DOMINANCE BEHAVIOR WITHIN CAPTIVE ZEBRA FINCHES *(TAENIOPYGIA GUTTATA)*

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by

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During this experience there have been many people along the way that helped me tremendously, all of whom I would like to graciously thank. Dr. Sean Veney for his guidance and patience as my advisor throughout my thesis despite the many challenges. Dr. Christie Bahlai for her statistical expertise. My committee members, Dr. Andrea Case, Dr. Mary Ann Raghanti, and Dr. Alison J. Smith, for taking the time to listen and provide advice for future avenues of study. Lori Michael and Ólöf Thórdardóttir for their advising and reassurance. Joshua Sutherland for proofreading and his relentless support.

PREFACE

The senior honors thesis process at Kent State University has been an extremely valuable experience and I am so grateful I had the chance to participate. My original question was if having only one parent in a traditionally biparental system would be beneficial to the offspring in the long run. Since having only one parent is stressful it may force that offspring to learn how to survive quicker, and thus, be beneficial for adulthood. Unfortunately, the zebra finches within my first study did not breed readily and only one offspring hatched. Although my original project did not work out as planned I learned even more about my field and all the challenges it may bring. I feel even more confident and ready for graduate school in the future. This experience, despite its difficulty, has solidified the fact that I want to specialize in animal behavior. I am forever grateful for Dr. Veney, my committee, and the Honors College's support.

CHAPTER 1

ABSTRACT

In zebra finches, dominance behavior can be beneficial to determine rank within a social group. These behaviors allow stronger and physically fit individuals to benefit from prime selection of food, mates, shelter, and other resources. In this species, fitness is measured by indices such as age, mass, tarsus length, wing chord length, and plumage but it is not entirely clear how these factors may contribute to agonistic behaviors. A group of captive male zebra finches were observed during and after a feeding context with birds that were familiar and unfamiliar to each other. The following hypotheses were tested: (1) Birds in the familiar social group will initiate more aggressive behaviors and have more individuals feeding at food dish as compared to the unfamiliar group; (2) Birds with the greatest amount of fitness indicators in both social groups will initiate the most aggressive behaviors, spend more time at the food dish, and prefer the higher perch location. Results indicated that familiar birds initiate more dominant behaviors than unfamiliar birds. Age and tarsus length significantly influenced the number of initiated aggressive behaviors, while mass and wing chord length had no effect. Furthermore, dominant birds spent more time at the food dish as compared to the subordinate bird, however, birds in neither group exhibited a spatial perch preference. This study highlights the social dynamic differences amongst familiar and unfamiliar birds as well as dominant and subordinate individuals.

Key words: dominance behavior; social behavior; zebra finch; fitness

CHAPTER 2

INTRODUCTION

Zebra finches *(Taeniopygia guttata)* are native to Australia yet are a common bird in labs worldwide as they are great models for research. They are easily handled and bred in captivity for medicinal or behavioral studies (Paz-y-Miňo-C., et al., 2013). They also exhibit similar behaviors to humans such as monogamy and high social interactions. Social dominance, which can include hierarchies, are a widespread phenomenon seen in many species including zebra finches (Trainor et al., 2006; Paz-y-Miňo-C., et al., 2013). Dominance is usually measured through aggressive behaviors, the individual initiating the most agonistic behaviors being dominant over the other(s) (Ardia et al., 2010), but can also be exhibited in less aggressive displays, such as threats. Threats in zebra finches are through direct eye contact and standing erect over another individual (Guillermo et al., 2018). Because fighting is costly, animals will often engage in non-physical dominant behaviors (i.e. threats and other displays) as a first measure of engagement. More physical aggressive behaviors are used only in extreme circumstances (Huntingford, 2018).

During agonistic interactions there is always a dominant and subordinate individual. In zebra finches, dominant behaviors are characterized by pecking and displacement (Zann, 1996). Displacement is when an individual occupies the close vicinity of another, forcing them to move. The initiators of these behaviors are considered the dominant individuals while the recipients are subordinate. Subordinate behaviors may include being displaced or a submissive bowing of the head. In this study, the most dominant individual was determined by the highest number of initiated

aggressive behaviors (displacement, pecking, and threats) while the least dominant, or subordinate, exhibited the fewest aggressive behaviors.

In previous studies, to determine dominance, individuals were monitored for aggressive behaviors between dyads of group members (Paz-y-Miño-C., et al., 2013; Sasaki et al., 2016). Traditionally studies would pair individuals in a competitive setting where there was a single winner and loser during a task. This task could be in a feeding context or exploration of a novel place or item (Beauchamp, 2000). In many species, feeding is often used to measure dominance because it naturally promotes competition. Dominant individuals typically have first choice of food and are the first to reach a food source (Beauchamp, 2006; David, et al., 2010). Individuals who explore new places or items are considered to be less anxious, which is positively correlated with high testosterone levels (Cornwell-Jones & Kovanic, 1981; Zhang et al., 2011), and in turn, is associated with dominance (Ardia et al., 2010). This traditional technique of measuring dominance has been effective but does not account for more complicated relationships amongst group members (Lahti et al., 1994).

Dominance behaviors are common and can influence an individual's survival and reproductive success. They allow the stronger and more fit individuals to benefit from prime selection of food, mates, shelter, and other resources. Fitness in male zebra finches is typically evaluated by measuring tarsus length, wing chord length, and mass as well as plumage, beak, and cheek patch vibrance (Zann, 1996). Tarsus is the arrangement of bones within the pes or foot of an organism from the knee to toes (Roberts et al., 2017). The growth of the tarsus is positively correlated with a high-quality diet as well as cognitive abilities (Bonaparte et al., 2011). Wing chord is the measurement from the wing-torso attachment to the tip of the most prominent feather (Baldwin et al., 1931). Longer wing chord is indicative of higher fitness (Bergtold 1925; Krause

et al., 2015). Additionally, greater body mass has been correlated with fitness in studies on multiple species including the zebra finch (Deslippe et al., 1990; Bolund et al., 2006). Male zebra finches are also known for their vibrant plumage, red beak, and orange cheek patches. These traits have been selected for by females and thus is another fitness indicator (Zann, 1996; Bolund et al., 2006; Ardia et al., 2010; Paz-y-Miňo-C., et al., 2013). All of these fitness measurements contribute to reproductive success, which in turn, can influence dominance behaviors since the main goal of these behaviors is to acquire resources, especially mates.

