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Chapter

Ecology of Feral Pigeons: Population Monitoring, Resource Selection, and Management Practices

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Abstract

Feral pigeons (*Columba livia*) are typically ignored by ornithologists but can be found roosting in the thousands within cities across the world. Pigeons have been known to spread zoonoses, through ectoparasites and excrement they produce. Along with disease, feral pigeons have an economic impact due to the cost of cleanup and maintenance of human infrastructure. Many organizations have tried to decrease pigeon abundances through euthanasia or use of chemicals that decrease reproductive output. However, killing pigeons has been unsuccessful in decreasing abundance, and chemical inhibition can be expensive and must be used throughout the year. A case study at Texas Tech University has found that populations fluctuate throughout the year, making it difficult to manage numbers. To successfully decrease populations, it is important to have a multifaceted approach that includes removing necessary resources (i. e. nest sites and roosting areas) and decreasing the number of offspring through humane techniques.

Keywords: birth control, nest sites, nuisance, rock doves, zoonoses

1. Introduction

Of the 7.53 billion people that live on Earth, over half inhabit cities [1, 2]. Increase in development has altered biodiversity through an increase in fragmentation and invasive species abundance. Urban areas are highly susceptible to invasions of nonnative species [3], which can increase threat to native species and increase economic costs due to environmental and structural damage [4, 5]. One species that is associated with urban areas, but is often ignored by ornithologists, is the invasive feral pigeon (*Columba livia*) [6].

Descendants of cliff-dwelling rock pigeons, feral pigeons have a close relationship with humans [7]. Most likely originating in southern Asia, wild rock pigeons colonized areas in Europe and North Africa [7]. Around 5,000–10,000 years ago,

rock pigeons became the first known domesticated bird [8]. Throughout history, these domesticated birds were honored for their reproductive ability and because they were an important food source [9]. As agriculture developed, the use of pigeons for meat dwindled, leading to the species escaping and creating feral flocks in urban areas across the world [9].

Humans did not consider pigeons to be a nuisance until the twentieth century [10]. Pigeon abundance is positively correlated with human density [11]. Because of the increase in human abundance and activity, pigeon ability to exploit many different food types [5, 12] and this combined with low predation risks caused an increase in pigeon population growth [13]. Buildings found in cities closely resemble cliffs and pose a synthetic habitat for pigeons [14]. Moreover, cities provide a wide variety of resources for pigeons, from nesting [15] and roosting locations [5] to increased ambient temperature [11]. Nowadays, they can be seen roosting in the thousands throughout many cities [10].

1.1 Pigeon problem

With an increase in abundance comes an increase in economic impacts and health issues associated with pigeons. Each year in the United States, pigeons cause approximately 1.1 billion dollars in environmental and infrastructural damage [4]. For example, pigeons residing in cities that are surrounded by agriculture often steal grain from nearby silos [6]. One such warehouse lost 3 tons of grain a week due to pigeon theft [6]. Feral pigeons can also cause building damage. An individual pigeon can excrete up to 12 kg of excrement a year [16]. Due to their human-modified diet, feral pigeons typically have more acidic excreta compared to wild rock pigeons [17]. The compounding effects of high pigeon abundance, large amounts of excreta, and high levels of acidity can have devastating results for building structures. The acidity alone can cause structural and esthetic damage over time [7]. Feces and nest material can clog drainage systems, causing internal damage to buildings [7]. The costs to clean and repair structural damage caused by pigeons can be straining on family and commercial businesses [7].

1.2 Human impacts

Damage to buildings is insignificant when it comes to health concerns that pigeons pose. Many citizens view pigeons as pests that can spread plague-like diseases via excreta, secretions, parasites, and dust from their feathers [7, 18]. Diseases can be spread by excrement and dust, and thus direct contact is not needed for transmission [19]. Diseases that can be potentially transmitted from pigeons to humans include aspergillosis, borreliosis, coccidiosis, chlamydiosis, equine encephalitis, influenza, paramyxovirus, paratyphoid, toxoplasmosis, and tuberculosis [19, 20], and some can potentially be lethal [18]. How often these diseases spread to humans is uncertain [7]. The most common pathogen transmitted to humans via pigeons is *Chlamydophila psittaci* [21]. The fungus *Histoplasma capsulatum* found in pigeon excrement is even more concerning [7]. With a large amount of excreta present in areas of high human activity, the possibility of humans becoming infected is high [7]. Maintenance workers have been infected with *histoplasmosis* after cleaning up pigeon excrement [22, 23].

