Factors Affecting Alert Distance and Flight-initiation Distance in Black Swans (*Cygnus atratus*) at Albert Park Lake, Victoria, Australia

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Abstract

Globally, human disturbance is a major contributing factor to population decline in many wild species. Flight-initiation distance (FID) is commonly used to assist with determining sensitivity to disturbance. Alert distance (AD) is highly correlated with FID and AD should be considered when developing wildlife buffer-zones to minimise disturbance. Many factors have been shown to influence both FID and AD in many species, including intruder starting distance, distance from protective cover, approach duration, animal wariness, and in some cases, gender. Habituation and urbanisation can lead to shorter FID and AD than in wild populations. A population of collared Black Swans *(Cygnus atratus)* at Albert Park Lake was studied to examine relationships between swan starting behaviour, intruder starting distance, duration of approach, distance from shore and gender with FID and AD. Both FID and AD were found to be reduced when compared to wild populations, assumed to be through habituation or urbanisation. A relationship between both FID and AD and starting distance was found, which is consistent with other findings. Starting distance was highly correlated with duration of approach. Both FID and AD were reduced in swans close to shore as compared to the group further away; however distance to shore was only significant for AD in this group. No relationship was found between either FID or AD and gender. Increased sample size and studying populations in other urban and wild areas may provide a clearer indication of some of these relationships specific to Black Swans.

Introduction

Human Disturbance

Outdoor recreation is an important part of human life, but is also a major documented cause of population decline in many species around the globe (Thiel et al., 2007, Beale and Monaghan, 2004). These activities can have a large impact on animals, even when human activity is not directly threatening or is non-consumptive (Steidl and Anthony, 2000). Disturbance in wild animals refers to any activity undertaken by humans that causes a deviation from the normal behaviour or activities of the animal affected (Frid and Dill, 2002), and has been linked to decline in successful breeding in animals, even in species which do not show behavioural changes in response to human disturbance (Carney and Sydeman, 1999). Many studies have shown continued or repeated human presence in wild areas can result in a decline in some species as they move to suboptimal areas to reduce necessity for vigilance (Price, 2008). The energy cost associated with predator surveillance can lower energy availability for feeding and reproductive activities (Blumstein, 2003, Frid and Dill, 2002). Even brief indirect human disturbance can have long-term impacts (Steidl and Anthony, 2000), and at critical times can lead to nest abandonment during breeding seasons, resulting in the loss of young (Carney and Sydeman, 1999, Steidl and Anthony, 2000).

In some areas, buffer zones (set-back distances) have been created to establish suitable distances between recreational paths and wildlife habitats to reduce impact on wildlife. However, due to different levels of predator wariness and flightiness it is difficult to create a common set-back distance for all animals (Blumstein, 2003). Additionally, visitors may not stick to an established trail, causing greater disturbance to sensitive species (Thiel et al., 2007).

Response to Disturbance

Animals usually react in one of three ways to approaching threats: remain and ignore the predator, risking capture but maximising the benefits of continuing the current activity; flee immediately, removing predator threat but at the cost of ceasing current activities; or remain in the area and monitor the threat. This final choice carries a high energy cost where the animal must cease (Blumstein, 2003) or reduce (Frid and Dill, 2002) its current activity to monitor the threat. The cost of monitoring is likely to outweigh any potential gain in staying if carried out for a length of time.

The measurement of the distance at which an approaching predator disturbs an animal enough to make it move away from the threat is known as the flight initiation distance (FID) (Blumstein, 2003) , or flush distance (Runyan et al., 2004, Thiel et al., 2007). The alert distance (AD) is the point at which an animal pauses or ceases its current activity to divert its attention to an approaching threat. Birds with a greater body size generally have longer FIDs and ADs than smaller species (Blumstein, 2006,

Blumstein et al., 2005) which may be due to reduced agility, therefore requiring more time and energy to flee. They are also theoretically easier to spot by a predator, providing increased motive to leave earlier (Blumstein, 2006). Smaller species tend to tolerate increased risk, with shorter observed FID (Blumstein, 2006). Wariness tends to increase in bird species which consume live prey, likely because this activity requires a heightened awareness of movement around them (Blumstein, 2006). Social species are also found to be more wary, probably due to the need to recognise other individuals of the same species (Blumstein, 2006), or due to the fact that flight initiation distance is likely to be determined by the most sensitive individual in the flock. Birds that live in areas of dense or obstructive cover are found to be more wary than those in open habitats where visibility is easier (Blumstein, 2003). Where suitable refuge is present or nearby; animals could therefore theoretically afford to take greater risk when in easy reach of relative safety, (Frid and Dill, 2002). Fleeing itself is energetically costly and so assessing each situation for its associated risk can reduce energy expenditure (Eason et al., 2006).

Starting distance has been shown to influence FID; Blumstein (2003) undertook a study of FID in 68 Australian bird species and found that birds able to detect an approaching predator from longer distances are more likely to flee while the approaching threat is further away to reduce potential energy cost associated with monitoring and rapid escape movement. However, animals are not expected to flee at the earliest possible opportunity; rather evaluating the level of risk to flee at the point where the risk of staying outweighs the cost of fleeing (Bonenfant and Kramer, 1996, Thiel et al., 2007, Dill, 1990). Blumstein (2006) also found a positive, although not statistically significant relationship between FID and age in species which reach reproductive maturity later in life. This could imply that increased wariness results from a necessity to survive to reproductive maturity. Migratory species have been found to flee at greater distances than resident species due to a lesser degree of habituation to humans (Blumstein et al., 2005).

Although humans are generally not a real predation risk, the response in animals to approaching humans has been found to be synonymous with that of an actual predator (Eason et al., 2006, Frid and Dill, 2002) so can be used as a standardised fear stimulus (Frid and Dill, 2002). In a study of Royal Penguins on Macquarie Island, nesting penguins showed an increase in heart rate and vigilance level when a single pedestrian tourist was present; greater than the reaction observed when a known predator flew overhead (Holmes et al., 2005). This increase in stress may lead to an overall decrease in fitness (Price, 2008), even in habituated birds (Burger and Gochfeld, 1991).

