5-2015

Distribution of the Egyptian Goose (Alopochen Aegyptiacus) in Northwestern Arkansas and in the United States of America

Cameron Chesbro
University of Arkansas, Fayetteville

Distribution of the Egyptian Goose (*Alopochen aegyptiacus*) in northwestern Arkansas and in the United States of America

Distribution of the Egyptian Goose (*Alopochen aegyptiacus*) in northwestern Arkansas and in the United States of America

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Biology

By

Cameron Ross Chesbro
Northeastern State University
Bachelor's of Science in Biology 2011

May 2015
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

____
Dr. Douglas James
Thesis Director

Dr. Daniel Magoulick
Committee Member

Dr. Kimberly Smith
Committee Member

Abstract

The Egyptian Goose (*Alopochen aegyptiacus*) is an exotic member of the Anatidae that has been residing in northwestern Arkansas since the 1980s (Smith and James 2012). Following the discovery of Egyptian Geese in the area, not much attention has been given to the consequences of population increase. The Egyptian Goose has shown many diverse population growth patterns in areas where it has been introduced and started feral populations. The purpose of this study was to assess the current population size of the Egyptian Goose in northwestern Arkansas,and confirm successful breeding. The methods used in this study included conducting road surveys of suitable habitats for the Egyptian Goose, and recording number of adults, chicks, and other avian species interacting with the geese. Yearly densities, as well as monthly densities were compared between two years of data collection to determine population growth. The results showed a reasonably constant population size with relatively low breeding success. More study needs to be conducted on the breeding success of the Egyptian Goose, with radio tagging during the non-breeding season so that pairs can be more easily found during the breeding season. Along with looking at Egyptian Geese in northwestern Arkansas, data from the United States of America was analyzed to see if areas with Egyptian Geese are increasing in population size. The final recommendation of this study proposes that northwestern Arkansas is a dispersal point for the Egyptian Goose for more suitable habitats in surrounding areas, and should be eradicated from the area before the species follows other non-native species and becomes invasive.

Acknowledgements

I wish to thank Dr. Douglas James for giving me the opportunity to take part in the world of graduate school. He took a leap of faith accepting me as his student because I did not have the top grades (not bad, just not great) or even an idea of what I would want to study, except it had to be with birds. I want to thank Dr. James for really helping me through every step of the thesis process. Everything from my proposal to my final thesis output is a result of just how much he cares about his students and how much he wants you to succeed. I will never forget listening to stories of how graduate school use to be, or how previous students did not know a lick of English, or the nightmares from stories of computers crashing and all of someone's work being destroyed. I know I could have not made it through this journey without a great leader, advisor, and mentor. I would lastly like to thank him for all of the editing and critiquing of my thesis, as well as leading me through the statistical analysis needed for my thesis.

I would like to thank Dr. Kimberly Smith for helping steer me towards a completed thesis. I was fortunate enough to have him as a professor, as well as a committee member. His lectures will be part of my memory forever, and I hope to pass on the knowledge I learned to anyone willing to hear, or just my family. I would like to thank him for editing my thesis drafts down to my thesis appearing as if it was bleeding from all the red ink.

I would like to thank Dr. Daniel Magoulick for being one of my committee members. He was always able to think of another perspective when thinking of my project. I thank him for suggestions on expanding my research base, something that led me to learn completely new statistical analysis tests. Thank you for suggestion, but never acting, on killing the Egyptian Geese. It would have been even more difficult to conduct field surveys on a bird actively being hunted; also I have read they do not taste very good. I would like to also thank him for his assistance in editing my thesis.

I would like to thank Dr. Mia Revels for essentially setting in place my future in graduate school. She helped begin my quest to learn as much about birds and birding. I have never had a class that I enjoyed more than that 5 a.m. ornithology lab class.

I would like to thank Leon Wilmoth of the Wild Wilderness Drive-Through Safari for allowing me access to the zoo for no charge, there is absolutely no way I could have completed as many surveys as I did without his kindness.

I would like to thank everyone in the James' Lab, Kapil, Anant, and Marla. You three put up with my shenanigans constantly, and helped to keep me sane. I thank you for giving me your knowledge and expertise when I was struggling through my analysis or writing. I know all of you will go on to do great things and save the world.

My last acknowledgment goes to my family. I first would like to thank my ever loving wife Kateri, who has given me support when I needed it and a slap in the head when it was called for. To the most beautiful little girl on the planet, my daughter Kestrel, you are already bound for greatness and with your bravery I know you will succeed in everything you try. I would have bludgeon myself to death trying to finish my thesis and degree without you two girls with me. You are my rock and my comfort. I would like to thank Mom and Dad for never letting me give up on anything I started. I thank you for always supporting me and having faith that your son would achieve this goal. To Mom, thank you for persuading me to keep striving and to keep pushing myself. To Dad, thank you for always being there, for always taking me fishing or hunting when I needed it most. I could go on forever thanking everyone who has ever had an

impact in my life, but I end with a simply thank you to my sister, Mackenzie, thank you for being a loving, supporting sister. Thank you to everyone I did not mention but had an impact on my life.

Dedication

I would like to dedicate this thesis to my daughter Kestrel Elili Chesbro. She is the most precious gift I have ever received. I hope one day when she is older she will read this thesis and laugh at it in comparison to the dissertation she has just completed. I want her to know that even as she is just now running around, pulling everything out of drawers, and eating from sunrise to sunset, that she and her mom were the ones keeping me from going insane. Thank you daughter.

Table of Contents

Chapter 1. Distribution and Breeding Success of Egyptian Goose in Northwestern Arkansas

Chapter 2. Distribution of Egyptian Goose in the United States of America

Chapter 1. Distribution and Breeding Success of Egyptian Goose in Northwestern Arkansas

Introduction

New species are discovered in new locations constantly. When found, the first question is whether the species is native or non-native. Understanding whether a species is native or non-native will determine conservation status and threat to other species. Species that have previously been overlooked or have recently migrated from a nearby habitat would be considered native. Non-native species are classified as any species outside of its natural range. Non-native species are introduced every year into North America, either accidently or purposefully. When non-native species are introduced to an area there is always the potential of it become an invasive species if not monitored. Species can be introduced to new areas through human negligence when traveling to other countries, e.g., the Brown Tree Snake (*Boiga irregularis*) invasion of Guam after a military aircraft unknowingly transported the species in the 1950s (Lowe et. al 2000). Some species are introduced to an area for a particular purpose, but eventually escape and create wild populations, e.g., numerous plants brought from other countries for decoration, such as the Mimosa (*Mimosa pigra*) The Egyptian Goose (*Aplopchen aegyptiacus*) is an introduced, non-native species to North America with a high potential to becoming invasive. Research on the Egyptian Goose in areas where it has been introduced (Lensink 1999, Shropfer 2011) and in its native range (Mangnall, 2001) has shown a progression toward becoming invasive. In the Netherlands, a single pair of Egyptian Geese was first reported breeding in 1967 and in 1994 there were around 1,200 pairs (Lensik 1998), and in 2010 the number of breeding pairs was estimated at 11,421 (Gyimesi 2012). The Egyptian Goose did not follow the same growth rate pattern everywhere it was introduced. The first populations of Egyptian Goose in England were for ornamental value by wealthy estate owners. Since the late 17th century, when the Egyptian Goose was introduced, the populations have stayed within the parameters of these estates; Bleckling Hall, Gunton Park, Holkham Hall, and Kimberley Park, where the species was originally introduced for ornamental value (Lever 1987). The lack of expansion in England has been assumed to be correlated with cold climate limiting their range. This assumption could be part of the reason, with temperatures averaging about 10°C cooler in England than in the Netherlands. Determining the current population size of the Egyptian Goose in northwestern Arkansas will help determine a growth trend for future studies to detect whether the Egyptian Goose is becoming invasive. A major component of population growth will be the reproductive success of the Egyptian Goose within the area, since multiple studies have shown the Egyptian Goose is prone to be a sedentary bird (does not migrate).

In its native habitat, the Egyptian Goose is considered a nuisance species, causing large amounts of damage to crops (Mangnall, 2002). Areas where it has been introduced has caused problems for local species (Lensink 1998). The Egyptian Goose is currently not considered invasive in the United States, but, based on studies of the Egyptian Goose outside its native range the likely hood of it becoming invasive is high. There are many ecological consequences if the Egyptian Goose successfully establishes itself in the United States. These consequences include: competition of food with native species, competition for nesting sites and habitat, and destruction of property and crops.

This study will assess the current number of Egyptian Goose in northwestern Arkansas, as well as its breeding success. The second objective is to assess the population growth throughout the United States.

