Effects of Corn Availability on Diets, Body Condition, and Stress in American Black Ducks and Mallards on Long Island, New York

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EFFECTS OF CORN AVAILABILITY ON DIETS, BODY CONDITION, AND STRESS IN AMERICAN BLACK DUCKS AND MALLARDS ON LONG ISLAND, NEW YORK

by

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A thesis submitted in partial fulfillment of the requirements for the Master of Science degree State University of New York College of Environmental Science and Forestry Syracuse, New York April 2020

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ABSTRACT


Winter habitat and forage for American black ducks (*Anas rubripes*) can be limiting. Urbanization, sea level rise, and other stressors often make restoration of coastal wetlands infeasible or logistically difficult. Agriculture fields may need to increasingly serve as winter foraging sites for black ducks. I compared diets, body condition, and stress indices of black ducks and mallards (*A. platyrhynchos*) on Long Island, New York. Isotopic diet signatures differed by species and habitats. Body condition and stress indices differed between habitats. I also determined initial corn yield, depletion rates, waterfowl use days, and waterfowl energy needs on corn sites. My results do not suggest substantial benefits of corn to black ducks because they exploit and benefit from waste corn resources less than mallards. Continuing protection and restoration of coastal wetlands along the Atlantic coast is important with the aim of increasing black duck carrying capacity.

Key Words: *A. platyrhynchos, Anas rubripes*, black duck, body condition, coastal wetlands, corn, diet, Long Island, mallard, stress, winter

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CHAPTER 1: INTRODUCTION

American Black Duck and Eastern Mallard Population Dynamics

From 1950 – 1980 the American black duck (*Anas rubripes*; hereon black duck) population declined as much as 50% and has not recovered to the historic level, despite focused harvest and habitat conservation efforts (Black Duck Joint Venture 2008, USFWS 2017). Mallards (*A. platyrhyhchos*) are closely-related to black ducks and environmental and landscape change, as well as mallard releases by people in eastern North America reduced barriers and increased interactions between these sister taxa. (Mank et al. 2004, Lavretsky 2014). In the early 1900s, mallards were rare in eastern New York and only occurred as a transient in the rest of the state (Eaton 1910, Heusmann 1991). Soon thereafter, mallard range expansion into historic range of black ducks began in part with habitat fragmentation, deforestation, and captive-reared mallard releases (Heusmann 1974). Concurrent with the black duck decline, game-farm mallards of European origin were released in abundance in the United States (Heusmann 1991, USFWS 2002). In New York, no breeding mallards were detected in a statewide survey in the 1920s (Saunders 1926), they were rare breeders of feral stock in the 1930s (Spiker 1935, Hyde 1939), but by the early 1960s they were recorded breeding in every county of the state (Foley et al. 1961). Research has been conducted on comparing diets, habitat use, and behaviors in black ducks and mallards during the breeding season to understand competition for resources between these species and resulting population dynamics between these species (Johnsgard 1960, Merendino and Ankney 1994, Hoysack and Ankney 1996, Barboza and Jorde 2018). Despite research conducted during the breeding season and that the non-breeding period can affect black duck and mallard population dynamics, little research has been conducted on wintering areas where they are sympatric (Nichols et al. 1987, Conroy et al. 1989, English et al. 2017).
Influences of Landscape Change on Black Duck and Mallard Abundance in the Atlantic Flyway

The Atlantic coast historically had 24 million ha of wetlands, but between 1780 and 1980 wetlands in this region declined by 41%, with a 50% decline worldwide (Dahl 1990, Davidson 2014). As human encroachment and urban development increased, coastal wetlands and freshwater wetlands declined substantially, resulting in less wetland area and food availability for black ducks that rely on these resources to survive and reproduce (Cramer et al. 2012). Forested wetlands of the interior Atlantic flyway are often selected by black ducks for breeding, whereas mallards are generalists, that also nest in various habitats (e.g., grasslands; Baldassarre 2014). Forest fragmentation favored expansion of mallards in eastern North America where black ducks and mallards now compete for resources (Heusmann 1974, Heusmann 1991, USFWS 2003, Harrigan 2006, Bleau 2018). Mallards are now the most common breeding duck in New York and throughout much of the northeast United States; they also occupy much of the available freshwater resources during winter (Heusmann 1974, Heusmann 1991, USFWS 2017). With interior wetlands primarily dominated by mallards, black ducks rely on coastal wetlands during winter to segregate from mallards (Heusmann 1991, English et al. 2017). Loss of interior wetlands to mallards and coastal wetlands to development and degradation may be problematic for black ducks because remaining coastal wetlands are a less energy-dense environment than those available to dabbling ducks elsewhere. Thus, black ducks may be required a greater proportion of the day for foraging and more area of habitat per individual during winter (Plattner et al. 2010). As such, availability of wintering habitat and associated foods may be limiting to the black duck population (Cramer et al. 2012). Coastal wetlands are used as foraging sites by black
ducks due to their reliable food sources, but during prolonged freeze events when these sites become unavailable, black ducks have experienced substantial mortality (Conroy et al. 1989).

**Role of Agricultural Grain on Energy Acquisition by Wintering Black Ducks**

Waterfowl feed on agricultural grains left in fields following harvest (i.e., waste grain) and this food resource may increase carrying capacity for black ducks on the Atlantic coast, but how foraging in this habitat type relative to coastal wetlands influences diets, body condition, and stress during winter is unknown. Moreover, mallards, a resource competitor with black ducks (Merendino and Ankney 1994), may benefit from feeding on waste grain to a greater degree than black ducks because they may be better adapted to landscape change to agriculture and human development (Ankney et al. 1987, Baldassarre 2014, Bleau 2018, Droke 2018). Mallards also appear to display dominant behavior when competing with other waterfowl for resources and may influence the decline of black ducks in the at the Atlantic coast (Hoysack and Ankney 1996). Dominant waterfowl may display aggressive behavior and exploit available resources and this effect may be exacerbated by harsh winter weather (Hepp and Hair 1984, Alexander 1987). Dominant species or individuals at wintering areas would have access to reliable, high-quality, energy-dense food, and may more efficiently store nutrients for winter survival (Hoysak and Ankney 1996). Agricultural fields can be energy dense foraging sites allowing black ducks to take less time to meet their energy needs compared to natural foraging areas (Quinlan and Baldassarre 1984), but how they use these locations and benefit relative to mallards is unknown.

Waterfowl populations can be limited by the quality of wintering habitat due to carry-over effects (Sedinger et al. 2011, Cramer et al. 2012, Sedinger and Alisauskas 2014). Carry-over effects are events of one season that can affect survival and reproduction in subsequent
seasons. In ducks, initiation of spring migration is influenced by weather, but also a threshold of lipid reserves necessary to cause migratory restlessness (Newton 2006). Lipids are used to fuel migration to breeding areas and, in some species, as endogenous reserves to acquire nutrients for egg production (Sedinger and Flint 1991, Baldassarre and Bolen 2006, Stafford et al. 2014). As such, if mallards exploit agricultural fields to a greater degree and complete winter with greater lipid reserves than black ducks it may serve as a precursor to successful migration and reproduction, possibly at the expense of black duck productivity because nesting habitat overlaps (Petrie et al. 2012).

Lipids are the primary form of energy storage in birds, are typically strongly correlated with body mass during winter in waterfowl, and are considered an index of body condition (Owen and Cook 2009). Although lipid reserves play an important role in winter survival, the amount of lipid reserves and its relation to body condition can be affected by endogenous mechanisms and environmental conditions (Baldassarre and Bolen 2006). The primary pattern in waterfowl is for lipids to decline throughout winter, even when food resources are available (Baldassarre et al. 1986). As such, an endogenous mechanism is thought to be adaptive, whereby waterfowl familiar with foraging sites where food is predictable, mobilize lipid stores acquired during autumn and early-winter throughout the remainder of winter rather than expose themselves to potential risk by attempting to maintain lipids (Whyte et al. 1986). Further, the likelihood of starvation declines as spring approaches, so maintaining large lipid stores throughout winter is not adaptive. Overall, lipid declines in waterfowl during winter are considered an adaptation to, rather than a consequence, of environmental conditions (Baldassarre and Bolen 2006). In accordance, while it may appear intuitive that agricultural grains would increase body condition (i.e., lipid stores) and decrease seasonal stress, these highly available,
predictable and energy-rich foods may result in less storage of lipids relative to black ducks foraging in coastal wetlands where the energy density of foods is less and ice conditions can make food unavailable. Alternatively, agricultural fields and nearby freshwater wetlands are likely subject to greater snow and ice cover, respectively, than coastal wetlands that are saline and experience daily tides. As such, concurrently determining diet, body condition, and stress indices helps determine if drivers of seasonal patterns of body mass are endogenous or exogenous and to what extent agricultural grains (i.e., corn) are beneficial to black ducks and mallards during winter.

**History of Waterfowl Habitat and Abundance on Long Island, New York**

Long Island, New York is a traditional wintering area for black ducks (Johnsgard 1961, Baldassarre 2014), with an extensive history of waterfowl hunting and commercial domestic duck farming (C. Kessler, Long Island Wildfowl Heritage Group, personal communication). Long Island has not had the traditional grain crop agricultural landscapes available to waterfowl in other regions along the Atlantic flyway. However, practices on private waterfowl hunting clubs in concert with those of the commercial duck farming industry, traditionally attracted black ducks to Long Island. Approximately 20,000 black ducks wintered annually on the estimated 6,880 ha influenced by these two activities (C. Kessler, Long Island Wildfowl Heritage Group, personal communication). Since the 1970s, hunt clubs, duck farms, and the abundance of wintering black ducks have decreased substantially and during this time, interest and overall participation in waterfowl hunting on Long Island decreased (Steiner 1984, C. Kessler and S. Sandford, Long Island Wildfowl Heritage Group, personal communication). In effort to combat loss of foraging habitat an experimental corn chopping program was established in 2018 to add
foraging sites to the landscape during winter with the objectives of increasing carrying capacity of wintering black ducks on Long Island.

**Thesis Goal and Objectives**

My goal was to evaluate effects of feeding on corn by black ducks and mallards wintering on Long Island, New York. I sampled fields that were experimentally manipulated by chopping standing corn to determine initial corn yield and corn depletion rates. At these same fields, I surveyed waterfowl and other wildlife use to determine relationships between corn depletion and waterfowl use. I also compared diets, body condition, and stress indices of black ducks using coastal wetlands where corn was not readily available to those using corn fields. I also collected similar data for mallards at corn sites, to compare with my results for black ducks. I used these metrics to infer if managing for corn as a winter food resource was beneficial to black ducks and mallards wintering on Long Island, New York.


**LITERATURE CITED**


U.S. Fish and Wildlife Service, Newton Corner, Massachusetts, USA.

