Examining the Potential Effects of Climate Change on the Mating Efficiency of Hyla versicolor

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Abstract

Hyla versicolor males emit release calls when gripped by other males, the frequency of which affects the time it takes for the gripping male to release him and move on to a suitable mate. This study aims to assess the effect of water and air temperatures, barometric pressure, humidity, and precipitation level on the frequency of *Hyla versicolor* release calling. Release call frequency was measured by capturing adult calling male *Hyla versicolor* at several vernal pools in Land O Lakes, WI in June of 2017 and imitating a mating grip with thumb and forefinger while recording their calls. No significant effect of any of the environmental factors tested on release call frequency were found, so I am unable to conclude how these factors will affect *versicolor* mating success in upcoming years.

Introduction

For many species of frogs and birds, sexual selection relies upon the vocalizations made by the male in order to alert and attract females to their location (Halliday and Tejedo 1995). It has also been found that aspects of frog calls such as pulse frequency and call duration influence female sexual selectivity (Briggs 2010, Gerhardt 2004). Mating calls, however, are not the only vocalization type to influence mating success. Release calls are aggressive calls given off by males who have been gripped by another male so as to alert them that the gripped male is not, in fact, a female and therefore cannot be mated with (Boyd 1992). The influence of this type of calling on sexual success has not yet been examined, but it can be supposed that male frogs who more readily produce this call when gripped allow for greater sexual success. This is because, logically, a frog who is alerted quickly and insistently that he is not gripping a suitable mate can move on to an actual female all the faster.

With the rising of the earth's temperatures and a changing climate, anticipating the impact these changes will have on ecosystems and the organisms that live within them is becoming increasingly important (Hansen 2006). This is because all species living on this earth have developed adaptations over time that allow them to live in specific environmental conditions. When these environmental conditions change, especially at the accelerated rate that we are currently seeing, some species cannot adapt quickly enough and face the possibility of extinction if the environmental changes affect its ability to survive and reproduce (Hansen 2006, Karl and Trenberth 2003). Of particular interest to me is the effect that environmental factors such as temperature, barometric pressure, humidity, and precipitation have on frog release calling, since these are the primary environmental factors that describe climate change (Karl and Trenberth 2003, Mishra 2010). Their effects on frog release calling, as discussed above, could then disturb mating success and, therefore, the survival of the species.

Previous studies have mostly focused on environmental impacts concerning the mating calls of frogs. Some studies have indicated that frequency of mating calls in *Bombina variegata* increases with increasing temperature, though intervals between calls decreases with increasing temperature and the same has been found for *Hyla versicolor* (Zweifel 1959, Gayou 1984). A separate study focusing on the effects of different environmental factors on the calling of different species of frogs found that calling frequency increased with increasing barometric pressure and humidity, but that there was no significant relationship found between calling and precipitation (Oseen et al. 2002). However, a study performed in a Puerto Rican wetland found that calling activity in *Eleutherodactylus coqui* and *E. cochranae* was found to decrease during dry months, but for *E. brittoni* and *E. juanariveroi*, calling decreased during intense precipitation and high temperatures, since the frogs would retreat into the vegetation during these times (Ospina et al. 2013).