Background

The Egyptian Goose is a member of the avian Family Anatidae and is actually a shelduck not a goose. The native range of the Egyptian Goose is throughout eastern and western Africa, Afrotropics, and Southern Africa (Taylor 1999). Over the last 50-60 years, the Egyptian Goose has gradually expanded its geographic distribution (Lensink 1998, Schropfer 2011). The Egyptian Goose has shown to be a species with the potential to become an invasive against native species and people. Currently in Europe, the Egyptian Goose is becoming a pest, especially in the Netherlands (Lensink 1999). It is also very abundant in Germany, according to University of Arkansas faculty member Dr. Lehimann (per. obs). The Egyptian Goose has been documented taking over nesting sites for the native Black Sparrowhawks (*Accipiter melanoleucus*) in South Africa (Curtis 2007). In South Africa, damage caused by Egyptian Goose to growing plants was US$ 70,000 (Mangnall 2002). In the United States, the Egyptian Goose was a favorite bird of aviculturist up until 1928 (Lever 1987). During that time, the Egyptian Goose did escape captivity frequently, but never was able to establish a population in the wild (Lever 1987). Though Lever (1987) reports a population of Egyptian geese failed to establish in Florida, there has since been reports of successful feral populations (Braun 2004). The Egyptian Goose was also introduced into Australia and New Zealand, where all populations failed.

The breeding success of the Egyptian Goose has been studied in native and non-native areas. In Africa, the breeding success of the Egyptian Goose has been studied in hippo wallows of Uganda (Eltringham 1974). The five year study showed an average of 60.4 % survival of broods, with a total of 62 broods observed (Eltringham 1974). In the Netherlands, the breeding success of the Egyptian Goose has been estimated depending on the area. Newly colonized areas showed a success rate between 60-70%, and established areas showed a success rate of only 15-30% (Gyimesi 2012). The success of the Egyptian Goose in the Netherlands has been positively correlated with severity of winters and negatively with the number of flood days along rivers (Gyimesi and Lensink 2010). British breeding populations have been observed. The success rates have not been established, but has been predicted to be poor (Sutherland 1991).

The first sightings of the Egyptian Goose in Arkansas were in the 1980s, with continual sightings and some established groups in northwestern Arkansas (Smith and James 2012). After these initial sightings, Dr. Douglas James contacted the National Audubon Society and was able to get the Egyptian Goose added to the Christmas Bird Count (CBC) checklist in 1998 (D. James pers.obs.). Though responsible for getting the Egyptian Goose on the CBC, the exact population size of the Egyptian Goose in Arkansas is unknown, the bird only being reported once to the CBC (National Audubon Society 2014), but it was estimated to be under 100 (Smith and James 2012). There have been reports of the Egyptian Goose in northwestern Arkansas, and of at least one account of purchasing the goose for ornamental value (Dr. D.A James *unpublished data*). If the population is small, then successful breeding and population growth will be vital in assessing the overall success of the Egyptian Goose.

Methods

The Egyptian Goose life history was reviewed in the literature to establish an appropriate breeding cycle and habitat (Lensink 1998, Schropfer 2011). The current population in northwestern Arkansas was assessed by conducting road surveys following a general route during February-December in 2012 and January-October in 2013. The route covered areas where sightings have been recorded (Smith and James 2012), and from probable areas of appropriate habitat based on the literature. The general survey route ran through Tontitown, West on 412, North on 59 through Gentry, around the nearby Wild Wilderness Drive-Through Safari (WWDTS), North to Decatur, East to Centerton, South by the northwestern Arkansas Airport XNA, and finally heading back through Tontitown to Fayetteville. Areas of Benton, Washington, Carroll, and Madison County were all surveyed, but Egyptian Geese were only found in Benton County. This main survey route was driven for every survey. Each survey deviated from this route in areas to cover habitats notably frequented by Egyptian Goose (Geldenhuys, 1980; Lensink 1998, 1999; Kear 2005; Schropfer et al. 2011; Gyimesi 2012; Smith and James 2012). Flyers where posted in local businesses asking for reports of Egyptian geese from the general public. The survey was conducted every two weeks.

When an Egyptian Goose was sighted, the location was established using a Garmin GPS unit. Other variables recorded were number of adults and chicks, whether adults were paired, other avian species present, and habitat use. To determine if the adults were paired, there could only be two adult geese present. If there were more than two adults in one location, the geese were counted as unpaired individuals. The total number of birds were compared between the two years to establish any population growth between months, and the highest density per year was used as a crude measure of population size. The total number of chicks from the start of the breeding season to the end of the breeding season established a breeding success rate for Egyptian geese in northwestern Arkansas. Incubation time was set at 30 days, and they were monitored up to 10 weeks, after which they were considered fledged (Braun 2004). The fledglings would not reach sexual maturity for at least a full year and further study will need to be conducted to see how many fledglings survive to breed.

When an Egyptian Goose was found, a GPS point established the location. The GPS point was used in Google Earth to establish habitat variables. These variables included: distance to nearest pond (DTP), size (perimeter) of closest pond (SOP), distance to nearest wooded area (DTW), area of the closes pond (AOP), distance to closest man-made structure (DTS), distance to closest single large tree (DTBT), and the distance to the closest road (DTR). Determination of the importance of these variables was assessed using a multivariate statistical test. The occupancy estimation program PRESENCE (Hines 2006) used to estimate the probability of detection given presence (p), the probability of a site being occupied in the 2012 season (ψ), going extinct, and being colonized (MacKenzie 2006). The probability of a site staying occupied or staying extinct were calculated from the output data. The probability of a site being occupied in the 2013 season was derived from the equation: $\psi_2 = \psi_1 (1-\varepsilon_1) + (1-\psi_1)\gamma_1$, the fraction of sites occupied in season 1 that failed to go extinct, $\psi_1 (1-\varepsilon_1)$, plus the fraction of unoccupied sites in season 1 that were colonized, $(1-\psi_1)\gamma_1$. (Donovan 2007).

Results

The Egyptian Goose is currently successfully breeding in northwestern Arkansas and appears to be maintaining minimal contact with other species within the avian community. Breeding success is difficult to assess with the small number of nests found. Due to the ability of the Egyptian Goose to nest in a variety of locations, it is probable there were many nest not found on private properties in the area. There were a total of 22 sites established for the

Egyptian Goose, and all seven variables were measured for each site (Table 1). Many of the sites located at WWDTS shared the same ponds, leading to the duplication of some of the variables in Tables 1 and 2. The data was not very useful it is original state, so the data was transformed using the logarithmic transformation in R, to attain a more normal distribution (Table 2).). The locations of variables were established from GPS readings (Table 3). The contribution of each variable per principal component is given (Table 4), with the largest contributor identified as the leading factor of the component. Principal components were established by using the eigenvalues, cumulative percent of the total variance, and a Bartlett Test to test probabilities (eigenvalue > 1.0, cumulative percent > 70%, and chi square > 0.05) (Table 4). The data supported the use of three principal components (PC1, PC2, and PC3), which were then analyzed further by rotating the factor loading and establishing the most important factor for each principal component (Table 5). The first principal component is designated by the openness of the site. This is the only component that appears to be positively influenced by two variables, the distance to the nearest wooded area (DTW) and the area of the nearest pond (AOP), contributing 83% and 69% (Table 5), respectively. The second principal component can be named proximity to the pond based on the variable distance to the nearest pond (DTP) contributing 98% of the variation (Table 5). The third principal component is also associated with the openness of the site, with the distance to the nearest lone tree contributing 97% of the variance (Table 5). The three principal components were calculated by rotating the factor loadings.

The highest count of Egyptian Geese per month was compared between the 2012 and 2013 surveys (Figure 1). A Wilcoxon test on the yearly data showed no significant difference between the surveyed years, $p = 0.2041$. Data collection began in February 2012 and ended in

October 2013, so there was no data for January 2012 or November and December 2013. The breeding success of young was established by calculating the number of broods surviving for 10 weeks (Figure 2), at which time they are considered fledged (Lensink 1999). In 2012, 14 nesting sites with chicks were observed. From these 14 sites, only one site was successful, giving 2012 a success rate of only 0.07. In 2013, there were only seven nesting sites found with chicks. Three nests successfully fledge out of the seven total sites, giving a success rate of 0.42. The number of young observed for both years was relatively small and better detection of nests would lead to a more confident breeding success evaluation.

Occupancy generated from PRESENCE (Hines 2006) showed that only 33.8% of the observed sites were occupied for the 2012 season (ψ_1). Between the 2012 and 2013 season, 33.3% of the occupied sites went extinct (ε_1), and 11.1% of previously unoccupied sites were colonized (γ_1). This allows the assumption that sites occupied in the 2012 season had a 66.7% chance of remaining occupied, and sites that were unoccupied had 88.9% chance of remaining unoccupied. Using the formula $\psi_2 = \psi_1 (1-\varepsilon_1) + (1-\psi_1)\gamma_1$, the occupancy of observed sites in the 2013 season (ψ_2) dropped to 29.8%. The detectability of Egyptian Goose in the 2012 and 2013 season was only 34.4%.

Conclusion

It is established that there are feral, breeding populations of Egyptian Geese in northwestern Arkansas. The majority of the Egyptian Geese can be split into two small flocks found at the Wild Wilderness Drive-Through Safari (WWDTS) and at Lake Bella Vista. At both of these location the Egyptian Geese are regularly fed. The estimated number of the Egyptian

Goose in northwestern Arkansas is between 30 to 50 individuals. The population does not appear to be increasing or decreasing to any significant ount, but lengthier studies may discover some significant changes. Though considered a relatively residential species (Lensink 1998), it is plausible that northwestern Arkansas is acting as a dispersal point for more suitable locations around the country. This concept could explain why the population has not increased considerably in northwestern Arkansas since the very first report in 1988 (Figure 1).

