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# Lava Heron Fishing Success: The Impact of Water Depth

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# Lava Heron Fishing Success: The Impact of Water Depth

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Abstract:

The Galápagos Lava Heron *(Butorides striata sundevalli)* is a small bird that is endemic to the Galápagos Islands, Ecuador. It is territorial and primarily preys on small fish. Currently, there is little research on these herons, so any information will be helpful in better understanding their ecological processes. During a biology course on the islands (July 2017), we observed the hunting patterns of herons specifically their strike patterns. We hypothesized that Lava Heron's fishing practices would differ depending on water depth. We predicted the successful strike rates would be higher in shallower water, and herons would more likely to hunt standing in the water in shallow water versus standing on rocks when hunting in deeper water. To test our hypothesis, we observed Lava Herons as they hunted in a tidal stream for ten days in Puerto Baqueriza Moreno, Isla San Cristóbal. The water depth, whether they were successful, time between strikes, and location of where the heron was when it struck was recorded for each strike attempt. Our results showed a significant difference between the success in shallow versus deep water strikes ($\chi^2 = 63.74$, df = 2, $p < 0.001$). Specifically, the strike success rate was higher in shallow water and more strikes into shallow water originated from water than land. These results suggest that shallow water is an important aspect in the Lava Heron's territory. Hunting territories that lacked the important component of shallow water could result in negative impacts on the heron's heath. Continued observation of strike patterns across an extended period of time would contribute more information to our results.

## Introduction

The Galápagos Lava Heron *(Butorides striata sundevalli)* is a small, dark-plumaged heron endemic to the Galápagos Islands. It is currently considered to be a subspecies of the South American Striated Heron (*Butorides striata striata*) (Kushlan 2009). While its classification as a subspecies is still under contention, the Lava Heron can only be found in the Galápagos Islands whereas the Striated Heron can be found in North and South America, Africa, Asia, and Australia in addition to the Galápagos Islands (Hancock and Elliot 1978). The Galápagos population of Lava Herons also differs from the South American Striated Heron by having a longer and stouter bill. Like the South American Striated Heron, the Lava Heron has distinctive dark color, but lacks the striated pattern on its plumage. Its dark appearance has been assumed to provide camouflage against the lava rock shoreline (Kushlan, 2009).

Individual Lava Herons defend areas that they primarily hunt in. Territories seem to be well established, as birds will usually stop at a consistent boundary. Defense of a boundary was seen as necessary as they can be contested by other birds. Lava Herons are known to attack both Striated Herons as well as other Lava Herons that enter their territory. Kushlan hypothesized that the system of holding territories influences the size of the population of Lava Herons on the islands (2009).

The Lava Heron hunts by walking slowly along the water's edge or in shallow tidepools watching for fish, and then striking by rapidly extending its neck and catching fish in its long bill. The heron's diet can include small Sally Lightfoot Crabs *(Grapsus grapsus)*, flying insects, and there is even a report of the Lava Heron preying on the Small Ground Finch (*Geospiza fuliginosa*) on Española Island (Moran 2010). Its primary source of food, however, are small fish found near the rocky shores of the islands (Kushlan and Hancock 2005). Herons feed throughout the tide-cycle, and find most success either at the edge of the water or when prey became isolated in pools by the falling tide. The herons may follow the changing tide lines or perch during high tide and wait for the low tide to move in and hunt (Kushlan 2009).

We hypothesize that water depth has an impact on the Lava Heron's fishing practices. If our hypothesis is supported, we predict the rate of successful strikes will be higher in shallow water than in deep water, and Lava Herons would most likely hunt by standing in the water in shallow areas versus on land or rocks when hunting in deeper water.

## Methods

We gathered data from July 16th until July 26th, 2017 on San Cristóbal Island, in the Galápagos, Ecuador. The Galápagos Islands, owned by Ecuador, are located 600 kilometers west of the mainland. San Cristóbal Island is in the eastern region of the islands. Observations took place by the military base in south-eastern Puerto Baqueriza Moreno. Next to the military base there is a tidal/ flood runoff drainage creek which is a man-made narrow walled in area that water can flow through during high tide or flooding (Figure 1 and Figure 2). The creek runs along the edge of the boat repair beach, a wide open sandy area where Galapageños beach their boats to work on them on land. There is a shallow pond area with mangroves further in land.

