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Barnacle geese (*Branta leucopsis*) in urban parks of Helsinki – How interactions with humans and dogs affect their behaviour

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Abstract

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Abstract: Urbanisation is increasingly bringing humans and wildlife closer together, which leads to urban human-wildlife conflicts. An example of this is urban barnacle geese (*Branta leucopsis*) in the Helsinki metropolitan area. Large flocks of geese in the late summer cause people to complain about droppings fouling the park lawns and reducing their recreational values. On the other hand, for citizens interested in nature, barnacle geese are an opportunity to observe nature close to home. It is unclear how people's attitudes are reflected in their daily interactions with geese, and what effect this has on the geese. In this master's thesis, I answer the questions: 1. How often do barnacle geese and people interact in parks, and what type of interactions do they have? 2. How do interactions with people, vehicles and dogs affect barnacle geese behaviour? and 3. What is the role of flock size for geese behaviour as in aims 1) and 2)? As methods, I use field observations about human-barnacle geese interactions and barnacle geese behaviour (focal goose observations and flight initiation distance). According to my results, barnacle geese and people are mostly habituated to each other, but for example, people walking their dogs cause geese to increase time spent vigilant and decrease foraging time. These results let me discuss the current state of coexistence between people and geese and future possibilities to facilitate it in a positive direction.

Abstrakti: Urbanisaation seurauksena ihmiset ja villieläimet kohtaavat toisiaan yhä enemmän, minkä seurauksena urbaanit ihmisten ja villieläinten väliset ristiriidat lisääntyvät. Eräs esimerkkitapaus on ihmisten ja valkoposkihanhien (*Branta leucopsis)* välinen ristiriita Helsingin urbaaneilla alueilla. Laajat valkoposkihanhiparvet loppukesällä aiheuttavat ihmisissä negatiivisia asenteita likaamalla nurmia ulosteella, joka heikentää puistojen virkistysarvoja. Toisaalta luonnosta kiinnostuneille kaupunkilaisille valkoposkihanhet tarjoavat mahdollisuuden tarkkailla luontoa läheltä. Ei ole selvää, miten ihmisten asenteet näkyvät päivittäisessä kanssakäymisessä hanhien kanssa ja millaisia vaikutuksia sillä on hanhiin. Tässä pro gradu- tutkielmassa vastaan kysymyksiin: 1. Kuinka usein ihmiset ja valkoposkihanhet ovat vuorovaikutuksessa kaupunkipuistoissa ja minkälaisia nämä vuorovaikutukset ovat? 2. Miten vuorovaikutus ihmisten, polkupyörien ja koirien kanssa vaikuttaa valkoposkihanhien käyttäytymiseen? ja 3. Millainen rooli parven koolla on valkoposkihanhien käyttäytymisessä, kuten kysymyksissä 1) ja 2)? Menetelmänä käytän kenttähavaintoja ihmisten ja hanhien vuorovaikutuksesta ja hanhien käyttäytymisestä Helsingin ja Espoon kaupunkien puistoalueilla. Tuloksieni perusteella hanhet ja ihmiset ovat pääosin tottuneet toisiinsa, mutta esimerkiksi ihmisten ulkoiluttamat koirat aiheuttavat muutoksia hanhien käyttäytymisessä lisäten hanhien valppautta ja vähentämällä ravinnon hankintaan käytettyä aikaa. Tulosten perusteella voidaan tehdä tulkintoja ihmisten ja valkoposkihanhien yhteiselon tilasta ja mahdollisuuksista edistää sitä positiiviseen suuntaan.