Although the size of the data set is small, suitable habitat can be recognized using the first 3 principle components that account for 74.5% of the total habitat variance (Table 4). The first principle component accounts for 31% of the variance and showed a positive relationship between the area of the pond and the distance to the nearest wooded area (Tables 1, 4 and 5). This is interpreted to be related to how open the area is. The second principle component explains 25% and showed a pond was in close proximity to the Egyptian Goose (Tables 1, 4 and 5). The third principle component accounts for 19% of the variance and showed an isolated tree was nearby but a wooded area was in the distance (Tables 1, 4 and 5). The variables used in the principal components may show a slight biasness, due to multiple sites being linked to the same pond (five sites attached to one pond at WWDTS). These factors coincide with how the Egyptian Goose has been choosing sites in the Netherlands and in Africa (Lensink 1998 and Ndlovu 2013).

It is clear that detectability and occupancy of the Egyptian Goose in northwestern Arkansas is low. The low occupancy level may be explained by the small population size of Egyptian Geese in the area. If Egyptian Geese do begin to increase significantly, similar to populations in Netherlands (Lensink 1998), then it can be hypothesized there will be a dramatic increase in the occupancy level. The low detectability of the Egyptian Goose also impacts the ability to properly assess the occupancy level. Detectability of the Egyptian Goose was mostly inhibited by inaccessible locations where many farm ponds and open areas were blocked by tree growth or man-made structures.

Suitable habitat is limited in northwestern Arkansas, but more suitable habitat is assumed to be available further west in Oklahoma, Kansas, Nebraska, and Texas where there is a major market for crops the Egyptian Goose would find appealing, such as wheat and soybean. These states also provide habitat that is more open and less wooded with manufactured farm ponds, main factors in establishing suitable habitats for the Egyptian Goose. The populations in northwestern Arkansas appear to be centered on areas where the birds are fed (WWDTS and Lake Bella Vista). One of the most interesting observations during these two years of surveys was lack of Egyptian Goose present at the C.B. Craig State Fish Hatchery near Centerton. Previous to the present study, many of the reported sightings of Egyptian Geese were from the fish hatchery (Smith and James 2012). This observation could be the result of a dispersal by a local population to more suitable habitat elsewhere in the area.

The survival rate of observed broods is difficult to determine with any confidence because of the small number that were found. Detectability of broods is difficult due to highly available farm ponds that were inaccessible and would go undetected without the pond owner reporting the nesting. Nesting Egyptian Geese are also difficult to detect because of the opportunistic nesting habits of the birds. They have been recorded to nest in a variety of areas including on the ground, in old tree hollows, using Black Sparrowhawk (*Accipiter melanoleucus*) nests, and even utilizing just two boards and a tub in a tree (Appell 2011, Curtis 2007). Radio tagging of adult Egyptian Geese during the non-breeding season would be an effective way to monitor where breeding may be occurring during the breeding season, and would establish a stronger estimation of breeding success. Even though the population is small, the Egyptian Goose should either be monitored or eradicated immediately. This suggestion comes from the potential of exponential growth as observed in Netherlands (Lensink 1999).

Literature Cited

Appell, S. 2011. *A Wild Egyptian Goose Tale: A short story about the Egyptian Geese and their Five Chicks, Born at the San Joaquin California Wildlife Sanctuary in July 2011*. http://talesofrelentlesspursuit.blogspot.com/2011/10/wild-egyptian-goose-tale.html.

Braun, D.G. 2004. First Documented Nesting In The Wild Of Egyptian Geese In Florida. *Florida Field Naturalist*. 32:138-143.

Curtis, O.E., Hockey, P.A.R., and Koeslag, A. 2007. Competition with Egyptian Geese *Alopochen aegyptiaca* overrides environmental factors in determining productivity of Black Sparrowhawks Accipiter melanoleucus. *Ibis.* 149:502-508.

Donovan, T. M. and J. Hines. 2007. Exercises in occupancy modeling and estimation.

Eltringham, S.K. 1974. The Survival of broods of the Egyptian Goose in Uganda. *Wildfowl*. 25:8.

Gyimesi, A., and Lensink, R. 2010. Risk analysis of the Egyptian Goose in the Netherlands. Bureau Waardenburg.

Gyimesi, A. 2012. Egyptian Goose, *Alopochen aegyptiaca*, an introduced species spreading in and from the Netherlands. *Wildfowl*. 62:128-145.

Geldenhuys, J.N. 1980, Breeding seasons of Egyptian geese and South African shelducks in central South Africa. *Proceedings of the fourth Pan-African ornithological congress*. Southern African Ornithological Society. 1980.

Hines, J.E. 2006. PRESENCE – Software to estimate occupancy and related parameters. USGS – PWRC. http://www.mbr-pwrc.usgs.gov/software/presence.html.

Kear, J. 2005. Ducks, Geese, and Swans: Volume 1: General chapters, and Species accounts. Oxford Press. 401-407.

Lensink, R. 1998. Temporal and Spatial Expansion of the Egyptian Goose *Alopochen aegyptiacus* in the Netherlands, 1967-94. *Journal of Biogeography*. 25:251-263.

Lensink, R. 1999. Aspects of the biology of Egyptian Goose *Alopochen aegyptiacus* colonizing The Netherlands. *Bird Study*. 46:195-204.

Lever, C. and Gillmor, R. 1987. Naturalized birds of the world. Harlow, Essex, England: Longman Scientific & Technical.

Lowe, S., Browne, M., Boudjelas, S., and De Poorter, M. 2000. 100 of the world's worst invasive alien species: a selection from the global invasive species database (p. 12). Species Survival Commission, World Conservation Union (IUCN), Auckland, New Zealand: Invasive Species Specialist Group.

MacKenzie, D. I. 2006. Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence. Amsterdam: Elsevier.

Mangnall, M.J. and Crow, T.M. 2002. Population dynamics and the physical and financial impacts to cereal crops of the Egyptian Goose *Alopochen aegyptiacus* on the Agulhas Plain, Western Cape, South Africa. *Agriculture, Ecosystems, & Environment*. 90:231-246.

Ndlovu, M., Cumming, G.S., Hockey, P.A.R., Nkoso, M.D., and Mutumi, G.L. 2013. A study of moult-site fidelity in Egyptian geese, *Alopochen aegyptiaca*, in South Africa. *African Zoology*. 48:240-249.

Schropfer, L., Vermouzek, Z., Sirek, J., and Stolarczyk, J. 2011. Occurrence and breeding of the Egyptian Goose (*Alopochen aegyptiacus*) in the Czech Republic in the years 1979-2009.*Sylvia*. 47:67-75.

Smith, K.G. and James, D.A. 2012. History and Current Status of Egyptian Goose (*Alopochen aegyptiacus*) in Northwestern Arkansas. *Journal of the Arkansas Academy of Sciences*. 66:200-204.

Sutherland, W.J. and Allport, G. 1991. The distribution and ecology of naturalized Egyptian Geese Alopochen aegyptiacus in Britain. *Bird Study*. 38:128-134.

Taylor, P.B Navarro, R.A., Wren-Sargent, M., Harrison, J.A., Kieswetter, S.L. 1999. *TOTAL CWAC report: coordinated waterbird counts in South Africa 1992-97*. Avian Demography Unit, University of Capetown. 1-251.

Tables and Figures

Table 1. Untransformed habitat data. DTP = Distance to Pond (m), SOP= Size of Pond (m), DTW= Distance to Woods (m), AOP=Area of Pond (m^2), DTS= Distance to Structure (m), DTBT=Distance to Large Single Tree (m), DTR= Distance to Road (m)

Site	DTP	SOP	DTW	AOP	DTS	DTBT	DTR
1	2	1420	278	17485.6	230	1	13
2	0	105	337	1283.5	33.82	2	20
3	60	146	150	4307.84	10	39.67	50
4	82	320	350	4027.53	22.87	9	14
5	0	110	220	13481.32	61	5	30
6	5	490	220	55780	34.54	0	10
7	0	155	60	43132.11	375.81	79.99	30
8	29	83	55	3560.17	38.95	61.58	15
9	0	160	130	84937.25	257.42	84.74	112
10	51	1420	347	25608.1	50	10	28
11	56	490	172	55780	39.35	60.31	5
12	0	2825	31	0	141.14	0	27
13	18	170	1437	99587.18	70.98	0	87
14	30	1420	42	1771.62	5	54.17	11
15	36	1420	213	17485.6	58.96	5	10
16	0	1750	145	115128.4	177.09	39.24	84
17	2	80	490	52269.57	108.38	171.07	130
18	0	1420	355	1262.57	62.89	0	22
19	96	490	401	4027.53	47.12	8.21	35
20	41	490	313	55780	103.86	93.31	49
21	3	162	325	69852.19	40.16	0	37
22	0	320	336	16499.5	108.06	0	55
Mean	23.22727	702.09090	291.2273	33774.89	94.42727	32.92227	39.72727

Table 2. Log transformed data from Table 1.