1.3 Impacts on other species

Pigeons are a vector of several diseases that can be a hazard to domestic fowl and native species within cities. The paramyxovirus is a highly contagious respiratory

infection that is fatal among birds [24]. In the 1980s, a large outbreak of paramyxovirus started in Italy and spread throughout Europe [25]. The outbreak in Great Britain in 1984 had devastating economic costs due to pigeons transmitting the disease to chickens [27]. In 1985, approximately 30% of pigeons were infected with the disease in Germany [26]. Nowadays, domestic fowl and other species of birds are still at risk from paramyxovirus outbreaks [28].

In invasive Columbiformes (avian order of feral pigeons), disease transmission tends to have the highest impact on other avian species [23, 29]. Research on how pigeons interact with other species via competition is limited. A study on direct competition among food patches of native and invasive birds in South Wales found that feral pigeons were the only exotic species that could potentially be considered an aggressive competitor [30].

There is no denying that invasive feral pigeons impact the lives of humans, through food theft, building damage, and increased risk of disease transmissions. Due to adverse effects of pigeons, businesses and campuses have tried to decrease their population size.

2. Case study of Texas Tech campus

Reducing pigeon numbers requires a multifaceted approach based on robust ecological information. Texas Tech University (TTU) located in Lubbock, Texas has had a history with pigeons. In the 1950s, TTU would host annual pigeon hunts on campus to decrease pigeon abundance and to supply food for the Christmas celebration at Milan's Children's home [31]. In the winter of 1957, 475 pigeons were shot on campus for the annual hunt [31]. Today, the main campus has approximately 100 Spanish Renaissance adorned buildings [32] on a 744 ha lot [33]. According to the physical plant at TTU, around $200,000 is spent each year cleaning up after pigeons on campus (Sean Childers, personal communication).

Because of the adverse effects caused by pigeons, TTU is conducting a detailed ecological study of their population residing on campus. The purpose of this study is to obtain estimates of population size. This will form a baseline to determine if there are significant decreases in abundance due to management strategies. Secondly, we will be able to recognize areas that have a high abundance of pigeons (hot spots), where we can then impose population reduction methods more aggressively. Thirdly, we will study how populations fluctuate throughout the year due to seasonal changes in the environment.

In 2017, we estimated abundance to be approximately 9819–13,757 pigeons [34]. We also found hot spots scattered across campus that had 649–750 pigeons [34]. To reduce the population, TTU is planning a management strategy that includes habitat modification and sterilization techniques. The estimated abundance can be used to determine if the strategy is effective and if there is a significant reduction over time. Hot spots in abundance can assist in determining where habitat modification and sterilization processes can be most effective in decreasing population size.

Along with enumerating pigeon abundance, we characterized population variation over time (**Figure 1**). By examining two buildings, the Experimental Sciences Building (ESB) and Holden Hall (HH), on campus that housed large pigeon populations, we found that there were daily and seasonal differences in numbers [35]. Abundance typically increased in the winter, except for ESB in the morning. Normally, morning counts for ESB were higher than afternoon counts [35]. Holden Hall pigeon abundance fluctuated from morning to the afternoon but increased throughout the year [35].

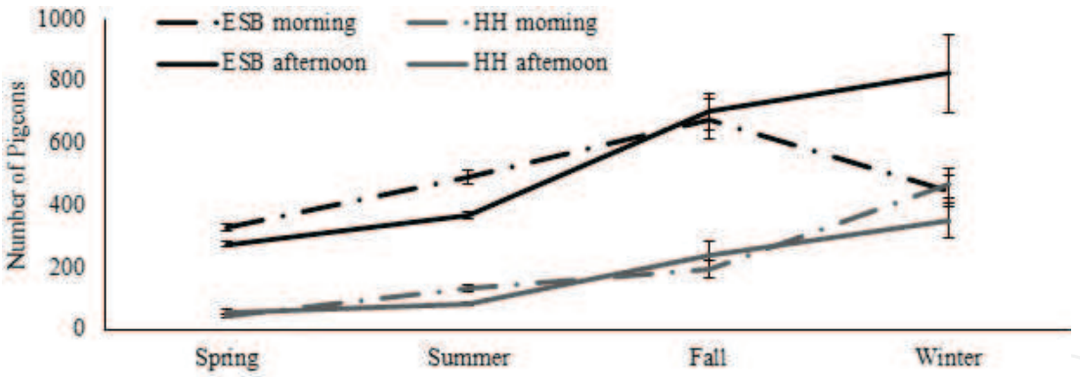


Figure 1.
Seasonal counts in the morning and afternoon of pigeons on two buildings on Texas Tech campus in 2017. ESB = experimental science building, HH = holden hall. Standard error ± 1.

