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Habitat Use and Behaviours of Introduced Muscovy Ducks (*Cairina moschata*) in Urban and Suburban Environments

Cover Page Footnote

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1.1. Introduction

The Muscovy duck (Figure 1) is a species of waterfowl native to South America, Central America, Mexico, and a small portion of southern Texas in the United States (Stahl 2003). Also known as the Barbary duck, the species is commonly domesticated and raised for meat across the globe (Gille and Salomon 1998, Zhu et al. 2012, Awde et al. 2013, Yakubu 2013). Muscovy ducks have a high reproductive potential (Nikolova and Gerzilov 2004), and escaped or



Figure 1. A Muscovy duck.

intentionally introduced populations have become established in many areas. Naturalized Muscovy ducks can be found in North America (Hanson and Willis 1976, Belant et al. 1999), Europe (Niklus 1990, Mason and Macdonald 2000, Nankinov 2009), Africa (Yakubu 2011), and Asia (Shieh et al. 2006), where they are often considered a nuisance. This is particularly the case in the United States, where the Muscovy duck is legally recognized as an invasive species due to threats it poses to other species and the environment (USFWS 2010). Some of these potential concerns include: interbreeding with wild waterfowl (Brun et al. 2012), competition for resources with native wildlife (USFWS 2010), degradation of water quality (Chen et al. 2014), and transmission of various diseases to native birds and domestic poultry (Takahashi et al. 1996, Lvov et al. 2008, Zhu et al. 2012, Niqueux et al. 2014, Yun et al. 2014). Accordingly, the species is exempt from protection by the Migratory Bird Treaty Act in the United States (16 U.S.C. 703 et seq.) outside its native breeding range in Texas, which allows it to be captured or harvested without a federal permit.

Despite their abundance and widespread geographical distribution, native and naturalized Muscovy ducks have been little studied. Most research on free-ranging Muscovy ducks has been conducted within their native geographical range where they are in some cases threatened. For example, a number of studies have reported counts of Muscovy ducks as a part of larger studies of bird abundance in Mexico and South America (Alves and Gomes 2006, Alava et al. 2007, Ayala-Perez et al. 2013). Woodyard and Bolen (1984) provide the most comprehensive findings on the nesting, food habits, health, and growth of wild Muscovy ducks in Mexico. They found that Muscovy ducks used wetland and agricultural habitats, as well as fed on seeds of aquatic vegetation, invertebrates, and corn. They also documented Muscovy ducks nesting in trees and artificial nest boxes erected near water. Markum and Baldassarre (1989) also reported their usage of nest boxes located near aquatic habitats in Mexico. Eitniear et al. (1998) documented an unusual case of Muscovy nesting on the side of a cave in north-eastern Mexico.

Comparatively little has been reported on the life history of Muscovy duck populations established in the United States or elsewhere. A few brief notes are mentioned in books and field guides (eg. Johnsgard 1975). Domesticated Muscovy ducks are large—averaging 2.7 kg for males and 1.5 kg for females (Raji et al. 2009)—and characterized by variable white and black, iridescent plumage and red caruncles on

the face and bill (Fig 1). Johnson and Hawk (2012) also provide a brief extension factsheet about Muscovy ducks as an introduced species in the State of Florida. Downs et al. (2013) presented one of the first studies of Muscovy duck movements and habitat use patterns in the United States, where they quantified the home range and habitats used by a single Muscovy duck tracked by GPS in Florida. This male duck occupied a home range of 0.17 km² and utilized water, grass, tree, shrub, and urban habitats. Aside from this, no scientific studies on introduced Muscovy ducks in the United States have been published to date. Considering the large number of potential threats posed by the species, along with their widespread distribution and high levels of abundance in some areas, basic research on their behaviours and habits is needed. Such information would be valuable to wildlife managers who might aim to control or remove established populations occupying urban and suburban ponds, or to prevent their spread to new habitats. Knowledge of the adaptability of the species to habitats outside its native range might also lend insights for its conservation in areas where it is indigenous.