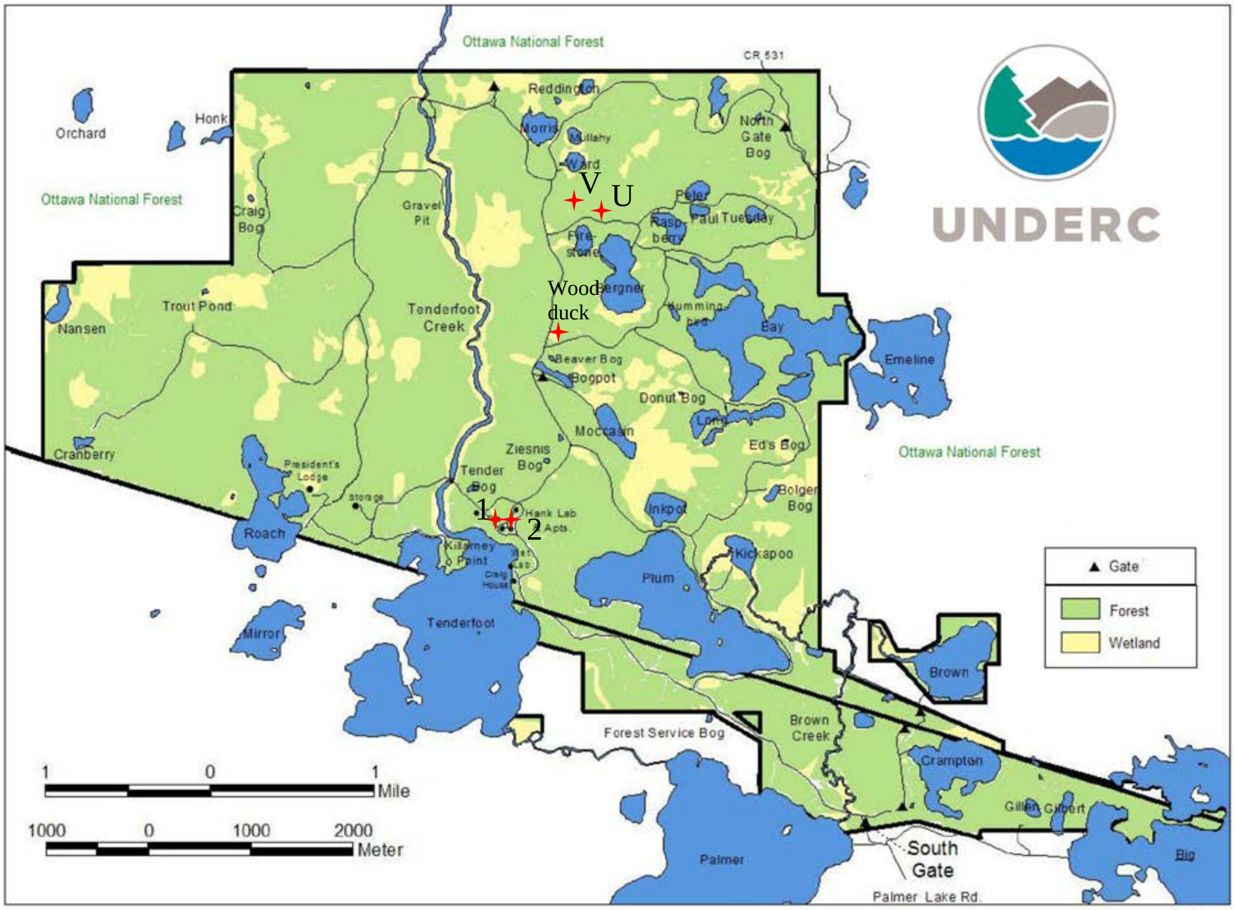
There is little information known, however, on the impacts of environmental factors on release calls of frogs. It is possible that the factors that impact mating calls will affect release calls in a similar way, but the two types of calls are generated out of different motivations and thus could be influenced differently by environmental factors (Gelder 1975). The species whose breeding season coincided with my presence in Land O' Lakes, Wisconsin, however, was *Hyla versicolor*. Thus, this is the species of interest for investigating the impact of the aforementioned environmental factors on release calling. This also makes it difficult to determine if the effects of the environmental factors on release calls of other species are at all indicatory of their effects on *Hyla versicolor,* since call attributes vary significantly amongst species (Boyd 1992).

My research will focus on answering the question, "what is the effect of varying water and air temperature, barometric pressure, precipitation, and humidity on the frequency of release calling in *Hyla versicolor*?" I expected that release calling will increase with increasing water and air temperature, barometric pressure, humidity, and precipitation.

Methods

Study Sites:

We took samples from five different vernal pools at the University of Notre Dame Environmental Research Center in Land O' Lakes, Wisconsin: Wood duck, Pond U, Pond V, Pond 1, and Pond 2 (See map below). Each vernal pool contained plentiful emergent and floating vegetation and had overhanging tree branches from which the *versicolor* would call. Data were collected between 9 and 11:30 pm for each site from June 1, 2017 to June 15, 2017, when mating calls began to decline. Field sites were rotated so as to allow time for the frogs to recover after being handled.



Field Sampling

When arriving at each study site, we would first take the air and water temperatures using a glass thermometer. Next, we waded into the water, catching only the adult male frogs that were producing mating calls for our study. Once a frog was caught, it was brought back to the edge of the pool where we would measure its release calling. Release calls were induced by grasping the frog between thumb and forefinger below the front legs and applying constant pressure for the duration of one to two minutes while a nearby recording device documented the call frequency. After being recorded, if the time was before 10:30 pm, the frog would be put in a moist container with breathing holes to be re-recorded an hour later, when the measured environmental factors had changed, all-the-while keeping the frog at the location from which it was collected. If the time was after 10:30 pm, then the frog was simply released.

Data Analysis

Measures of relative humidity, barometric pressure, and precipitation were recorded using the UNDERC weather data site, which records these measurements once every hour. Thus, for each sample, we used the values of variables from the time closest to that at which calling was recorded. Afterwards, I calculated call frequency using the equation f=c/t, with f indicating call frequency, c indicating the number of calls from first call to the last call made, and t being the time in between this first and last call. This was to avoid error in time spent attaining a proper grip on the frog and then time spent releasing the frog at the end of each recording. Since there was a significant portion of frogs that did not release call, I also calculated the ratio of frogs that did call to the frogs that did not.

A simple linear regression analysis was then run for each of the environmental factors (x) and release call frequency (y) as well as with the ratio of calling to non-calling (y) using Rstudio in order to determine whether water temperature, air temperature, precipitation, barometric pressure, or humidity had a linear relationship with release calling. I decided to calculate the ratio of release calling frogs to non-release calling frogs and use this as an alternate variable to call frequency after observing that there was a considerable proportion of frogs which did not release call.