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1. Introduction

Climate change and urban development are changing habitats fast, causing many species to struggle due to loss of suitable habitats, introduction of exotic species, pollution and other factors (Pereira *et al.* 2012; Aronson *et al.* 2014; Sol *et al.* 2014). However, some species appear to be able to cope with or even take advantage of these rapid changes and they move to inhabit or visit cities (Soulsbury & White 2015). For these species, urban environments offer new habitats providing benefits such as easily available food and reduced predation and competition. However, the movement of wildlife into urban areas may not be as positive as it first appears. In cities, species can experience lower welfare from novel pressures such as light pollution (Candolin 2024), noise pollution, heat stress (Blackburn *et al.* 2024), and disease (Bradley & Altizer 2007). For example, northern goshawks (*Accipiter gentilis*) living in cities can feast on a high abundance of urban pigeons, but they also suffer more from infections from parasites and are more likely to die from collisions with anthropogenic objects, most commonly windows (Merling De Chapa *et al.* 2020). In cities, wildlife is also interacting with humans more often, which can lead to conflicts between humans and wildlife, affecting the welfare of both (Soulsbury & White 2015).

1.1 Urban human-wildlife conflict

Human-wildlife conflicts can be simply defined as interactions between humans and wildlife that have a negative outcome (Madden 2004). Urban human-wildlife conflicts refer to human-wildlife conflicts specifically occurring in urban areas. The conflicts vary in their intensity from minor to severe and in their frequency from rare to common. For example, direct attacks by wildlife are rare but severe, as they can cause serious injuries or even death. Injuries are more commonly caused by territorial or defensive attacks, for example, protecting the young (Australian magpies (*Cracticus tibicen*); Warne *et al.* 2010), than by predation by large predators, which are absent in most cities (Soulsbury & White 2015). Other conflicts that are more common but less severe are usually related to damage to property, e.g. stone martens (*Martes foina*) damaging roof insulation of buildings (Kistler *et al.* 2013), sika deer (*Cervus nippon*) damaging fields in Kyoto (Yu *et al.* 2024) and wild boars (*Sus scrofa*) damaging gardens in Berlin (Moesch *et al.* 2024), or damages to aesthetical values, such as beavers (*Castor canadensis*) cutting urban trees (Westbrook & England 2022).

Urban human-wildlife conflicts are not only causing harm to humans but also to wildlife. For example, road vehicle collisions can cause serious injuries and mortality (Riley *et al.* 2014), but in urban park areas collisions with bicycles and motorised scooters are also possible. This could become more prevalent given the rapid increase and interest by the public in using silent but fast-moving electric vehicles. Although wild predators may be less common in urban areas, domestic animals, such as cats, can cause serious injuries to wildlife (Loss *et al.* 2013; Soulsbury & White 2015), and the presence of dogs can increase stress and avoidance behaviours, and reduce foraging efficiency (Hohmann & Woog 2021). Even the presence of people walking or jogging in parks and urban areas can affect wildlife. Studies investigating the escape responses of birds often show that the strongest escape response is to dog walkers, but when approaches closer the walkers and joggers also increase vigilance and make the birds escape by walking or flying (Glover *et al.* 2011; Hohmann & Woog 2021). The study by Glover *et al.* (2011) investigating suitable buffers for Australian shore birds found that birds escaped earlier when approached by a jogger than by a walker. Even some activities that may seem to benefit wildlife and are enjoyed by humans can actually cause harm for wildlife. For example, feeding fallow deer (*Dama dama*) in the park with food not suitable for their diet can cause them health problems (Griffin *et al.* 2022).

While on the surface the conflicts are between humans and wildlife, they often include also conflict among people with different goals, attitudes, feelings and values (Madden 2004). In cities, this could be, for example, between the city officials and citizens, who feel like their voice is not heard when making decisions about how to address problems caused by wildlife or between citizens with different attitudes towards protecting nature. It is critical to understand public attitudes towards urban wildlife to get wide support for biodiversity conservation in urban areas (Basak *et al*. 2023). Attitudes towards wildlife vary among citizens from positive to negative. Some may get pleasure from watching wildlife while others are afraid of it or annoyed about damages to property they cause. For example, public attitudes towards protection of flying squirrels (*Pteromys volans*) in Finland vary from strongly favouring protection to strongly opposing it (Juutinen *et al.* 2023). Behind the negative attitudes is for example property losses due to the protection (Juutinen *et al.* 2023). In a study done in Krakow Poland, citizens considered urban wildlife as a problem because of property damage, noise, road accidents and anxiety (Basak *et al*. 2022).