This study aimed to document the habitat use and behavioural patterns of a naturalized breeding population of Muscovy ducks in an urban/suburban area of Tampa, Florida. A time-activity budget approach was used to collect basic information about the behaviour of adult males and females. The goal of the research was to identify which habitats were used by Muscovy ducks and what activities and behaviours were performed in each. Tail-wagging was also documented, as it is a characteristic behaviour of the species but little studied.

2.1 Study Area

The research was conducted at the University of South Florida main Campus in Tampa, Florida (28.06°N, 82.42°W). Tampa has a humid, subtropical climate characterized by hot, rainy summers (24-32°C) and dry, mild winters with temperatures rarely dropping below freezing. The campus is approximately 5 km² and consists of a variety of land cover types, including: grass (lawn), sparse tree and shrub cover, and urban components (roads, buildings, parking lots, sidewalks, etc.), as well as several lakes, ponds, and wetlands (Figure 2). The campus supports a breeding population of Muscovy ducks numbering approximately 120 individuals (unpublished data). Although it is unknown when the campus population became established, Muscovy ducks have been present in the Tampa area since at least the 1980s and Florida since 1967 (Johnson and Hawk 2012).

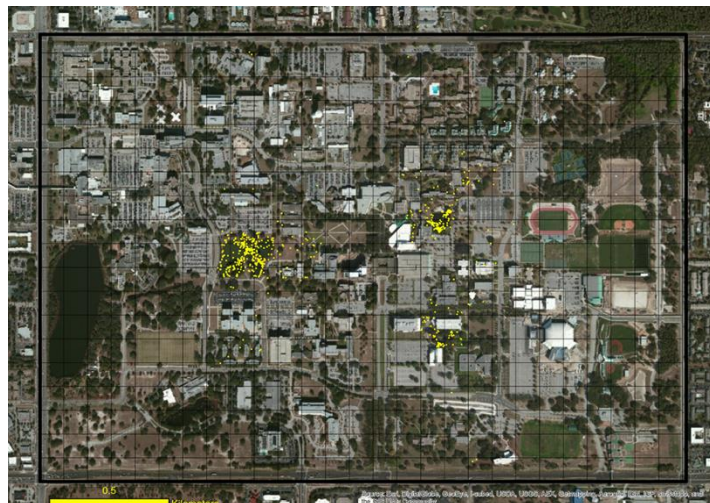


Figure 2. Study area map showing starting locations of Muscovy duck focal time-activity budgets.

3.1 Methods

Muscovy duck behaviours and habitat use patterns were studied using a time-activity budget approach (Altmann 1974). Similar methods have been often used to study the behaviour of numerous species of wetland birds (Tacha

1988), including waterfowl (Poulton et al. 2002, Michot et al. 2006, Crook 2007, Crook et al. 2009). Field observations were conducted from January 2012 to January 2013 during daylight hours. The protocol began by the researcher visiting a quadrant of the campus and selecting an adult duck randomly. As the ducks were accustomed to human activity, they could be approached within several meters without any apparent alteration of their behaviour. Observations were conducted by naked eye or with the aid of low power binoculars. The date and time were recorded, along with the sex of the duck. The geographic location of the duck at the start of the observation was also recorded by either plotting the location on a digital map using a geographic information system (GIS) or by using a handheld GPS. Observations were conducted for 10-min time periods, in which the focal duck's behaviour and habitat were recorded at 15-second intervals. Behaviours were recorded according to the ethogram in Table 1. The ethogram included six major categories of activities, which were further divided into more specific behaviours. Potential active incubation by females was recorded as resting, as they frequently nested on the ground, and the incubation and resting could not be distinguished without disturbing them. In conjunction with the behaviours listed in the ethogram, it was also recorded if the duck was 'tail-wagging' at the same time, a characteristic display of the species whereby the individual vigorously shakes its tail back and forth. Habitats for each behaviour were recorded in the following classes: water (pond or seasonal wetland), shoreline (edge of pond or wetland), grass (open lawn), tree cover, shrub, urban, and out of sight. Additionally, items observed to be eaten by focal individuals were noted when visible, and any unusual behaviours were recorded. The process was repeated for up to 12 different ducks on a given day, depending on the availability of field assistants.