Results

I found there to be no significant linear relationship between air temperature and release call frequency (linear regression p=0.654, R^2= 0.002556, df= 1,79) (Figure 1). I did not find any significant linear relationship between call frequency and water temperature (linear regression p=0.0729, R^2= 0.04014, df= 1,79)(Figure 2), relative humidity (linear regression p=0.5213, R^2= 0.003379, df= 1,122)(Figure 3), barometric pressure (linear regression p=0.225, R^2= 0.01207, df= 1,122)(Figure 4), or precipitation (linear regression p=0.296, R^2= 0.008954, df= 1,122) (Figure 5).

Regarding the ratio of release calling to non-release calling frogs, I found there to be no significant linear relationship between air temperature and this ratio (linear regression p=0.09466, R^2= 0.2542, df= 1,10)(Figure 6). The other variables tested: water temperature (linear regression p=0.0833, R^2= 0.2701, df= 1,10)(Figure 7), relative humidity (linear regression p=0.27442, R^2= 0.05939, df= 1,20)(Figure 8), barometric pressure (linear regression p=0.731, R^2= 0.006019, df= 1,20)(Figure 9), and precipitation (linear regression p=0.1957, R^2= 0.08223, df= 1,20)(Figure 10) also had no significant linear relationships with the ratio of release calling to non-release calling frogs.

Discussion

I hypothesized that that release calling would increase with increasing water and air temperature, barometric pressure, humidity, and precipitation. However, the data collected did not support my hypotheses, since I found that none of the variables had significant linear relationships with the release call frequency of adult male *versicolor*. If there had been a significant relationship with any of the factors, a negative linear relationship with release call frequency would have indicated that release call frequency would most likely decrease when the factor increases, inhibiting fitness of the species because mate-search efficiency is decreased. This would have been potentially worrying for *versicolor*, especially since the variables precipitation, relative humidity, air temperature, and water temperature, since these are the environmental factors predicted to increase in the Midwest in the next century (Mishra 2010).

On the other hand, if a factor were to have a significantly positive linear relationship with release call frequency, this would indicate that as the value of that factor increases, then so might frequency of release calls, potentially increasing fitness of the species since there is less time wasted on unrealistic mates. Since the vice-versa would also have been true, this relationship would have been worrying for barometric pressure, since this variable is projected to decrease in the upcoming years (Mishra 2010). Since I did not find any significant linear relationships between the environmental factors and release call frequency, however, I am left unable to determine potential impacts of climate change in the Midwest on the release calls of adult male *versicolor* and, in turn, their mating efficiency.

I also found no significant linear relationship between any of the environmental factors and the ratio of release-calling *versicolor* to non-release-calling *versicolor*. Though this wasn't a measurement with which my original objectives were concerned, this is an interesting result, since it indicates that whether or not a male *versicolor* chooses to release call towards another male who is clasping it is uninfluenced by the environmental factors subject to climate change. This measurement is also potentially more important than general release call frequency, since the choice not to call indicates complacency with being clasped, which is a trait not favorable to the survival of the species (Leary 2001).

That this particular study did not find any significant effect of environmental factors on the number of *versicolor* who release call, more research is most likely needed with a higher number of replicates. An improved method in order to achieve this higher number of replicates would be to manipulate water and air temperatures, barometric pressures, precipitation levels, and humidity in a controlled environment instead of the field, since the field is subject to constantly changing conditions. This dynamic environment: a) makes it difficult to get a high number of replicates at specific levels of these variables and b) decreases the accuracy of the measurements of these variables in terms of their values at the exact moment release calls were recorded. Methods to introduce a controlled temperature environment for *versicolor* have already been used in previous studies, from which I could derive my improved methodology for future research (Gerhardt 1978, Gayou 1984).

Further research would also be required as to what effect these environmental factors have on the time between initial gripping and when the *versicolor* begins release calling. This measurement would also have potential implications for mating efficiency, since a quicker reaction by the clasped male frog allows for the clasping frog to realize sooner that he has made a mistake and for him to thus move on to a female mate. This would require more precise methodology so as to begin recordings and gripping of the *versicolor* simultaneously.

Another possible explanation for the lack of significant findings in this study is other factors that may affect release calling such as comfort with capture and social cues from other *versicolor*. For example, some of my samples were too concerned with escaping from my grasp to call, possibly because these frogs had not experienced being caught before. On the other hand, there were a number of frogs who had clippings indicating that they had been captured in previous years for other studies and returned, which would make them less skittish when caught.

In some cases, frogs that had been released earlier in the night would choose not to move away from the site where I was taking release calls, and would begin mating calls nearby. This may have affected the test *versicolor's* willingness to release call, as previous studies have detailed that distance from other individuals of the species affect release call frequency (Sullivan and Wagner 1988).

Overall, more study is very much needed on the release calling of frogs, especially *Hyla versicolor.* As the looming threat of climate change gets larger and larger, being knowledgeable of its effects on our ecosystems and the organisms within gets all the more crucial. Specifically, animal behaviors involved with mating should be investigated as much as possible in order to assess the ability of these organisms to survive these oncoming changes, release calls being only one of these behaviors.