Habituation and Urbanisation

Given that urban areas are increasingly taking over wildlife habitats as cities grow, urban parks can be important habitat for many native species in densely populated cities (Fernández-Juricic and Tellería, 2000). Behaviour in birds in urban areas has been studied to assess behavioural changes through habituation to human presence (Fernández-Juricic and Tellería, 2000, O'Neal Campbell, 2006, Webb and Blumstein, 2005). Changes in selection of foraging sites have been recorded in urban settings when humans are present, leading to a potential decrease in foraging ability for affected species (Fernández-Juricic and Tellería, 2000). Humans can also be regarded as possible food sources which can result in modification of 'natural' behaviour (O'Neal Campbell, 2006). Webb and Blumstein (2005) found that the FID for Western Gulls in southern California decreased dramatically in areas with high visitation, demonstrating a behavioural change due to human presence and a rise in opportunistic foraging. More tolerant individuals were likely to remain in areas with a high level of human disturbance, while less tolerant individuals moved further away (Webb and Blumstein, 2005). Møller (2010) found that colonising species in urban areas possess a good degree of behavioural flexibility and that urban populations of birds are more homogeneous than ancestral rural populations, with a loss of heterogeneity over time as less sensitive individuals remained in urban areas (Møller, 2010).

While habituation to human disturbance commonly shows reduced AD and FID; in some cases, stronger antipredator behaviour has resulted from repeated exposure to disturbance (Blumstein, 2003, Dill, 1974). In a study conducted by Dill (1974), longer FID was recorded in Zebra Danio fish with repeated exposure to an approaching predator. Because the cost of overestimation is likely to be less than the cost of underestimation, animals are generally much more likely to overestimate risk (Bouskila and Blumstein, 1992). Where accurate predator information is not easily available, animals are more likely to flee earlier; Bouskila and Blumstein (1992) found that animals who overestimate risk suffered reduced mortality levels when compared to those that underestimate.

While several studies have been carried out on various factors affecting FID in birds, little research shows the relationship between gender, distance from shore or starting behaviour and FID. Therefore, these factors will be examined when measuring FID in Black Swans *(Cygnus atratus)* at Albert Park Lake.

Methods

Study Site and Observations

Albert Park in Victoria, Australia (37°50'S, 144°58'E) is a 225-hectare area of parkland surrounding Albert Park Lake in Melbourne's inner city. The lake provides habitat for a large resident population of Black Swans *(Cygnus atratus)* in addition to many other waterbird species. A portion of the swan population has been tagged with identification collars for research purposes. The park and the lake itself are also areas of high human recreational use, with a walking and cycling track surrounding the water, sporting grounds in the surrounding parkland and the international Formula One Grand Prix event held annually in March.

Study Species

Black Swans are a native herbivorous bird species with a resident population of approximately 250 at Albert Park Lake (Guay and Mulder, 2009). Although these swans are habituated to humans, it is not expected that this will influence the relationships being examined.

Black Swans with identification collars at Albert Park Lake have been targeted in this study because it allows observations to be made about relationships between gender and FID, which would not be possible in studies of uncollared animals. To obtain this data with uncollared animals, a more invasive observation approach involving capture of each animal would need to be taken to determine these characteristics. Identification collars are also a valuable tool in avoiding pseudoreplication; the identity of each individual is known which can therefore account for the number of times an individual has been sampled during the study to attempt to minimise repetitive sampling of the same bird.

Black Swans at Albert Park Lake were fitted with individually numbered neck collars in 2007 in a study by Guay and Mulder. Data on individuals was collected, including body condition, gender, radius length and mass. During observations in 2008, no negative change in body condition of collared swans was found, and behaviour and time spent on normal activities was not significantly different to that in uncollared swans (Guay and Mulder, 2009). Length of time spent upending to forage was found to be slightly less in collared birds, but overall time spent foraging was roughly equal to that of uncollared birds (Guay and Mulder, 2009). From these observations, it is expected that studying collared swans should not produce any experimental bias due to the presence of the collar. In a study by Lorenz (2010) collared swans at Albert Park Lake had greater alert distances, likely as a result of previous capture stresses placed upon them, but did not have significantly different flight-initiation distances.

Despite a level of habituation to humans, there is no reason to assume that Black Swans at Albert Park Lake will react differently to approaches by humans than by potential predators, or that habituation will influence the relationships being studied. It is expected that flight-initiation distances will be much shorter than in birds found in wild areas.

Methodology

The study was conducted over a two month period at Albert Park Lake from March to May 2011. Targeted swans were found on land close to the shore, on the grass beside the water's edge or on man-made structures such as jetties, or further from the shore, foraging in grassy areas. Each visit to the lake began at the same point and an entire circuit of the lake was made by bicycle. Observations were made each time swans were found on land while moving around the lake. If approaching a group, one bird was selected for observation. Only other members of the group that appeared not to respond or alter their behaviour were selected for subsequent approach. Individuals were not approached more than once per visit. Only collared birds were measured in the study.

For each observation, the date and time, estimated cloud cover and observation position around the lake were recorded. The swan collar identification number was documented, along with the starting behaviour, classified as foraging, resting or preening. Approaches were made perpendicular to the shore with varying starting distances used. Perpendicular approaches were made to eliminate this variable; Lorenz (2010) found angle of approach to be an influencing factor.

Measurements recorded were the starting distance (SD), flight-initiation distance (FD), alert distance (AD) and the distance between the bird and the shore. The SD is the distance between the observer and the swan before approach, and was measured using a rangefinder (Bushnell Pro 1600 Tournament Edition Laser Rangefinder). All other measurements were made using a tape measure. FID was recorded when the swan took its first step away from the observer, and response behaviour and direction of movement was also recorded. Small markers were placed on the ground during approach to mark the AD and FID measurements. The distances from the starting point to both AD and FID markers were measured and AD and FID calculated by deducting these measured distances from the SD. Duration of approach was also timed with a stopwatch.

To avoid variability of results due to potential reaction to colour, clothing worn for the duration of the field work remained the same. A navy shirt was worn, with dark jeans and brown shoes. The person approaching the animals was the same each time, and approached at a similar pace (normal walking pace) each time. A backpack was carried and a bike used to move around the site, which were left a short distance away from the starting point. The bike helmet was always removed prior to approach.