1.2 Coexistence

Instead of focusing only on human-wildlife conflict, an increasing amount of research has begun to focus more on the concept of coexistence (König *et al.* 2020). In human-wildlife coexistence, humans and wildlife are living in shared landscapes, where wildlife populations are long-term persistent and the risks to humans related to wildlife are at tolerable levels (Carter & Linnell 2016). This is achieved with governance from effective institutions that ensure the persistence of populations, risk management and social legitimacy (Carter & Linnell 2016).

In an urban setting, coexistence requires accepting that urban wildlife is part of the urban ecosystem, and alongside managing the risks, the many benefits that arise from human-wildlife interactions should be appreciated and utilised (Soulsbury &White 2015). The benefits include aesthetic values (Basak *et al.* 2022), and the calming effect of observing nature (Cox & Gaston 2016). For example, having bird feeders in the garden is a popular hobby, and people who follow birds in their yards report that they feel relaxed and connected to nature (Cox & Gaston 2016). However, while changing attitudes towards nature in urban settings is not necessarily straightforward (Basak *et al.* 2022), the first step should be documenting the presence and potential for conflict and coexistence from the perspectives of both humans and wildlife.

1.3 Urban animal behaviour in relation to increased human disturbances

Urban wildlife often exhibits behaviours that differ from their rural counterparts, which is often found to be a response to novel conditions of the urban environment (Lowry & Wong 2013). For example, foraging behaviour can be altered both because of higher abundance of food resources, often associated with cities, but also because foraging efficiency can be negatively affected by the high human disturbance levels, such as pedestrian and vehicle traffic in urban parks (Lowry & Wong 2013).

As wildlife in urban areas are exposed to higher levels of human disturbances, tolerating human disturbances is hypothesised to be key to successfully colonising urban environments (Samia *et al.* 2017). In urban environments, where animals are repeatedly exposed to humans, who rarely pose a direct threat, it is beneficial to prolong the escape and save energy. This increased tolerance to humans can be due to habituation, which can be seen as reduced escape responses when people get close to habituated animals. Habituation can also be seen as increased boldness, for example, by animals approaching humans in the hope of getting food.

Flight initiation distance (FID), the distance at which animals flee from an approaching threat, is a common measure of the boldness or habituation to human disturbances (Stankowich & Blumstein 2005). FID is shown to reduce in urban areas compared to rural areas in many bird species (Samia *et al.* 2017), such as song sparrows (*Melospiza melodia*; Fossett & Hyman 2021), cattle egret

(*Ardea coromanda*), pond heron (*Ardeola grayii*; Charutha *et al.* 2021), willie wagtails (*Rhipidura leucophrys*) and magpie larks (*Grallina cyanoleuca*; Davey et al. 2019). The FID is affected by both animal physiological and behavioural characteristics. For example, larger bodied birds (Samia *et al.* 2017), and birds in bigger flocks have been found to have shorter FIDs (Ardila-Villamizar *et al.* 2022).

1.4 Barnacle goose as a newcomer species in cities

A great model to investigate urban human-wildlife conflict and the behavioural response to living in an urban habitat is the barnacle goose (*Branta leucopsis*) population in the Helsinki metropolitan area. Barnacle geese have recently inhabited the coastal cities of Finland, with the largest population being in the Helsinki metropolitan area. The original breeding grounds of barnacle geese are in the Russian Arctic region, but they have successfully occupied new breeding grounds around the Baltic, where first breeding was recorded in Sweden in 1971 (Larsson *et al.* 1988). To Finland, barnacle geese expanded later, with the first successful breeding recorded in the Helsinki archipelago in 1989 (Väänänen *et al.* 2011). The establishment of the population was also facilitated by Korkeasaari Zoo, which released rehabilitated barnacle geese into nature, thinking that they would join the migrating barnacle geese. Instead, they ended up returning to Helsinki to breed, accompanied by wild barnacle geese. Since then, the population has increased drastically (Yrjölä *et al.* 2017). In 2023, the total number of geese counted at the end of the summer in the Helsinki metropolitan area was over 5600 individuals (Finnish Environmental Institute, Syke, monitoring data).