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Figures

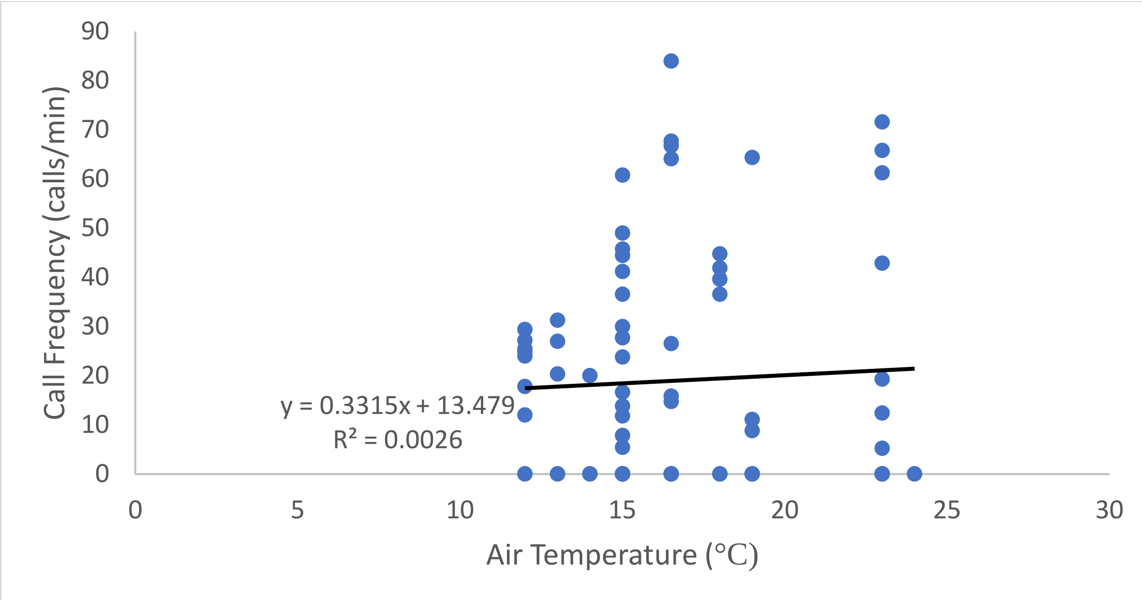

Figure 1. Number of release calls made per minute by calling adult male *versicolor* during breeding season across different air temperatures, analyzed with a simple linear regression.

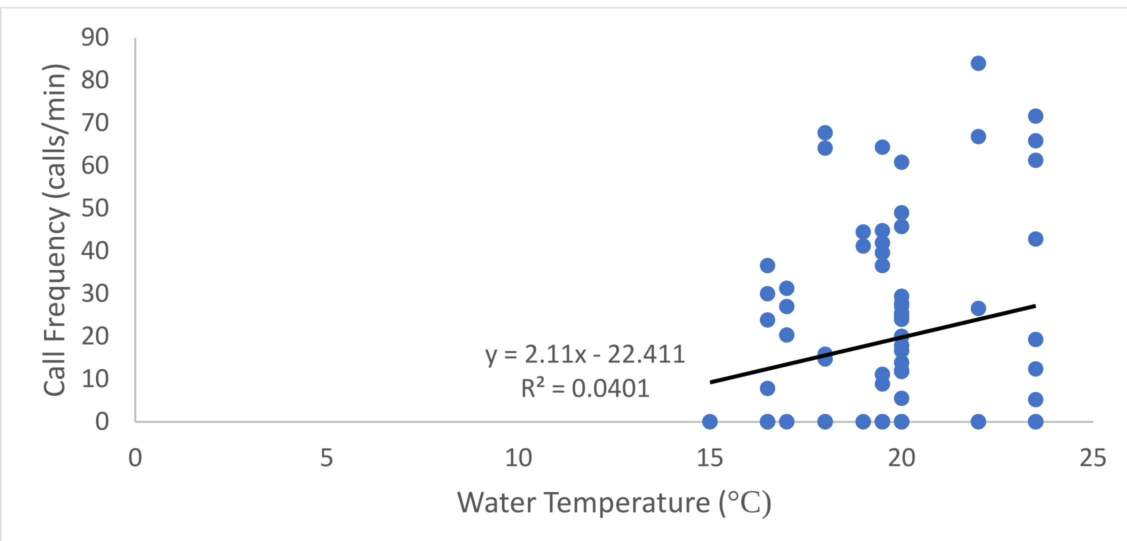

Figure 2. Number of release calls made per minute by calling adult male *versicolor* during breeding season across different water temperatures, analyzed with a simple linear regression.