Data analysis

Statistical analyses were carried out using PASW Statistics for Windows version 18 (SPSS Inc., Chicago, IL, USA). Univariate analyses of variance and linear regression models were used, using $P < 0.05$ as significant. In cases where significance was found in a factor with more than two states, such as swan starting behaviour, a Tukey test was performed to assess where the significance lay within that factor.

Due to the fact that swans foraging on land were often able to be approached with larger start distance, and were also often found further from shore, the data was analysed first as a whole, and then in two groups: foraging; and resting or preening combined, to reduce confounding variables. Resting and preening birds were usually found in similar locations, close to the shoreline. An independent samples t-test was used to compare the mean starting distances of the two groups.

Results

In a total of 92 observations; prior to approach, 48 swans (52%) were foraging, 37 (40%) were preening and 7 (8%) were resting. All were approached perpendicular to shore, at varying starting distances. The mean AD was 10.1m, with a minimum of 0.3m and a maximum of 24.1m. The mean FID was 3.6m; minimum 0.1m, maximum 18.5m. AD was correlated with FID ($t_{1,90}$ = 6.011; P < 0.001).

A Univariate Analysis of Variance was performed to compare all factors against FID and AD (see Table 1 – Appendix). Cloud cover, group size, distance to water, gender and behaviour were not found to be significant.

In the full model, both starting distance in FID ($F_{1,81}$ = 112.735; P < 0.001) and AD ($F_{1,81}$ = 49.461; P < 0.001) and duration of approach in FID ($F_{1,81}$ = 96.444; P < 0.001) and AD ($F_{1,81}$ = 13.892; P < 0.001) were found to be highly significant factors. Using a regression analysis, a significant correlation was found between starting distance and duration of approach ($t_{1,90}$ = 7.391; P < 0.001). In a reduced model, starting distance was found to be the significant factor ($F_{1,82}$ = 13.106; P = 0.001), so duration of approach was removed from further analyses. Figures 2 & 3 (Appendix) show the relationship between AD and starting distance ($t_{1,90}$ = 7.013; P < 0.001) and FID and starting distance ($t_{1,90}$ = 4.178; P < 0.001).

Despite obtaining a non-significant P value ($F_{1,81}$ = 0.063; P = 0.803) for the effect of distance to shore on FID using linear univariate analysis, it was found that foraging swans were observed at an average of 16m from shore, while preening or resting swans were an average of 1.4m from shore. Therefore, further analysis was undertaken separately on these two groups to determine any significant factors. Results demonstrated that foraging swans had a mean AD of 12.1m and a mean FID of 4.5m, while preening or resting swans had a mean AD of 7.9m and a mean ID of 2.7m (see Figure 1 – Appendix). Mean starting distances for each group were analysed using an independent samples t-test, with significantly shorter distances found in approaches to preening and resting swans than to foraging swans (t_{90} = 3.356; P = 0.001).

Using a regression analysis, a relationship between distance to shore and AD was confirmed in preening and resting swans ($t_{1,42}$ = 3.574; P = 0.001) (see figure 4 – Appendix). However, no significance was found for this relationship for FID ($t_{1,46}$ = 0.166; P = 0.869) (figure 5 - Appendix). No relationship was found between AD or FID and distance to shore in either foraging swans (see figures 6 & 7 - Appendix). Figures 4 and 5 contain outliers which make it difficult to see these relationships.

There was no correlation found between either AD or FID, and cloud cover, group size or gender.

Discussion

Reduction of AD and FID in Urban Populations

When compared to a study by Blumstein (2003), flight initiation distances found in Black Swans at Albert Park Lake were consistently shorter than other birds of a similar body size. In another study at the Fivebough Swamp in NSW by Taylor (2006), both AD (mean 205m) and FID (159m) in the Black Swan FID were also much, with a mean AD of 10.1m and a mean FID of 3.6m. Similarly, in waterbirds at several locations near the Murray Mouth estuary in South Australia, AD mean distance was 313m, with FID at 149m (Paton et al., 2000). These areas, although subject to periods of high human visitation, are considered wilderness areas. The study by Paton et. al (2000) was carried out by measuring both AD and FID of birds in flocks, which may provide different results given that the most sensitive individuals in a flock are likely to respond first and affect the wariness of surrounding birds. However, AD and FID are comparable with that of Taylor (2006), with approaches to both individuals and groups. In another study at Albert Park Lake by Lorenz (2010), reduced AD and FID were found in Black Swans, with a mean AD of 13.45m in collared swans, and 8m for uncollared swans, and a mean FID of 12.65m for collared swans, and 9.23m for uncollared swans. Regardless of the presence or absence of neck collars, these results are comparable with distances observed in this study.

Reduced AD and FID in this study are likely to be a result of urbanisation and habituation to human presence; as seen by Møller (2010), FID was found to be much smaller in urban populations than in wild populations of the same species (Møller, 2010). Comparing AD and FID between the studies of Taylor (2006) and Paton et al. (2000) in wild areas and Lorenz (2010) at Albert Park, which correlates with results seen in this study, clearly shows an effect of urbanisation or habituation here.

Distance to Shore

There was a significant difference found between both AD and FID for each group, with foraging swans reliably fleeing at greater distances. Given this group were found further from shore, this is consistent with other studies which have found that distance to cover (in this case, water) is a determining factor in FID in some species, such as Dill (1990) who observed this relationship with cichlid fish consistently fleeing earlier with greater distance to cover, and Bonenfant and Kramer (1996) who found reduced FID in woodchucks (a small mammal species) closer to burrows. However, statistical analysis showed a significant relationship only between distance to shore and AD in preening and resting swans but no significant relationship with FID. There was no significance found in either of these relationships in the foraging group, which does not correlate with studies which show distance to cover as a significant factor. Given that these relationships were not found to be

significant for both groups, it could be suggested that this is a species dependent factor which is not observed in Black Swans.

Given that distance to shore was found to be significant only for the group closest to shore, it is also possible that the importance of distance to shore reduces once a threshold distance is reached. Once beyond this distance, a clear relationship is unlikely to be observed. Preening and resting swans were found close to the water, which could explain why this relationship was observed in this group only.