Compared to other parts of the Baltic, where barnacle geese live in comparatively natural habitats, the Helsinki population of geese is special as they live in an urban area (Väänänen *et al.* 2011). The barnacle geese use mosaic of the habitats in urban Helsinki and near the archipelago in a complementary way (Väänänen *et al.* 2011). They nest in the archipelago and move their hatched broods to parks near water to forage on nutrient rich urban lawns. This way, they can first avoid nest predation by small terrestrial mammalian predators, and later urban parks give them protection from avian predators like white-tailed eagles. The barnacle geese have a moulting period during the summer, when the non-breeding temporally flightless geese also need to stay close to water when foraging. When the goslings learn to fly, and the moulting ends, the geese can start to utilise the foraging areas further away.

The barnacle goose population has increased in both their natural habitats and cities (Fox & Madsen 2017). Behind the increase is the successful protection by the European Union (Annex I in 1979 EU Birds Directive 2009/147/EC and Annex II in the Bern Convention) and the fact that geese are starting to use agricultural fields instead of natural wetlands for foraging in their wintering grounds (Fox & Madsen 2017). The increased populations are causing conflicts between people and the barnacle geese. In rural areas, barnacle geese cause damage to agriculture in their wintering habitats and resting sites (Buitendijk & Nolet 2023; Heldbjerg *et al.* 2022; Hiedanpää *et al.* 2023). The damages are substantial as Finnish Ministry of Environment reported more than 3 million euros worth of compensation for damages caused by geese in 2020 (Hiedanpää *et al.* 2023). The impact of urban barnacle geese is more complex to assess. Large flocks foraging in parks cause overgrazing and leave large amounts of excrement making the parks less attractive for people using them. The geese also cause fear for diseases, and geese parents protecting their broods can result in the geese attacking people.

The barnacle geese forming large foraging flocks at the end of summer before migration to their wintering grounds, can serve as an advantage for adapting to urban life, but at the same time increase the problems with people. For the geese, foraging in flocks may decrease the individual cost of vigilance, as it is shown that when flock size increases the time individual geese spend vigilant decreases (Drent & Swierstra 1977). This is explained by the dilution effect, which predicts that in larger flocks the probability of being predated is smaller (Stankowich & Blumstein 2005). In cities where the disturbances by humans and their pets are high, the formation of flocks could benefit the geese by allowing them to spend less time vigilant. However, the large flocks also intensify the fouling of lawns and overgrazing, which can potentially lead to more negative attitudes towards geese. Additionally, if the number of geese exceeds people's acceptance capacity, the number itself can be seen as a problem, even if people in general would like them, which is seen for example, in public attitudes towards several species of wild geese in Sweden (Erikkson *et al*. 2020).

The human-barnacle geese conflict is especially apparent in the media (Kauppinen 2020), even making headlines in international media (Nierenberg & Lemola 2025), but how it appears in the actual interactions between humans and geese has not been studied yet. By investigating the nature of those interactions, we can get a deeper understanding of the problem, which could potentially lead to better well-being for both the barnacle geese and people.

1.5 Aims and objectives

In my master's thesis, I investigate how people and barnacle geese interact in city parks of the Helsinki metropolitan area and how living in an urban area affects the behaviour of the geese. I will answer three questions:

(1) How often do barnacle geese and people interact in parks, and what type of interactions do they have?
(2) How do interactions with people, vehicles and dogs affect barnacle geese behaviour?
(3) What is the role of flock size for geese behaviour as in aims 1) and 2)?

To answer the first question, I will investigate whether the number of people, vehicles or dogs in the parks influences the probability of barnacle geese being present. If the presence is negatively affected by people's activity, it would mean that the geese would try to avoid interactions with people. To investigate the type of interactions, I am classifying the interactions between geese and people as positive, neutral or negative.