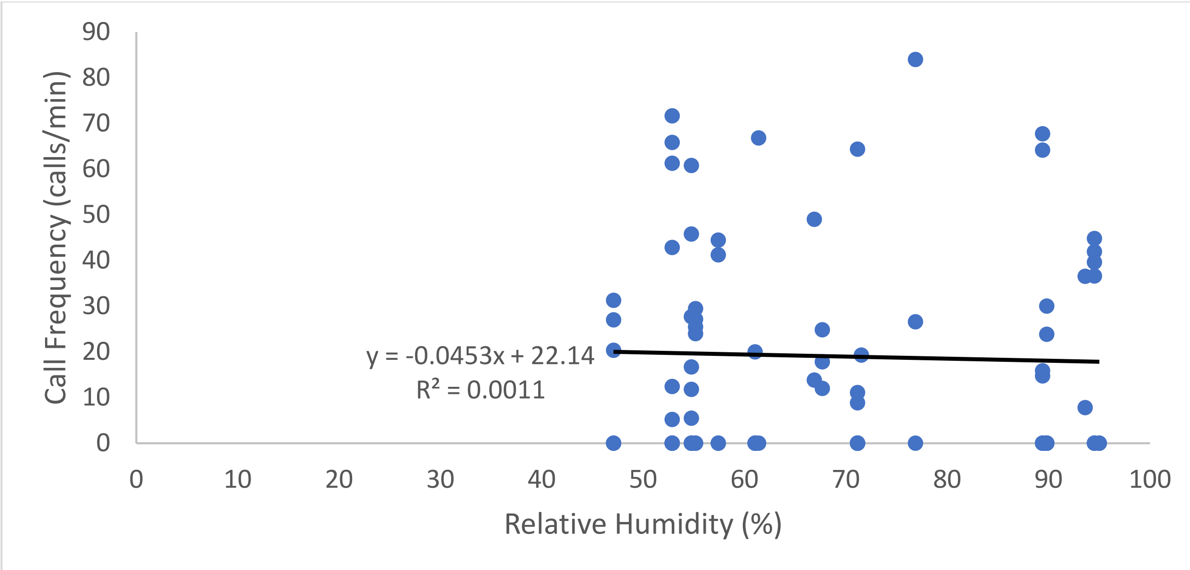

Figure 3. Number of release calls made per minute by calling adult male *versicolor* during breeding season across different relative humidity values, analyzed with a simple linear regression.

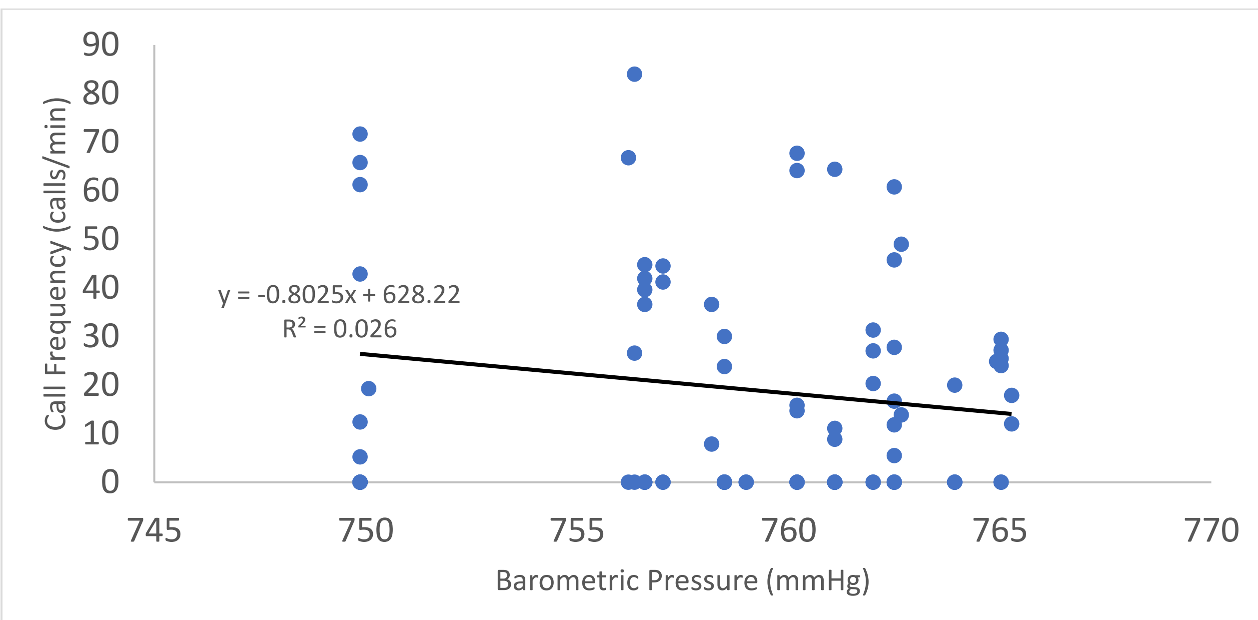

Figure 4. Number of release calls made per minute by calling adult male *versicolor* during breeding season across different barometric pressures, analyzed with a simple linear regression.

