviors by Tank**

N - Nest Preparation, H - Hovering, S - Spawning, C - Chase, P - Patrol

<table>
<thead>
<tr>
<th>Tank</th>
<th>Behavior</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>N H S C P</td>
<td>2 25 0 13 0</td>
<td>5 11 0 1 1</td>
<td>10 31 2 5 0</td>
<td>2 5 0 0 2</td>
</tr>
<tr>
<td>Group 2</td>
<td>N H S C P</td>
<td>20 35 0 1 4</td>
<td>18 47 2 2 3</td>
<td>1 2 9 0 5</td>
<td>10 12 0 1 1</td>
</tr>
<tr>
<td>Group 3</td>
<td>N H S C P</td>
<td>29 48 0 0 27</td>
<td>10 47 22 6 15</td>
<td>2 13 43 38 26</td>
<td>22 20 19 15 9</td>
</tr>
<tr>
<td>Group 4</td>
<td>N H S C P</td>
<td>1 20 0 1 1</td>
<td>6 20 0 0 0</td>
<td>3 13 1 1 0</td>
<td>0 22 4 3 0</td>
</tr>
<tr>
<td>Total</td>
<td>N H S C P</td>
<td>52 128 0 15 32</td>
<td>39 125 24 9 19</td>
<td>16 59 55 44 31</td>
<td>34 59 23 19 12</td>
</tr>
</tbody>
</table>
The graphed behaviors (shown above) illustrate a strong similarity between the data of tanks A and B, the control tanks, as well as among C and D, which contained the lead-exposed fish. The two pairs of tanks differed greatly among the occurrences of specific behaviors. For example, the leaded fish exhibited far more behaviors in the lower half of the nesting area and outside of it than in the control tanks. This includes spawning, chase and patrol. On the other hand, the unaffected fish stayed much closer to the top of the PVC piping (where the eggs were)
and consequently, they tended to hover and practice nest preparation more frequently than those in a lead environment. Similarly, the physical traits of the minnows in tanks C and D were ill-defined in relation to those in A and B. Specifically, it was found that the dorsal fin spot and side bars were faint, the head pad almost unnoticeable, and tubercles that were miniscule. Lastly, after each day the PVC piping was checked for the presence of eggs, but none were found under any piping except in tank A (which had two eggs).

**Conclusion**

Although I hypothesized that the unaffected minnows would exhibit more occurrences of all traits, this was wrong in several cases. For example, tanks A and B had a total number of chases below 20 occurrences whereas tanks C and D both had greater values (of the same trait) than the control tanks. Specifically, there were only 15 and 9 chases in tanks A and B respectively, both of which were lower than the chase values of tanks C and D, 44 and 19. Due to the fact that the unaffected fish showed a tendency to illustrate traits near the nesting site of the PVC piping (hovering and nest prep.), it can be concluded that these minnows are more focused on the care of the fertilized eggs. Consequently, it can be assumed that these fish are more sexually mature than those exposed to lead. As a result, lead poisoning among humans may result in the same consequences as fish, such as infertility, decreased sexual development, and death. This statement is also supported by the lack of physical development and eggs produced in the exposed minnows. A major possible source of error was in defining and recording the behaviors of the fish. Because there were a variety of different groups and people recording the information, it is very likely that two different groups would record the same event in different ways. However, this could only be prevented by continuously practicing and collecting more
data. Therefore, in order to improve this experiment, the class should conduct more trials with multiple sets of fish.

**Additional Questions**

- How does increased lead content during exposure effect the exposed fish (30 PPM, 50 PPM, etc.)?
- How does the amount of exposure time affect the reproductive patterns of the minnow?
- How would eggs exposed by lead affect the offspring?
- How might other toxic/radioactive elements (arsenic, mercury, thallium, radon, etc.) affect the reproductive behaviors of minnows?

**Works Cited**