CHAPTER 2: CORN DENSITY, WATERFOWL USE, AND DEPLETION AT CHOPPED CORN FIELDS DURING WINTER ON LONG ISLAND, NY

ABSTRACT

Decreased winter carrying capacity for waterfowl on the Atlantic coast from urbanization, coastal wetland loss, and other stressors may necessitate novel management options. On corn fields that were experimentally manipulated by chopping standing corn I sampled corn to determine initial yield and determined waterfowl and other wildlife use, corn depletion rates, and relationships between depletion and waterfowl use on Long Island, New York. Mean (± SE) initial yield for corn fields in 2018 and 2019 was 5,156.0 ± 1306.7 kg/ha. Mallards (Anas platyrhynchos) were 50% more abundant at corn sites than black ducks (A. rubripes). Canada geese (Branta canadensis) accounted for 54% of all waterfowl use. Corn depletion in kg and kcal per ha were best explained by depletion by waterfowl and blackbird use but there was 2,586.8 ± 548.7 (SE) kg/ha surplus of corn after winter. On average (± SE), 1.99 ± 0.51 ha less corn can be planted to meet daily energy needs of foraging waterfowl on eastern Long Island than was planted in our plots. However, 27% of chopped sections were depleted to zero or near zero during the first two weeks of sampling, whereas sections chopped in the last two weeks of sampling had 1,954.9 ± 1,309.9 kg/ha of corn remaining. Chopping should be adjusted to provide 0.5 ha more corn earlier in winter and less as spring approaches to meet daily energy needs of waterfowl. Waterfowl using corn sites could potentially gain an advantage by storing greater lipid reserves, initiating spring migration sooner, and acquiring higher quality breeding territories, but a better understanding of diets, body condition, and seasonal stress is needed. Due to the abundance of Canada goose use, determining if these geese are from the temperate nesting (i.e., a nuisance) or North Atlantic population should also be explored.
Waterfowl typically gain mass, which is mostly lipids, during autumn migration and staging when resources are available and then mobilize lipids towards spring. It is advantageous to sustain less body mass when food resources are predictable and decrease energy expenditure during non-foraging activities (i.e., flight and predator avoidance; Baldassarre and Bolen 2006). However, during cold and snow events waterfowl will increase food intake to curtail declines in nutrient reserves and thermoregulate, but under the most extreme conditions, resting becomes the best strategy when the cost of foraging is greater than intake (Prinzinger 1991, Batt et al. 1992, Poulton et al. 2002). As spring approaches, waterfowl eat foods beyond daily energy needs and store lipids and other nutrients in preparation for spring migration and breeding (Heitmeyer 1988, LaGrange and Dinsmore 1988, Newton 2006). This period of hyperphagia, or rapid lipid storage, is a critical period when food resources can limit migration and future productivity (Alisauskas and Ankney 1992a, Arzel et al. 2006, Anteau and Afton 2009). As such, food resources during the non-breeding period can be limiting to waterfowl due to immediate effects on survival (Trautman et al. 1939, Conroy et al. 1989) and carry-over effects (COEs) that can influence reproduction and survival in the following seasons (Whyte et al. 1986, Sedinger et al. 2011, Sedinger and Alisauskas 2014). Spring migration is heavily influenced by lipid reserves because with greater lipid reserves waterfowl pair and initiate spring migration sooner (Newton 2006). American black ducks (Anas rubripes; hereon black ducks) and mallards (A. platyrhynchos) use a mix of endogenous and exogenous mechanisms to regulate body lipids throughout their life cycle. They use endogenous lipid reserves to fuel migration, egg laying, and
to acquire exogenous protein for egg production once a breeding territory is established (Sedinger and Flint 1991, Baldassarre and Bolen 2006, Stafford et al. 2014). Overall, lipid reserves are often acquired by consuming carbohydrate dense foods and play a primary role in survival and reproduction in black ducks and mallards.

Conversion of wetlands and uplands to agriculture and human residences decreased the availability of traditional waterfowl habitats and foods in North America (Dahl 1990, Johnston 1994). However, granivorous waterfowl changed their foraging strategies to exploit grain resources left in fields following harvest (i.e., waste corn) (Bossenmaier and Marshall 1958, Baldassarre and Bolen 2006). Waste corn is an energy and carbohydrate dense food that granivorous waterfowl exploit during the non-breeding period to meet energetic requirements for migration and survival (Martin et al. 1951, Bellrose 1976, Alisauskas and Ankney 1992b, Petrie et al. 2002, Manley et al. 2004). Feeding in agricultural fields may be of increasing importance for granivorous waterfowl during winter because of declines in wetlands and associated seed and tuber resources (Baldassarre and Bolen 1984). During winter, waterfowl often make morning and evening flights to agriculture fields with a greater concentration of evening flights (Baldassarre and Bolen 1983, Baldassarre and Bolen 1984). Where it is available, energy-dense foods such as corn can allow for shorter foraging times by waterfowl. However, corn should not be considered a replacement for natural foods, rather it should be considered beneficial as a supplement for waterfowl (Baldassarre and Bolen 1983) because, while energy-dense, waste corn is nutritionally incomplete (Dabbert et al. 1996).

Increased area in row crop agriculture greatly increased the availability of waste grain to non-breeding waterfowl in North America during the mid-1900s (Bossenmaier and Marshall 1958, Petrie et al 2002, Schummer et al. 2011). However, harvester efficiency has increased,
leading to a decrease in available waste corn in fields (Krapu et al. 2004, Barney 2008, Foster et al. 2010). Decreased waste corn has implications for waterfowl because there is a lower bound to foraging efficiency whereby the density of food makes it more profitable to feed elsewhere than remain at a location and search for food (i.e., giving-up density or GUD) (Foster et al. 2010). For corn, GUD was conservatively approximated as 50 kg/ha for waterfowl using fields in Tennessee (Foster et al. 2010), and 20 kg/ha for field feeding mallards in Texas (Baldassarre and Bolen 1984). Further, Baldassarre and Bolen (1984) detected that fields needed at least 60 kg/ha for mallards to initiate feeding. In southern Ontario, Barney (2008) estimated that up to one third harvested corn fields were below the 60 kg/ha threshold at the beginning of autumn migration and by spring up to 74% were below the 20 kg/ha GUD. The combination of decreased availability of wetlands, associated foods, and declines in available waste corn may necessitate novel management options to meet the foraging needs of North American waterfowl.

An estimated 50% of world wetlands have been drained or filled since 1900 and the losses of inland wetlands have occurred at a faster rate than coastal wetlands (Davidson 2014). Between the 1950s and 1970s wetlands were being altered at a rapid pace before regulations to slow human development and encroachment, particularly along the Atlantic coast in major urban areas (Gooselink and Baumann 1980). Along the Atlantic coast, urbanization and sea level rise has led to a decrease in quantity and quality of coastal wetlands important for wintering waterfowl. New York has experienced landscape scale reductions in availability of interior forested wetlands for black ducks, which are used during migration (USDA 2012, Bleau 2018) and in coastal wetlands which are important wintering areas for black ducks (BDJV 2008).

Much of the Atlantic coast has an abundance of row crop agriculture accessible to non-breeding waterfowl, but these resources on Long Island are limited to the north and south forks
because of urbanization on the west end of the island. Black ducks forage extensively in coastal wetlands (Plattner et al. 2010) and thus, wintering habitats may now be a limiting factor for black ducks (Cramer et al. 2012) and corn fields may increasingly serve as a food source. In contrast to coastal wetlands, corn sites are energy-dense and may require less foraging time (Quinlan and Baldassarre 1984). However, mallards are often a competitor for resources with black ducks (Merendino and Ankney 1994, Hoysak and Ankney 1996) and may better exploit corn sites than black ducks (Ankney et al. 1987, Drilling 2002, Baldassarre 2014, Bleau 2018, Droke 2018).

There has been little research to determine relative use of corn fields by black ducks and mallards where they are sympatric (English et al. 2017).

National Wildlife Refuges, state wildlife areas, and private landowners plant corn to provide supplemental food resources to waterfowl during the non-breeding period, but few assessments exist to efficiently deliver these planting programs. Further, these fields are typically harvested using normal practices, and likely do not provide an abundance of waste corn because of harvester efficiency and corn that is not flooded, and left standing, is not readily available on the ground. Chopping standing corn after the regular waterfowl season (i.e., January) is an alternative method that may provide substantial food resources to granivorous waterfowl.

My goal was to determine initial corn yield, corn depletion rates, and relationships between corn depletion and waterfowl use. My focus was on black ducks because they are a species of special concern and capacity to restore coastal wetlands used during winter, is limited relative to freshwater wetlands used by mallards and Canada geese (Branta canadensis), especially on Long Island.
STUDY AREA

My study took place in corn fields in Suffolk County, Long Island, New York, 7 February – 4 April 2018 and 7 February – 10 April 2019 (Fig. 2.1). Suffolk County contains coastal wetlands, freshwater ponds, and rural landscapes where corn fields are available to wintering waterfowl. I sampled initial corn yield and surveyed waterfowl at two corn fields in 2018 (Cutchogue [41.023° N, -72.511° W] and Orient Point [41.141° N, -72.278° W]) and included another corn field in 2019 (Brookhaven [40.798° N, -72.891° W]).

METHODS

Estimating Corn Yield

I divided corn fields into three sections, marked with flagging, to identify them from a distance. The mean (± SE) corn field size was 4.08 ± 0.20 ha (Cutchogue = 3.99 ha, [0.87 ha, 1.33 ha, and 1.79 ha sections]; Orient = 4.47 ha, [1.46 ha, 1.46 ha, and 1.55 ha sections]; Brookhaven = 3.78 ha, [1.26 ha, 1.26 ha, and 1.26 ha sections]).

I sampled corn fields to obtain an index of corn availability and corn depletion rates following Barney (2008). One section in each field was chopped with a brush-hog every 2 weeks until all three sections in a field were chopped. I sampled field sections once the day before chopping and thereafter once every two weeks in 2018 and weekly in 2019. I adjusted to sampling weekly in 2019 because some sections were depleted to zero or near zero kg/ha in < 2 weeks during 2018. I used a random sampling design to distribute samples throughout the field. I established 3 main transects perpendicular to the field edge in each section of a field (evenly spaced 20-26 m apart). Each sampling period, I used a random number generator to select sampling points along each main transect. The same number of samples were taken along each main transect (n = 4; n = 12 per section). I used a random number generator to determine the left
or right direction of samples to be taken off of the main transect along a perpendicular transect. I then used a random number generator to determine the distance of the sampling point along the perpendicular transect (between 1 – 10 m). I sampled corn using a 1 m × 1 m quadrat at each sampling point and all corn within each quadrat was collected and placed in marked plastic bags. All individual kernels, cobs, and partial cobs were included in the sample and frozen within 4 hrs of sampling. In the lab, I thawed the corn, removed kernels from cobs, and dried samples of individual kernels at 60°C until a constant mass at 48 hrs and weighed them to ± 0.1 g (Baldassarre et al. 1983).

**Waterfowl Counts**

I conducted daily waterfowl use surveys at each field 8 February – 3 April 2018 and 8 February – 9 April 2019. I conducted morning and evening surveys switching the time of survey at each field weekly. Morning surveys were conducted 30 min before to 2 hrs after sunrise. Evening surveys were conducted 2 hrs before to 30 mins after sunset. In order to survey two fields on the same day, one field was surveyed in the morning and another field in the evening following weekly protocol for switching survey times. Each field was surveyed 3 times a week. Observation points were adjusted accordingly to maximize clear line of site when each section was chopped. Waterfowl flew into and landed in fields during my sunrise and sunset surveys. At times, Canada geese were in fields when I arrived to start my counts. This scenario reduced error in counting and identifying waterfowl to species, so I assumed 100% detection rate. For each field section, I recorded the total number of waterfowl, species composition, and other wildlife use which included blackbirds (*Icteridae* spp.), white-tailed deer (*Odocoileus virginianus*), and wild turkeys (*Meleagris gallopavo*) for each field (Barney 2008).
Analysis

I applied analysis of variance to determine if initial corn yield (kg), prior to chopping, was influenced by field and year. I nested section in field as a random variable. I calculated mean (± SE) initial corn yield for each field section prior to chopping. I estimated total corn (dry mass) available (kg and kcal) for each field in 2018 and 2019. I was unable to compute GUD comparable to other studies because additional corn was made available once every two weeks by chopping and corn remained in fields even after winter when waterfowl began to leave my study area. However, I calculated and report mean (± SE) kg/ha of corn remaining for sections that were abandoned and not used again.