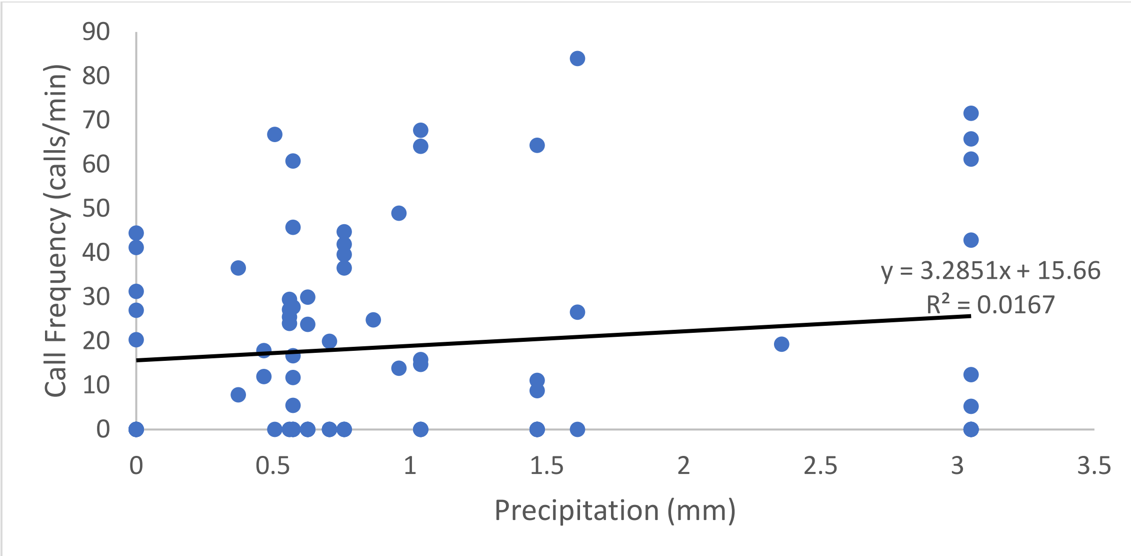

Figure 5. Number of release calls made per minute by calling adult male *versicolor* during breeding season across different amounts of precipitation that had fallen in the preceding 24 hours, analyzed with a simple linear regression.

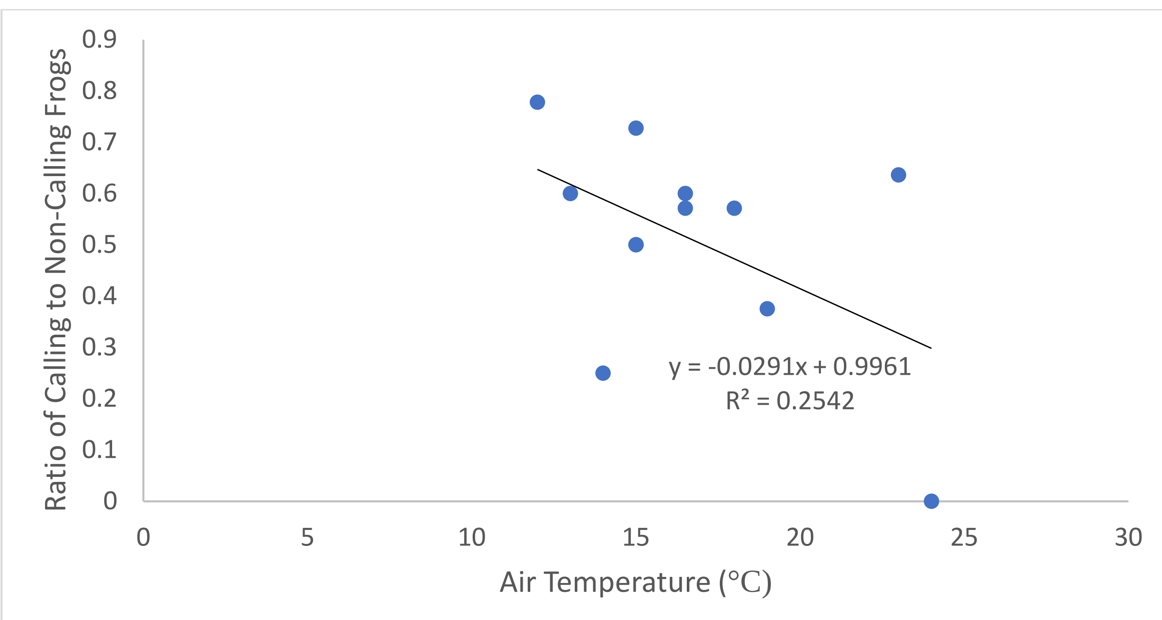

Figure 6. Ratio of the number of adult male *versicolor* frogs who exhibited release calls at different air temperatures during breeding season to the number of frogs who did not release call, analyzed with a simple linear regression.