Information on fluctuations in pigeon abundance can help when trying to organize a successful management plan. For example, we can determine if decreases in pigeon abundance are due to seasonal variation or due to management strategies, or when efforts to decrease abundance could be eased or made more active. However, to determine the most effective management for decreasing pigeon numbers, further understanding of ecology is necessary.

3. How to relieve the pigeon problem?

3.1 Removal of pigeons

One tactic to rid pigeons of an area is by humanely capturing them and transferring them to a new location [7]. This strategy has been proven to be ineffective, due to biological characteristics of pigeons. Pigeons have an excellent homing ability. Immediately after fledging, pigeons become imprinted to the site [36]. When taken to an unknown location, a pigeon will orient itself by using the Sun's orientation [37], Earth's geomagnetism [38], environmental odors [39], and landmarks [40] to navigate themselves homeward.

3.2 Killing pigeons

Another tactic to rid pigeons of an area is through euthanasia or culling. However, the tactic often is ineffective at decreasing pigeon abundance [18]. In Basel, Switzerland in the 1980s, pigeon populations were reduced by 80% through euthanasia. Within a few weeks, pigeon populations returned to the original size or even larger than before [41]. The removal of individuals opened up space for new migrants to come in, such as juveniles [41]. Because in urban areas pigeons reproduce throughout the year and have reduced mortality rates due to reduced predation, flock sizes can exceed carrying capacities and competition for breeding sites can increase [42].

In Stuttgart, Arkansas, controlled hunting was used to decrease pigeon abundance. Following the hunt, pigeon numbers decreased dramatically but within a few months rose to original levels [43]. From 1983 to 1991, Barcelona, Spain started a program of capturing and euthanizing pigeons. One single capture caught 362 individuals. However, pre- and post-census showed no significant difference in abundance [44]. Killing pigeons has proven to be only a temporary solution. Due to their high fertility rates, pigeons can rebound quickly.

3.3 Modifying habitat

A management plan can become successful by carefully studying what an organism selects for within its habitat. Pigeons are granivorous [7] and need a large feeding source to support their large population and offspring [7]. Furthermore, if a pigeon does not eat in 3 days, it can lose up to 5% of its body weight [45].

When killing pigeons proved ineffective for the city of Basel, the local government tried to decrease abundance by decreasing pigeon food supply [41]. In their situation, people created a huge food base for pigeons. They instituted an outreach program to educate people on the harm of feeding pigeons and the importance of maintaining a small population [41]. The decrease in food supply increased competition, decreased the probability of juveniles entering the population, and decreased reproductive success due to unfavorable conditions [41]. Within 4 years, one of the central flock sizes went from 1400 to 708 pigeons [41].

However, finding the primary source of food for pigeons may be difficult. Pigeons are opportunistic species [7] and have the ability to exploit a variety of food types [12], even human refuge [7]. Therefore, pigeons will feed within cities, consuming food left behind by humans, and can also travel to the outskirts of urban areas to eat from agricultural fields [7]. While it is common to see pigeons eating food distributed by humans, this rarely represents a high percentage of their diet [7]. Instead, pigeons are more likely to select grain from agricultural sources or from wild plants [7]. Therefore, simply limiting the food source may only have a limited effect. Moreover, such an effect depends on the foraging behavior of the flock [7]. If the majority of a flock feeds on a source that can potentially be managed, then it is possible to decrease their abundance [7].

If an organization has a population that forages outside their property, similar to the situation at TTU, influencing nest sites may be a more favorable way to decrease abundance than limiting the food source. As we have mentioned in this chapter, pigeons are prolific breeders. For most avian species, the breeding period is seasonal [46]. Pigeons have the advantage of being granivorous, where their food supply can survive during the winter months [7]. This consistent food supply helps pigeons feed their offspring with crop milk throughout the year [7]. Interestingly, wild rock pigeons have a seasonal breeding period, while feral pigeons breed throughout the year, even in winter (**Figure 2**) [46]. The ability to do so is probably due to the selective breeding done by humans in the past to produce a bird that can breed throughout the year [47].