I calculated waterfowl and blackbird use days (WUD and BBUD, respectively) by adding their daily abundances and total bird use days (BUD) by adding WUD and BBUD. To determine waterfowl energy needs (WEN), I multiplied use days for each species by the daily energy requirement (DER) for black ducks and mallards (356.84 kcal/day), Canada geese (871.89 kcal/day) and mean DER for other waterfowl use (OWU; Northern pintail, [Anas acuta], gadwall [Mareca strepera], American green-winged teal [Anas carolinensis], and wood ducks [Aix sponsa]; 244.74 kcal/day) observed in the surveys (Soulliere et al. 2017). I calculated blackbird energy needs (BBEN) by multiplying BBUD by their DER (24.8 kcal/day; Brenner 1966) and added WEN and BBEN to obtain total bird energy needs (BEN). I also calculated mean percent species composition of corn fields among Canada geese, mallards, black ducks, and OWU during my study.

I used linear mixed models to determine relative support for models predicting depletion in kg/ha and kcal/ha (in millions) between two sampling periods. I compared the competing models of WUD, WEN, BUD, and BEN. I expected that WUD and WEN and BEN would not
scale 1:1 because of differences among surveys in species composition and, thus energy needs. I included blackbirds into waterfowl models to determine if it produced more parsimonious models. I included year as a fixed effect and sampling week as a repeated measure with the experimental unit as field × section. I calculated Akaike’s information criterion (ΔAIC) for all models (Burnham and Anderson 2002). I designated depletion in kg and depletion in kcals (in millions) as my response variables. I calculated depletion in kcals by multiplying by 1,000 to convert corn in kg to g and then multiplying the result by the true metabolizable energy of corn (3.67 kcal/g; Gray et al. 2013). I used ΔAIC and AIC weights to assess the relative support for linear effects of field and year in explaining variation in WUD, WEN, BUD, and BEN (PROC Mixed, SAS Institute 2009). I considered models ≤ 2.0 ΔAIC units from top models (Burnham and Anderson 2002).

RESULTS

I did not detect an effect of year (P < 0.10) on initial corn yield and some evidence that initial corn yield differed by field (F2, 9 = 4.64, P = 0.04). Therefore, I calculated mean (± SE) initial corn yield (kg/ha) for each field (Cutchogue = 7,750.8 ± 1089.5 kg/ha; Orient = 3,588.9 ± 836.8 kg/ha; Brookhaven = 4,126.4 ± 1730.1 kg/ha), and combined fields (5,156.0 ± 1,306.7 kg/ha) (Fig. 2.2). I also calculated mean (± SE) initial energy yield from corn (kcals/ha) for each field by multiplying kg/ha by the true metabolizable energy of corn (3,670 kcal/kg; 3.67 kcal/g [Gray et al. 2013]; Cutchogue = 28.4 ± 4.0 million kcals/ha; Orient = 13.2 ± 3.1 million kcals/ha; Brookhaven = 15.1 ± 6.3 million kcals/ha), and combined fields (18.9 ± 4.8 million kcals/ha) (Fig. 2.2).

Mean (± SE) kg/ha of corn remaining for sections that were abandoned and not used again was 266.4 ± 220.3 kg/ha (range 0 – 1,825.1 kg/ha; median = 0.9 kg/ha). Early in winter,
the first sections chopped were reduced to 0 kg/ha and abandoned within 2 – 4 weeks at 3 of 5 fields among years, whereas none of the second and third sections chopped were reduced to 0 kg/ha until 5 weeks after chopping, and most had corn available until the end of the study.

I calculated mean WUD, by species, and WEN for each field and combined fields during my study (Fig. 2.3). Waterfowl use occurred in 58% of my surveys. The mean percent WUD during my study was 54% Canada geese, 30% mallards, 15% black ducks, and 1% OWU. I also calculated 30% more black duck than mallard use at the Orient field. Other wildlife at my study fields included blackbirds, white-tailed deer, and wild turkeys. I detected black birds, white-tailed deer, and turkeys during 10, 16, and 1% of surveys, respectively. Mean abundance when they were present was 542, 8, and 19 for black birds, white-tailed deer, and turkey, respectively. Raccoons (*Procyon lotor*) are also common wildlife in the area but were not present during my surveys.

The best model describing depletion of corn weight (kg/ha) and energy (kcal/ha) between two sampling weeks was BUD (Table 2.1). However, variation explained did not differ from other models (Table 2.1) and including BBUD did not greatly improve model fit as the WUD model ΔAIC = 1.2 (kg) and 0.0 (kcal). The top model for kg of depletion estimated 0.24 ± 0.03 kg of corn was depleted for every bird use day (Table 2.2). I multiplied kg by 1,000 to convert to grams and then multiplied by the true metabolizable energy of corn (3.67; Gray et al. 2013) to convert to kcals which equaled 894.7 ± 95.02 kcal of depletion. Similarly, the top model estimated 895 ± 95 kcal of corn was depleted for every bird use day (Table 2.2). On average, energy (kcal) produced from corn fields exceeded waterfowl energy needs by 9.5 ± 2.0 (SE) million kcal/ha and I calculated mean (± SE) 1.99 ± 0.51 less ha per field could be planted to meet energy requirements of foraging waterfowl.
DISCUSSION

Initial yields of corn fields vary among regions and years. In my study, mean initial corn yield in February (5,156 ± 1,306 kg/ha) was 18% less than the 6,260 ± 590 kg/ha for December, but similar to January (5,539 ± 568 kg/ha) for Tennessee (Foster et al. 2010). Regional differences between mid-continent and coastal Long Island such as soil, day length, and climate may explain some variation. Further, animals feeding on corn from autumn to February likely reduced available grains prior to chopping at my study fields. There also was substantial variation among my study fields (minimum = 3,588.9 kg/ha, maximum = 7,750.8 kg/ha), which likely occurred because of differences in planting times, soil nutrient quality, and wildlife feeding on seeds prior to germination. My GUD estimate for corn was not comparable to other studies because additional corn was made available throughout my study, but it was 55% greater than those reported elsewhere (Gray et al. 2013). This greater GUD likely occurred because of the surplus of corn at chopped fields during my study, whereby birds abandoned sections that still contained corn to feed on newly chopped sections.

Corn depletion attributable to bird use days best described depletion of corn weight (kg) and energy (kcal) between sampling periods. Blackbirds added some support. For every bird use day an estimated 895 kcal of corn was depleted from corn fields. This is well above the BUD estimates if 100% of their diets were corn. Therefore, unaccounted variation could be from additional waterfowl feeding, blackbird feeding during the day, white-tailed deer, wild turkeys, and raccoons not seen during my surveys. For example, my surveys, took place morning and evening to capture the periods of greatest waterfowl use, but blackbirds tend to feed in relatively large flocks (e.g., > 1,000 birds) throughout the day. It is likely that blackbirds along with
nocturnal feeding by other wildlife accounts for the difference detected between depletion attributed to waterfowl energy needs and my estimates of corn depletion (Barney 2008).

Due to foraging behavior, I expect white-tailed deer and racoons more frequently ate corn at night, which I did not see in my surveys because they were conducted morning and evenings when waterfowl use was greatest. Common wildlife species can impact pre-harvest corn yield and subsequent depletion. However, little research has been conducted on the quantity of corn removed by each species and their effect on corn depletion rates (Brenner 1966, Blackwell and Dolbeer 2001, Teft et al. 2005). Thus, more research should be conducted to quantify the effect of wildlife use on initial corn yield and corn depletion rates because I estimated corn depletion was at least 33% greater than possible by waterfowl alone.

Despite the use of corn fields by other wildlife in addition to waterfowl, there was a mean (± SE) surplus of 9.5 ± 2.0 million kcal/ha (2,586.8 ± 548.7 kg/ha) of energy provided by corn fields. These data provide guidance on the application of corn chopping to supplement traditional food resources for waterfowl during late-winter after the close of the regular waterfowl season (e.g., January). Using a conservative GUD of 183,500 kcals/ha (50 kg/ha) and mean percent waterfowl use (Canada goose = 54%, mallard = 30%, black duck = 15%, and OWU = 1%) each field could have supported more waterfowl per ha over 75 days (Canada geese = 77/ha, mallards = 104/ha, black ducks = 52/ha, and other waterfowl = 5/ha). Over 105 days, each field could have supported an additional 55 Canada geese, 75 mallards, 37 black ducks, and 4 other waterfowl per ha.

Corn fields may increasingly serve as a food source for black ducks when coastal wetlands are limiting (Cramer et al. 2012) and can provide additional foraging opportunities for black ducks, but foraging in corn fields can also lead to increased encounters and interactions
with mallards that are potentially adapted to better exploit agriculture food sources (Heusmann 1991, Champagnon et al. 2010, Lavretsky 2014). The most common species I observed at corn sites were Canada geese, mallards, and black ducks. I also observed other waterfowl, but they only contributed to 1% of all waterfowl use. Canada geese were the most abundant waterfowl (54% of all waterfowl) and this could be problematic and exacerbate nuisance issue where these geese nest if they are from the Atlantic Coast temperate-nesting population of Canada Geese (TNP). However, if these Canada geese are from the North Atlantic population (NAP), which are much less abundant and more sensitive to recruitment of goslings into the adult population, there may be benefits to providing foraging in predictable, energy-dense corn. I estimated that mallards used corn sites to a greater degree (50% more) than black ducks. However, I also detected 30% greater use of a corn site by black ducks than mallards on the eastern most site in Orient, which could be a result of less urban development and greater abundance of coastal wetlands and saline environments in proximity to the site. Selecting sites in closer proximity to coastal wetlands may be advantageous and promote more black duck use compared to mallards. Corn sites that are further away from coastal wetlands were exploited to a greater degree by mallards and Canada geese which could limit benefits for black ducks in immediate and cross-seasonal survival.

Management Implications

As wetland habitats decrease in quantity and quality waterfowl may increasingly need to use agricultural sites during winter to meet DER. However, if the aim is to benefit black ducks and increase carrying capacity on Long Island, benefits of adding corn foraging sites to the landscape may be limited due to a greater exploitation by mallards and Canada geese. Due to the abundance of Canada goose use and population status of the NAP of Canada geese (Cotter et al.
2011), determining if the geese are of TNP or NAP should be explored. Energy provided by corn sites exceeded WEN and 1.99 ± 0.51 ha less corn per field can be planted to meet daily energy needs of foraging waterfowl on eastern Long Island. If chopping corn fields continue, I recommend chopping 0.5 ha more corn earlier in winter and less as spring approaches focusing on fields closer to coastal wetlands.

ACKNOWLEDGMENTS

The State University of New York College of Environmental Science and Forestry (SUNY ESF), The Long Island Wildfowl Heritage Group (LIWHG), The Moore Charitable Foundation, and Central New York Wildfowlers (CNY) for providing funding and project assistance. Jack Ramirez and Emily Marchini assisted with all aspects of the field season. Suffolk County Parks, Danny Latham, and Troy Muller for providing access to private lands to complete corn field surveys.