Figure 1. Ariel view of the repair beach and the tidal creek. Puerto Baqueriza Moreno San Cristóbal Island, in the Galápagos, Ecuador. Image retrieved: Google Maps


Figure 2. A closer view of the tidal creek Puerto Baqueriza Moreno San Cristóbal Island, in the Galápagos, Ecuador. Photo taken by Munshower.

There was little vegetation within the observation area besides algae growing on the rocks in the creek. The only other vegetation was not natural, but planted for aesthetic purposes by the city government. There were some decorative shrubs and a tree along the sidewalk running alongside the creek. These shrubs were all thread-leafed chaff flowers (*Allernanthera filifolia*) and the tree was a yellow cordia (*Corida lutea*).

As the tide goes out, small pools of water are left on other sides of the stream. The pools varied in depth of water and often contained fish that were left behind. The variation in depths allowed for us to test our hypothesis. Sally Lightfoot Crabs lined the walls of the tidal creek and insects such as dragonflies were frequently seen. It was the excess of potential prey that attracted hunting herons. The fish were also more visible in the shallow water and the rocky streambed and human-built rock walls provided higher ground for the herons to stand on.

After walking along the observation sites, we chose two herons in different areas to observe. Observation would begin within two hours before or after low tide and would last about two and a half hours, or until the herons began preening.  We recorded the time between strikes with stop watches. On the first day of observation we measured the depth of the water in pools the herons had previously stood in. We noted beforehand approximately how high up their legs the water appeared to be, compared to how deep the water was. Moving forward we estimated the depth of the water based on where it rose on the legs of the heron when they stepped into the water. We wrote down the depth of the water as well as whether the heron struck from, on land or while standing in water. Water depth was divided into three categories (Table 1). If the heron caught a fish it was marked as a successful strike, if it did not it was recorded as a miss. After each day of observation, we copied the data onto an excel sheet.

**Table 1. Categories of water depth in centimeters**

| Shallow | Medium | Deep |
|---|---|---|
| 0-5 | 5.1-10 | 10.1+ |

When analyzing our data, we used a chi-squared goodness of fit test. Expected values were calculated by mean values. If there was no advantage to hunting in certain water depths, then the number of strikes in each would be approximately be the same.

## Results:

After observations were complete, we had recorded 245 total strikes. Of the strikes, 59.18% of them were successful and 40.81% of them were misses (Table 2). The Lava Herons appear to prefer hunting while standing in water, with 65.1% of strikes originating from water, rather than striking from shore (35.9%). Although the success rate was slightly higher when striking from land where 63.6% of strikes from land were successful, and only 56.7% of strikes from the water resulted in a catch (Table 2). The depth of the water also appeared to impact where the heron struck from (Table 3). As the depth of water increased, the time Lava Herons waited before striking also increased (Table 4). The depth of the water also impacted the success rate of the hunting heron, with shallow water having the most successful strikes (Table 5).

**Table 2. Total hits and misses by Lava Herons from land or water. Data collected 2017 on San Cristóbal Island, Galápagos n=245**

| Location of Strike | Hits | Misses | Total Attempts |
|---|---|---|---|
| Land | 56 | 32 | 88 |
| Water | 89 | 68 | 157 |
| Totals | 145 | 100 | 245 |

**Table 3. Attempted strikes by Lava Herons standing on land or wading in water compared to the depth of the water. Data collected 2017 on San Cristóbal Island, Galápagos. n=245**

| Water Depth | Attempts from Land | Attempts from Water | Total Attempts |
|---|---|---|---|
| Shallow | 43 | 95 | 138 |
| Medium | 22 | 50 | 72 |
| Deep | 23 | 12 | 35 |

**Table 4. Median time between Lava Heron strikes compared to the depth of the water. Data collected 2017 on San Cristóbal Island, Galápagos. n=245.**

| Water Depth | Time Between Strikes (seconds) |
|---|---|
| Shallow | 60.5 |
| Medium | 94 |
| Deep | 130 |

**Table 5. Total hits and misses compared to water depth for Lava Heron hunting. Data collected 2017 on San Cristóbal Island, Galápagos. n=245**

| Water Depth | Hits | Misses | Total Attempts |
|---|---|---|---|
| Shallow | 92 | 46 | 138 |
| Medium | 37 | 35 | 72 |
| Deep | 16 | 19 | 35 |

We analyzed data using a chi-squared goodness of fit on all strike attempts relative to water depth. We found a significant difference in the number of attempts relative to water depth ($\chi^2 = 66.63$, df = 2, $p < 0.001$) (Figure 3). The same analysis was also done for successful hits compared to water depth. Once again, we found a significant difference between successful attempts and the water depth. ($\chi^2$= 63.74, df = 2, p < 0.001) (Figure 4). There was also a significance difference in where the Lava Heron struck from while hunting (Figure 5). They struck while standing in water more frequent than while standing on land ($\chi^2$=19.44, df=1, p < 0.001).