Site	DTP	SOP	DTW	AOP	DTS	DTBT	DTR
1	0.30103	3.152288	2.444045	4.242681	2.361728	0	1.113943
2	0	2.021189	2.52763	3.108396	1.529174	0.30103	1.30103
3	1.778151	2.164353	2.176091	3.63426	1	1.598462	1.69897
4	1.913814	2.50515	2.544068	3.605039	1.359266	0.954243	1.146128
5	0	2.041393	2.342423	4.129732	1.78533	0.69897	1.477121
6	0.69897	2.690196	2.342423	4.746479	1.538322	0	1
7	0	2.190332	1.778151	4.634801	2.574968	1.903036	1.477121
8	1.462398	1.919078	1.740363	3.551471	1.590507	1.78944	1.176091
9	0	2.20412	2.113943	4.929098	2.410642	1.928088	2.049218
10	1.70757	3.152288	2.540329	4.408377	1.69897	1	1.447158
11	1.748188	2.690196	2.235528	4.746479	1.594945	1.780389	0.69897
12	0	3.451018	1.491362	0	2.14965	0	1.431364
13	1.255273	2.230449	3.157457	4.998203	1.851136	0	1.939519
14	1.477121	3.152288	1.623249	3.248371	0.69897	1.733759	1.041393
15	1.556303	3.152288	2.32838	4.242681	1.770557	0.69897	1
16	0	3.243038	2.161368	5.061182	2.248194	1.593729	1.924279
17	0.30103	1.90309	2.690196	4.718249	2.034949	2.233174	2.113943
18	0	3.152288	2.550228	3.101255	1.798582	0	1.342423
19	1.982271	2.690196	2.603144	3.605039	1.673205	0.914343	1.544068
20	1.612784	2.690196	2.495544	4.746479	2.016448	1.969928	1.690196
21	0.477121	2.209515	2.511883	4.84418	1.603794	0	1.568202
22	0	2.50515	2.526339	4.217471	2.033665	0	1.740363
Mean	0.830546541	2.595913683	2.314734	4.023633	1.787409	0.95898	1.450977

Table 3. The GPS coordinates for each site occupied by Egyptian Geese.

Site	Latitude	Longitude
1	36.30033333	94.49438611
2	36.30075833	94.49612778
3	36.29718056	94.49950278
4	36.29680833	94.49632222
5	36.29628056	94.49428611
6	36.29835556	94.49838056
7	36.29704444	94.50062222
8	36.30339722	94.49631389
9	36.28839722	94.49748889
10	36.30003611	94.49647778
11	36.29909444	94.49909444
12	36.33528056	94.10136111
13	36.32848056	94.29060556
14	36.3032	94.49323333
15	36.30101111	94.49411111
16	36.43186944	94.23152778
17	36.458925	94.12463333
18	36.29915	94.49333611
19	36.29741111	94.49653611
20	36.29711389	94.49768333
21	36.43222778	94.345775
22	36.29613056	94.49768889

Table 4. Eigenvalues for each Principal Component (PC). Prob>ChiSq generated with Bartlett Test.

PC	Eigenvalue	Percent of Variance	Cumulative Percent	ChiSquare	DF	Prob>ChiSq
1	2.1561	30.801	30.801	48.562	20.917	0.0006*
2	1.7348	24.783	55.584	37.470	17.376	0.0035*
3	1.3284	18.977	74.561	26.639	13.459	0.0171*
4	0.8038	11.483	86.044	15.900	9.469	0.0836
5	0.5798	8.283	94.327	9.658	5.438	0.1074
6	0.2801	4.002	98.329	2.865	2.346	0.2977
7	0.1170	1.671	100.00	0.000	0.023	0.3075

* Significant at $p < 0.05$

Table 5. Rotated factor loading for the principal components 1, 2, and 3			
	Principal Component		
Variables	1	2	3
DTP	0.099622	**0.982970**	0.154417
SOP	-0.416738	0.146095	-0.197104
DTW	**0.832199**	0.123974	-0.540440
AOP	**0.687822**	-0.001856	0.152291
DTS	0.157611	-0.626918	0.026145
DTBT	0.210244	0.113020	**0.971094**
DTR	0.505029	-0.420721	0.132447
Cum. %Variance	31%	56%	75%

Figure 1. Comparison between highest numbers of observations of Egyptian Geese counted per month in 2012 and 2013 in northwestern Arkansas.

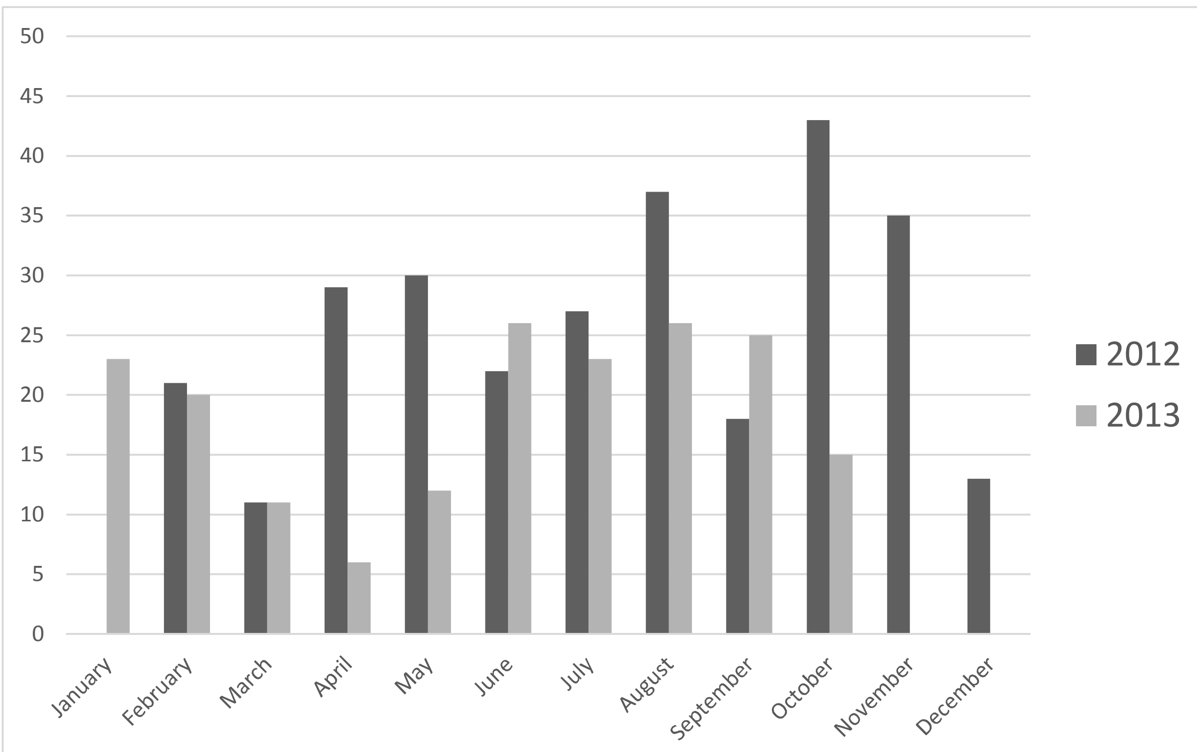
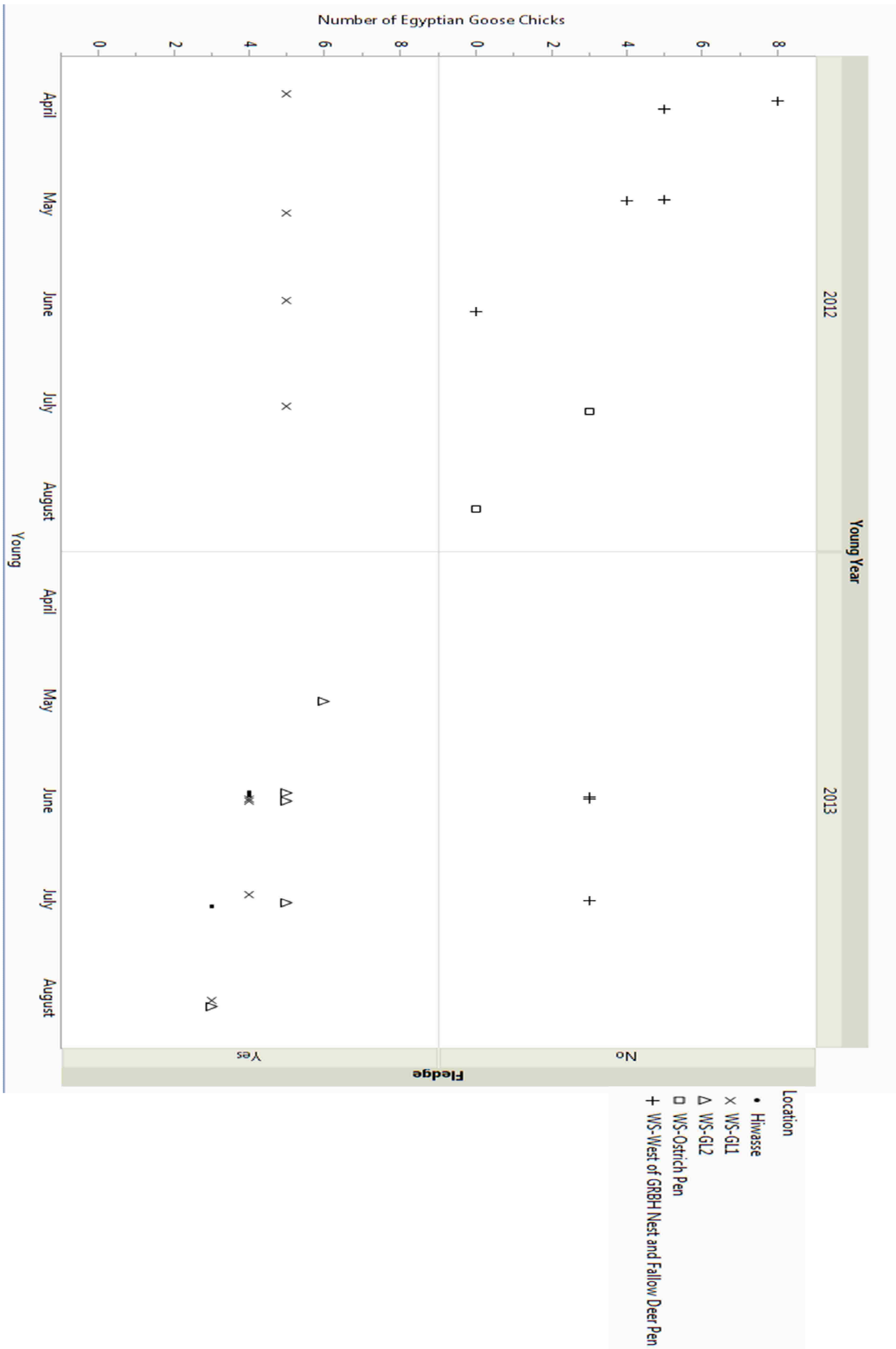