Starting behaviour should also be considered; foraging swans may choose to continue their current activity at a greater risk level because the benefit of foraging may outweigh the potential cost of staying. Additionally, habituation may have shown human presence to be generally non-threatening, and lowering calculated risk for continuing foraging behaviour. Proximity to shore may be therefore less important based on the high benefit of continuing foraging behaviour. Reduced antipredator behaviour has been observed in some bird species that require fat accumulation, whereby foraging behaviour takes priority over other activities (Paton et al., 2000). While this is generally seen in migratory birds, it is still possible that swans foraging prior to winter attempt to build fat reserves, showing lower antipredator behaviour.

It is possible that individuals foraging further from water may be more bold; so assessing individual activity budgets based on proximity to water at different times of the day and night (where park visitor numbers vary) may provide more insight into individual or overall population sensitivity. However, as found by Møller (2010), individuals in populations colonising urban areas are often less sensitive to human disturbance than in populations in wild areas where a wider range of sensitivities occur, so boldness may be related to habituation or urbanisation.

Starting Distance

While foraging swans had consistently larger AD and FID than preening and resting swans, average starting distance for foraging swans was not significantly larger (21.2m) than for preening and resting swans (17.4m). However, starting distances were consistently larger for foraging swans due to the fact that line of sight was often not able to be maintained in swans closer to shore. The relationship between FID and starting distance compares with findings by Blumstein (2003) that birds will make the most of the opportunity to monitor an approaching predator and move away earlier at reduced cost.

Using information on AD and FID can be useful to create buffer zones for minimising disturbance levels; however, Evans et al. (2010) suggest that individuals living in urban areas are generally bolder

and less sensitive to human presence. These individuals are more likely to be successful in these environments, leading to inheritance of these traits in offspring in urban populations (Evans et al., 2010, Møller, 2010). So while comparing data between wild and urban populations may give an indication of the degree of urbanisation, it is likely that required buffer zones in urban areas will be smaller than those in wild areas to similarly minimise disturbance. Blumstein (2003) found that birds with a larger body size are likely to flee at longer distances, and given the Black Swans are a large bird, they could be considered a useful species to use as a benchmark for creating buffer-zones.

Gender

No relationship between gender and either FID or AD was found. Thiel et al. (2007) found a significant relationship between FID and sex in capercaillie, an endangered grouse species in Central Europe, with males consistently fleeing at longer distances than females. However, capercaillie males are much larger than females, unlike Black Swans (Dunning, 2008). Given the findings that birds with a larger body size have a larger FID (Blumstein, 2006, Blumstein et al., 2005), this is more likely to be the determining factor in capercaillie rather than a sex-linked trait, and could therefore explain why no difference was found between male and female Black Swans. This finding is consistent with Lorenz (2010) who also found no relationship between gender and FID or AD.

Group size

Group size did not appear to play a role in either FID or AD. The swans at Albert Park are part of a resident population; according to Burger and Gochfield (1991), flocks of resident birds show a much reduced FID when compared to flocks of migratory birds. Observing Black Swans in wild populations may assist in determining if flock (group) size is a determining factor in FID or AD.

Limitations

The major limitation to this study was the fact that foraging swans and preening and resting swans were found in very different locations, with foraging swans further from shore than preening and resting swans. It is therefore difficult to assess whether either distance to shore, starting behaviour or both factors determined FID in either group.

If attempting to establish factors influencing AD and FID in Black Swans, urbanisation of birds is likely to provide different results as would be found in wild populations, so assumptions from this study do not necessarily relate to Black Swans as an entire species; rather urbanised and habituated resident Black Swans. The study was only performed over a two month period with a relatively small sample size, so increasing the sample size, duration of study, and taking into account the time of day (or night) could provide additional information about the factors examined.

Conclusion

Studying populations in wild areas and comparing both AD and FID between wild and urban areas shows a clear decrease in these measurements in urban areas.

While disturbance may not always appear to produce a change in behaviour or a negative impact on animal health, it should be taken into consideration that effects of human disturbance are not always easily visible and a reduction in breeding success may still result (Carney and Sydeman, 1999). Physiological stress from increased heart-rate is not evident but may still occur (Burger and Gochfeld, 1991). Habituation to humans can also lead to behavioural changes, and overall loss of reproductive fitness may result.

Understanding what factors contribute to disturbance in animals can be beneficial for determining appropriate set-back distances and setting guidelines for areas to minimise disturbance where human presence can pose a potential threat to wildlife (Fernández-Juricic et al., 2001) Alert distances may be a better indicator of disturbance than FID given that FID only takes into account the distance at which an animal will flee, rather than the distance at which human presence initiates behavioural changes for monitoring (Fernández-Juricic et al., 2001).

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References

BEALE, C. M. & MONAGHAN, P. 2004. Human disturbance: people as predation-free predators? *Journal of Applied Ecology,* 41**,** 335-343.

BLUMSTEIN, D. T. 2003. Flight-Initiation Distance in Birds Is Dependent on Intruder Starting Distance. *The Journal of Wildlife Management,* 67**,** 852-857.

BLUMSTEIN, D. T. 2006. Developing an evolutionary ecology of fear: how life history and natural history traits affect disturbance tolerance in birds. *Animal Behaviour,* 71**,** 389-399.

BLUMSTEIN, D. T., FERNÁNDEZ-JURICIC, E., ZOLLNER, P. A. & GARITY, S. C. 2005. Inter-specific variation in avian responses to human disturbance. *Journal of Applied Ecology,* 42**,** 943-953.

BONENFANT, M. & KRAMER, D. L. 1996. The influence of distance to burrow on flight initiation distance in the woodchuck, *Marmota monax*. *Behavioral Ecology,* 7**,** 299-303.

BOUSKILA, A. & BLUMSTEIN, D. T. 1992. Rules of Thumb for Predation Hazard Assessment: Predictions from a Dynamic Model. *The American Naturalist,* 139**,** 161-176.

BURGER, J. & GOCHFELD, M. 1991. Human Distance and Birds: Tolerance and Response Distances of Resident and Migrant Species in India. *Environmental Conservation,* 18**,** 158-165.