To answer the second question, I am recording the geese behaviour to see how the behaviour changes in relation to different activities of people. As the presence of humans increases vigilance and decreases foraging behaviour in Eurasian coots (Severcan & Yamaç 2011) and variation in those behaviours relates to the risk barnacle geese are perceiving (Black 2014), I expect that changes in the behaviours give insight into the tolerance of geese towards people. If geese are habituated to human presence, I expect them not to increase their vigilance behaviour or decrease foraging behaviour in response to people activities. I will also measure flight-initiation distance (FID) to see if the barnacle geese express habituation by having decreased FID in sites with an increased rate of people.

In the third question, I take flock size into consideration by first investigating whether people, vehicle or dog activity affects the flock size. Then I investigate whether the flock size affects the time urban barnacle geese spend vigilant, as larger flocks have been found to have a decreased proportion of vigilant geese (Drent & Swierstra 1977). I will also investigate does the flock size affect FID, which is a relationship well studied but with contradicting results (Shuai *et al.* 2024).

2. METHODS

2.1 Study area and barnacle geese population

I conducted the field observations of Barnacle geese flocks in Helsinki and Espoo (60N, 20E) in Southern Finland. I visited twelve study sites (presented in results section in Figure 2) between 20th of August to 28th of October at least once every week to make observations on geese behaviour.

For study site selection, I used Finnish Environmental institutes (Syke) annual barnacle goose counts to see which parks geese visited regularly. All sites were in urban areas where the geese encounter humans regularly, but with different rates. I chose the sites so that they would be accessible by bike and public transport, making it possible to visit multiple sites a day without a car. All sites had urban lawns suitable for geese to forage, but Herttoniemi and Hietaniemi sites also had beaches, that geese used for other activities such as resting and preening. All sites, but one (Viikki) had areas close to water, most often sea, where the flock could flee. In one of the areas in Tapiola site (Silkkiniitty park) there was a small pond.

The Autumn migration of the Arctic Russian barnacle goose started during the study period, so some of the flocks observed could have been part of that population (Birdlife Finland, Valkoposkihanhi tilanne 2025). However, because most of the geese are not ringed, I could not differentiate between these two populations. The expected increase of geese during the study period provided an opportunity to investigate the effect of flock size on behaviour of geese and interactions with humans.

Barnacle geese have a moulting period during the summer when they lose their ability to fly for a couple of weeks. For geese in the arctic the moult is in the middle of the summer ending in the late July (Black 2014). While there is no clear moulting period reported for urban barnacle geese, I expect that most of the geese had already moulted by the end of August when I started my field observations.

2.2 Field observations

I did the field observations between 8:00 and 18:00. I randomised the days and times by systematically visiting the sites in various times and days of the week (including days in weekdays and weekends). I visited the twelve sites at least once a week and observed the presence or absence of barnacle geese. When the geese were present, I observed the flock for a varying amount of time (mean = 59 min, minimum = 20 min, and maximum = 116 min) depending on how long it took to take the behaviour measurements. For smaller flocks, the observation session took less time as there were less geese to measure. On fifteen occasions the flock also flew away during the observations making the session end early. I defined a flock as group of geese that were closer than 20 m apart from each other. If a site had only one goose, that was also qualified as geese being present. Some of the sites also had few Canada geese (*Branta canadensis*) present, but they were not counted a part of the barnacle goose flock.

I observed geese behaviour with three measures: scan sampling, three-minute focal goose observations and measuring the FID (Figure 1). If geese were not present, I observed the number and activities of people in the location for 20 min after which I moved to the next site.