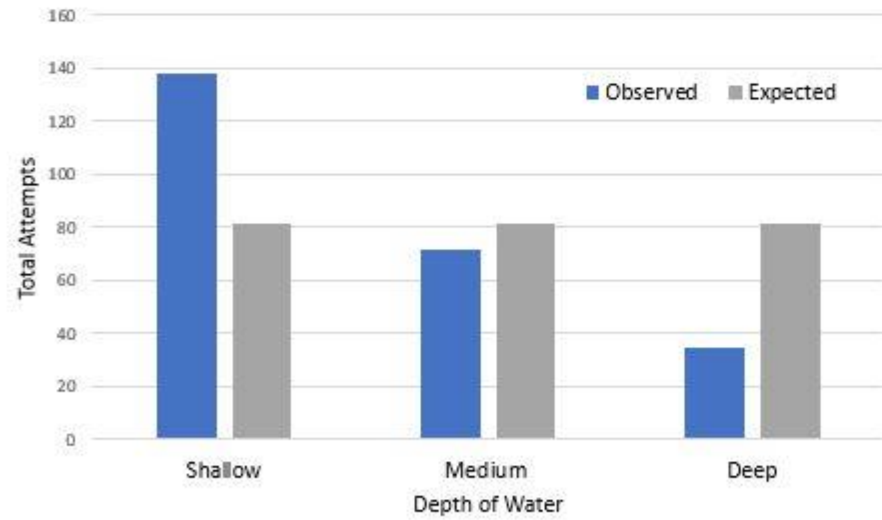


Figure 3. Overall observed strike attempts by lava herons compared to the expected number of strikes. Data collected 2017 on San Cristóbal Island Galápagos. n=245

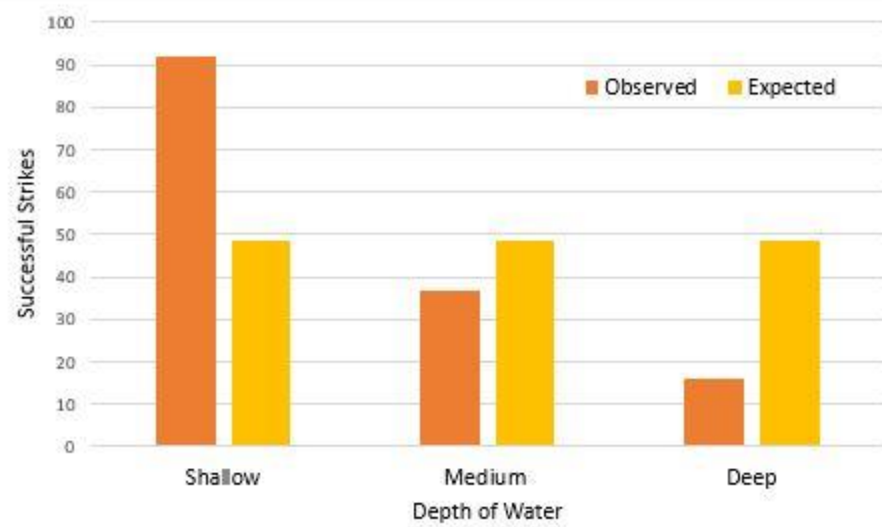


Figure 4. Observed successful strike attempts by lava herons compared to the expected number of successful strikes. Data collected 2017 on San Cristóbal Island, Galápagos. n=145