CARNEY, K. M. & SYDEMAN, W. J. 1999. A Review of Human Disturbance Effects on Nesting Colonial Waterbirds. *Waterbirds: The International Journal of Waterbird Biology,* 22**,** 68-79.

DILL, L. M. 1974. The escape response of the zebra danio (*Brachydanio rerio*) II. The effect of experience. *Animal Behaviour,* 22**,** 723-730.

DILL, L. M. 1990. Distance-to-cover and the escape decisions of an African cichlid fish, *Melanochromis chipokae*. *Environmental Biology of Fishes,* 27**,** 147-152.

DUNNING, J. B. J. 2008. *CRC Handbook of Avian Body Masses,* Boca Raton, FL, CRC Press Taylor & Francis Group.

EASON, P. K., SHERMAN, P. T., RANKIN, O. & COLEMAN, B. 2006. Factors Affecting Flight Initiation Distance in American Robins. *Journal of Wildlife Management,* 70**,** 1796-1800.

EVANS, J., BOUDREAU, K. & HYMAN, J. 2010. Behavioural Syndromes in Urban and Rural Populations of Song Sparrows. *Ethology,* 116**,** 588-595.

FERNÁNDEZ-JURICIC, E., JIMENEZ, M. D. & LUCAS, E. 2001. Alert distance as an alternative measure of bird tolerance to human disturbance: implications for park design. *Environmental Conservation,* 28**,** 263-269.

FERNÁNDEZ-JURICIC, E. & TELLERÍA, J. L. 2000. Effects of human disturbance on spatial and temporal feeding patterns of Blackbird *Turdus merula* in urban parks in Madrid, Spain. *Bird Study,* 47**,** 13 - 21.

FRID, A. & DILL, L. 2002. Human-caused Disturbance Stimuli as a Form of Predation Risk. *Conservation Ecology,* 6**,** 11.

GUAY, P.-J. & MULDER, R. A. 2009. Do neck-collars affect the behaviour and condition of Black Swans *(Cygnus atratus)*? *Emu,* 109**,** 248-251.

HOLMES, N., GIESE, M. & KRIWOKEN, L. K. 2005. Testing the minimum approach distance guidelines for incubating Royal penguins *Eudyptes schlegeli*. *Biological Conservation,* 126**,** 339-350.

LORENZ, R. 2010. Human approach response distances in Black Swans *(Cygnus atratus)* at Albert Park Lake, Melbourne, Australia. Melbourne: Victoria University.

MØLLER, A. P. 2010. Interspecific variation in fear responses predicts urbanization in birds. *Behavioral Ecology,* 21**,** 365-371.

O'NEAL CAMPBELL, M. 2006. Urban parks as shared spaces? The utility of alert distances as indicators of avian tolerance of humans in Stirling, Scotland. *Area,* 38**,** 301-311.

PATON, D. C., ZIEMBICKI, M., OWEN, P. & HEDDLE, C. 2000. *Disturbance distances for water birds and the management of human recreation with special reference to the Coorong region of South Australia. Final report for the migratory waterbird component of the National Wetlands Program.* The University of Adelaide.

PRICE, M. 2008. The impact of human disturbance on birds: a selective review. *Royal Zoological Society of New South Wales,* 21**,** 163-196.

RUNYAN, A. M., BLUMSTEIN, D. T. & RUSSELL 2004. Do individual differences influence flight initiation distance? *Journal of Wildlife Management,* 68**,** 1124-1129.

STEIDL, R. J. & ANTHONY, R. G. 2000. Experimental Effects of Human Activity on Breeding Bald Eagles. *Ecological Applications,* 10**,** 258-268.

TAYLOR, I. R. 2006. *Managing visitor disturbance of waterbirds on Australian inland wetlands. Wetlands of the Murrumbidgee River Catchment: Practical Management in an Altered Environment. .* Charles Sturt University.

THIEL, D., MÉNONI, E., BRENOT, J.-F. & JENNI, L. 2007. Effects of Recreation and Hunting on Flushing Distance of Capercaillie. *Journal of Wildlife Management,* 71**,** 1784-1792.

WEBB, N. V. & BLUMSTEIN, D. T. 2005. Variation in human disturbance differentially affects predation risk assessment in Western Gulls. *The Condor,* 107**,** 178-181.

Appendix

Table 1: Complete model of both FID and AD against all factors (Univariate Analysis of Variance)

Factor	*df*	*F*	*P*
	FID model		
Cloud cover	1, 81	0.129	0.720
Group size	1, 81	0.008	0.930
Distance from shore	1, 81	0.063	0.803
Starting Distance	1, 81	112.398	0.000
Duration	1, 81	96.337	0.000
Behaviour	2, 81	2.263	0.111
Gender	2, 81	0.425	0.517
	AD model		
Cloud cover	1, 81	0.270	0.605
Group size	1, 81	0.345	0.558
Distance from shore	1, 81	0.803	0.373
Starting Distance	1, 81	47.852	0.000
Duration	1, 81	13.714	0.000
Behaviour	2, 81	1.348	0.266
Gender	2, 81	0.340	0.561

Figure 1: Mean FID and AD of foraging swans and preening and resting swans.