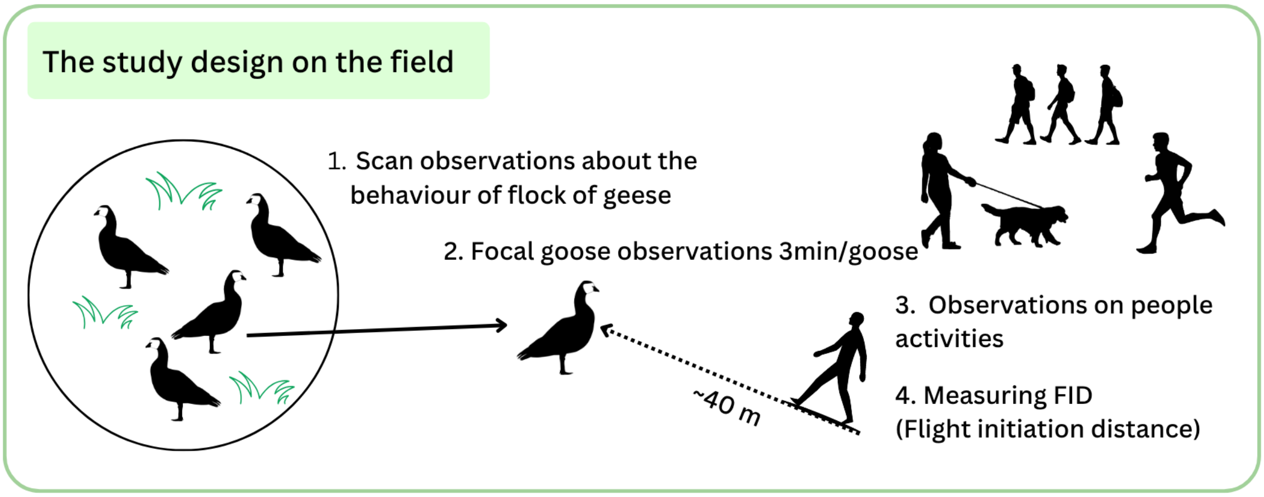

Figure 1. The study design on the field.

For every observation I measured weather conditions: temperature, cloud coverage and wind. The weather conditions can affect people activity, with warmer sunnier days without strong wind attracting more people to spend time in the parks and opposing weather conditions decreasing activity of people. I took temperature from closest meteorological station of the Finnish Meteorological Institute and rounded it to the closest degree. Cloudiness was observed on a scale of 1-6, where 1 is no clouds and 6 is full coverage. I also estimated wind on a scale of 1-6, where 1 is no wind and 6 is strong breeze. I did not do observations in rainy weather, to avoid problems with visibility.

2.2.1 Scan sampling

The behaviour of each flock of geese was observed with scan samples from the whole flock (< 100 geese) or subgroups (>100 geese). Before the sampling, I counted the number of geese in the flock. For flocks sized 100-300 geese, I scanned two subgroups of 25 individuals and for bigger groups I scanned three subgroups, to get better representation of the behaviours of the whole flock. The representation was also considered by scanning subgroups both from the edge and centre of the flock, as the birds' position in the flock has shown to affect behaviour (Inglis & Lazarus 1981). The scan sampling was optimally done every 15 minutes, but as there were many possible distractions (e.g. new geese arriving, people coming to talk to the observer, people being close to the geese), the time between scans varied. I also did a new scan if the size of the flock changed over 25% to keep up with the size of the flock. The behaviours recorded are presented in the ethogram (Table 1), compiled before the field observations.

Table 1. Ethogram of the observed barnacle goose behaviours

Behaviour	Type	Description
Extreme heads up (EHU)	Position	Goose has it head up with elongated neck, act of vigilance (when sitting EHUsit)
Heads up (HU)	Position	Goose has its head up as it observes the environment, standing or sitting (HUsit), head above the body
Rest	Position	Goose stands or lays head down/head on its back
Foraging	Activity	Goose pecks the grass head down, possibly walking at the same time
Relaxed but active	Activity	Preening and stretching
Walk	Activity	Goose walks head down and is not seemingly foraging at the same time
Swim	Activity	Goose is in the water floating
Drink	Activity	Goose takes water from water source and lifts it head up to swallow
Walk away	Reaction	Goose takes steps away from the cause of disturbance in EHU or HU posture
Run away	Reaction	Goose takes fast steps/runs away from the cause of disturbance
Fly away	Reaction	Goose flies away
Aggressive behaviour (low or mid threat*)	Reaction	Goose expresses agonistic behaviour towards the disturbance, hissing and showing tongue with lowered head and extended neck, possibly taking few steps towards the opponent
Chase*	Reaction	Run after the opponent
Contact*	Reaction	Bite or bump the opponent