The typical clutch size of feral pigeons is two eggs, very rarely is it more or less [7]. The incubation period lasts approximately 2 weeks, and depending on region and season, chicks will fledge from approximately 25–40 days after hatching [6, 7].

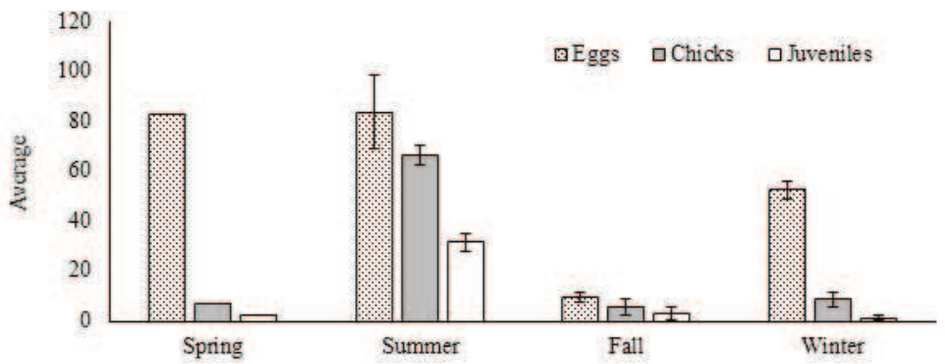


Figure 2.
Average number of eggs, chicks and juvenile pigeons on the experimental sciences building at Texas Tech University in 2017.

In Manchester, eggs hatched were approximately 62%, and chicks that fledged were around 66% [6]. Once chicks reached about 20 days of age, pigeons started laying another clutch [6]. With high reproductive success and year-long output, pigeon abundance can quickly increase.

Managing pigeon habitat via nest site removal could decrease reproductive output and decrease abundance. First, it is advantageous to locate areas that are selected for in terms of nesting locations. Pigeons typically nest in cavity-like structures on top of or within buildings (**Figure 3**) [7]. Any site that is covered and semi-dark provides a favorable site for pigeons to nest [7]. Nests can be found from inside attics to the underside of bridges and overpasses [7]. On TTU campus, pigeon nests can be found under heating, ventilation, and air conditioning (HVAC) equipment on top of buildings (**Figure 3**) that are protected from the elements and can provide a stable environment (e.g. temperature).

Modifying nest sites, such as blocking them off with screens or completely removing areas that house colonial nest sites, can reduce pigeon abundance [7]. Another strategy is removing or destroying eggs periodically. Dovecotes, structures used to house pigeon nests, have been used in cities to reduce egg production. However, maintenance of dovecotes can be time-consuming and costly, and removal of eggs may trigger pigeons to lay more [48]. Also, the use of dovecotes has not proven to be effective [18].

3.4 Chemical sterilization

Chemical sterilization is a humane strategy to decrease abundance but does not get rid of the entire population [7]. Research conducted on the effect of decreasing reproductive output through sterilization did decrease abundance in feral pigeons (among other species) and was more effective than killing individuals [49]. However, the majority of studies have been conducted in laboratory settings. How effective sterilization is in field settings with natural populations is not well understood.

3.4.1 Nicarbazin

Texas Tech University is investigating how OvoControl (Innolytics, LCC) can limit reproductive success and decrease abundance. The active ingredient in OvoControl is Environmental Protection Agency approved nicarbazin in the form of a ready-to-use bait. First developed to decrease the growth of coccidian parasites in chickens, researchers found that nicarbazin decreased egg production and



Figure 3.
Pigeon nests under a HVAC machine on top of the Biology building on TTU campus.

hatchability by compromising the internal egg structure and sperm receptors [50]. When consumed by a female, the hatchability rates decreased to near zero with no other side effects [50].

In Rimini, Italy, a population management strategy was conducted to decrease pigeon abundance with Ovistop (a similar bait with nicarbazin as the active ingredient) [51]. Using 10 locations and dispensing bait from March to November in 2005 and 2006, there was a decrease in abundance by 48% [51]. The city of Modena, Italy sought to decrease pigeon abundance but wanted to make sure that native swifts and bats could still flourish. They dispensed Ovistop and decreased the number of nesting locations [52]. The scaffold holes around the city that pigeons used for nesting were not completely covered, but reduced in size to allow bats and swifts to roost inside [52]. This program led to a decrease in pigeon abundance from 1060 pigeons to 205 pigeons in downtown Modena [52].