Each 10-min observation period was treated as a focal sample for the purposes of analysis. First, the percentage of time spent in each habitat was calculated for each sample and summarized by sex and time of day, where morning was considered 06:00-11:00, afternoon as 11:00-15:00, and evening as 15:00-21:00. Next, the percentage of time spent on each major behavioural category (i.e. social and reproductive, agonistic and alert, foraging and related, locomotion, and resting) was calculated for each sample. The percentage of time spent on specific behaviours within each of these categories was also calculated. A factorial multivariate analysis of variance (MANOVA) was used to examine differences in proportion of time spent in different habitats or behaviours between the two sexes or by time of day, as per (Davis and Smith 1998, Crook et al. 2009). MANOVA is typically used to analyse time-activity budget data, as it is robust to violations of multivariate normality and unequal variance. The Wilks' lambda test criterion was used for the analyses. If the MANOVA found differences between the categories ($p < 0.05$), a univariate analysis of variance (ANOVA) was utilized to determine where those differences occurred. Additionally, a chi-squared goodness of fit test was used to determine if tail-wagging was observed at different frequencies between males and females. All statistical analyses were performed using the *R* statistical software package (www.r-project.org).

4.1 Results

A total of 642 focal samples were collected during the study, 54% for males and 46% for females. The samples were nearly evenly distributed by time of day. Muscovy ducks used all six major habitat types during morning, afternoon, and evening time periods. There were no significant differences in the percentage of time spent in each habitat type between the sexes (Wilks' $\lambda = 0.99$; 6, 631 df; $p = 0.30$). There were some

differences in habitat use by time of day (Wilks' $\lambda = 0.89$; 12, 1268 df; $p = <0.001$), most notably higher use of shoreline in morning and evening, as well as shrubs in the afternoon (Tables 2 and 3). Grass was used most often throughout the day, 41.4% on average. Tree cover was the next most utilized (18.1%), followed by shoreline (12.9%), water (12.1%), shrub (8.4%), and urban (6.9%) habitats. The ducks rarely were out of the observer's sight (<1%).

Table 1. Ethogram of Muscovy duck behaviours.

Category	Behaviours
Social and Reproductive	Courtship (head pumping and similar displays) Copulation Nesting* Brood-rearing (physical contact with young, such as actively feeding or touching with bill them)
Agonistic and Alert	Fighting Directed threat Alert posture
Foraging and Related	Dabbling (feeding while tipping in water) Gleaning (feeding from the ground surface) Grazing (feeding on herbaceous vegetation) Probing (feeding by digging into the soil with bill) Searching for food Drinking Fed by humans
Locomotive	Walking Flying Swimming
Resting and Comfort	Loafing (laying, sitting, or standing with feet on ground) Sleeping (laying with eyes closed, head usually tucked) Perched (sitting or standing in a tree or on top of other structure) Stretching Preening Bathing
Other	Out of sight

* Note: nesting was not distinguished from resting in this study.

Males and females displayed relatively similar activity patterns with some differences (Wilks' $\lambda = 0.93$; 5, 636 df; $p < 0.001$). Figures 3 and 4 illustrate the percentages of time spent on each activity category by males and females in each habitat type. Overall, males spent more time on social and reproductive activities than females ($F = 8.46$; 1, 636 df; $p = 0.004$), as well as agonistic and alert behaviours ($F = 13.35$; 1, 636 df; $p < 0.001$). Females spent more time foraging ($F = 22.34$; 1, 636 df; $p < 0.001$). Additionally, tail-wagging accompanied the behaviour of males 11.0% of the time, which was significantly greater than the 3.1% observed for females ($\chi^2 = 240.4$, 1 df, $p < 0.001$). Tail-wagging was observed in all habitat types and in conjunction with all activity categories.