50
45
40
35
30
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December
2012
2013

Figure 2. The success rate of Egyptian Goose nests found in northwestern Arkansas. Locations refer to were the nest was first discovered. If any individuals from a nest survived to the fledge date (10 weeks) then the nest was considered successful. If no individuals fledged from the nest, the nesting site was considered a failure. Location definitions; WS=Wild Wilderness Drive-Thru Safari, GL1 and GL2=Pond names, and GRBH=Great Blue Heron.


Number of Egyptian Goose Chicks
Young Year
2012
2013
Fledge
No
Yes
Young
April
May
June
July
August
Location
Hiwasse
WS-GL1
WS-GL2
WS-Ostrich Pen
WS-West of GRBH Nest and Fallow Deer Pen

Chapter 2. Distribution of Egyptian Goose in the United States of America

Introduction

The earliest documentation of the Egyptian Goose in the United States of America (USA) is associated with aviculturists, mainly in the New England area, up until 1928 (Lever 1987). The bird was considered a favorite ornamental bird. The Egyptian Goose was largely ignored in the USA since 1928, until 1988 when the bird was documented in Arkansas (Smith and James 2012). This was not the first sighting of the Egyptian Goose in the USA or even in Arkansas since 1988, but it was the first documented sighting. Other states in the USA have since documented the Egyptian Goose in various areas. In Florida, the first documented nesting of a wild Egyptian Goose was in 2004, however, there has been captive breeding there (Braun 2004). The first reported sightings of the Egyptian Goose in Florida were made on the peninsula area of the state (Robertson and Woolfenden 1992). The Egyptian Goose has also been sighted in the west coast states, including Oregon and California in 1965 and 1964 respectively (Wilbur and Yocom 1971). There now have been reports of local populations of the Egyptian Goose in several states, Oklahoma, Texas, Florida, California, and Nebraska (Appell 2011, D.M. Brooks, *unpublished data,* James *unpublished data*, Chesbro *unpublished data*). Population numbers have been reported to the National Audubon Society through the Christmas Bird Count (CBC) since the addition of the Egyptian Goose to the count list in 1998, through the effort of Dr. Douglas James. This present study is to quantify the national Egyptian Goose population in the USA, as well assess significant population growth in states that have reported to the CBC.

Methods

Population data collected through The Christmas Bird Count (CBC) (National Audubon Society 2014) was used to assess population growth and expansion within the United States. The data provided the numbers of Egyptian Geese per state per year. A polynomial regression test was conducted to evaluate significant population growths for each state and for the total USA. Weather data was compiled through the CBC during the years Egyptian Goose were recorded for each state, including years with no report if there was a recite the following year. The weather data was plotted against the count data to assess shifts in weather coinciding with shifts in population size. Variables collected from the CBC for use in correlation analysis were year, number of Egyptian Goose observed, low temperature, high temperature, number of Egyptian Goose per party hour, number of counts reporting Egyptian Goose, and number of observers on counts. These variables were placed into categories as follows: Weather variables = low temperature and high temperature; birder effort = number of Egyptian Goose per party hour, number of counts reporting Egyptian Goose, and number of observers on counts; and year = year of observations. Simple correlations between the number of Egyptian Goose observed and all the other variables were evaluated using a correlation matrix. The simple correlation is able to give the relationship of how all the variables effect the number of Egyptian Goose observed. The fault in running only a simple correlation is it fails to take into account the interactions of any of the other variables (Zar 1996). This was corrected by running partial correlations, which considered the correlation between each pair of variables while holding constant the value of each of the other variables (Zar 1996). Three partial correlations were used: the first examined the weather variables with birder effort and year held constant, the second examined the birder effort with weather variables and year held constant, and the third examined year with weather variables and birder effort held constant (Smith 1979).

Results

The national data generated from records from the Christmas Bird Count (CBC) showed a very minimal amount of population growth within states (Figure 1). There is an increase in the number of states reporting Egyptian Goose numbers, the first year it was added to the list, 1998, only Arkansas and California reported the bird, but by 2012, six states had reported an Egyptian Goose to the list. Even though Arkansas was responsible for getting the Egyptian Goose on the CBC, there was no report, except for 1998, of an Egyptian Goose on the CBC in the state. The overall population growth for the United States of America (USA) appears to show a significant increase in size (Table 1)(Figure 2). The population size of Egyptian Goose in the USA shows a significant increase since 1998, P=1.659e-08. The only two states showing significant increases in population size were California and Florida (Table 2) (Figure 1 and 3). California has reported Egyptian Geese in the state every year since the addition to the CBC in 1998 and showed a significant increase in population size, P =0.009. Florida has only reported having Egyptian Geese in the state since 2001 and showed a significant population increase, p=0.0004. The weather data for Florida and California (Figures 4 and 5) were used to assess the effect of temperature on the Egyptian Goose population growth. There is not a significant correlation between population growth and temperature (Table 4). Weather data for Arkansas, New York, South Carolina, and Texas were gathered, but the data sets were too small for individual state use. Weather variables, birder effort and year were used in simple and partial correlation analysis to help explain population growth (Tables 3 and 4).

The results indicate that two distinct differences that can be associated with how many years the Egyptian Goose has been reported (Table 3). California and Florida show a significant correlation with years, while South Carolina and Texas do not show a significant correlation. There are two variables showing a significant correlation in all locations, except South Carolina, the number of Egyptian Goose observed per party hour and the number of observers per count (Table 3). The low temperature only showed a significant correlation in South Carolina (Table 3). This negative correlation suggests that colder the day the less likely an observation would be made. Texas and South Carolina showed significant positive correlations with high temperatures (Table 3). The correlation shows that the warmer the weather it is the less likely of to obsere an Egyptian Goose.

The partial correlation was used to see how the number of Egyptian Goose observations correlated with each variable while the other variables were held constant. California and Florida were the only states that a partial correlation could be used due to lack of data for the other locations. When the effect of observers was examined, year and weather held constant, there was a significant correlation for both locations for the amount of time spent in searching for Egyptian Geese (Table 4). Surprisingly, there was no significant correlation in year and weather.

Conclusion

There is some concern that the Egyptian Goose has already begun expanding its range to more suitable habitats, with official and unofficial reports of Egyptian Geese in other states including Texas, Oklahoma, Florida, Nebraska, and California (Appell 2011, D.M. Brooks, *unpublished data,* James *unpublished data*, Chesbro *unpublished data*). The Christmas Bird Count list had limited data on Egyptian Goose expansion throughout the USA (Figure 2), but a total of six, eastern and western, states reported Egyptian Geese (Figure 1). The overall trend shows no significant growth within the states. The exception is Florida which appears to have significant increase after 2009. After analysis of the data, California and Florida are significantly increasing in population size. It is not too surprising to see a significant increase in numbers of Egyptian Geese in California because California had reports of the bird every year since 1998. However, Florida did not report an Egyptian Goose in the state until 2001 with only 10 birds, however, by 2012 that number had significantly increased to 132 birds (Figure 1 and 3). There could be a number of factors that led to this increase including lack of competition with native species and the prevalence of numerous, small limestone karst ponds in Florida. The simple correlation shows the number of Egyptian Goose observed per party and the number of observers per count increase the chance of observing an Egyptian Goose (Table 3). This makes perfect sense because the more time and eyes spent looking for a bird the more likely an observation will take place. South Carolina may not show significance due to all the Egyptian Goose in the area being observed and it would not matter if there are extra eyes or time spent. MacArthur and Connell (1966) presented the idea of a "Tolerance Range", described as a certain range of values of the physical factors in an environment that individual organisms can live and reproduce. The "Tolerance Range" inspected for this study was weather, both the high and low temperatures of the CBC. Weather can by a key indicator when establishing when a population may increase or decrease drastically (MacArthur 1966, Williamson 1972). There is some speculation that weather may play a role in why the population in Britain has not increased considerable since being introduced (Lever 1987). The correlation between weather and the number of Egyptian Goose observed in the USA is significant in two states (Table 3). South Carolina shows a significant simple correlation with high and low temperatures. The low temperature suggests the colder the day the less likely an observation would be made (Table 3). This leads to the assumption there is less movement of the Egyptian Goose during the colder days. Texas and South Carolina showed a significant correlation between the high temperature and the number of Egyptian Goose observed (Table 3). The correlation shows the warmer the weather the less likely of observing an Egyptian Goose. This is surprising because intuitively the warmer the weather would bring more birders out, increase the activity of the Egyptian Goose, and increase the amount of time spent in the field, which would lead to higher observation numbers. South Carolina and Texas only have five and three years, respectively, of data, while California and Florida have fifteen and eleven years, respectively, of data. This discrepancy may explain why the weather variables are playing a significant role in the states with fewer observation years.