*Modified from the description of Black and Owen 1989, where the aggressive behaviour (low or mid threat) is agonistic behaviour with lower energy cost, and chase and contact have higher energy cost.

2.2.2 Focal goose observations

Between the scans, I made observations about focal goose behaviour and people activities in a 40 m radius of it to see how the activities affect the goose behaviour. I continuously observed the behaviour of the focal goose by describing the changes in behaviour to a voice recorder. At the same time, I recorded all the people in the 40 m radius using activities presented in Table 2. The focal observations lasted a maximum of 3 minutes, but if the goose left or disappeared from sight, I ended the recording early. To avoid recording the same goose multiple times, I selected geese in different parts of the flocks choosing both geese in the centre and edge of the flock. After the observation I transferred the voice recording data to Animal Behaviour Pro app (2020) to get the durations for each behaviour.

To investigate the nature of the interactions I divided the activities into positive, neutral, and negative in relation to both impact on geese and people. I classified people stopping to look or take pictures of geese as positive interaction and chasing geese, letting a dog chase them or throwing an object at them as negative interaction. As the negative and positive interactions were rare events, I also took notes on events happening outside the focal observations and include them in the counts to get better understanding of these interactions.

Table 2. Recorded people activities and the categories they were in. The people walking dogs could be either neutral or negative, depending on if people let the dog chase the geese.

Activity	Category	Positive/Neutral/Negative
Stop to look or take picture of the geese	People	Positive
Adult walking past the geese	People	Neutral
Jogging	People	Neutral
Walking with stroller	People	Neutral
Staying around the geese	People	Neutral
Child walking past the geese	People	Neutral
Bike	Vehicle	Neutral
Other vehicle: electric scooter or similar	Vehicle	Neutral
Car	Car	Neutral
Human walking dog	Dog	Neutral/Negative
People chasing geese	People	Negative
People throwing an object at geese	People	Negative

2.2.3 Flight initiation distance (FID)

I measured the FID in the end of the observation session from one goose per observed flock. If there were multiple flocks present in the site, I also measured the FID from geese in other flocks to increase the sample size. I approached the closest goose approximately from a 40 m distance with a continuous slow speed. The FID was the distance between where the goose was standing and where the observer stopped, when the goose started to flee by taking steps away. I did not measure the distance when the goose took flight, because the geese did not fly even when the observer walked to a 1 m distance of the goose. For measuring the distance, I used iPhone 13 Measure app, that uses augmented reality (AR) technology to measure dimensions with a camera on a smartphone (Apple Inc 2025).

Before the approach, I noted the behaviour of the approached goose, as the vigilant geese are expected to flee earlier, which could affect the FID (Blumstein 2003). As the starting distance of the observer and FID has been found to have a positive relationship (Blumstein 2003), I started to approach the goose always from around the same distance (40 m), which was the distance from where I was observing the geese. The population of barnacle geese in the Helsinki area is over five thousand geese (SYKE, Valkoposkihanhiseuranta, 2024), which makes measuring the same individual more than once unlikely.

2.2.4 Activity observations when geese were not present

When the geese were not present on the site, I collected data about the activity of people to see if the presence of geese depends on that. I observed the site for six three-minute periods. In those periods, I counted all people and vehicles in a 40 m radius from a randomly chosen point, to have comparable data with people activity from the focal goose observations. The categories for people activities were same as in the focal goose observations (Table 2).