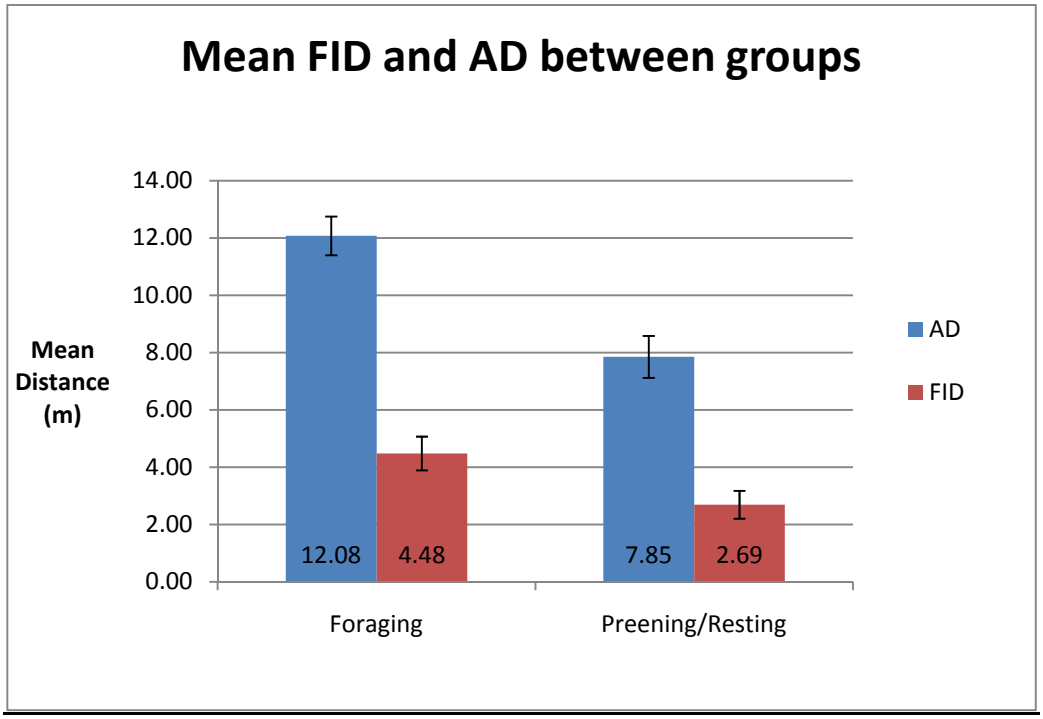

Figure 2: The relationship between AD and starting distance (all data).

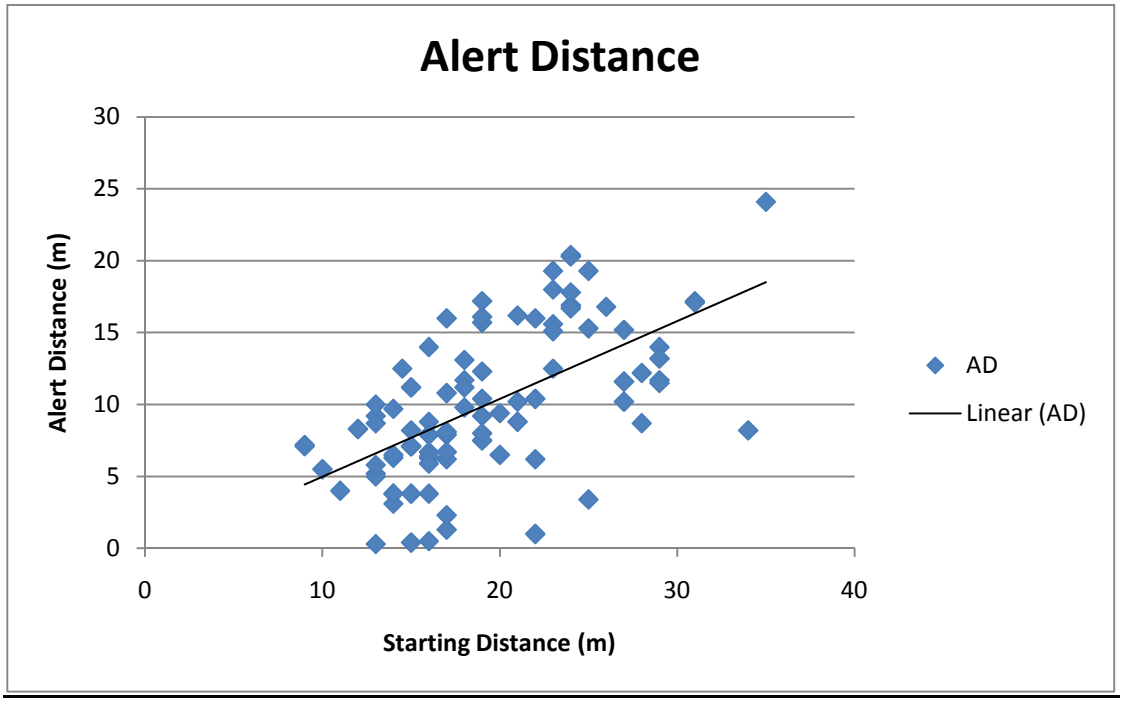

Figure 3: The relationship between FID and starting distance (all data).

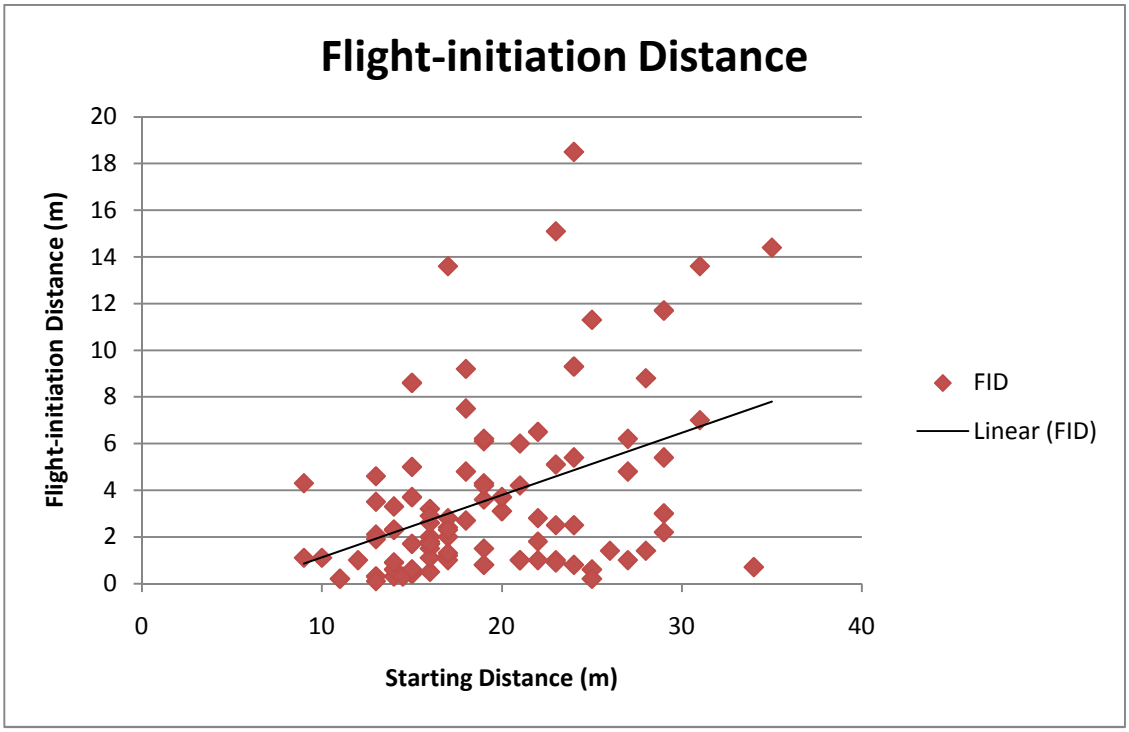

Figure 4: AD of preening and resting swans according to distance to shore.