Zebra finches are a social species of bird, thus age is often another important indicator of dominance since the eldest will typically have the greatest amount of life experience. However, due to fitness degradation over time, old age is not necessarily the most beneficial. Adulthood in zebra finches is 100 days after hatching while the life expectancy of captive zebra finches is approximately 5 years old. The individuals of this study ranged from 1-5 years of age.

Most studies that examine dominance and fitness test only a small group of animals at a time, thus little is known about how these behaviors manifest in animals that are interacting in larger groups. Some birds may have a stronger relationship if they are familiar to each other while unfamiliar birds that have not been previously housed together will probably take longer to form relationships. To further explore this concept, the aim of this thesis was to examine dominant behaviors within a larger group of captive zebra finches in familiar and unfamiliar contexts, in an effort to better understand how well fitness indices predict the display of dominant behaviors in this species. The following hypotheses were tested: (1) Birds in the familiar social group will initiate more aggressive behaviors and have more individuals feeding at the food dish as compared to those in the unfamiliar group; (2) Birds with the greatest amount of fitness indicators in both

social groups will initiate the most aggressive behaviors, spend more time at the food dish, and prefer a higher (more dominant) perch location.

CHAPTER 3

METHODOLOGY

3.1 DATA COLLECTION

Data were collected using captive male zebra finches housed in the animal facility at Kent State University. A group of familiar and unfamiliar adult male birds greater than 100 days of age (N=10 in each group) were separately housed and observed in flight cages (77 x 154 x 187 cm). Birds in the familiar group had been previously housed together for at least 3 months while unfamiliar birds had not been housed together before. Adults of evenly distributed ages (1-5 years) were used in this study. At the time of capture birds were randomly chosen, some from the highest perches with stereotypical plumage and bright beak color while others were chosen from the ground with high feather loss and plumage mutations. Every individual's mass, tarsus length, wing chord length, and overall physical appearance were noted immediately after capture. For easy identification individuals were marked with different colors on the top of their head using Apple Barrel acrylic, water-based paint.

In each testing aviary (familiar and unfamiliar) there were three levels: high perch (~180 cm), intermediate perch (~100 cm), and ground (0 cm) (Figure 1A). This was to observe each bird's spatial preference as well as agonistic behavior. On the ground three zones were constructed—food, intermediate, and beyond. Within the food zone, a small food dish (7.5 cm wide x 3.4 cm deep) was placed in the center (Figure 1B). A circle was drawn around this dish with a radius of approximately 8 cm marking the intermediate zone. Everything on the ground

outside of this circle was considered the beyond zone. The night before data collection all food was removed from the aviary just before lights-out (9pm). Since zebra finches do not feed in the dark, this was done primarily to control when they would start eating the next morning. By delaying the presentation of food after lights-on (when they typically start feeding), this would affect the rigor of their feeding behavior. On the mornings of data collection, the aviaries were checked to confirm there was no random seed on the ground from the day before or from nearby aviaries. Commencement of data collection began at approximately 11am about 3 hours after lights-on.

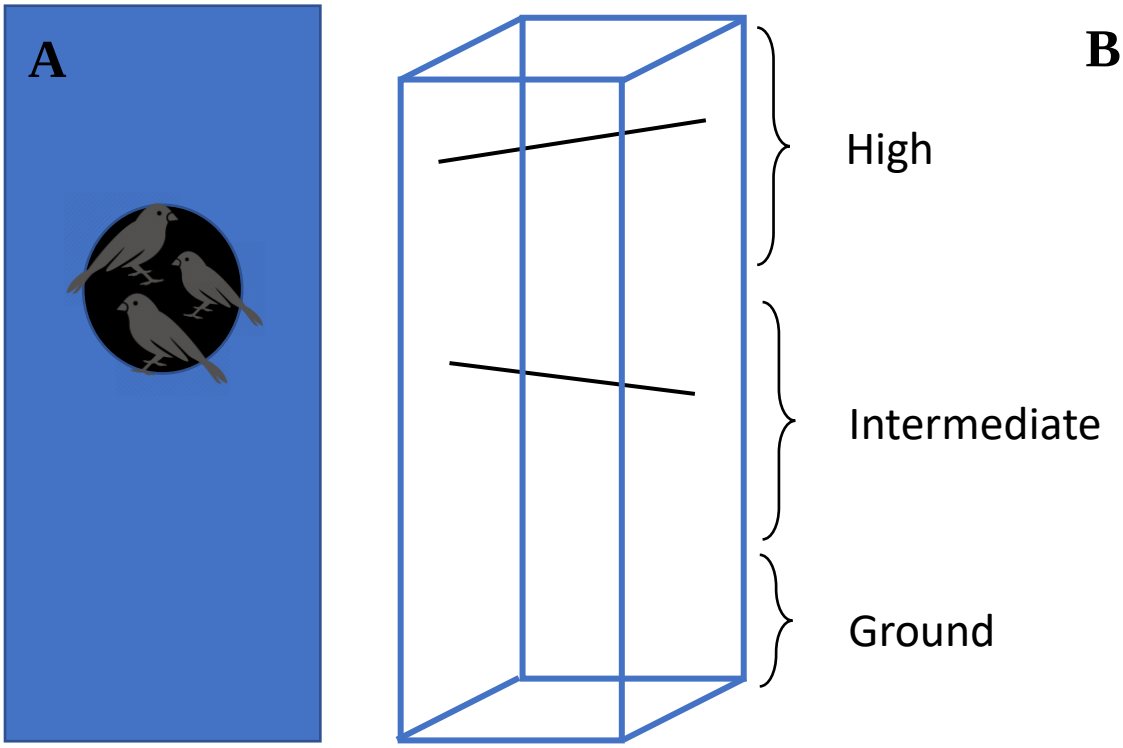

Figure 1.A Layout of ground in feeding phase with the black circle representing the food dish that can feed approximately three birds at once.