Innolytics, LCC helped the city of San Diego study how OvoControl influenced natural pigeon populations. Two sites that housed approximately 150 individual pigeons each were selected for the study. At the first site, they dispensed OvoControl for the pigeons to consume. At the second site, they did not dispense OvoControl to see how the population progressed without the influence of sterilization techniques. Within the first year of dispensing the bait, there was a decrease in pigeon abundance by 53% [53]. After 28 months, the population decreased by 88% [53].

Texas Tech University has been working closely with Innolytics, LCC to make sure that OvoControl is used as effectively as possible. We have found it to work best on top of flat buildings, where there are hot spots in abundance. To attract pigeons to the location, we dispensed cracked corn with deer feeders. Once an adequate number of pigeons were coming to the area to consume the corn, we slowly integrated OvoControl into the deer feeders. We started this process on top of the Biology building and HH in May of 2018. We are examining how effective the treatment is by candling eggs to look at fertilization rates [54] and abundance throughout the year.

Avian birth control decreases abundance by decreasing the number of pigeons entering the population through birth [54]. Due to pigeons being social and territorial, the feeders should only attract local flocks. Once the population decreases, no new pigeons should enter the area due to individuals from the current flock still being present and defending their roosting/nesting location [55]. However, once pigeons stop eating OvoControl, it can lose its effect within 1 week [55]. By placing feeders on top of buildings, exposure to native birds is limited. There are also no secondary trophic effects. Hawks will not be affected after preying on a pigeon that has consumed OvoControl [53]. OvoControl is only useful if it is directly consumed [55].

3.5 Limiting roosting locations

Another way to decrease habitat favorability for pigeons is to decrease roosting availability. Buildings are full of ledges for pigeons to roost on, and there are many ways to decrease roost selection. Increasing the angle of the ledge to 45° or more by using sheet metal or other materials can discourage pigeons from roosting or nesting on ledges [56]. Netting or mesh can be used as well. Texas Tech University has decreased roosting and nesting by screening off balconies that housed a large colony of pigeons. Netting can be placed below rafters to discourage pigeons from roosting in barns and sheds [56].

Porcupine wires are spikes that can also be placed on ledges to prevent pigeons from roosting [56]. The stainless steel spikes point in all directions and cause discomfort for pigeons who try to roost in the location [57]. A bird shocking device

(Bird-shock, Flex-Track) can also be placed almost anywhere and has limited visibility. The device shocks the bird enough to scare it away, without harming the bird [57].

Noise-making devices such as those that emit a high-frequency sound have proven to be ineffective in removing pigeons [56]. Scaring pigeons with lights, fake snakes, owls, and other devices also seem ineffective on pigeon abundance [56]. Chemical repellents have also been used to decrease pigeon presence [56]. While effective at first, pigeons can get used to the repellent and decrease repellent effectiveness [56].

3.6 Birds of prey

Falconry is becoming a popular and "new" method in pigeon management. Using falcons may be a useful technique if there is no way to pigeon proof an area or a building [58]. Birds of prey can scare away pigeons and greatly influence their behavior [58]. In Calgary, falcons have been released at the South Health Campus [59]. Effectiveness of commercial use falconry or having falcons permanently live on buildings is not known. Increase in predator abundance within a location would be more beneficial than in areas where pigeons have very few predator encounters. Such an approach may be more beneficial than using fake owls. Pigeons can become accustomed to fake owls and no longer fear them [56].

4. Conclusion

Pigeons can influence humans through disease transmission, infrastructure damage, or financial loss. How to rid an area of pigeons is not always straightforward. Some methods are not effective in decreasing populations (**Figure 4**). Due to their rapid reproductive output, high fledgling success and homing ability, culling or trapping pigeons does not work when trying to decrease abundance. Culling and removal deems to be a short-term solution to a long-term problem. Scaring pigeons with fake birds of prey or with sound or lights also proves to be ineffective.