There are other underlying factors besides weather effect the British population, due to the Egyptian Goose population in the Netherlands greatly increasing in size. The leading hypothesis concerning why the Netherland population has been successful is the presence of numerous small lakes surrounded by marshy woodlands and meadows that are preferred for breeding by the Egyptian Goose (Hagemeijer 1997). The British populations are thought to hatching goslings in the early spring when it is still cold and wet compared to the warmer, drier Africa homeland, thus fall prey to Carrion Crows (Lever 1987). The hypothesis that the colder, wetter hatching times negatively impact population growth could explain the population growth in the United States, with Texas and California having weather similar to Africa (dry and warm). Florida, like the Netherlands, has many lakes and marshy woodlands that would be preferred for breeding, as well the driest months occurring in the spring. The weather data for Florida is fairly consistent for all reporting years (Figure 4). The slight decrease in temperature in the 2002, 2004, and 2008 season does show a negative impact on the population growth (Figure 4). This trend does not continue between the 2009 and 2010 seasons, which still show a decrease in temperature but an exponential increase in the population (Figure 4). The increase in temperature in 2003 shows a positive growth for the following 2004 season (Figure 4). However, the overall change in high and low temperature and population growth did not show a significant correlation (Tables 3 and 4). California shows many fluctuations in high and low temperatures (Figure 5). There is an increase in the population in 2000, which is associated with a warmer high temperature, even though the low temperature was colder than the year before (Figure 5). The following year, there is an association with a drop in high temperature and a decrease in the population, but both increasing in 2002 (Figure 5). The anomaly in the California data is the dramatic increase in the population in 2007, when the high and low temperatures drop slightly, followed by a dramatic decrease in the population in 2008, when the high temperature increases and the low temperature stays constant (Figure 5). Despite the changes in temperature and population size, there was not a significant correlation between the low and high temperature and population growth (Tables 3 and 4). Arkansas, New York, South Carolina, and Texas did not have enough data to properly assess the effect of weather on the Egyptian Goose population. There is a limitation to the correlations derived in this study. Correlations derived from data with a sample size less than 50 does not support large reliability (Zolman 1993). Taking under consideration the small sample size, the data still must be analyzed because the Egyptian Goose has not even been recorded on the CBC for 50 years (added in 1998 = 16 years). The assumption can be confidently made that the best way to increase the chances of observing an Egyptian Goose is to spend more time in the field and have an increased number of observers for areas the Egyptian Goose has a large population. Since all the data for this study were taken from the CBC, it can be assumed there were Egyptian Geese not counted accurately in states reporting, and for states that failed to report an Egyptian Goose. Assuming the birders were able to find and report every Egyptian Goose correctly it would be imperative to look at factors, other than weather, to explain the fluctuation in the population size. Further monitoring of the Egyptian Goose in known areas in states is crucial in establishing more accurate population sizes and establishing management practices for removal, if needed, of the bird from areas.

Literature Cited

Appell, S. 2011. *A Wild Egyptian Goose Tale: A short story about the Egyptian Geese and their Five Chicks, Born at the San Joaquin California Wildlife Sanctuary in July 2011*. http://talesofrelentlesspursuit.blogspot.com/2011/10/wild-egyptian-goose-tale.html.

Braun, D.G. 2004. First Documented Nesting In The Wild Of Egyptian Geese In Florida. *Florida Field Naturalist*. 32:138-143.

Hagemeijer, W. J. M., Blair, M. J., & European Bird Census Council. 1997. The EBCC atlas of European breeding birds: Their distribution and abundance. London: T & A D Poyser.

Lever, C. and Gillmor, R. 1987. Naturalized birds of the world. Harlow, Essex, England: Longman Scientific & Technical.

MacArthur, R. H., and Connell, J. H. 1966. The Biology of Populations. New York: Wiley.

National Audubon Society. 2014. The Christmas Bird Count Historical Results [Online]. Available http://www.christmasbirdcount.org. 8 January 2014.

Robertson, W.B. and Woolfenden, G.E. 1992. Florida Bird Species: An Annotated List. The Florida Ornithological Society. Gainesville, Florida. Special Publication No.6.

Smith, K.G. 1979. The effect of weather, people, and time on 12 Christmas Bird Counts, 1954-1973. *American Birds*. 33:698-702.

Smith, K.G. and James, D.A. 2012. History and Current Status of Egyptian Goose (Alopochen aegyptiacus) in Northwestern Arkansas. Journal of the Arkansas Academy of Sciences. 66:200-204.

Wilbur, S. R., & Yocom, C. F. 1971. Unusual geese in the Pacific Coast states. *The Murrelet*. 52:16-19.

Williamson, M. H. 1972. The analysis of biological populations. London: Edward Arnold.

Zar, J.H. 1996. Biostatistical Analysis. Upper Saddle River, NJ: Prentice Hall.

Zolman, J. F. 1993. Biostatistics: Experimental design and statistical inference. New York: Oxford University Press.

Tables and Figures

Table 1. Polynomial regression test of the USA's Egyptian Goose population (data from National Audubon Society).

	Estimate	Std. Error	t-value	p-value
USA	0.20877	0.01707	12.23	1.659×10^{-8}

Table 2. (A) Polynomial regression test of California's Egyptian Goose population (B) Polynomial regression of Florida's Egyptian Goose population (data from National Audubon Society).

(A)

	Estimate	Std. Error	t-value	p-value
California	0.09218	0.02049	4.499	5.98×10^{-4}

(B)

	Estimate	Std. Error	t-value	p-value
Florida	0.25671	0.03748	6.849	4.47×10^{-5}

Table 3. Simple Correlations (r) between the number of Egyptian Goose observed in the found in states ≥3 years and year, weather, and birder effort (data from National Audubon Society).

State	Year	Low Temp	High Temp	# / Party Hour	#Reports	#Observers
California	0.76[a]	-0.18	-0.02	0.98[a]	-0.07	0.66[a]
Florida	0.86[b]	0.22	0.05	0.98[b]	0.87[b]	0.82[b]
South Carolina	0.57	-0.56[c]	-0.71[c]	0.4	0	-0.17
Texas	0.53	0.39	-0.82	1[d]	0	0.99[d]

[a] $p \leq 0.05$ d.f.=14
[b] $p \leq 0.05$ d.f.=10
[c] $p \leq 0.05$ d.f.=4
[d] $p \leq 0.05$ d.f.=2

Table 4. Partial Correlations (r) between the number of Egyptian Goose observed in the found in states ≥ 5 years and A (year), B (weather), and C (birder effort) (data from National Audubon Society).

	A	B		C		
State	Year	Low Temp	High Temp	#/Party Hour	#Reports	#Observer
California	0.37	0.05	-0.17	0.97[a]	-0.40	-0.02
Florida	0.34	-0.1	0.07	0.85[b]	-0.11	0.39

[a] $p \leq 0.05$ d.f.=9

[b] $p \leq 0.05$ d.f.=5

Figure 1. The national census data for each state, based on Christmas Bird Count (data from National Audubon Society).