Figure 1.B Schematic of aviaries during activity phase with three zones: ground, intermediate perch, and high perch.

There were two fifteen-minute phases of data collection: feeding and activity. Five trials were conducted over the course of a week totaling 75 minutes of observations for each group. All trials were video recorded as well as observed in person. During the feeding phase a single food dish was put in the center of the feeding zone allowing approximately three birds to feed at once. Order of feeding, duration spent in each zone, and any agonistic behaviors that occurred on the ground during this time were recorded for each social group. Feeding duration began once an individual entered the intermediate zone (where seeds may have been discarded by birds already feeding at the food dish) and was actively feeding. Once this phase was completed, the food dish was removed from the aviary and replaced with larger hanging feeders which allowed multiple birds to feed at once. This second, activity phase, did not start until at least fifteen minutes after the feeding phase. The activity phase consisted of recording each bird's duration of time spent at each perch level within the aviary as well as any agonistic behaviors.

3.2 STATISTICAL ANALYSES

Student t-tests was utilized to test hypothesis 1 (Birds in the familiar social group will initiate more aggressive behaviors and have more individuals feeding at food dish as compared to the unfamiliar group). A two-way ANOVA was used in hypothesis 2 to test how well various indicators of fitness in both social groups determined the number of aggressive behaviors. Student t-tests were also used in hypothesis 2 when comparing time spent at food dish and high perch between dominant and subordinate birds.

CHAPTER 4
RESULTS

4.1 HYPOTHESIS I

Over the five days of observation, birds that were previously familiar with each other initiated more agonistic encounters (Figure 1.1, t=3.61, p=0.002), and had more individuals feeding (Figure 1.2, t= 3.24, p=0.012) as compared to the unfamiliar birds.

4.2 HYPOTHESIS II

Across the four fitness indices (age, tarsus length, mass, and wing chord length), data revealed significant variation in the number of initiated behaviors. More specifically, the age of animals in familiar and unfamiliar groups influenced the number of aggressive behaviors. Intermediate aged birds (2-3 years old) initiated more aggressive behaviors than older (4-5 years) and younger (1 year) individuals (Figure 2.1, F=7.85, p=0.006). Similarly, tarsus length also influenced the number of aggressive encounters (Figure 2.2, F=4.25, p=0.04) with birds of shorter tarsus length initiating more agonistic encounters than those with longer tarsus bones. Surprisingly, there were no effects of mass (Figure 2.3, F=0.99, p=0.32) and wing chord length (Figure 2.4, F=1.02, p=0.32). There was one dominant and one subordinate individual within each social group. The dominant individual was defined as the bird with the most initiating behaviors while the subordinate had the least. When comparing the amount of time at the food dish between the dominant and subordinate individuals, data revealed significant differences between the familiar

(Figure 3.1, t= 3.86, p=0.001) and unfamiliar (Figure 3.2, t=2.69, p=0.015) groups. In both social groups, the dominant bird fed the longest while the subordinate did not feed at all, revealing a clear social rank. In contrast, time spent at the high perch between the dominant and subordinate individual of each social group was found to not be significantly different (Figure 4.1, t=1.73, p=0.12 & Figure 4.2, t=0.68, p=0.51).

4.3 RESULTS FIGURES

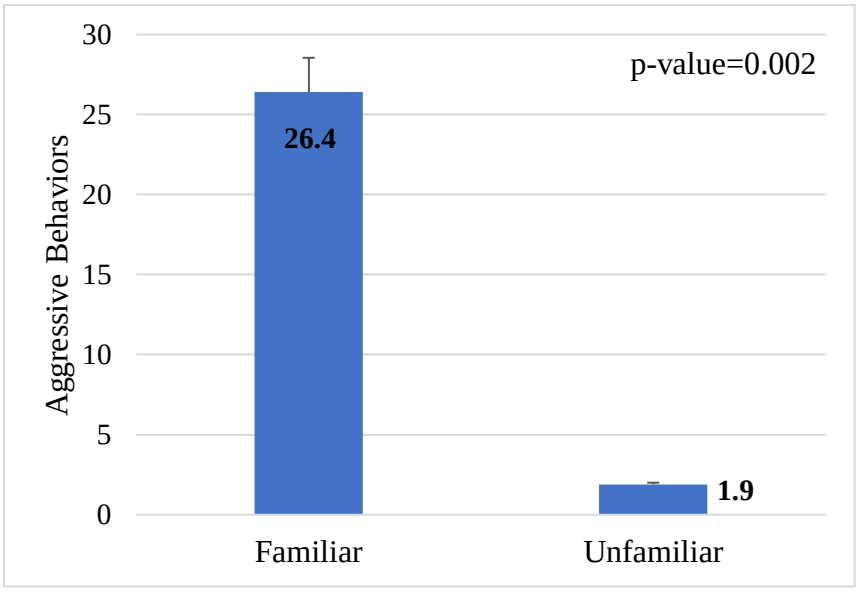

Figure 1.1 Average number of aggressive behaviors that occurred during the feeding and activity phases for five trials within familiar and unfamiliar social groups (t= 3.61, p=0.002). Error bars represent standard error of the mean.