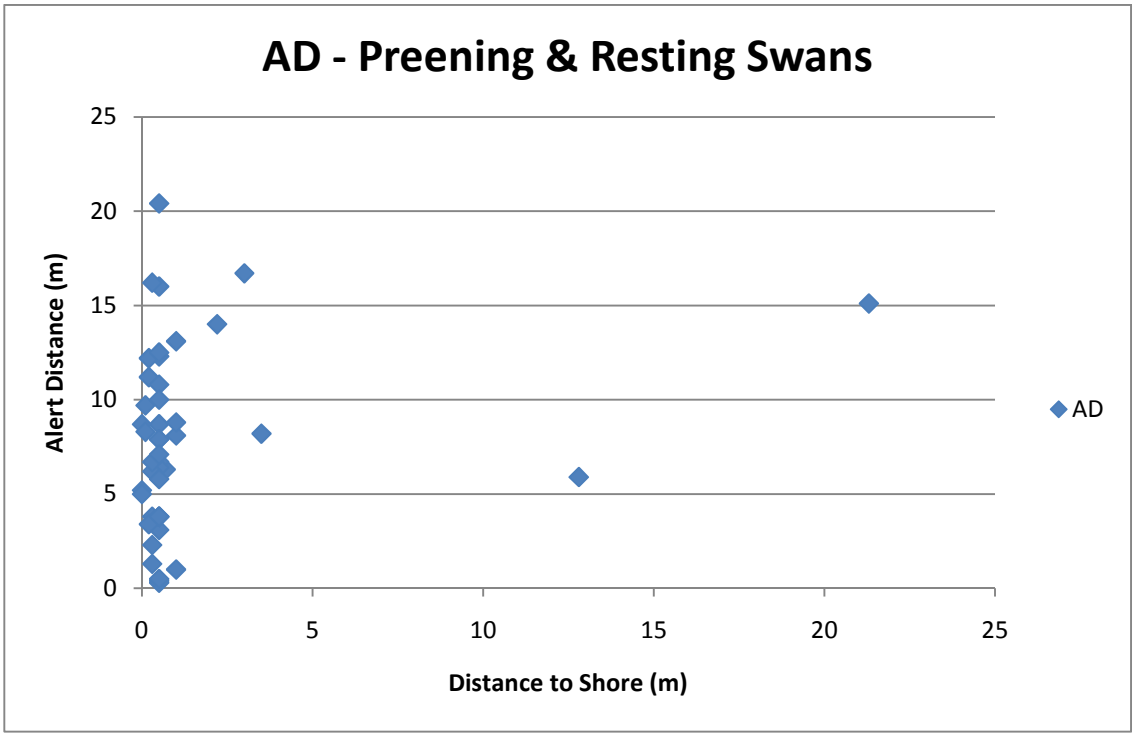

Figure 5: FID of preening and resting swans according to distance to shore.

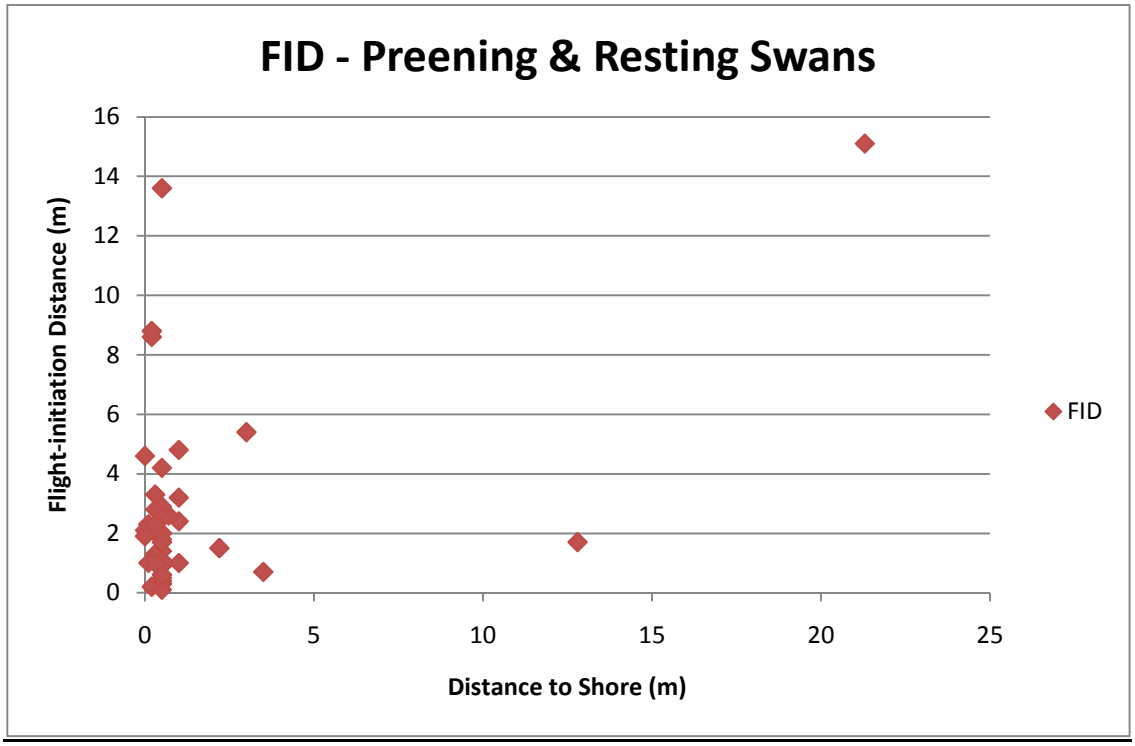

Figure 6: AD of foraging swans according to distance to shore.