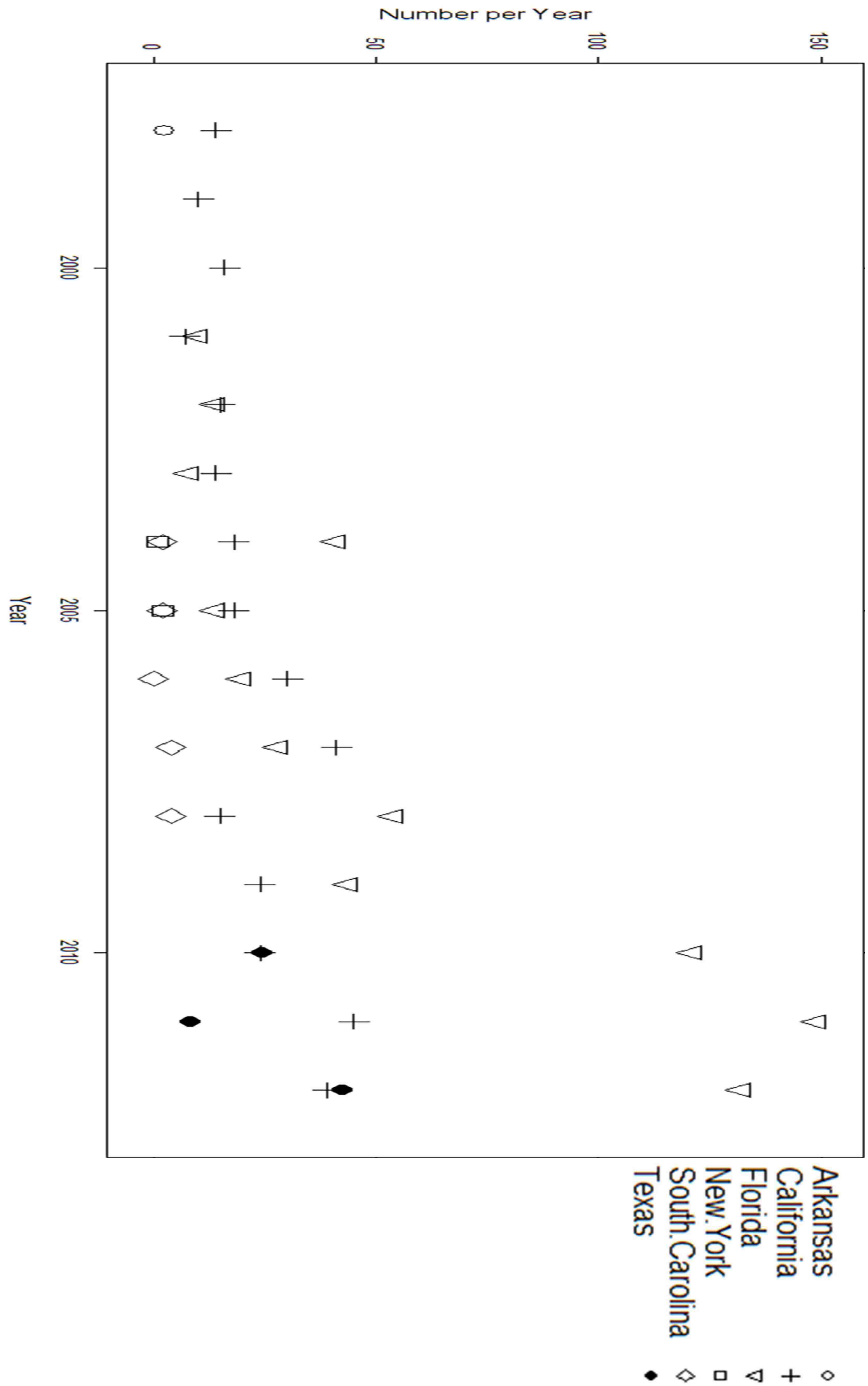
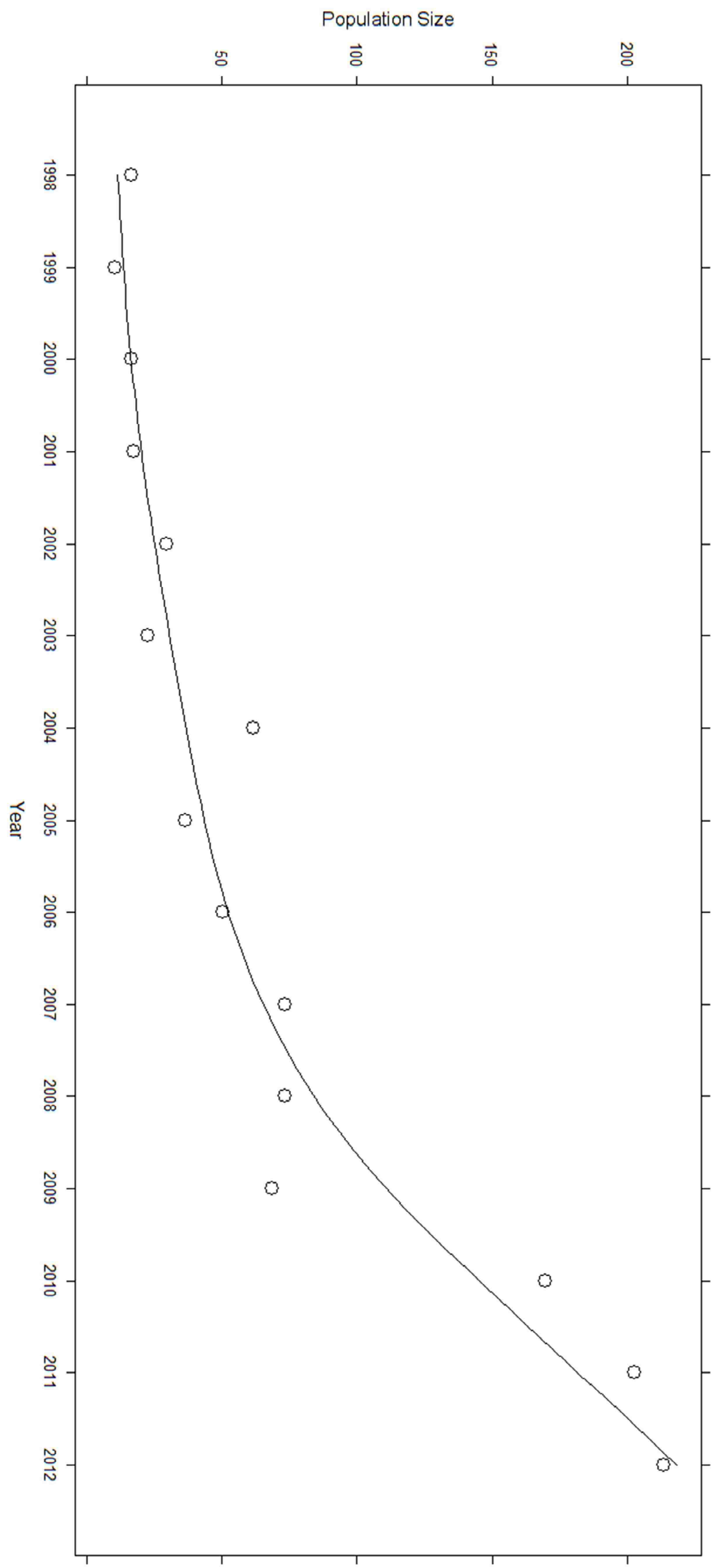

Number per Year
0
50
100
150
Year
2000
2005
2010
Arkansas
California
Florida
New.York
South.Carolina
Texas

Figure 2. Egyptian Goose population growth for the United States of America, based on Christmas Bird Count (data from National Audubon Society).



Population Size
50
100
150
200
Year
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 3. Egyptian Goose population growth in Florida and California based on Christmas Bird Count (data from National Audubon Society).

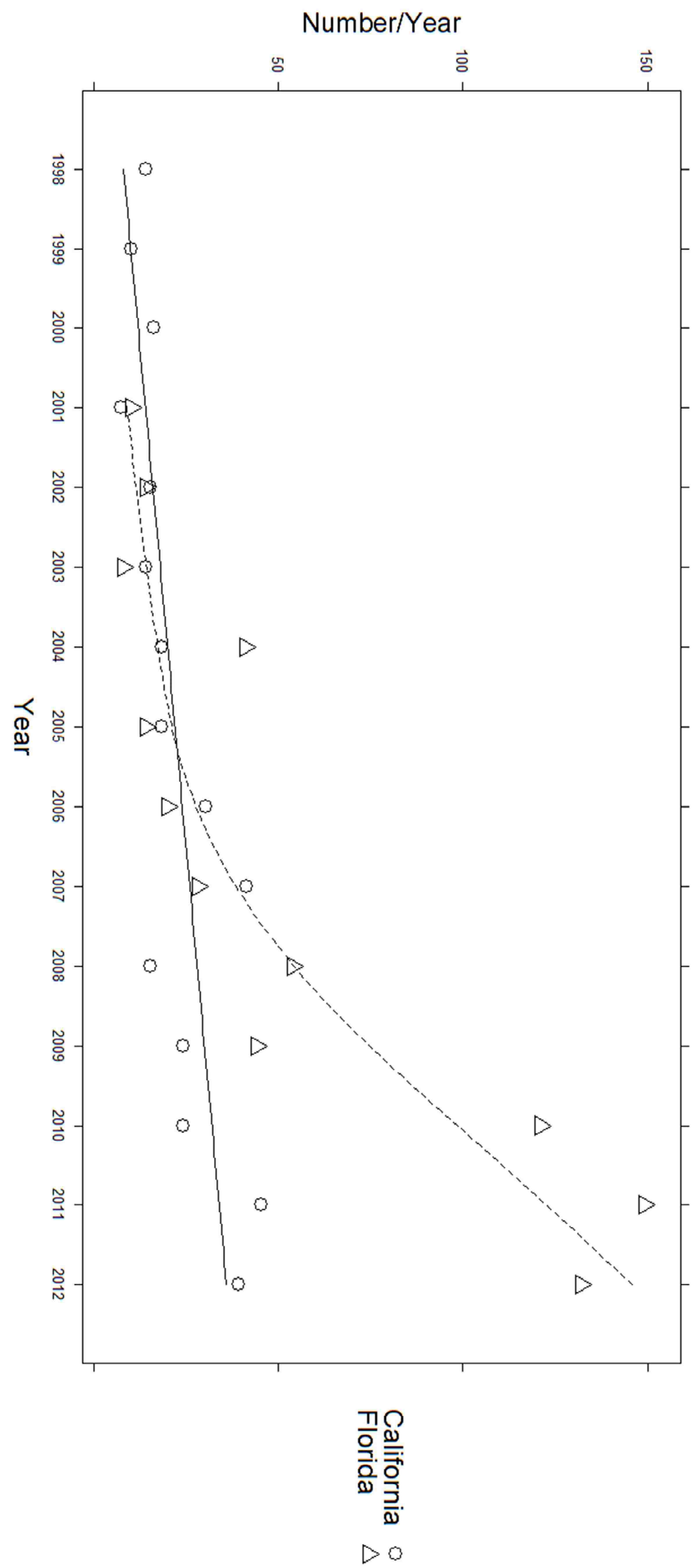

Number/Year
50
100
150
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year
California
Florida