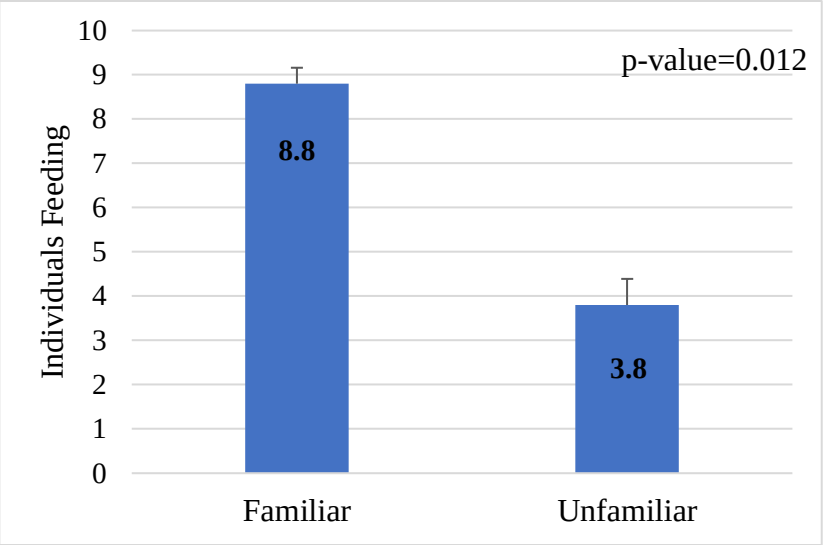

Figure 1.2 Average number of feeding individuals during feeding phase across five trials within the familiar and unfamiliar social groups (t= 3.24, p-value=0.012). Error bars represent standard error of the mean.

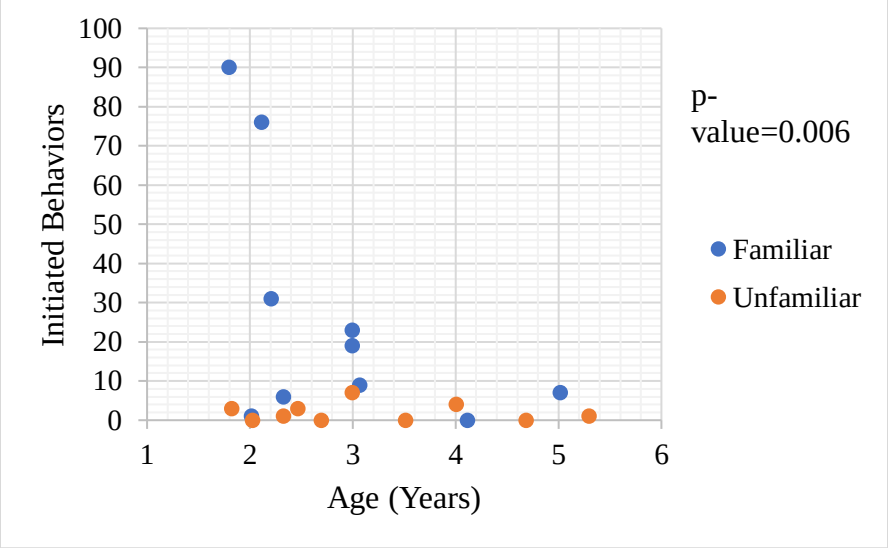

Figure 2.1 Each bird's initiated behaviors compared to age (years) in familiar and unfamiliar social groups (F=7.85, p=0.006).

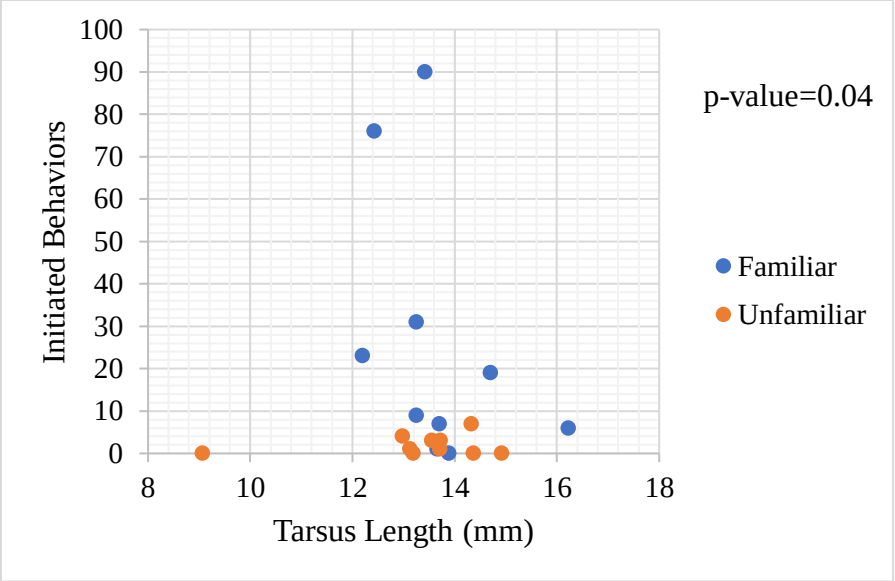

Figure 2.2 Each bird's initiated behaviors compared to tarsus length (mm) in familiar and unfamiliar social groups (F=4.25, p=0.04).