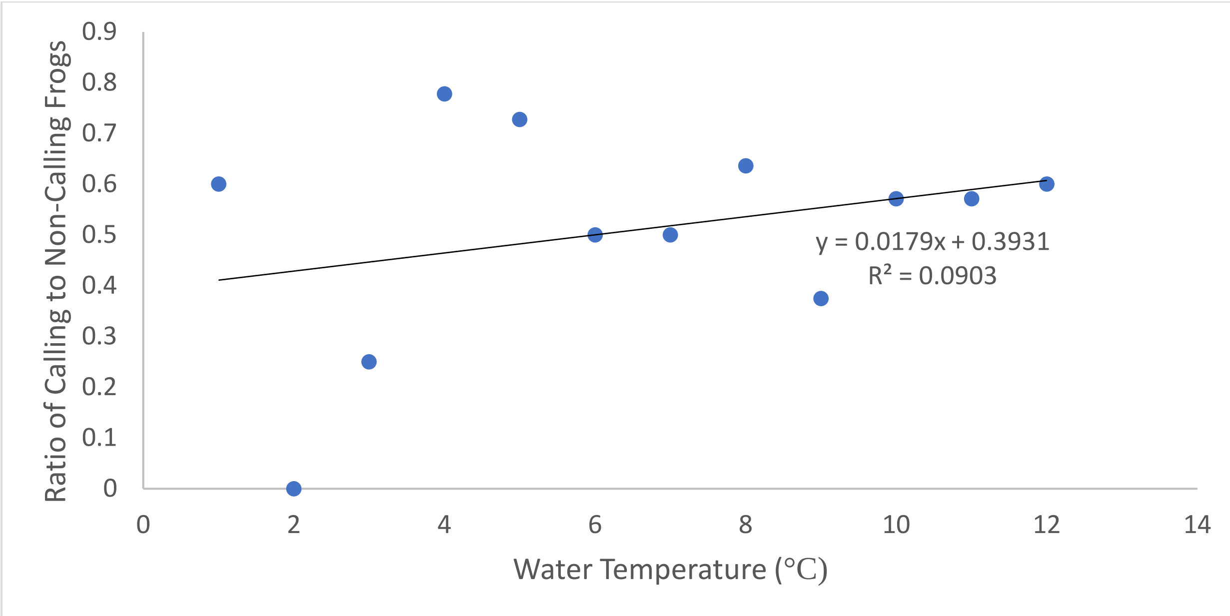

Figure 7. Ratio of the number of adult male *versicolor* frogs who exhibited release calls at different water temperatures during breeding season to the number of frogs who did not release call, analyzed with a simple linear regression.

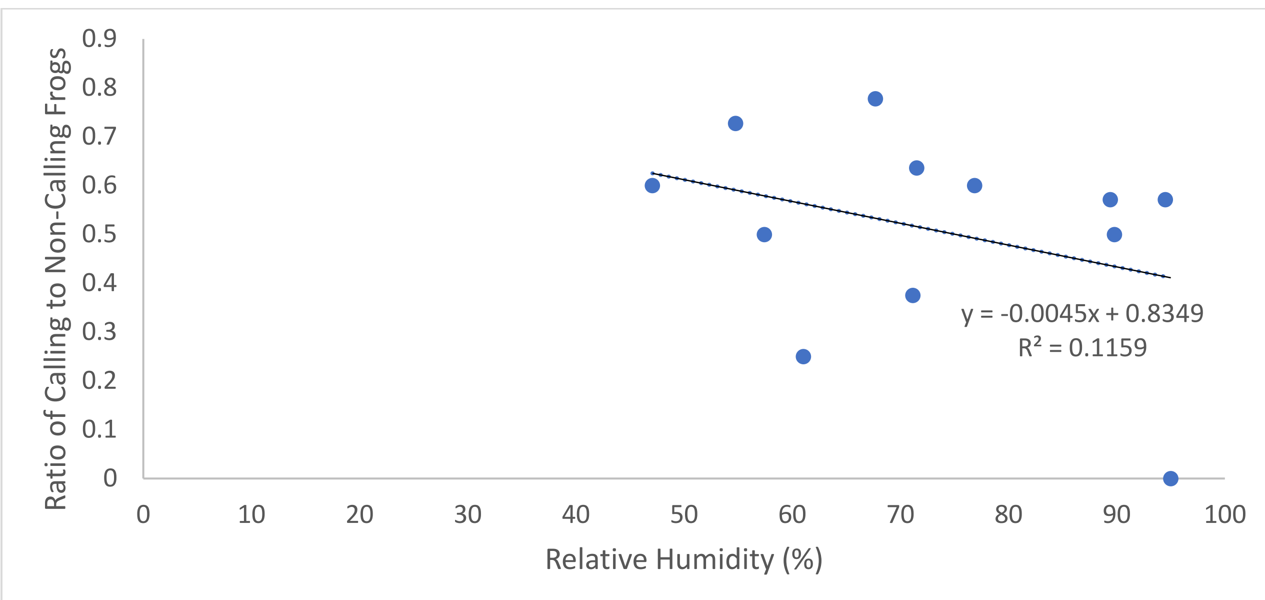

Figure 8. Ratio of the number of adult male *versicolor* frogs who exhibited release calls at different values of relative humidity during breeding season to the number of frogs who did not release call, analyzed with a simple linear regression.