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Table 2.1. Mixed-effects models of corn depletion kg/ha and kcal/ha of fields sampled, February – April 2018 and 2019.

<table>
<thead>
<tr>
<th>Depletion</th>
<th>Model&lt;sup&gt;a&lt;/sup&gt;</th>
<th>K</th>
<th>Δ AIC&lt;sup&gt;c&lt;/sup&gt;</th>
<th>w&lt;sub&gt;i&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/ha</td>
<td>BUD</td>
<td>3</td>
<td>0.0</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>BEN</td>
<td>3</td>
<td>0.1</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>WEN</td>
<td>3</td>
<td>0.2</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>WUD</td>
<td>3</td>
<td>1.2</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Null</td>
<td>1</td>
<td>50.4</td>
<td>0.00</td>
</tr>
<tr>
<td>kcal/ha</td>
<td>BUD</td>
<td>3</td>
<td>0.0</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>WUD</td>
<td>3</td>
<td>0.0</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>BEN</td>
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<td>0.1</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>WEN</td>
<td>3</td>
<td>0.3</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Null</td>
<td>1</td>
<td>50.5</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<sup>a</sup>Models incorporated parameters of waterfowl energy needs (WEN kcal/period) if 100% of their diet was corn, waterfowl use days (WUD), total bird use days including black birds (BUD), and total bird energy needs including black birds (BEN).

<sup>b</sup>Models are sorted by AIC, and models with ΔAIC≤ 2.0 and null models are shown. The AIC values for the top models were 931.3 and 314.4 for weight and energy, respectively.
Table 2.2. Model parameter estimates (β) and standard errors derived from the top model, bird use days (BUD) predicting corn depletion in kg/ha and kcal/ha for fields (n = 2; 2018, n = 3; 2019) on Long Island, New York, February – April 2018 and 2019.

<table>
<thead>
<tr>
<th>Depletion</th>
<th>Parameter&lt;sup&gt;a&lt;/sup&gt;</th>
<th>β</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/ha</td>
<td>Intercept</td>
<td>312.87</td>
<td>171.03</td>
</tr>
<tr>
<td></td>
<td>All depletion</td>
<td>0.24</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Year (1)</td>
<td>173.82</td>
<td>382.62</td>
</tr>
<tr>
<td>kcal/ha</td>
<td>Intercept</td>
<td>1.15</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>All depletion</td>
<td>0.0009</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>Year (1)</td>
<td>0.64</td>
<td>1.40</td>
</tr>
</tbody>
</table>

<sup>a</sup>Parameters included all depletion in corn fields.
Figure 2.1. Map of Suffolk County, Long Island, New York showing corn sites (top to bottom, left to right: Brookhaven, Cutchogue, and Orient).
Figure 2.2. Mean initial corn yield (A; kg/ha, B; kcal/ha) (± SE) for corn fields in Cutchogue, Orient, Brookhaven, and combined fields in 2018 and 2019.
Figure 2.3. Mean waterfowl use days (A) and waterfowl energy needs (B) for corn fields in Cutchogue, Orient, Brookhaven, and combined fields in 2018 and 2019.
CHAPTER 3: DIETS, BODY CONDITION, AND SEASONAL STRESS IN AMERICAN BLACK DUCKS AND MALLARDS ON LONG ISLAND, NY DURING WINTER

ABSTRACT

Availability of winter habitat and forage for American black ducks (*Anas rubripes*; hereon black ducks) can be limiting. Increasing urbanization, sea level rise, and other stressors often make restoration of coastal wetlands infeasible or logistically difficult. Corn fields may need to increasingly serve as winter foraging sites for black ducks. I determined if diets, body condition, and stress indices of black ducks and mallards (*A. platyrhynchos*) differed between coastal and corn sites on Long Island, New York. I captured and sampled black ducks and mallards at corn sites (i.e., cornfields and traps with corn) and lethally collected black ducks in coastal wetlands. Mallards did not use coastal sites. Stable isotope analysis indicated that black ducks ate more animal matter (δ¹⁵N) and less corn (δ¹³C) at coastal than corn sites, whereas mallards and black ducks at corn sites had similar animal diets, but mallards ate more corn than black ducks. Body mass decreased in black ducks at coastal and corn sites, and increased in mallards at corn sites between January and March 2018 and 2019. Stress indices, packed red blood cell volume and heterophil/lymphocyte ratios, suggested less stress for black ducks using corn than coastal sites. Results suggest an endogenous mechanism for weight loss in black ducks during winter that differs from mallards. Black ducks appeared to benefit less from availability of corn than mallards. Continuing protection and restoration to increase quantity and quality of coastal wetlands with the aim to increase carrying capacity of black ducks should be the focus on Long Island and elsewhere where black ducks and mallards are sympatric.
American black ducks (*Anas rubripes*, hereon black duck) experienced an estimated 50% population decline throughout much of their range since the 1950s (Steiner 1984, USFWS 2013). The target goal is 640,000 breeding pairs of black ducks, and while the population has stabilized, the current 541,000 pair estimate it is still well below the goal (USFWS 2017). Reduced quantity and quality of forested wetland breeding habitat may limit black duck abundance, recruitment, and survival (Conroy et al. 2002). Although, black ducks also use forested wetlands of eastern North America during the non-breeding season, during winter they are most abundant on the Atlantic coast. Coastal wetland loss, fragmentation, and degradation affect habitat availability which is as limiting factors for the black duck population (Conroy et al. 2002).

In addition to loss of coastal wetlands, conversion of forested wetlands to other human uses, overharvest of black ducks, and competition and hybridization with mallards (*A. platyrhynchos*) have been hypothesized as contributors to population decline in black ducks (Ankney et al. 1987, Longcore et al. 1998, Mank et al. 2004, Maisonneuve et al. 2006). Forest fragmentation, which created greater open landscapes, likely encouraged mallard expansion eastward into areas historically occupied by black ducks. In addition, mallards are now the most common wintering duck in much of eastern North America because they naturally filled the prior breeding niche of black ducks as humans cleared forests and initiated large-scale agriculture (Crinigan 1960, Heusmann 1991, Harrigan 2006, USFWS 2017). Millions of domestic mallards of European genetic origin were also released directly into the breeding and wintering range of black ducks throughout the 1900s (Heusmann 1991, Harrigan 2006, Lavretsky 2014). Mallards
primarily use inland freshwater resources during winter (Drilling 2002, Davis 2014), but although black ducks use the same freshwater resources, they also use coastal wetlands (Plattner et al. 2010, Cramer et al. 2012). However, increasing human population and development of coastal wetlands has resulted in less habitat and subsequent food resources for wintering black ducks (Cramer et al. 2012). Specifically, food resources in coastal wetlands are generally less dense than inland freshwater wetlands where mallards feed, resulting in black ducks having to allocate a greater proportion of the day foraging and requiring more ha of habitat per individual (Plattner et al. 2010). Capacity to sustain nutrient reserves (e.g., lipids) affects survival within and among seasons and has cross-seasonal effects on reproduction (Dann et al. 1996, Sedinger and Alisauskas 2014, Alisauskas and DeVink 2015). Thus, availability of wintering habitat and associated foods represented in coastal wetlands appear limiting to the black duck population (Cramer et al. 2012).

Black ducks commonly use coastal wetlands during winter, but, where available also make feeding flights to corn fields where they eat energy-rich waste corn (i.e., corn kernels unintentionally left in the fields after harvest; Baldassarre and Bolen 1984, Delnicki and Reinecke 1986, Combs and Fredrickson 1996, Cramer et al. 2012). Mallards typically forage at inland freshwater sites, and similarly, make foraging flights to feed on waste corn. This behavior results in black ducks typically feeding without competition from mallards at coastal wetlands, whereas they encounter and feed alongside mallards at inland freshwater wetlands and corn sites. Stable isotopes can be used to differentiate and compare diets in waterfowl using coastal wetlands and corn fields where δ¹⁵N function as trophic level (animal matter) indicators while δ¹³C indicate plant matter (Fry 1988). While corn may provide supplemental foraging opportunities for black ducks it is unknown to what extent black ducks benefit from these
resources compared to mallards (a foraging and breeding season competitor). Understanding the
contribution of corn to black duck body condition and seasonal stress is important, especially
considering the decline in quantity and quality of coastal wetlands. Waste corn may increase
black duck wintering carrying capacity, but concurrently understanding how mallards may
benefit from this resource is also important.

Body condition describes the degree to which an organism’s physiological state
influences its performance in daily tasks and requirements (Brown 1996). In waterfowl, lipid
reserves are strongly related to body mass and are used as an index of body condition (Owen and
Cook 2009, Schummer et al. 2012). Endogenous and exogenous mechanisms can affect lipid
reserves of waterfowl that play critical roles in winter survival, migration, nesting propensity,
and clutch size (Krapu 1981, Whyte et al. 1986, Esler and Grand 1994, Baldassarre and Bolen
2006). Mallards and black ducks have a similar strategy of using a mix of endogenous and
exogenous mechanisms in winter, migration, and breeding (Reinecke et al. 1982, Hepp 1986,
Heitmeyer 1988). Lipids are used as energy for thermoregulation and daily activities in winter,
energy to fuel migration, and during the breeding season, as energy to obtain protein (i.e.,
invertebrates) necessary for egg production (Rohwer 1986, Alisauskas and Ankney 1992, Esler
and Grande 1994, Baldassarre and Bolen 2006). Thereafter, remaining lipids (endogenous) and
local carbohydrate rich food resources (exogenous) are used in clutch formation (Ankney et al.
1991, Alisauskas and Ankney 1992). Body condition, as indexed by body mass, and
corresponding lipid reserves are influenced by food availability and predictability (Baldassarre et
al. 1986, Whyte et al. 1986). When food is predictable, storing lipids is maladaptive because it
necessitates greater exposure during foraging and feeding flights, and decreases flight mobility
for predator avoidance (Batt et al. 1992). Overall, ducks foraging on energy dense foods that is
predictably available during winter tend to lose more weight (i.e., lipids) than those using sites with unpredictable food resources (Barboza and Jorde 2002).

In addition to body mass, several indices of stress can be useful in understanding how food availability and predictability affect animals during winter (Gross and Siegel 1983, Gross and Siegel 1986, Vleck et al. 2000). Animals face a variety of potential stressors throughout their life-cycle including weather severity, functional food availability, predators, injury, disease, competition, and social interactions (Vleck et al. 2000). While stress is well studied in a controlled environment (Broom and Johnson 1993), sampling and determining stress in the field on wild populations can be more difficult. Hematocrit levels or packed red blood cell volume (PCV), can be used as an index to stress as it compares the quantity of whole red blood cell volume to total blood volume (Vleck et al. 2000). Similarly, heterophil to lymphocyte (H/L) ratios in blood is also a common index used for stress (Gross and Seigel 1983). Heterophils are phagocytosing cells and are often the first line of defense against bacterial pathogens (Minias 2019). Lymphocytes produce immunoglobulins which recognize antigens from pathogen processing and have an important role in cell-mediated adaptive immunity and humoral adaptive immunity (Minias 2019). Elevated H/L ratios can be advantageous in response to injury and infection (Minias 2019). Food and water deprivation, extreme temperatures, light variability, and social interactions can elevate the number of heterophils which has an inverse relationship with lymphocytes (Gross and Siegel 1986, Gross 1989, McFarlane and Curtis 1989). Blood smears are used to determine H/L ratios, as well as, blood parasites, disease, and other abnormalities. In wintering waterfowl PCV and H/L ratios can provide greater insight into the relationships between habitat use, diets, and body condition on stress indices.
My goal was to determine and compare diets, body condition, and stress indices between black ducks using corn and coastal sites and I used the same response metrics to compare black ducks and mallards where they were sympatric at corn sites. I hypothesized that black ducks and mallards would lose body mass throughout winter despite foraging at corn sites because endogenous weight loss is adaptive. I predicted that black ducks using coastal wetlands would forage more on animal matter (i.e., $\delta^{15}$N) than plant matter (i.e., corn; $\delta^{13}$C) compared to those using corn sites, but these differences in foraging would not affect their body mass dynamics. However, relative to mallards, I predicted that black ducks would sustain less body mass throughout winter and have greater stress at corn sites because mallards exploit agricultural landscapes more than black ducks (Baldassarre and Bolen 1983, Ankney et al. 1987, Davis et al. 2014, English et al. 2017) and social interactions and competition with mallards would increase stress in black ducks. Further, most mallards in eastern North America are descendants of domestic mallards released by people and these ducks were artificially selected to feed on commercial pellets and whole grains for greater survival and quick growth in captivity (Heusmann 1991, Lavretsky 2014).