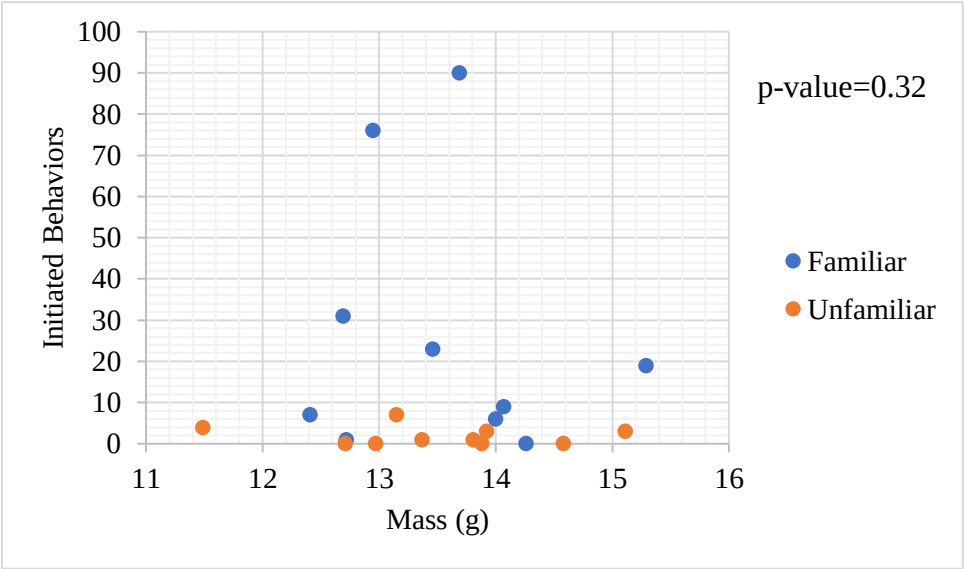

Figure 2.3 Each bird's initiated behaviors compared to mass (g) in familiar and unfamiliar social groups (F=0.99, p=0.32).

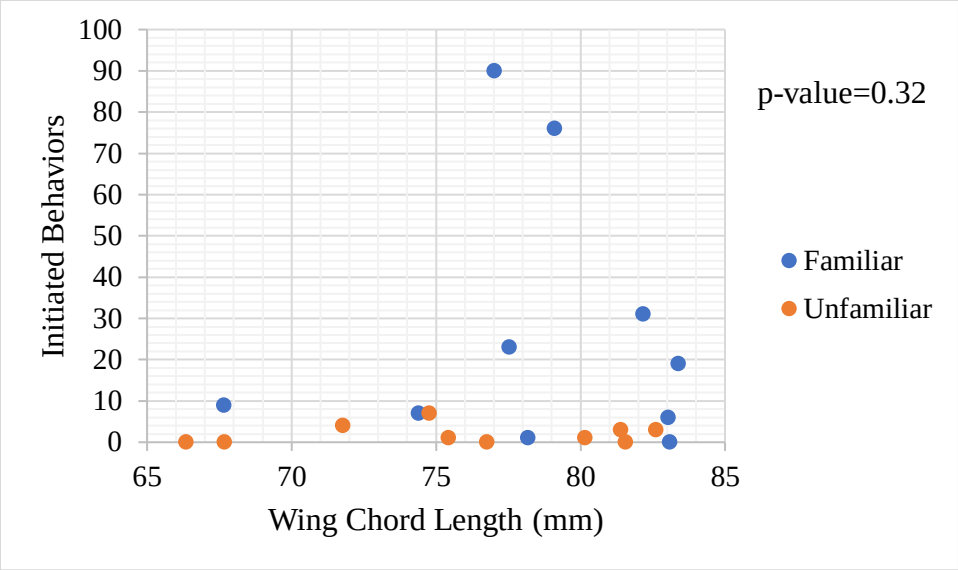

Figure 2.4 Each bird's initiated behaviors compared to wing chord length (mm) in familiar and unfamiliar social groups (F=1.02, p=0.32).

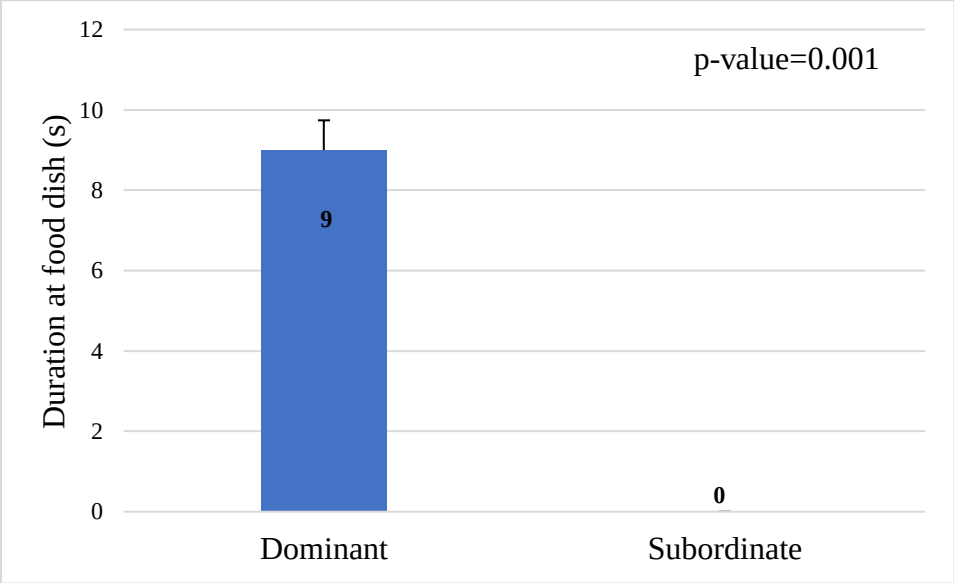

Figure 3.1 Amount of time spent (s) actively feeding at food dish across five trials of data collection for the dominant versus subordinate individual of the familiar social group (t= 3.86, p-value=0.001). Error bars represent standard error of the mean.