One of the most important aspects and the first step to any population management plan is to study the population that is a nuisance. Studying abundance, population hot spots, colonial nest locations, and primary food resources can create the building blocks of an effective plan to modify habitat and decrease carrying capacity of the location. Nest and roosting locations can be removed by modifying ledges or crevices. Decreasing the attractiveness of buildings in Perugia, Italy resulted in a 23% decrease in pigeon abundance within a year [60]. If an organization can determine the primary food source for the population, decreasing it or educating the public can prove to be very effective. Venice, Italy used to have more than 10,000 pigeons living in St. Mark's Square [18]. When they decreased the number of tourists feeding the population, the number dropped to 1,000 individuals [18]. However, if the population is flying to nonurban areas, such as agricultural fields, this method of decreasing carrying capacity by decreasing feeding sources may not work. Population models performed by Guinchi et al. found that influencing the habitat is the most effective and long-lasting method in decreasing abundance [18]. Simply killing off pigeons was least likely to control the population [18].

Guinchi et al. also discovered that controlling fertility with habitat modification may create the most profitable outcome [18]. However, when designing this plan, a city or organization needs to take into account effective budgeting. A population decrease will not happen immediately and it may take years to reach an optimal abundance. A multifaceted approach, using sterilization and habitat modification

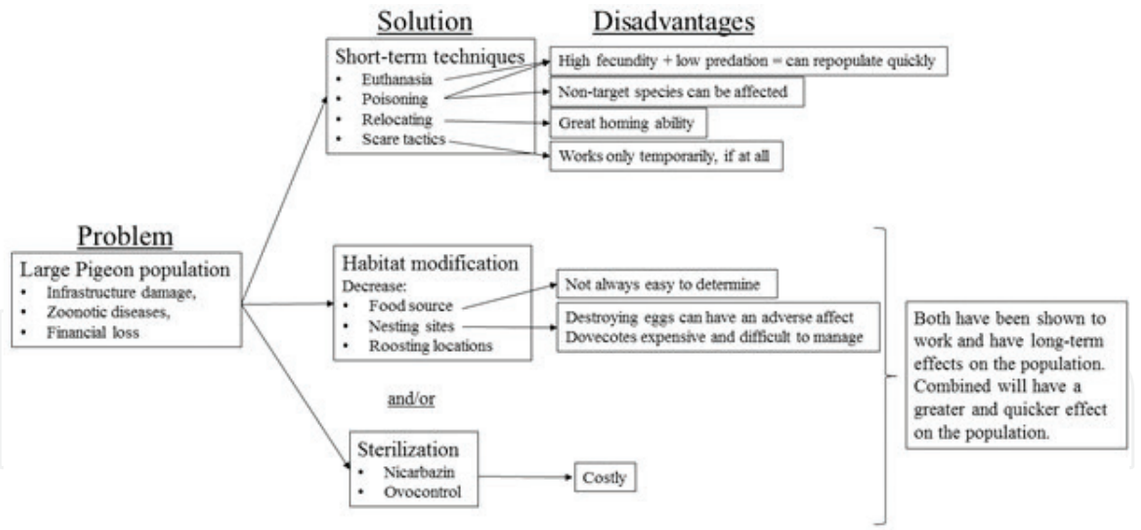


Figure 4.
Flowchart shows the most common methods and disadvantages at attempting to decrease pigeon abundance.

techniques, is useful in decreasing abundance, but can be expensive over time [7, 18]. If a sterilization technique is preferred, studying seasonal egg-laying patterns may be useful to know when to dispense nicarbazin-laced bait and when it can be suspended. Therefore, the organization is not spending money when it is not necessary.

The most effective management strategy for TTU includes habitat modification to decrease roost and nest sites, and sterilization techniques via dispensing OvoControl in locations of high pigeon abundance. Texas Tech University has decreased roosting locations using bird wire and decreased nesting locations by screening off balconies that housed a large colony. OvoControl is currently being dispensed on top of buildings that house large pigeon populations. Preliminary results from enumerating pigeon abundance on ESB and Holden Hall have shown a significant reduction within the last year. The Experimental Sciences Building is next to the Biology building where OvoControl is being dispensed, while OvoControl is being dispensed on top of Holden Hall. Bird wire has been placed on both buildings, and balconies have been screened off at ESB to decrease nesting locations. Texas Tech University is furthering their study of pigeon ecology and conducting more detailed analyses of nesting and roosting locations to further decrease habitat favorability.

Acknowledgements

We would like to thank TTU for their financial help in conducting our research. We would like to thank all volunteers for their time and efforts in researching pigeon ecology on Texas Tech campus. We would also like to express our gratitude toward Eric Wolf and Alex McDonald from Innolytics, LCC for their valuable insight on using nicarbazin bait to decrease reproductive output of pigeons on TTU.

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