**STUDY AREA**

My study area was in Nassau and Suffolk County, Long Island, New York, 10 February – 28 March 2018 and 26 January – 30 March 2019. Nassau County contains coastal wetlands and freshwater ponds surrounded by residential homes for wintering black ducks while Suffolk County contains coastal wetlands, freshwater ponds, and rural landscapes where corn fields are available. I lethally collected black ducks at coastal wetlands in Nassau County (Toll Booth Pond [40.313° N, -73.5477° W], High Hill Pond [40.604° N, -73.497° W], and Meadow Island [40.602° N, -73.558° W]) (Fig. 3.1). I trapped black ducks and mallards in Suffolk County (New
Suffolk [41.627° N, -72.774° W], Cutchogue [41.023° N, -72.511° W], Brookhaven [40.798° N, -72.891° W], Flanders [40.906° N, -72.583° W], and Aquebogue [40.933° N, -72.611° W]) (Fig. 3.2). On average, corn fields were 91 km away from the lethal collection area in western Long Island coastal wetlands.

I conducted activities as per State University of New York College of Environmental Science and Forestry Animal Care Protocol #171201, United States Fish and Wildlife Service Scientific Collection Permit #23928, and New York State Department of Environmental Conservation Scientific Collection Permit #2323.

METHODS

Lethal Collection and Trapping


I aged each duck using guidelines from Ashley et al. (2006) as second year (birds hatched the year prior to capture) or after second year (birds hatched >2 years prior to capture) and sexed by cloacal examination and plumage (Carney 1992, Ashley et al. 2006). For each duck, I recorded body mass (± 1 g), tarsus length (± 0.02 mm), culmen length (± 0.02 mm), wing chord (± 1 mm), and head length (± 0.02 mm). For ducks at corn sites, I recorded an index of corn present in the esophagus and proventriculus (Conroy et al. 1989) to adjust body mass for corn ingested by ducks sampled at corn sites. I recorded the amount of corn as 0 to 3, (0 = no corn, 1 = 1/3 full, 2 = 1/2 full, and 3 = full). I estimated mean (± SE) corn wet weight for these indices using 30 samples each; 1 = 60 ml (42.65 g ± 0.29), 2 = 80 ml (57.06 g ± 0.26), and 3 = 120 ml
volumes (86.23 g ± 0.51), and subtracted the corresponding amount from the total mass to calculate adjusted mass. Black ducks at coastal sites never had corn in their esophagus and preventriculus.

I collected blood samples for stable isotope (δ\(^{13}\)C, and δ\(^{15}\)N), PCV, and H/L analysis. I used a 23-gauge needle to collect blood from trapped ducks by bleeding the metatarsal vein and from lethally collected ducks by cardiac puncture. I collected 2 – 3 ml of blood and allocated 1 ml into a sterile eppendorf tube for δ\(^{13}\)C and δ\(^{15}\)N analysis, filled a 70 µl capillary tube for PCV analysis, and a drop to make a blood smear for H/L ratio analysis. I froze stable isotope samples within 6 hours of collection and later shipped them, frozen, to the Cornell Stable Isotope Lab for analysis. Using clay sealant, a centrifuge at 12,000 RPM for 10 minutes, and a rotor cover (± 1%) (Owen 2011), I calculated PCV values.

**Diet Analysis**

I used δ\(^{13}\)C and δ\(^{15}\)N to compare diet compositions between treatments and species (English et al. 2017). At the Cornell Stable Isotope Lab, samples were combusted in an elemental analyzer, and gases were sent to the isotope-ratio mass spectrometer using a continuous flow interface. Data are reported as differences in isotopic ratios, for which the units are parts per thousand (or per mil; ‰), compared to Pee Dee Belemnite (PDB), for carbon, and atmospheric nitrogen (AIR), for nitrogen, according to the following equation: 

\[ \delta X = \left( \frac{R_{sample}}{R_{std}} - 1 \right) \times 1000, \]

where \( \delta X \) is the isotope of interest (either δ\(^{15}\)N or δ\(^{13}\)C, in ‰), R is the ratio of the abundance of the heavy to the light isotope (\(^{15}\)N/\(^{14}\)N or \(^{13}\)C/\(^{12}\)C), with \( R_{sample} \) being the ratio within the sample, and \( R_{std} \) the ratio of heavy to light isotope within the international standard (Hobson et al. 1995, English et al. 2017).
**Statistical Analysis**

I modeled diet, body mass, PCV and H/L ratios as a function of an index of body size (mass model only), treatment, species, date, year, and their interactions using a linear mixed model (PROC Mixed, SAS Institute 2009). To obtain the index of body mass, I conducted a Principal Components Analysis (PCA) of 4 morphological measurements (tarsus, culmen, head, and wing chord). I used an Information Theoretic approach to determine support for different model structions, based on Akaike’s information criterion (AIC) (Burnham and Anderson 2002). I controlled for sex × age and year as covariates in all models and PC1 for body mass. For each species, black ducks and mallards, I considered models ≤ 2.0 ΔAIC units from top models to have some support (Burnham and Anderson 2002). When competing models were ≤ 2.0 ΔAIC units from top models (Burnham and Anderson 2002) I model-averaged predicted values. The most complex model used for analysis was treatment × species × date × year, while controlling for sex × age and as a covariate and there were no random effects.

**RESULTS**

I sampled 52 black ducks from coastal sites and 170 black ducks and 61 mallards from corn sites. However, due to logistical issues of collecting samples in the field and lab processing, the number of samples used for δ\textsuperscript{13}C and δ\textsuperscript{15}N (black ducks n = 217 [2018 = 88, 2019 = 129]; mallards n = 61 [2018 = 14, 2019 = 47]), body mass (black ducks n = 222 [2018 = 92, 2019 = 130]; mallards n = 61 [2018 = 14, 2019 = 47]), PCV (black ducks n = 211 [2018 = 88, 2019 = 123]; mallards n = 61 [2018 = 14, 2019 = 47]), and H/L ratio (black ducks n = 64 [2018]) analysis varied.
Diet Analysis

The best model for $\delta^{13}$C was the interaction of species, treatment, date, and year (Table 3.1) and parameter estimates were calculated (Table 3.2). The next closest model was 2.5 AIC units away from the best model and model averaging was not needed. In 2018, black ducks $\delta^{13}$C was stable at corn sites (0.1% decrease) and decreased by 27.9% at coastal sites, whereas $\delta^{13}$C increased by 14.6% for mallards at corn sites (Fig. 3.3). In 2019, black ducks $\delta^{13}$C increased by 34.4% and 7.5% at corn and coastal sites, whereas $\delta^{13}$C increased by 48.8% for mallards at corn sites (Fig. 3.3).

The best model for $\delta^{15}$N included the interaction of species, treatment, and year (Table 3.1) and parameter estimates were calculated (Table 3.2). The next closest model was 2.6 AIC units away from the best model and model averaging was not needed. I calculated mean ($\pm$ SE) $\delta^{15}$N of black ducks using coastal sites (11.53 $\pm$ 0.45; 2018, 11.35 $\pm$ 0.40; 2019), black ducks at corn sites (8.58 $\pm$ 0.24; 2018, 9.32 $\pm$ 0.23; 2019), and mallards at corn sites (7.70 $\pm$ 0.49; 2018, 8.12 $\pm$ 0.35; 2019) (Fig. 3.4).

Body Mass

Principal Component 1 explained 64% and 74% of the variation in body size in black ducks and mallards. The best model included the interaction of species, treatment, date, and year (Table 3.1) and parameter estimates were calculated (Table 3.2). The next closest model was 5 AIC units away from the best model and model averaging was not needed. Mass decreased in black ducks by 4.8% (2018) and 2.0% (2019) at corn sites and by 4.5% (2018) and 9.5% (2019) at coastal sites, whereas body mass for mallards increased by 7.6% (2018) and 1.0% (2019) at corn sites during winter (Fig. 3.5).
Stress Indices

The best model for PCV included interactions among species, treatment, and year with an additive effect of date (Table 3.1). I applied model averaging because the next closest model (interactions of species, treatment, sex, age, and year) was 1.4 AIC units away from the best model. Parameter estimates were calculated (Table 3.2). I calculated mean (± SE) PCV of black ducks at coastal and corn sites and mallards at corn sites (Fig. 3.6). Black ducks and mallards at corn sites had greater mean PCV than black ducks at coastal sites.

The best model for H/L ratios included treatment (Table 3.1). I applied model averaging because the next closest model (interactions of treatment, sex, age, and date) was 1 AIC unit away from the best model. Parameter estimates were calculated (Table 3.2). In 2018, the H/L ratio in black ducks using corn sites increased by 132.4% while black ducks in coastal sites increased by 1868.1% from February to March in 2018 (Fig. 3.7). I did not produce H/L ratios in 2019 due to logistical issues.

DISCUSSION

Consistent with prior research (English et al. 2017, Barboza and Jorde 2018), I detected that black ducks using coastal wetlands are likely consuming more animal foods during winter than mallards (i.e., greater δ15N signatures in blood). During lethal collection of black ducks on coastal wetlands, mallards were absent, suggesting habitat use differences between these closely related species. Black ducks and mallards foraging in corn fields may meet daily energetic demands in a shorter period of time than those foraging in coastal wetlands on Long Island (Baldassarre and Bolen 1984, Brodsky and Weatherhead 1984, Kross et al. 2008, Plattner et al. 2010). However, differences in isotopic signatures suggest that mallards use energy-dense corn sites more than black ducks. Also, densities of mallards feeding in corn fields in my study area
were, on average, 50% greater than black ducks (Chapter 2). Mallards tend to use freshwater wetlands and corn fields, whereas black ducks also use coastal wetlands on Long Island (Plattner et al. 2010, English et al. 2017). Coastal wetlands remain one of the rare ecosystems where black ducks can forage free of competition with mallards. Corn fields provide additional opportunities for black ducks to feed, but they also encounter and interact with mallards at these sites.