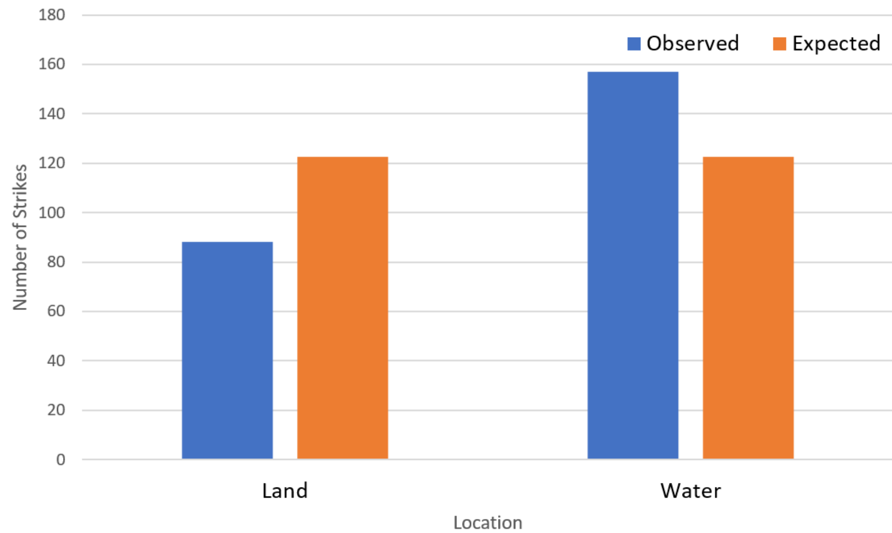


Figure 5. Frequency of Lava Herons standing on land versus standing in water when striking at fish while hunting. Data collected 2017 on San Cristóbal, Galápagos 2017.

## Discussion

Our hypothesis that water depth has an impact on the Lava Heron's fishing practices was supported by our data. We saw an overall decrease in successful strikes by Lava Herons as the depth of the water increased. We interpret this result to be a function of lower visibility as water becomes deeper as well as more room for the fish to escape an oncoming strike. In shallow pools, it is likely easier for the heron to see its prey and the fish have less room to swim away when the heron strikes.

The depth of the water appeared to have an impact on where the herons chose to hunt from - whether from land or while standing in the water. As the water became deeper, the herons became more likely to strike from land rather than while wading in the water, with 65.7% of the strikes into deep water originating from land compared to 30.6% of strikes coming from land in medium water and 31.1% into shallow water (Table 3). While land strikes were slightly more successful, the total number of overall strikes from water was significantly greater than those from land with 145 attempts from land (59.2%) and 100 attempts from water (40.8%). If striking from land was a viable option, the herons would often choose to stand out of the water. Because there was not always a rock or outcropping to perch on, the Lava Herons needed to walk in the water to reach some schools of fish. This is likely why there were more strikes from the water rather than from land.

With rising sea levels due to climate change or seasonally with El Niño events, the hunting success of Lava Herons may be altered. Climate change is expected to raise sea levels due to melting ice caps and El Niño events raise the water levels on the islands due to the change in trade winds. Territories could change as previously held areas may no longer be viable with an increase in water depth and resulting lowered success rate of hunting. This could lead to an increase in intra-species competition for territory. Lava Herons can be extremely aggressive to invading Striated and Lava Herons when their territory is infringed upon. Although they usually chase off other herons as a warning, they will resort to violence if provoked (personal observations, Munshower and Westendorf, 2017). If they are forced to move to new areas that have shallow pools, they could disrupt other feeding animals on the island as well.

Potential confounding factors in our study include sample size, length of time observed, time of year data was collected, and where it was collected. Our sample size of birds observed, which was approximately five, was extremely small. If some herons we observed were better or worse at hunting than the average Lava Heron, then our data would be skewed. Our sample size of total strikes is also relatively small. The larger the number of strikes recorded, the more accurate the results would be. Our observation was normally one to two hours and we observed for ten days. A more extensive study over a longer period of time would provide more accurate results. Our data was only collected during the dry season. Hunting tactics may change throughout the year. Once again, a more extensive study would resolve this issue. Our data was only collected in a man-made tidal stream. We recommend observing herons in a more natural habitat as well.

For future studies, we recommend a study that looks at the impact of the angle of the sun and the frequency/ success of strikes. There was a noticeable difference in the success of the birds hunting on different days and we hypothesize this may be due to the time of day. We also recommend looking at any differences in success rates between herons hunting in man-made tide pools compared to those hunting in a natural environment without human influences or construction, as our study was only done in a man-made area.

**References**

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