Table 2. Percentages (mean and standard deviation) of time spent by male Muscovy ducks in each habitat during morning, afternoon, and evening time periods.

Habitat	Morning (<i>n</i> =117)		Afternoon (<i>n</i> =117)		Evening (<i>n</i> =112)	
	\bar{x}	<i>s</i>	\bar{x}	<i>s</i>	\bar{x}	<i>s</i>
Water	18.0	31.4	11.4	25.8	6.5	16.8
Shoreline	11.2	25.2	6.5	19.1	19.6	37.2
Grass	41.9	39.7	31.2	39.7	48.9	43.5
Tree	20.0	34.2	29.4	41.8	8.1	26.2
Shrub	4.1	17.3	12.5	31.7	5.0	20.8
Urban	4.6	14.3	9.0	25.6	11.9	26.7
Other	0.1	0.7	0.0	0.0	0.0	0.0

Table 3. Percentages (mean and standard deviation) of time spent by female Muscovy ducks in each habitat during morning, afternoon, and evening time periods.

Habitat	Morning (<i>n</i> =76)		Afternoon (<i>n</i> =115)		Evening (<i>n</i> =105)	
	\bar{x}	<i>s</i>	\bar{x}	<i>s</i>	\bar{x}	<i>s</i>
Water	12.5	27.4	11.5	25.9	13.0	29.9
Shoreline	12.7	27.1	8.8	23.3	19.4	36.2
Grass	37.5	40.6	40.8	42.0	47.7	42.7
Tree	25.5	36.9	19.4	36.0	7.2	24.2
Shrub	6.8	22.6	12.9	31.1	8.5	25.3
Urban	4.5	15.6	6.4	21.1	4.1	14.3
Other	0.5	1.7	0.3	2.8	0.1	0.5

Males (Figure 3) and females (Figure 4) used the six habitats for similar types of activities. Table 4 summarizes the time spent on activities in each habitat type for males and females combined. Locomotion (swimming) accounted for 69% of the ducks' time in the water. They spent 16.3% of time in the water on resting and comfort activities. They spent 13.6% of their time in the water on foraging and related activities, mostly dabbling and drinking but sometimes grazing on aquatic vegetation.

Pond and wetland shorelines, where the majority of the Muscovy ducks roosted at night, were used for resting and comfort 82.4% of the time. Remaining time was spent on locomotion and foraging, including drinking, grazing on emergent vegetation, searching for food, dabbling (bill under water while

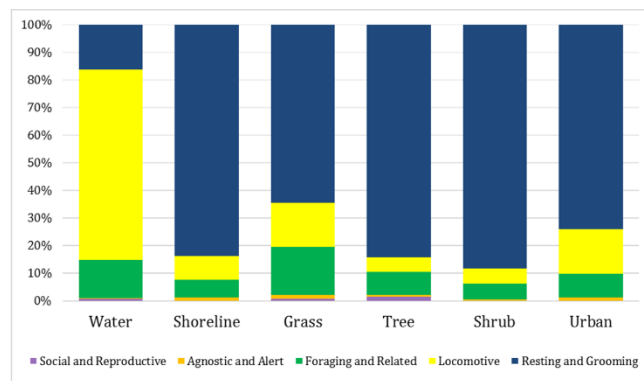


Figure 3. Percentage of time spent by male Muscovy ducks on five activity categories in six habitat types.