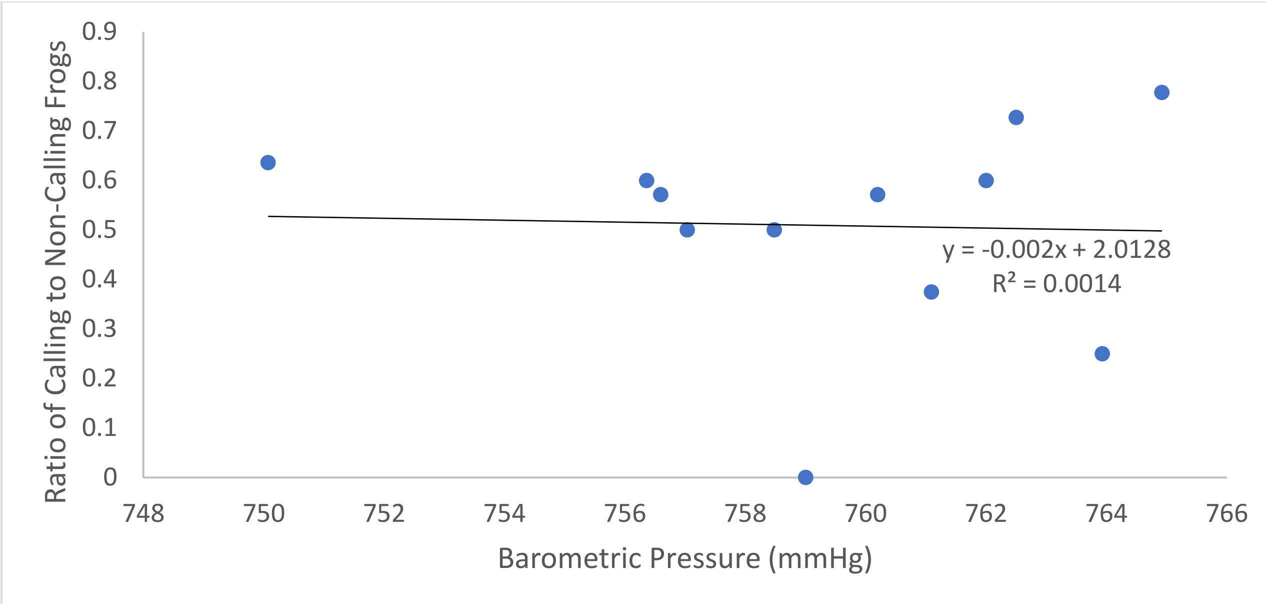

Figure 9. Ratio of the number of adult male *versicolor* frogs who exhibited release calls at different barometric pressures during breeding season to the number of frogs who did not release call, analyzed with a simple linear regression.

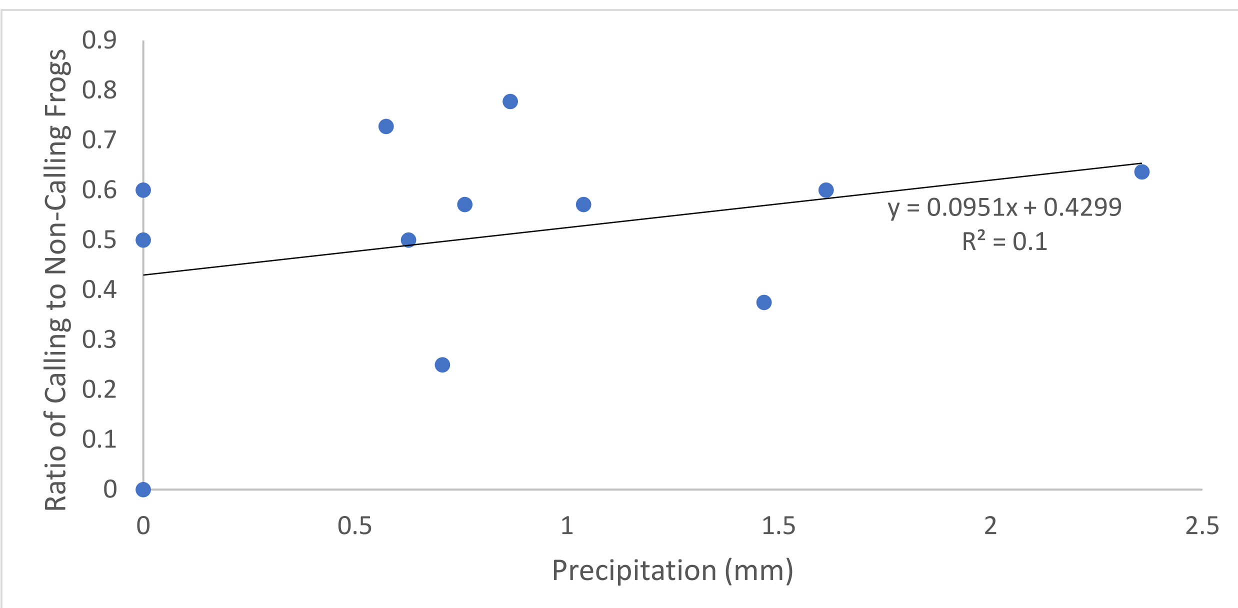

Figure 10. Ratio of the number of adult male *versicolor* frogs who exhibited release calls at different amounts of precipitation that had fallen in the preceding 24 hours, during breeding season to the number of frogs who did not release call, analyzed with a simple linear regression.