Consistent with differences in diet and similar to previous studies (Barboza and Jorde 2018), mallards gained or sustained mass throughout winter, whereas black duck mass declined or was stable during the same period, even where they were sympatric at corn sites. Although an endogenous mechanism is thought to control lipid reserves during winter in black ducks and mallards, my results suggest subtle differences in nutrient storage and mobilization strategies during winter between these closely-related species. Trends in body mass were different between years, but mallards were heavier at the end of winter when food resources are considered most limiting (Straub et al. 2012). Sustaining greater lipid reserves during winter, into spring, may give mallards a competitive advantage over black ducks by allowing them to initiate spring migration sooner and consequently to select and occupy higher quality breeding territories (Petrie et al. 2012). This advantage may lead to greater productivity because clutch size is related to lipid reserves in mallards (Krapu 1981).

Differences in body mass dynamics during winter between black ducks and mallards may result from differences in predictability and energy density of food resources among landscapes. Food availability is more consistent in coastal than freshwater wetlands (Plattner et al. 2010) and coastal wetlands are less likely to be affected by ice and snow events that can make foods less predictable in freshwater wetlands and corn fields (Schummer et al. 2010). Food and energy density are typically less in coastal wetlands than freshwater wetlands and corn fields, but these
resources are also more consistently available because daily tides can refresh animal foods in coastal wetlands (Albright et al. 1983, Jorde 1986). When food is predictable, but at relatively low density (i.e., coastal wetlands), storing lipid reserves early in the non-breeding period and then mobilizing those reserves throughout winter would be adaptive (Baldassarre and Bolen 2006). However, when food resources are unpredictable, but abundant (i.e., freshwater wetlands and corn fields), the strategy may change towards storing lipid reserves throughout winter when possible. Body mass of black ducks declined at corn sites even though isotopic analysis suggested they increased corn consumption throughout winter and animal matter intake was less at corn than coastal sites. This pattern further suggests an underlying endogenous mechanism of lipid mobilization in black ducks, even when energy-dense, corn food resources are available and used. However, this pattern was not evident in mallards which maintained or increased body mass during winter. Overall, I think subtle differences in habitat use and forage strategies between black ducks and mallards during winter explain the differences detected in body mass dynamics.

Black ducks have a strategy of strong winter philopatry, whereby they do not leave wintering areas during severe cold and ice events and are subject to starvation (Albright et al. 1983, Morton et al. 1989b, Ringleman et al. 2015). This behavior may have evolved because black ducks use coastal wetlands that rarely freeze for extended periods and food resources were historically abundant and predictable (Stephens et al. 2007, Plattner et al. 2010). In contrast, mallards tend to move south when cold temperatures persist (Schummer et al. 2010) and may use a risk-aversion strategy of storing lipids as fuel for migration in-case of unpredictable weather. Mallards tend to be flexible in resource use during winter. Mallards migrate farther south during wetter and colder winters (Nichols et al. 1993) and individual mallards that survive winter at one
location may not return the following year (Krementz et al. 2012). Declines in quantity and quality of coastal wetlands and differences in body mass between black ducks and mallards using corn sites could provide a survival advantage to mallards over black ducks wintering at Long Island because of the subtle differences in feeding and body mass strategies I observed.

In my study, PCV was similar for black ducks and mallards using corn sites, but substantially less for black ducks using coastal sites, indicating that black ducks in coastal sites are experiencing stress (Vleck et al. 2000). For black ducks, I also detected that H/L ratios increased throughout winter, but were greater at corn than coastal sites. Corn sites provide a greater density of energy-rich foods than coastal wetlands, which may limit stress for ducks using such sites, because food is relatively more predictable. Although body mass declined at corn sites in black ducks, the relative predictability and abundance of corn was likely greater than food sources in coastal wetlands. Consistent access to food resources at corn sites may have decreased winter stress in black ducks, despite the recorded declines in body mass. Alternatively, lower lymphocytes (white-blood cells) at corn sites may make ducks more susceptible to disease because their immune system is less prepared. Also, if increased H/L ratios follow recent trends of glucocorticoid (Bonier et al. 2009), there may be a positive relationship with increased H/L ratios as spring migration and the breeding season nears.

Management Implications

If the goal is to positively influence the black duck population, I do not recommend adding supplemental corn throughout winter where mallards also occur. However, during prolonged freeze events when coastal food resources are functionally unavailable for >7 days it may be advantageous to temporarily provide supplemental corn to the landscape to reduce starvation risk in black ducks because black ducks have a strong winter philopatry compared to
mallards that will migrate further south in colder conditions. Black ducks using corn sites had greater PCV and H/L ratios than black ducks using coastal wetlands. However, black ducks used and appeared to benefit less from corn than mallards. Therefore, the focus should be on continued protection and restoration of coastal wetlands with the aim of increasing winter carrying capacity of black ducks.

ACKNOWLEDGMENTS
The State University of New York College of Environmental Science and Forestry (SUNY ESF), The Long Island Wildfowl Heritage Group (LIWHG), The Moore Charitable Foundation, and Central New York Wildfowlers (CNY) for providing funding and project assistance. Jack Ramirez and Emily Marchini assisted with all aspects of the field season. Dr. Gavin Hitchener for all your help, equipment, and time during my field seasons. Dr. Brian Leydet for coordination and H/L ratio analysis. Craig Kessler provided assistance with trapping and information about the study area. George Combs III provided equipment and helped lethally collect black ducks in coastal wetlands. Suffolk County Parks and Danny Latham for providing private land access. Troy Muller for providing private land access and a huge trapping effort that I could not have done without.

LITERATURE CITED


Harrigan, R. J. 2006. Global phylogeography of the mallard complex (genus *Anas*): speciation, hybridization, and lineage sorting, Boston University, Massachusetts, USA.


Table 3.1. Mixed-effects models of $\delta^{13}$C, $\delta^{15}$N, mass, PCV, and H/L ratios for American black ducks and mallards sampled during winter on Long Island, New York, January – March 2018 and 2019. Only models with $\Delta$AIC <2 and the null models are shown.

<table>
<thead>
<tr>
<th>Response</th>
<th>Model$^a$</th>
<th>K</th>
<th>$\Delta$ AIC$^c$</th>
<th>$w_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\delta^{13}$C</td>
<td>SPECIES $\times$ TREATMENT $\times$ SEX $\times$ AGE $\times$ DATE $\times$ YEAR</td>
<td>17</td>
<td>0.0</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>Null</td>
<td>1</td>
<td>124.4</td>
<td>0.00</td>
</tr>
<tr>
<td>$\delta^{15}$N</td>
<td>SPECIES $\times$ TREATMENT $\times$ SEX $\times$ AGE $\times$ YEAR</td>
<td>15</td>
<td>0.0</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Null</td>
<td>1</td>
<td>160.0</td>
<td>0.00</td>
</tr>
<tr>
<td>Mass</td>
<td>SPECIES $\times$ TREATMENT $\times$ SEX $\times$ AGE $\times$ DATE $\times$ YEAR $\times$ PC1</td>
<td>19</td>
<td>0.0</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Null</td>
<td>1</td>
<td>350.0</td>
<td>0.00</td>
</tr>
<tr>
<td>PCV</td>
<td>SPECIES $\times$ TREATMENT $\times$ SEX $\times$ AGE $\times$ YEAR DATE</td>
<td>16</td>
<td>0.0</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>SPECIES $\times$ TREATMENT $\times$ SEX $\times$ AGE $\times$ YEAR</td>
<td>15</td>
<td>1.4</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Null</td>
<td>1</td>
<td>232.6</td>
<td>0.00</td>
</tr>
<tr>
<td>H/L</td>
<td>TREATMENT $\times$ SEX $\times$ AGE</td>
<td>8</td>
<td>0.0</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>TREATMENT $\times$ SEX $\times$ AGE $\times$ DATE</td>
<td>9</td>
<td>1.0</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>Null</td>
<td>1</td>
<td>32.3</td>
<td>0.00</td>
</tr>
</tbody>
</table>

$^a$Models incorporated parameters of structural size (PC1), age, sex, American black duck or mallard (SPECIES), study date (DATE), sampling year (YEAR) and coastal or agriculture site (TREATMENT).

$^b$Models are sorted by AIC, and models with $\Delta$AIC ≤ 2.0 and null models are shown. The AIC values for the top models were 1260.0, 958.2, 3206.7, 1678.9 and 454.7 for $\delta^{13}$C, $\delta^{15}$N, mass, PCV and H/L, respectively.
Table 3.2. Parameter estimates ($\beta$), standard errors (SE), and 95% confidence intervals derived from candidate models (\Delta AIC \leq 2) of $\delta^{13}$C, $\delta^{15}$N, mass, PCV, and H/L ratios for American black ducks and mallards wintering on Long Island, New York, January – March 2018 and 2019.