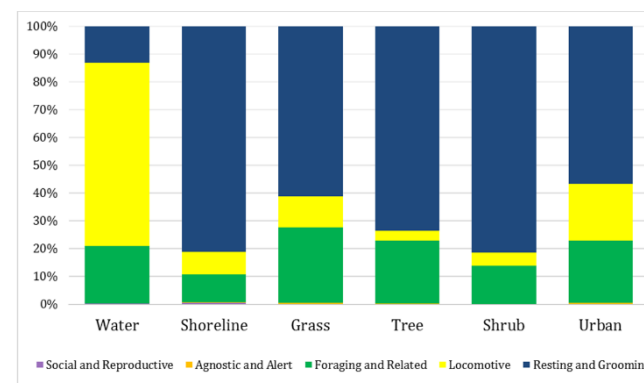


Figure 4. Percentage of time spent by female Muscovy ducks on five activity categories in six habitat types.

standing on the shore), gleaning (insects or seeds off the ground surface), probing the ground for food, and occasionally consuming food offered by humans (bread, cereal, and other items).

Table 4. Percentages of time spent by Muscovy ducks on different behaviours in six habitat types.

Category	Behaviour	Habitat					
		Water	Shoreline	Grass	Tree	Shrub	Urban
Social and Reproductive	Courtship	0.0	0.0	0.2	0.3	0.0	0.1
	Brood-rearing	0.2	0.1	0.6	0.6	0.0	0.0
	Copulation	0.8	0.4	0.2	0.5	0.0	0.0
Agonistic and Alert	Fighting	0.2	0.1	0.1	0.1	0.0	0.0
	Directed threat	0.1	0.1	0.2	0.1	0.1	0.2
	Alert posture	0.0	0.4	0.6	0.4	0.3	0.8
Foraging and Related	Dabbling	11.8	0.3	0.0	0.0	0.0	0.0
	Gleaning	0.0	0.3	2.7	3.4	0.2	0.3
	Grazing	0.0	5.6	9.0	0.9	0.3	2.4
	Probing	0.0	1.1	8.7	2.9	0.0	0.1
	Searching for food	1.4	0.1	0.2	5.4	2.1	1.4
	Drinking	0.0	0.1	0.4	0.0	3.3	9.2
	Fed by humans	0.2	0.1	0.3	0.5	0.0	0.0
Locomotive	Walking	0.1	7.9	13.4	4.4	5.4	17.5
	Flying	0.2	0.1	0.1	0.1	0.0	0.1
	Swimming	68.7	0.4	0.0	0.0	0.0	0.1
Resting and Comfort	Loafing	2.1	36.8	42.9	50.7	62.4	38.0
	Sleeping	0.0	23.3	3.8	12.8	16.3	0.8
	Perched	0.0	0.0	0.0	5.7	0.0	17.4
	Stretching	0.2	0.5	0.6	0.3	0.3	0.7
	Preening	5.6	21.4	15.6	10.4	9.3	11.2
	Bathing	8.3	0.3	0.0	0.0	0.0	0.0

The Muscovy ducks spent 62.9% of their time in grass habitats on resting and comfort activities. They spent 22% of time in grass on foraging activities, mostly grazing on herbaceous vegetation, searching for food, and gleaning items such as seeds and insects off the ground surface. Probing and consuming food from humans occurred less often. They spent 13.7% of time on locomotion, mostly walking and seldom flying.

The ducks spent 79.8% of their time in tree cover resting and comfort. They were perched in the trees 5.7% of the time. They spent 14.4% of the time foraging under the tree cover, mostly searching for food, gleaning food from the surface (primarily acorns from live oak trees), and probing the soil. They also sometimes grazed on herbaceous vegetation and fed from human hand-outs. About 4.5% of the time was spent walking. The Muscovy ducks used shrub habitats for resting and comfort activities 88.3% of the time, mostly for loafing and sleeping but also preening and stretching. The remainder was spent mostly on foraging and locomotion.