Figure 4. The effect of high and low temperatures on Egyptian Goose observations in Florida, based on Christmas Bird Count (data from National Audubon Society)

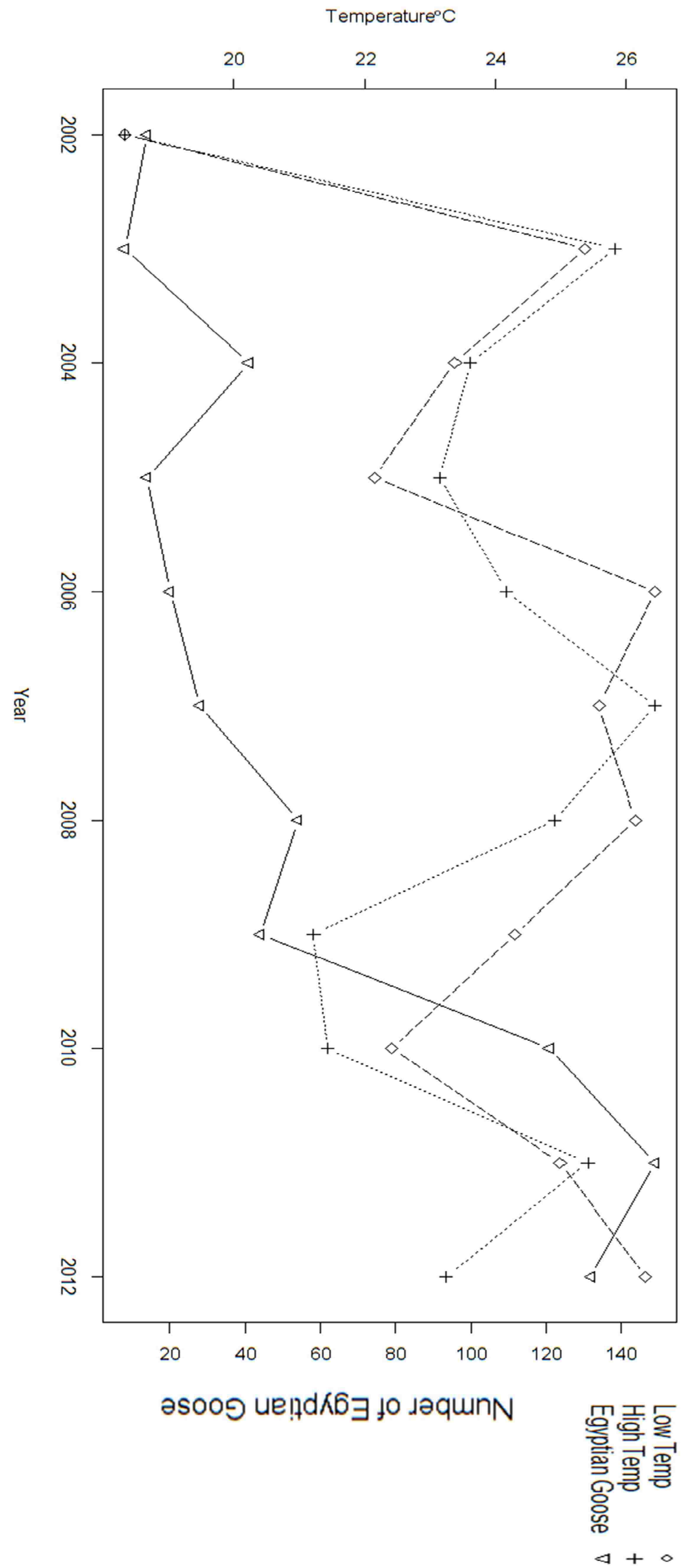
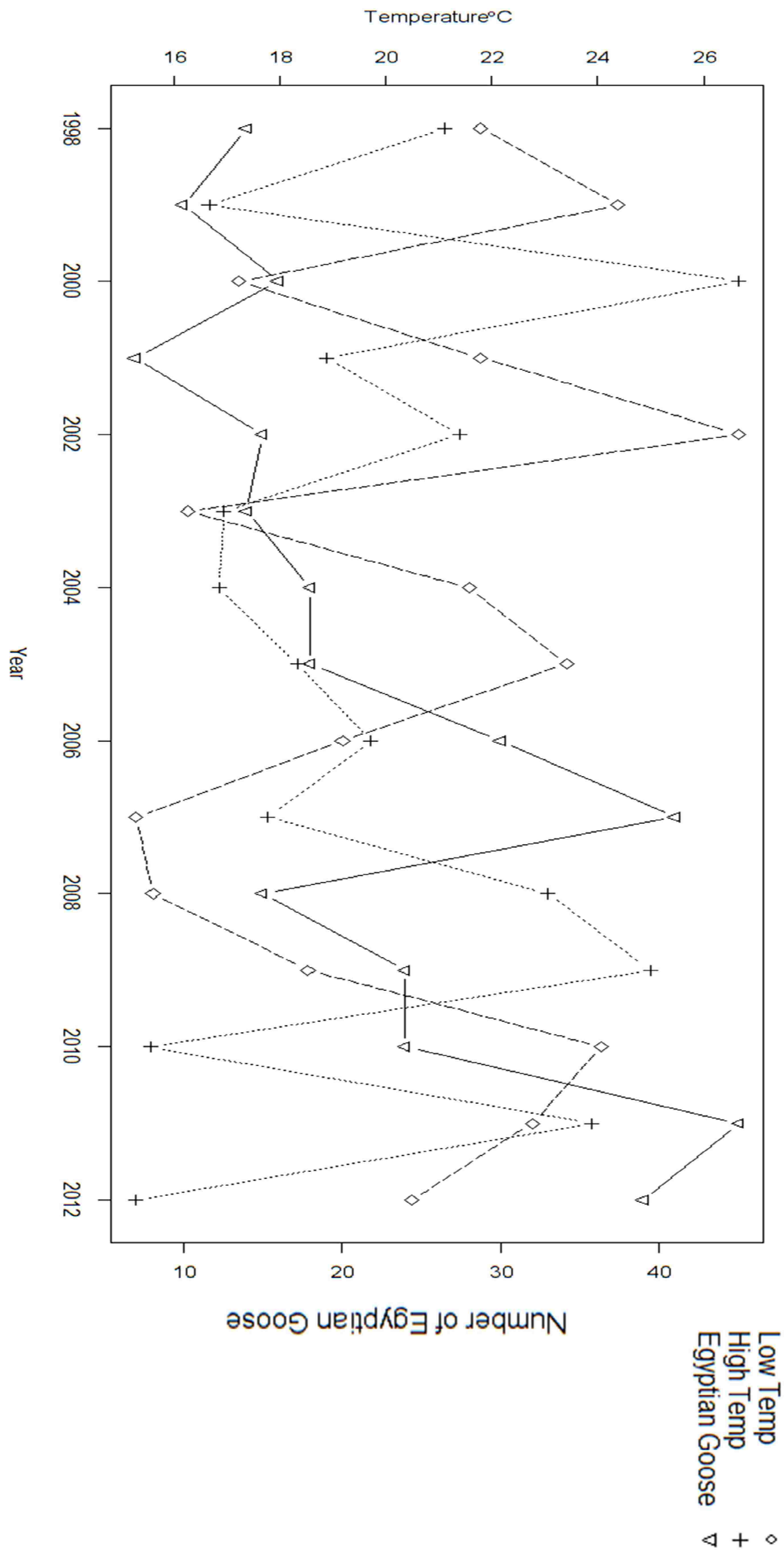

Temperature°C
20
22
24
26
Year
2002
2004
2006
2008
2010
2012
20
40
60
80
100
120
140
Number of Egyptian Goose
Low Temp
High Temp
Egyptian Goose

Figure 5. The effect of high and low temperatures on Egyptian Goose observations in California based on Christmas Bird Count (data from National Audubon Society)


Temperature°C
16
18
20
22
24
26
Year
1998
2000
2002
2004
2006
2008
2010
2012
10
20
30
40
Number of Egyptian Goose
Low Temp
High Temp
Egyptian Goose