<table>
<thead>
<tr>
<th>Response$^a$</th>
<th>Parameter</th>
<th>$\beta$</th>
<th>SE</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\delta^{13}$C</td>
<td>Intercept</td>
<td>-18.350</td>
<td>0.709</td>
<td>-19.747 to -16.953</td>
</tr>
<tr>
<td></td>
<td>MALL × date</td>
<td>0.125</td>
<td>0.030</td>
<td>0.066 to 0.184</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (F ASY)</td>
<td>-5.938</td>
<td>1.573</td>
<td>-9.036 to -2.841</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (F SY)</td>
<td>-6.468</td>
<td>1.366</td>
<td>-9.157 to -3.778</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (M ASY)</td>
<td>-5.975</td>
<td>1.326</td>
<td>-8.586 to -3.365</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (M SY)</td>
<td>-5.451</td>
<td>1.406</td>
<td>-8.220 to -2.682</td>
</tr>
<tr>
<td></td>
<td>ABDU × coastal × sex × age (F ASY)</td>
<td>4.106</td>
<td>1.090</td>
<td>1.960 to 6.253</td>
</tr>
<tr>
<td></td>
<td>ABDU × coastal × sex × age (F SY)</td>
<td>2.845</td>
<td>1.933</td>
<td>-0.963 to 6.653</td>
</tr>
<tr>
<td></td>
<td>ABDU × coastal × sex × age (M ASY)</td>
<td>3.719</td>
<td>0.961</td>
<td>1.826 to 5.611</td>
</tr>
<tr>
<td></td>
<td>ABDU × coastal × sex × age (M SY)</td>
<td>3.142</td>
<td>1.358</td>
<td>0.469 to 5.816</td>
</tr>
<tr>
<td></td>
<td>DATE × ABDU × coastal</td>
<td>-0.132</td>
<td>0.027</td>
<td>-0.184 to -0.079</td>
</tr>
<tr>
<td></td>
<td>sex × age (F ASY)</td>
<td>-1.455</td>
<td>0.545</td>
<td>-2.528 to -0.382</td>
</tr>
<tr>
<td></td>
<td>sex × age (F SY)</td>
<td>-0.562</td>
<td>0.557</td>
<td>-1.659 to 0.536</td>
</tr>
<tr>
<td></td>
<td>sex × age (M ASY)</td>
<td>-0.883</td>
<td>0.514</td>
<td>-1.895 to 0.129</td>
</tr>
<tr>
<td></td>
<td>date × year (1)</td>
<td>0.001</td>
<td>0.019</td>
<td>-0.037 to 0.039</td>
</tr>
<tr>
<td></td>
<td>date × year (2)</td>
<td>0.149</td>
<td>0.020</td>
<td>0.111 to 0.187</td>
</tr>
<tr>
<td></td>
<td>year (1)</td>
<td>2.763</td>
<td>0.938</td>
<td>0.917 to 4.610</td>
</tr>
<tr>
<td>$\delta^{15}$N</td>
<td>Intercept</td>
<td>9.0823</td>
<td>0.252</td>
<td>8.587 to 9.579</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (F ASY)</td>
<td>-0.968</td>
<td>0.547</td>
<td>-2.045 to 0.109</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (F SY)</td>
<td>-0.788</td>
<td>0.454</td>
<td>-1.682 to 0.107</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (M ASY)</td>
<td>-1.435</td>
<td>0.359</td>
<td>-2.142 to 0.727</td>
</tr>
<tr>
<td></td>
<td>MALL × sex × age (M SY)</td>
<td>-1.469</td>
<td>0.450</td>
<td>-2.355 to -0.584</td>
</tr>
<tr>
<td></td>
<td>MALL × year (1)</td>
<td>0.357</td>
<td>0.488</td>
<td>-0.604 to 1.317</td>
</tr>
<tr>
<td></td>
<td>ABDU × coastal × sex × age (F ASY)</td>
<td>1.662</td>
<td>0.469</td>
<td>0.739 to 2.585</td>
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<tr>
<td></td>
<td>ABDU × coastal × sex × age (F SY)</td>
<td>2.917</td>
<td>1.023</td>
<td>0.902 to 4.932</td>
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<tr>
<td></td>
<td>ABDU × coastal × sex × age (M ASY)</td>
<td>1.517</td>
<td>0.384</td>
<td>0.762 to 2.272</td>
</tr>
<tr>
<td>Term</td>
<td>Coefficient</td>
<td>Standard Error</td>
<td>95% Confidence Interval</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------------------------</td>
<td></td>
</tr>
<tr>
<td>ABDU × coastal × sex × age (M SY)</td>
<td>2.611</td>
<td>0.569</td>
<td>1.490 to 3.732</td>
<td></td>
</tr>
<tr>
<td>ABDU × coastal × year (1)</td>
<td>0.863</td>
<td>0.468</td>
<td>-0.058 to 1.784</td>
<td></td>
</tr>
<tr>
<td>sex × age (F ASY)</td>
<td>0.275</td>
<td>0.322</td>
<td>-0.358 to 0.908</td>
<td></td>
</tr>
<tr>
<td>sex × age (F SY)</td>
<td>-0.412</td>
<td>0.328</td>
<td>-1.057 to 0.234</td>
<td></td>
</tr>
<tr>
<td>sex × age (M ASY)</td>
<td>0.824</td>
<td>0.302</td>
<td>0.230 to 1.419</td>
<td></td>
</tr>
<tr>
<td>year (1)</td>
<td>-0.771</td>
<td>0.216</td>
<td>-1.197 to -0.346</td>
<td></td>
</tr>
<tr>
<td>Mass Intercept</td>
<td>1256.950</td>
<td>27.862</td>
<td>1202.060 to 1311.780</td>
<td></td>
</tr>
<tr>
<td>MALL × date × year (1)</td>
<td>2.154</td>
<td>1.134</td>
<td>-0.079 to 4.386</td>
<td></td>
</tr>
<tr>
<td>MALL × date × year (2)</td>
<td>4.607</td>
<td>1.407</td>
<td>1.836 to 7.378</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (F ASY)</td>
<td>-92.631</td>
<td>62.227</td>
<td>-215.160 to 29.895</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (F SY)</td>
<td>-59.819</td>
<td>55.337</td>
<td>-168.780 to 49.142</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (M ASY)</td>
<td>-52.188</td>
<td>56.017</td>
<td>-162.490 to 58.112</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (M SY)</td>
<td>-68.250</td>
<td>59.014</td>
<td>-184.450 to 47.951</td>
<td></td>
</tr>
<tr>
<td>ABDU × coastal × sex × age (F ASY)</td>
<td>-100.900</td>
<td>41.154</td>
<td>-181.940 to 19.871</td>
<td></td>
</tr>
<tr>
<td>ABDU × coastal × sex × age (F SY)</td>
<td>-89.159</td>
<td>73.532</td>
<td>-233.950 to 55.629</td>
<td></td>
</tr>
<tr>
<td>ABDU × coastal × sex × age (M ASY)</td>
<td>-79.659</td>
<td>37.266</td>
<td>-153.040 to -6.282</td>
<td></td>
</tr>
<tr>
<td>ABDU × coastal × sex × age (M SY)</td>
<td>-140.980</td>
<td>48.995</td>
<td>-201.450 to -8.504</td>
<td></td>
</tr>
<tr>
<td>date × ABDU × coastal × year (1)</td>
<td>-0.479</td>
<td>1.357</td>
<td>-3.150 to 2.193</td>
<td></td>
</tr>
<tr>
<td>date × ABDU × coastal × year (2)</td>
<td>3.613</td>
<td>1.032</td>
<td>1.582 to 5.645</td>
<td></td>
</tr>
<tr>
<td>sex × age (F ASY)</td>
<td>-40.321</td>
<td>23.198</td>
<td>-85.999 to 5.356</td>
<td></td>
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<tr>
<td>sex × age (F SY)</td>
<td>-69.912</td>
<td>23.840</td>
<td>-116.850 to 22.969</td>
<td></td>
</tr>
<tr>
<td>sex × age (M ASY)</td>
<td>27.323</td>
<td>19.627</td>
<td>-11.323 to 65.969</td>
<td></td>
</tr>
<tr>
<td>date × year (1)</td>
<td>-1.354</td>
<td>0.755</td>
<td>-2.840 to 0.132</td>
<td></td>
</tr>
<tr>
<td>date × year (2)</td>
<td>-4.110</td>
<td>0.808</td>
<td>-5.701 to -2.518</td>
<td></td>
</tr>
<tr>
<td>year (1)</td>
<td>-51.366</td>
<td>37.489</td>
<td>-125.180 to 22.451</td>
<td></td>
</tr>
<tr>
<td>PCV Intercept</td>
<td>50.715</td>
<td>1.266</td>
<td>48.223 to 53.207</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (F ASY)</td>
<td>0.473</td>
<td>2.324</td>
<td>-4.104 to 5.049</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (F SY)</td>
<td>-0.449</td>
<td>1.927</td>
<td>-4.242 to 3.345</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (M ASY)</td>
<td>-0.249</td>
<td>1.532</td>
<td>-3.266 to 2.768</td>
<td></td>
</tr>
<tr>
<td>MALL × sex × age (M SY)</td>
<td>1.034</td>
<td>1.930</td>
<td>-2.767 to 4.834</td>
<td></td>
</tr>
<tr>
<td>MALL × year (1)</td>
<td>-0.501</td>
<td>2.060</td>
<td>-4.558 to 3.555</td>
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<td>Estimate</td>
<td>Std. Error</td>
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<td>Upper 95%</td>
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<td>-7.446</td>
<td>2.101</td>
<td>-11.584</td>
<td>-3.308</td>
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<td>ABDU × coastal × sex × age (F SY)</td>
<td>-7.950</td>
<td>4.330</td>
<td>-16.476</td>
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<td>ABDU × coastal × sex × age (M ASY)</td>
<td>-15.505</td>
<td>1.697</td>
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<td>-12.162</td>
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<td>1.404</td>
<td>-1.409</td>
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<td>0.019</td>
<td>0.135</td>
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<tr>
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<td>ABDU × coastal × date</td>
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*a*Response-averaged parameter estimates are reported for $\delta^{13}$C, $\delta^{15}$N, mass, PCV and H/L ratios.

*b*Abbreviations: MALL = mallard; ABDU = American black duck; coastal = treatment; date = study date (January – March 2018 – 2019); ASY = After Second Year, SY = Second Year, M = Male, F = Female.
Figure 3.1. Lethal collection sites (top to bottom: Meadow Island, Toll Booth Pond, and High Hill Pond) on coastal wetlands in Nassau County, Long Island, New York 2018 and 2019.
Figure 3.2. Map of trap sites (left to right: Brookhaven, Flanders, Aquebogue, Cutchogue, and New Suffolk) in Suffolk County, Long Island, New York 2018 and 2019.
Figure 3.3. Mean $\delta^{13}C$ vs. date ($0 = 26$ January) for corn site ($n = 70$; 2018, $n = 99$; 2019) and coastal black ducks ($n = 18$; 2018, $n = 30$; 2019) and corn site mallards ($n = 14$; 2018, $n = 47$; 2019) sampled during January – March 2018 (A) and 2019 (B). Note, no coastal mallards were sampled.
Figure 3.4. Mean $\delta^{15}$N ratios for corn site ($n = 70; 2018, n = 99; 2019$) and coastal black ducks ($n = 18; 2018, n = 30; 2019$) and corn site mallards ($n = 14; 2018, n = 47; 2019$) sampled during January – March 2018 (A) and 2019 (B). Note, no coastal mallards were sampled. Standard error bars are shown.
Figure 3.5. Body mass (g) vs. date (0 = 26 January) for corn site (n = 70; 2018, n = 100; 2019) and coastal black ducks (n = 22; 2018, n = 30; 2019) and corn site mallards (n = 14; 2018, n = 47; 2019) sampled during January – March 2018 (A) and 2019 (B). Note, no coastal mallards were sampled.
Figure 3.6. Mean packed red blood cell volume (PCV) for corn site \((n = 70; 2018, n = 96; 2019)\) and coastal black ducks \((n = 18; 2018, n = 27; 2019)\) and corn site mallards \((n = 27; 2018, n = 47; 2019)\) sampled during January – March 2018 (A) and 2019 (B). Note, no coastal mallards were sampled. Standard error bars are shown.
Figure 3.7. Heterophil to lymphocyte ratios (H/L) vs. date (0 = 26 January), for corn site (n = 54) and coastal black ducks (n = 10) during January – March 2018 (A).
CHAPTER 4: CONCLUSIONS

I determined initial corn yield, waterfowl use, and relationships between waterfowl use and corn depletion in chopped fields in Long Island, New York. I did not detect an effect of field or year and only some evidence that yield differed by field. In my study, there was 50% greater use of chopped corn fields by mallards \( (Anas platyrhynchos) \) than American black ducks \( (A. rubripes; \) hereon black ducks), and Canada geese \( (Branta canadensis) \) accounted for 54% of all waterfowl use. Greater mallard use was expected because they are known to exploit corn sites more than black ducks \( (\text{Ankney et al. 1987, Drilling 2002, Baldassarre 2014, Bleau 2018, Droke 2018}) \), and in the northeast United States, most mallards are descendants of domestic mallards, of European origin selected for rapid growth by feeding on commercial pellets and whole grains \( (\text{Heusmann 1991, Champagnon et al. 2010, Lavretsky 2014}) \). Up to 300,000 domestic mallards are released annually in the Atlantic flyway \( (\text{USFWS 2003}) \). Waterfowl energetic needs and use best explained depletion of corn mass (kg) and energy (kcal) between sampling periods. Unaccounted variation could be attributed to additional waterfowl feeding, blackbirds, white-tailed deer, wild turkeys, and raccoons not captured in my surveys. Little research has been conducted to quantify the effects of wildlife on initial corn yield and corn depletion \( (\text{Blackwell and Dolbeer 2001, Tefft et al. 2005}) \), and determining such could provide insight for future management scenarios.