While in urban habitats, the Muscovy ducks also spent the majority of time on resting and comfort activities. The primary activities were loafing, perching on urban structures (including park benches, refuse containers, or building rooftops), and preening. Locomotion was the next highest percentage at 17.6%, followed by foraging at 13.3%. Foraging behaviours included drinking, gleaning, and grazing. Across all habitat types, they spent less than 1% of time on social and reproductive or agonistic and alert behaviours.

5.1 Discussion and Conclusion

This is one of the first studies to systematically explore the behaviours and habitat use patterns of Muscovy ducks outside their native range. As Muscovy ducks in this study were visually conspicuous, accustomed to human activity, and occupied an area composed only of open habitats with high visibility, the observers were able to document their behavioural and habitat use patterns in detail rarely possible for other species of waterfowl. Muscovy ducks in Tampa occupied open water ponds and wetlands, and they used a variety of surrounding cover types associated with suburban landscapes, including grass, sparse tree and shrub cover, and urban habitat components. They engaged in a variety of feeding strategies and foraged in all habitat types in the study area. Invertebrates, seeds, and herbaceous vegetation were all consumed, along with occasional meals from human sources. The findings suggest that free-ranging populations of domesticated Muscovy ducks are highly adapted to suburban and urban areas dominated by human activity. They also display different habitat usage and nesting habits than their wild counterparts, which are more secretive, are cavity nesters in riparian forests in locations where they are indigenous (Woodyard and Bolen 1984).

Muscovy ducks are frequently observed at storm water ponds and small wetlands across Tampa Bay. As Muscovy ducks are thought to pose a threat to native waterfowl and the environment, management efforts may involve the removal of nuisance individuals, preventing the re-release of captured individuals, addling of eggs found in nests, and habitat modification to deter the species from occupying particular areas. As Muscovy ducks utilize a wide range of habitats, habitat modification efforts may need to focus on the open water and shoreline components, which appear necessary for duck persistence. Future studies might explore how fencing or shoreline modification might impact duck usage of storm water ponds and other wetlands.

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Table 4. Percentages of time spent by Muscovy ducks on different behaviours in six habitat types.

Category	Behaviour	Habitat					
		Water	Shoreline	Grass	Tree	Shrub	Urban
Social and Reproductive	Courtship	0.0	0.0	0.2	0.3	0.0	0.1
	Brood-rearing	0.2	0.1	0.6	0.6	0.0	0.0
	Copulation	0.8	0.4	0.2	0.5	0.0	0.0
Agonistic and Alert	Fighting	0.2	0.1	0.1	0.1	0.0	0.0
	Directed threat	0.1	0.1	0.2	0.1	0.1	0.2
	Alert posture	0.0	0.4	0.6	0.4	0.3	0.8
Foraging and Related	Dabbling	11.8	0.3	0.0	0.0	0.0	0.0
	Gleaning	0.0	0.3	2.7	3.4	0.2	0.3
	Grazing	0.0	5.6	9.0	0.9	0.3	2.4
	Probing	0.0	1.1	8.7	2.9	0.0	0.1
	Searching for food	1.4	0.1	0.2	5.4	2.1	1.4
	Drinking	0.0	0.1	0.4	0.0	3.3	9.2
	Fed by humans	0.2	0.1	0.3	0.5	0.0	0.0
Locomotive	Walking	0.1	7.9	13.4	4.4	5.4	17.5
	Flying	0.2	0.1	0.1	0.1	0.0	0.1
	Swimming	68.7	0.4	0.0	0.0	0.0	0.1
Resting and Comfort	Loafing	2.1	36.8	42.9	50.7	62.4	38.0
	Sleeping	0.0	23.3	3.8	12.8	16.3	0.8
	Perched	0.0	0.0	0.0	5.7	0.0	17.4
	Stretching	0.2	0.5	0.6	0.3	0.3	0.7
	Preening	5.6	21.4	15.6	10.4	9.3	11.2
	Bathing	8.3	0.3	0.0	0.0	0.0	0.0