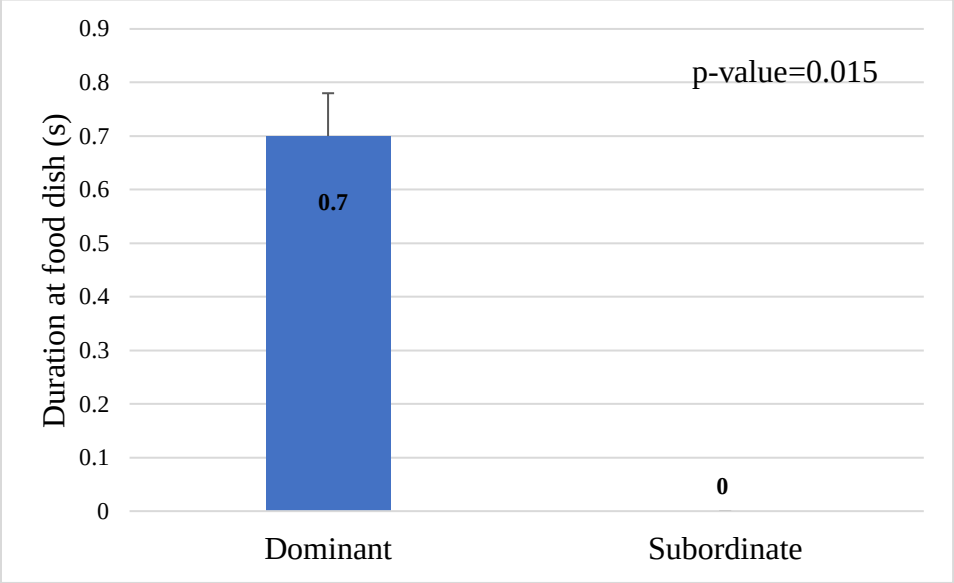

Figure 3.2 Amount of time spent (s) actively feeding at food dish across five trials of data collection for the dominant versus subordinate individual of the unfamiliar social group (t=2.69, p-value=0.015). Error bars represent standard error of the mean.

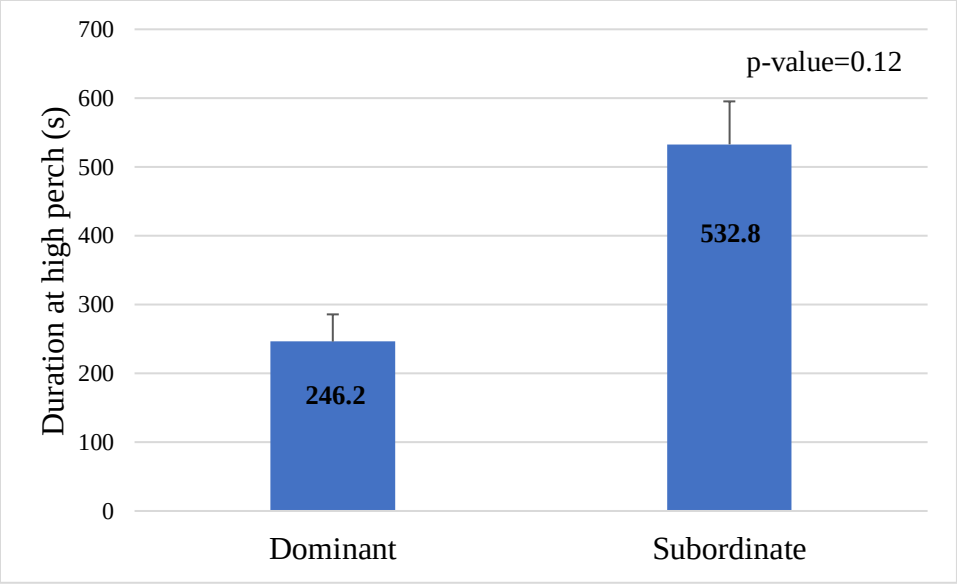

Figure 4.1 Amount of time spent (s) at the high perch across five trials of data collection for the dominant versus subordinate individual of the familiar social group (t=1.73, p-value=0.12). Error bars represent standard error of the mean.

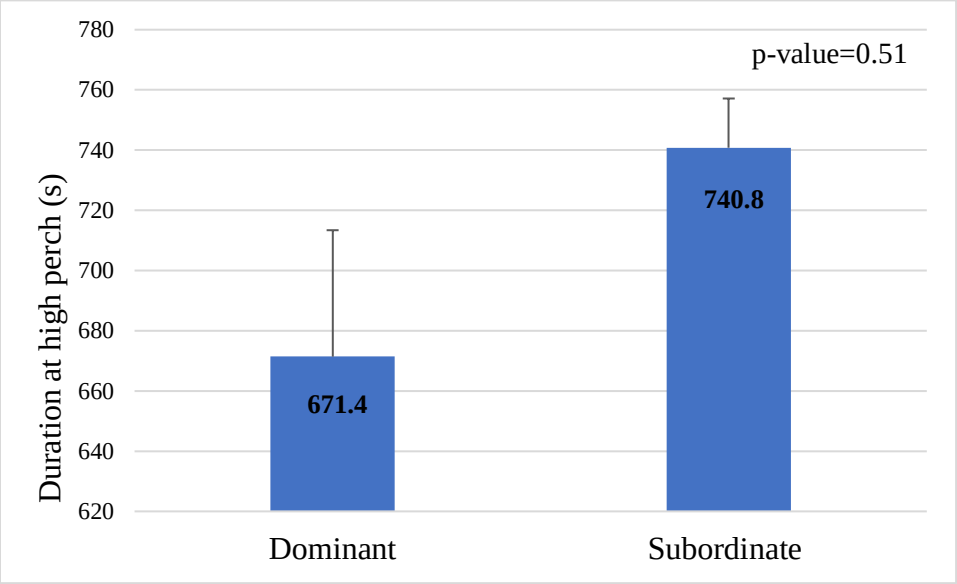

Figure 4.2 Amount of time spent (s) at high perch for the dominant versus subordinate individual of the unfamiliar social group (t=0.68, p-value=0.51). Error bars represent standard error of the mean.

CHAPTER 5

DISCUSSION

Results of this study support the hypothesis that birds in the familiar social group initiate more aggressive behaviors and have more individuals feeding at the food dish as compared to the unfamiliar group. This was expected due to possible prior relationships within the familiar group while the unfamiliar birds may take longer to decide who is dominant. Most birds in the familiar group came to feed for various durations, while very few unfamiliar birds fed at all. Individuals in the unfamiliar group rarely came to the food dish despite several hours without food suggesting that zebra finch social arrangements take time to develop.