During winter, black ducks often use coastal wetlands, but, where available, make feeding flights to agricultural fields \( (\text{i.e., corn fields}) \) and eat energy-dense corn \( (\text{Baldassarre and Bolen 1984, Delnicki and Reinecke 1986, Combs and Fredrickson 1996, Cramer et al. 2012}) \). I predicted black ducks using coastal wetlands would have greater \( \delta^{15}N \) and less \( \delta^{13}C \) compared to black ducks using corn sites. Isotopic analysis indicated black ducks ate more animal matter
(δ¹⁵N) and less corn (δ¹³C) at coastal than corn sites, whereas mallards and black ducks at corn sites had similar animal diets, but mallards consumed more corn than black ducks. I also, predicted body mass of black ducks using corn sites would be greater than those using coastal wetlands, but less relative to mallards at corn sites. I predicted that black ducks would sustain less body mass throughout winter and have greater stress levels than mallards at corn sites. I found body mass decreased in black ducks at coastal and corn sites, and increased in mallards at corn sites. Results suggested less stress (PCV and H/L ratios) for black ducks using corn compared to coastal sites and PCV did not differ between black ducks and mallards at corn sites. Foraging on corn sites improved stress levels in black ducks, but due to greater exploitation by mallards, adding corn to the landscape may entail a detriment to black ducks. Mallards could potentially gain a competitive advantage by allowing them to initiate spring migration sooner resulting in high quality breeding territories (Petrie et al. 2012). Ducks in poorer condition at the end of winter have to quickly acquire fat reserves for spring migration, resulting in later arrival to the breeding areas and lower quality breeding territories (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987).

Coastal wetlands have decreased in quantity and quality and waterfowl, including black ducks, may need to increasingly use agricultural landscapes to meet daily energy demands. However, if the aim is to increase carrying capacity of wintering black ducks in Long Island, the focus should be to continue protection and restoration of coastal wetlands. Increased quantity of coastal wetlands will reduce resource competition with mallards that primarily use inland freshwater wetlands. However, black ducks also require inland freshwater resources during winter and reducing resource competition from mallards for these freshwater resources, may further increase black duck carrying capacity. In addition, understanding dynamics of black duck
breeding and wintering in freshwater forested wetlands may help determine causes of population decline and feasible population goals in a region where mallards have become the dominant duck species and historic black duck habitat is largely gone.

**Future Directions**

My study suggests black ducks foraging on corn have improved stress levels compared to black ducks in coastal wetlands. However, black ducks at corn sites still experienced decreased body mass throughout winter, whereas, mallard mass, and presumably lipids, increased. Storing lipids can be maladaptive when food is predictable due to increased exposure and energy expenditure in flight (Batt et al. 1992). Barboza and Jorde (2002) suggest ducks foraging on energy dense foods, that are predictable during winter, tend to lose weight. Subtle differences in foraging behavior between black ducks and mallards could explain these differences. However, further studies on carry-over effects (COEs) entering the breeding season for black ducks foraging on corn where mallards are sympatric may shed some light on the long-term consequences.

Canada geese accounted for 54% of waterfowl use on corn fields. The North Atlantic Population (NAP) of Canada geese was once the most abundant goose population in the northeast United States with nearly 1 million birds until the 1980s when they experienced a sharp decline (Hindman and Ferrigno 1990, Cotter et al. 2011). The decline prompted wildlife agencies to close hunting seasons and develop the “Action Plan for the NAP of Canada Geese” (Cotter et al. 2011). The NAP Canada geese has since recovered but understanding population ecology is important. Future research should be conducted to determine which population (TNP or NAP) I observed in chopped corn fields on eastern Long Island.

**LITERATURE CITED**


PERSONAL MISSION STATEMENT

My goal is to acquire a professional position in waterfowl, wetlands, and private land management to promote proper management and conservation where I may be a steward of the land while educating and preserving our natural resources for future generations.

EDUCATION

SUNY College of Environmental Science and Forestry, Syracuse, New York  Jan. 2018-May 2020
Master of Science: Fish and Wildlife Biology and Management  GPA: 3.92/4.00

Major: Range & Wildlife Management – GPA: 3.65/4.00
Minor: Biology

Del Mar College, Corpus Christi, Texas  Aug. 2011-May 2013
GPA: 3.90/4.00

WORK EXPERIENCE

SUNY College of Environmental Science and Forestry, Syracuse, New York  Jan. 2018-Current
Thesis Research and Teaching Assistantship:

- Conducting all aspects of field research including lethal collection, trapping, banding, blood sampling, fecal sampling, aging, sexing, taking various morphological measurements, corn density sampling, conducting ground duck surveys, evaluating hematocrit levels in blood, evaluating heterophil to lymphocyte ratios in blood via smears, and coordinating with volunteers, NY DEC, private land owners, technicians, and private beneficiaries. Thesis writing, running statistical analysis, and data interpretation (supervisor: Dr. Michael Schummer).
- Teaching assistant for general biology lab which included lecturing, facilitating class discussions, setting up lab exercises, administrating and grading lab assignments and exams (supervisor: Dr. Gregory McGee)  Fall 2018-2019

SUNY College of Environmental Science and Forestry, Syracuse, New York  May 2018-Aug. 2020
Waterfowl/Wetland Research Technician:

- Conducting field and lab research including wetland composition surveys, invertebrate sampling, flush count surveys, Virginia rail banding, common gallinule banding, scaup banding, wetland seed identification and processing, and invertebrate identification and processing (supervisor: Dr. Michael Schummer, Ed Farley).

University of Waterloo, Ontario, Canada  May 2017-Aug. 2017
Waterfowl Research Technician:

- Assisted with a study investigating nest predation of ground nesting waterfowl in the Western Boreal Forest in north central Alberta near Slave Lake (supervisor: Matt Dyson).
• Waterfowl trapping and banding, radio-marking, tracking, nest searching, nest monitoring, habitat assessments, avian predator point-count surveys, installing and monitoring camera traps (supervisor: Matt Dyson).

**Mojo Guide Service**, Aransas Pass, Texas  
**Waterfowl Guide**:  
Nov. 2017-Jan. 2020  
• Calling and identifying ducks and geese, along the gulf coast salt marshes, by silhouette, sound, and flight in sometimes unfavorable weather conditions to supply the best experience for the customers (supervisor: J.C. Algueseva).

**Slay Ride Hunting Club**, Aransas Pass, Texas  
**Waterfowl Guide**:  
• Calling and identifying ducks and geese, along the gulf coast salt marshes, by silhouette, sound, and flight in sometimes unfavorable weather conditions to supply the best experience for the customers (supervisor: Dana Smith).

**Cinnamon Shore**, Port Aransas, Texas  
**Rentals**:  
Aug. 2016-May 2017  
• Working closely with management and customers with a large inventory of rental equipment consisting of golf carts, chairs, and fishing equipment to provide the best experience possible for the customer (supervisor: Jeff Martindale).

**Caesar Kleberg Wildlife Research Institute**, Kingsville, Texas  
**Undergraduate Research Assistant**:  
• Researching American kestrels and loggerhead shrikes, identifying wintering home ranges in south Texas. Driving county roads, spotting, identify species and sex, recording GPS location, taking brush and grass height measurements in a 100 square foot area, determining landscape type, using ERADUS and GIS to classify quadrangles as bare ground, woody, herbaceous, or water, and conducting accuracy assessments on each quadrangle (supervisor: Dr. Carter Crouch).
• Working with northern pintails conducting necropsies, taking stable isotope samples, sorting diet samples, identifying diet samples, taking molt samples, taking morphometric measurements, recording data, inputting data into Excel (supervisor: Nat Huck, Matt Garrick).
• Studying aflatoxins in corn at different percent moisture levels, different containers, and different environments. Ground dozens of samples (supervisor: Dr. Scott Henke).
• Working on white-tailed deer captures shaving hair samples, recording data, catching and releasing in Port Mansfield and Hebbronville, Texas (supervisor: Dr. Kory Gann).
• Conducting white-tailed deer nutrition analysis conducting a fiber analysis of plant species found in several enclosures on the Faith and Comanche Ranches in Carrizo Springs, Texas by conducting NDF, ADF, and ADL solution washes. Also, recording and inputting data into Excel (supervisor: Pierce Young).
• Working on bobwhite quail projects by building traps, baiting traps, using radio telemetry, GPS backpack units, and recording data (supervisor: Landen Gullick).
• Working with pocket gophers identifying home range sizes by using radio telemetry and subcutaneous GPS units (supervisor: Tara Hansler).

**Hixon Ranch**, Cotulla, Texas  
**Summer Intern**:  
May 2014-Aug. 2014
• Assisted in ranch hand work, repairing water lines, maintaining grounds, repairing fence, tracking bob white quail via radio telemetry, restoring 300 aces back to natural quail habitat via disking and mechanical and chemical brush removal, raising quail until proper release age, filling cotton seed and corn feeders (supervisor: Mike Hehman).

PRESENTATIONS


PUBLICATIONS

HONORS, AWARDS, & SCHOLARSHIPS
SUNY College of Environmental Science and Forestry
• Roy C. Glahn Central New York Wildfowlers Memorial Scholarship 2018

Texas A&M University-Kingsville
• Distinguished Undergraduate Student Award 2016
• Outstanding Undergraduate for Range and Wildlife Management 2016
• Who’s Who 2015-2016
• Brady M. Boyd Memorial, Colin Caurther’s Memorial 2014

Related Awards
• Shikar Safari Club 2015-2016

CLUBS & ACTIVITIES
SUNY College of Environmental Science and Forestry
• Ducks Unlimited 2012-Current

Texas A&M University-Kingsville
Ducks Unlimited, Extreme Anglers, The Wildlife Society
• Wildlife Society President 2013-2016
  o Western Conclave Host and Coordinator 2014-2015
  o TWS National Chapter of the Year 2015
  o TCTWS Chapter of the Year 2014-2015
• Texas Wildlife Association 2015
• Wildlife Society Freshman Rep. 2014
• National Honor Society 2013

RELATED COMMUNITY SERVICE
• Texas Youth Hunting Program Volunteer, 100 hours 2014-2019
• Texas Chapter Conservation Camp Leader, 400 hours 2010-2015
• TAMUK Wildlife Society (various events), 80 hours 2013-2015
• Salter Water Fisheries-Enhancement Association, planted wetland grasses on dredged islands in Nueces Bay to prevent erosion and build habitat, 6 hours 2011

RELATED COURSEWORK
• Wetlands Conservation and Management for Wildlife 2020
• Aquatic Ecosystems Restoration and Enhancement 2019
• Ecology and Management of Waterfowl 2019
• Private Lands Conservation 2019
• Forest Ecology 2019
• Regression Analysis 2018
• Landscape Ecology 2016
• Large Mammal Ecology and Management 2016
• Methods in Rangeland Ecology 2016
• Human Wildlife Conflicts 2015
• Mammalogy 2015
• Wildlife Policy and Law 2015
• Ornithology 2015
• Plant Taxonomy 2015
• Rangeland Plants 2014
• Wildlife Management Techniques 2014
• Range and Wildlife Ecology 2014
• Problems in Range and Wildlife Management 2014
• Principles of Wildlife Management 2014
• Technical Writing 2014

RELEVANT SKILLS
• Certified Hunter Education Instructor, Certified Texas Youth Hunting Program Hunt Master, Boater Education Certified, Hunter Education Certified, Archery (Instruction, Mechanics, and Repair), Bay boat, Airboat, Tractor, & Skidder Operation, G.P.S., Cleaning game, Track identification, Radio Telemetry, Mist Netting, Trailer Experience, Microsoft (Word, Power Point, and Excel), G.I.S classifying quadrangles for geospatial analysis in program ERADUS and Arch GIS

REFERENCES
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Dr. Bart Ballard  bart.ballard@tamuk.edu (361)522-3210
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