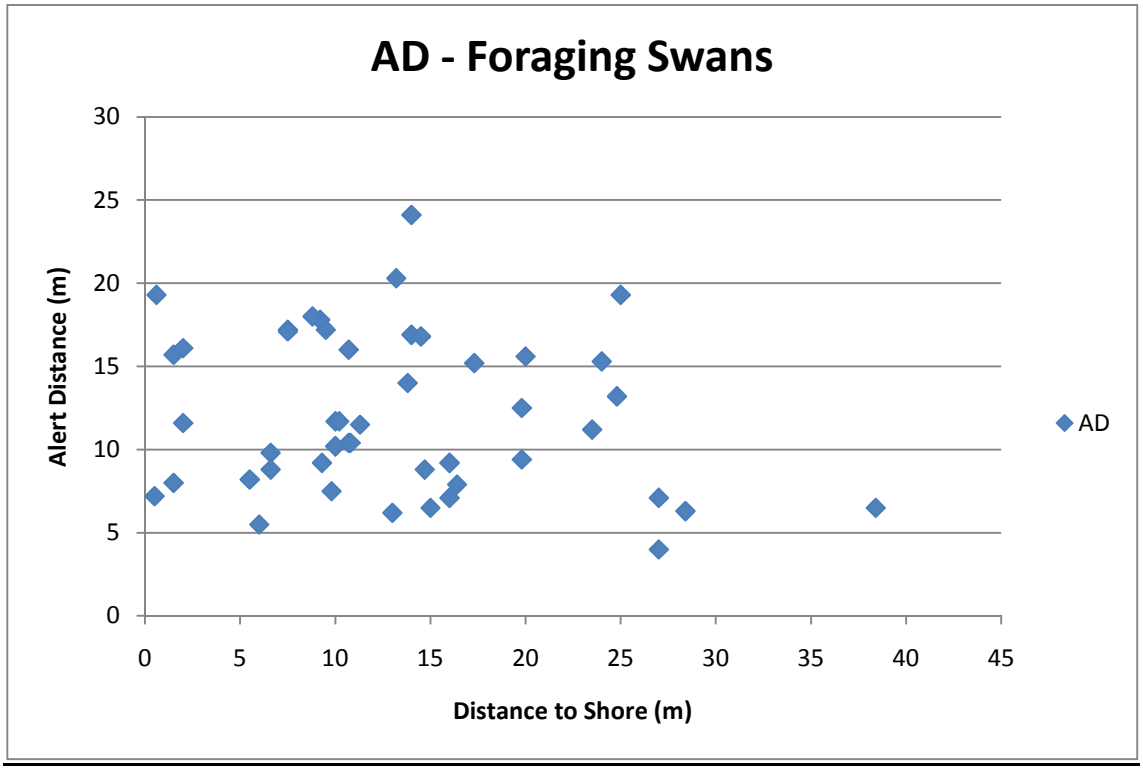
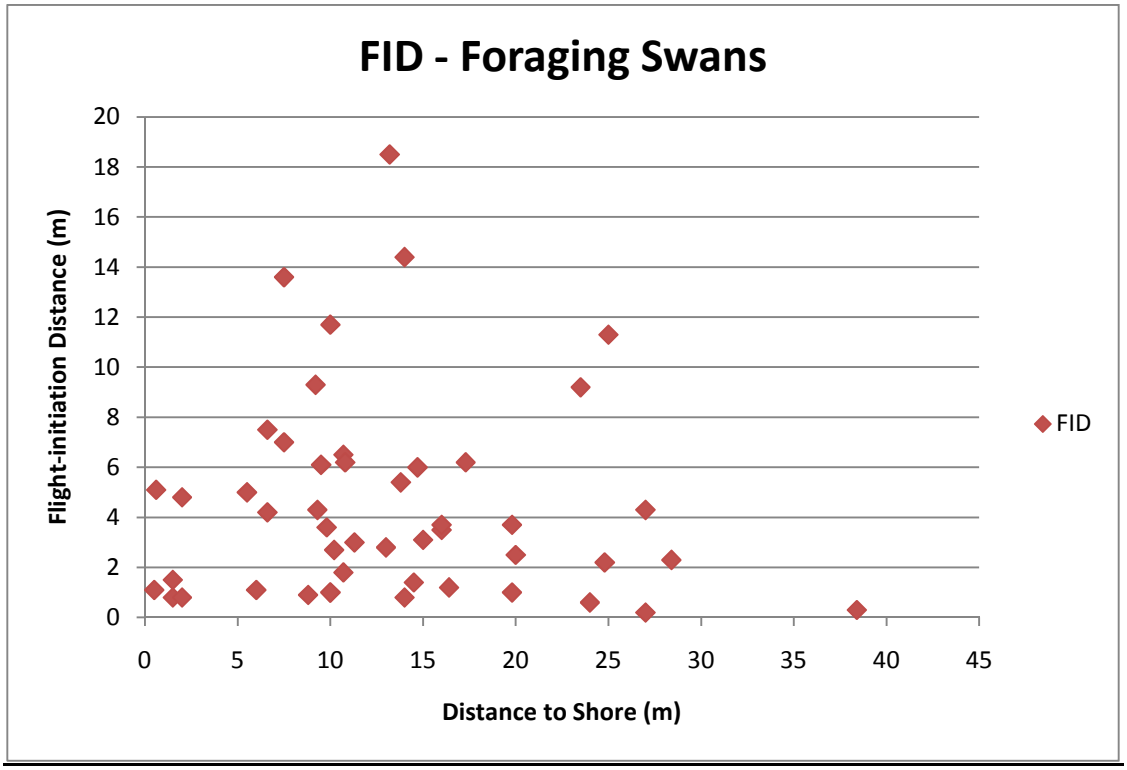
Figure 7: FID of foraging swans according to distance to shore.