The second hypothesis that the birds with the greatest amount of fitness indicators in both social groups will initiate the most aggressive behaviors and spend more time at the food dish was also supported by the data. However, there was no significant difference related to perch preference. Results indicated that age and tarsus length significantly affected the amount of aggressive initiating events that occurred. Adulthood in zebra finches is 100 days after hatching. The individuals of this study ranged from 1-5 years of age with animals of an intermediate age demonstrating more agonistic behaviors. This would suggest that 2-3 years old is an optimal age for feeding and mating in this colony due to perceived fitness. Older birds initiated fewer agonistic behaviors, most likely due to decreased fitness.

Contrary to previous findings, birds with longer tarsi initiated significantly fewer

aggressive behaviors than did birds with shorter tarsi. This was the opposite of what was predicted since prior research indicated that longer tarsus is correlated with higher fitness (Bonaparte et al., 2011). According to results from the current study, shorter tarsus length was a better predictor of higher amounts of initiated aggression. It is not clear why this discrepancy exists, but it is possible that this is just an exception seen in this captive population due to differences in supplier. Previous studies have revealed differences in supplier involving behavior and physiology (Lundberg et al., 2017). Mass and wing chord length were found not to be associated with dominant behaviors which may indicate that they are not the best ways to determine fitness in zebra finches. This may be because larger birds are not as agile as smaller birds. Additionally, wing chord length has been studied as a fitness indicator in captive and wild animals, but may be less useful in captivity with reduced space.

Feeding duration was found to be significantly different between the dominant and subordinate individuals in both the familiar and unfamiliar group. The subordinate individuals within both social groups did not approach nor feed at or near the food dish at all, further enforcing the ability of a feeding context to depict social rank. Even the dominant individual of the unfamiliar group did not feed very long at the food dish with an average of 0.7 seconds while in the familiar group the dominant individual fed for an average of 9 seconds. In the familiar group there was one individual that always came first to feed while the unfamiliar group had various first-comers over the five days of data collection. Again, this supports the idea that familiar animals seem to have established relationships that allow them to feed more readily with minimal confrontation.

Duration spent at the high perch location resulted in non-significant differences amongst the dominant and subordinate individuals in both social groups. This suggests that social rank does not play a key role in spatial preference in zebra finches. In fact, subordinate individuals seemed

to prefer the higher perch versus dominant. A larger data set and a longer collection period may find a more direct spatial preference as there would be fewer choices to make with a larger group taking up more space.

For future studies, I would like to explore in more detail the spatial preference of dominant and subordinate individuals of the zebra finch species. From observation alone, it seems that less fit animals (age exceeding 4 years and poor physical appearance including high feather loss or non-stereotypical plumage) are on the ground most of the time while more fit animals (median age of 2 years, longer tarsus and wing chord length, and stereotypical plumage) were on the intermediate or high perches. With more data collection, I may uncover a spatial preference with dominant individuals choosing perches rather than the ground. This could reveal the type of social hierarchy within zebra finches, as it is unknown.

Hierarchies within a social group are also heavily based on dominant interactions amongst conspecifics. If the initiating aggressive behaviors of all individuals could be mapped out the hierarchy type within zebra finches could also be determined (Figure 5). During data collection a Complex hierarchy type seemed to be present by observation alone, but was never tested in this study. This hierarchy is seen in large, social populations forming multiple triangular schemes thus creating a convoluted pattern. A complex hierarchy type has an underlying linear model with some exceptions. For instance, individual A may be dominant to B and B dominant to C, but C is dominant to A (Figure 5). There is little known about the type of hierarchy zebra finches form thus further investigation into this question would be beneficial.

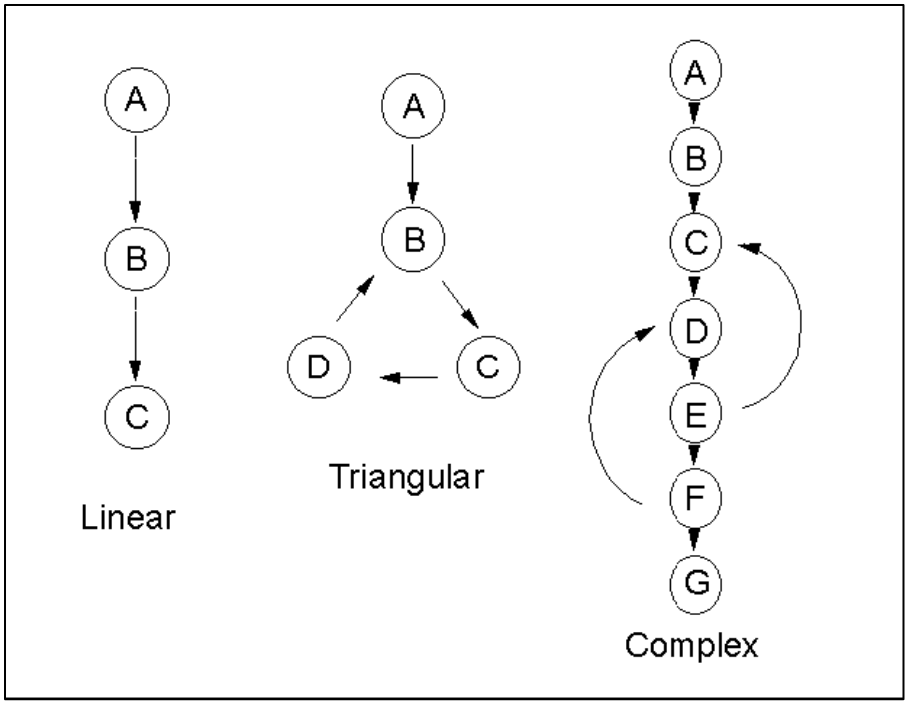

Figure 5 Types of social dominance hierarchies (Haynes & Moore-Crawford, 1996)

CHAPTER 6

CONCLUSIONS

Dominance behaviors were clearly observed within the familiar social group when compared to the unfamiliar group due to previous formed relationships. This was evident in the high amount of aggressive behaviors and feeding durations. Spatial preference did not appear to be related to dominance in this study. Age is still considered an efficient fitness measurement with intermediate individuals considered the more fit. Shorter tarsus length was found to indicate a more dominant individual versus longer tarsus. Mass and wing chord length were not efficient indicators of dominance in this species.

REFERENCES

Ardia, D., Broughton, D. R., and Gleicher, M. J. (2010). Short-term exposure to testosterone propionate leads to rapid bill color and dominance changes in zebra finches. Hormones and Behavior 58 (2010) 526–532.

Baldwin, S., Obrholser, H. C., Worley, L. G. (1931). "Measurements of birds". *Scientific Publications of the Cleveland Museum of Natural History*. 2: 1–165.

Beauchamp, G. (2000). Individual differences in activity and exploration influence leadership in pairs of foraging zebra finches. Behaviour 137, 301—314.

Beauchamp, G. (2006). Phenotypic correlates of scrounging behavior in zebra finches: role of foraging efficiency and dominance. Ethology 112, 873–878.

Bergtold, W. H. (1925). "The Relative Value of Bird Measurements". *The Condor*. **27** (2): 59–61. doi:10.2307/1363054.a

Bolund, E., Schielzeth, H., Forstmeier, W. (2006). Effects of beak color and body size on dominance in male and female zebra finches. J. Ornithol. 147 (5), 140.

Bonaparte, K. M., Riffle-Yokoi, C., Burley N. T. (2011). Getting a head start: diet, sub-adult growth, and associative learning in a seed-eating passerine. *PLoS One, 6*(9):e23775. doi: 10.1371/journal.pone.0023775.

David, M., Auclair, Y., and Cezilly, F. (2010). Personality predicts social dominance in female zebra finches in a feeding context. Animal Behaviour 81, 219-224.

Deslippe, R. J., R. T. M'Closkey, S. P. Dajczak, and C. P. Szpak. (1990). A quantitative study of the social behavior of tree lizards, Urosaurus ornatus. Journal of Herpetology 24:337–341.

Eikenaar, C., Källstig, E., Andersson, M. N., Herrera-Dueñas, A., Isaksson, C. (2016). Oxidative Challenges of Avian Migration: A Comparative Field Study on a Partial Migrant. Physiological and Biochemical Zoology 90(2):223-229.

Harcourt, A. H., and F. B. M. de Waal. (1992). Coalitions and alliances in humans and other animals. Oxford University Press, Oxford.

Haynes, Marina and Moore-Crawford, Cassandra. (1996). Social dominance. [Class handout].

Department of Animal and Avian Sciences, University of Maryland, College Park, MD.

Hölldobler, B., and E. O. Wilson. (1990). The ants. Harvard University Press, Cambridge, MA.

Huntingford, Felicity A. (2018). Aggressive behaviour. *Encyclopaedia Britannica* Retrieved from, https://www.britannica.com/science/aggressive-behaviour.

Krause, J. S., Németh, Z., Pérez, J. H., Chmura, H. E., Ramenofsky, M., Wingfield, J. C. (2015). Annual Hematocrit Profiles in Two Subspecies of White-Crowned Sparrow: A Migrant and a Resident Comparison. *Physiological and Biochemical Zoology* 89:1, 51-60.

Lahti, K., Koivula, K., and Orell, M. (1994). Is the Social Hierarchy Always Linear in Tits? Journal of Avian Biology, Vol. 25, No. 4, pp. 347-348.

Lundberg, S., Abelson, K. S. P., Nylander, I., & Roman, E. (2017). Few long-term consequences after prolonged maternal separation in female Wistar rats. *PLoS ONE*, *12*(12), e0190042. http://doi.org/10.1371/journal.pone.0190042

Paz-y-Miño-C., G., Bonoan, R., Clodius, F., Dawson, A., Caetano, S., Yeung, E. (2013). Dominance hierarchy formation in a model organism, the zebra finch (*Taeniopygia guttata*), and its potential application to laboratory research. Bios, Vol. 84, No. 4, pp. 201-209

Roberts, M., Buchanan, K., Hasselquist, D., Bennett, A. (2007). Physiological, morphological and behavioural effects of selecting zebra finches for divergent levels of corticosterone. *Journal of Experimental Biology*, 210(24), 4368-4378.

Sasaki, T., Penick, C. A., Shaffer, Z., Haight, K. L., Pratt, S. C., and Liebig, J. (2015). A Simple Behavioral Model Predicts the Emergence of Complex Animal Hierarchies. Am. Nat. Vol. 187.

Schjeldrup-Ebbe, T. (1922). Contributions to the social psychology of the domestic chicken. *Z. Psychol*, 88:225-252.

Setchell, J. M., (1999). Socio-sexual development in the male mandrill (Mandrillus sphinx) (PhD thesis). Cambridge: University of Cambridge.

Silk, J. B. 2007. Social components of fitness in primate groups. Science 317:1347–1351.

Trainor, B. C., H. H. Kyomen, and C. A. Marler. 2006. Estrogenic encounters: how interactions between aromatase and the environment modulate aggression. Frontiers in

Neuroendocrinology 27:170–179.

Zann, R. (1994). Effects of band color on survivorship, body condition and reproductive effort of free-living australian zebra finches. Auk 111: 131–142.

Zhang, G., Shi, G., Tan, H., Kang, Y., & Cui, H. (2011). Intranasal administration of testosterone increased immobile-sniffing, exploratory behavior, motor behavior and grooming behavior in rats. *Hormone and Behavior, 59* 477-483.

Zann, R. (1996). The zebra finch: a synthesis of field and laboratory studies. Oxford University Press; Oxford, UK.