2.3. Research ethics and animal welfare

The observations on barnacle geese were non-invasive and did not expose the geese to more stress than they would normally experience in a city park with human visitors. There was no need for any permits to conduct the study as the animals were not handled. In case of discomfort equal or larger than needle prick needs a review from the Research Ethics Committee on Animal Research. There was no personal data collected on people during observations of their activity, so I did not need to take General Data Protection Regulation (GDPR) into account in this thesis.

2.4. Modelling approach

I conducted all analyses with R version 4.5.0 (R Core Team, 2025). Before analysis, I explored data by plotting variables against each other, calculating Pearson correlations and investigating distributions of variables by plotting histograms. I then used generalised linear mixed effect models (GLMMs, using glmmTMB package (v1.1.11; Brooks *et al.* 2017) to investigate the effects of the variables to the response variable. To account for the variation between sites, and in case of the focal goose observations variation between flocks, I considered site and observation session as random effects. I assessed the fits of the models using DHARMa package (v0.4.7; Hartig 2024). The QQ-plots and residual plots were inspected for potential problems in the models and to investigate alternative error distributions. I used an AIC model selection approach (following recommendations of Richards et al. 2011) using corrected Akaike Information Criteria (AICc; recommended for small sample sizes) to derive results. To build a model set I used all possible combinations of variables using the “dredge” function (MuMIn; Barton 2018) and then pruned it to include models with AICc difference less than six from the model with smallest AICc including only models, which were not more complex versions of models with smaller AICc value. Table 3 presents the selected models. In the following sections, the specifics of the different model sets are explained.

2.4.1 Effect of people, vehicle and dog activity on barnacle geese presence

I used GLMM with a binomial error distribution to determine if people activity correlates with the presence of barnacle geese (response variable) at a site. I divided the activities into three categories: people, vehicles and people walking dogs (Table 2). Then I calculated the activity for each category by dividing the total count of people/vehicles/dogs by the number of the activity observations/focal observations made in the visit. There was a small number of observations lasting less than 180 seconds due to the focal goose disappearing from view. Even though these observations may have missed some people activity, I expect them to have minimal impact on the activity estimates, because they are only a small proportion of the number of the observation (44 from 534, 7,7%) and they spread evenly across the flock observations and are not extreme values.

Other covariates in the model were date (measured as days from the start of the field observations) and time of the day. Observation site was included as a random effect.

2.4.2 The effect of people activities on focal goose behaviour

To investigate changes in behaviour of the focal goose in relation to different people activities I chose four behaviour categories as response variables for models: foraging, vigilance, relaxed active behaviour and moving away. Vigilance behaviour includes both extreme head up and head up states, standing and sitting (see Table 1). Relaxed active behaviour includes preening and stretching and moving away behaviour includes moving away by walking, running, and flying.

The activities of people included as explanatory variables in the models are based on recorded activities in Table 2. However, some of the activities were rare or there was little variation in the rate of activities between observations. The observations with limited variation were included as binary variables and some of the categories were combined giving the following explanatory variables: cars (binary), people (adults walking + children, continuous), vehicles (bikes + other vehicles, continuous), dogs (binary), jogger (binary), people around (people around + people taking pictures, binary). The continuous variables people, and vehicles, were used as a rate (variable count divided by the observation time) to account for the range in observations lasting less than 180 s.

Covariates considered for models were weather variables, date (as days from the start of the field observations) and time of the day. In the data exploration phase, I found a strong negative correlation between temperature and day of the observation (Pearson's $r = -0.82$). To avoid problems with collinearity I left the temperature variable out from the behaviour models. In all the models the random effects were site and observation session.

To investigate the impact of people activities on vigilance behaviour I used GLMM with beta-binomial error distribution for proportional data as it fit my data well. The model was structured as: glmmTMB(cbind(time spend vigilant, time spend in other behaviours) ~ explanatory variables + (1|site) + (1|ID), family= betabinomial), where seconds spent vigilant is "successes" and seconds spent in other behaviours are "fails". I also built similar type of model for foraging and relaxed active models. As the flock size has been found to affect the time individuals spend vigilant, I also included the flock size in the model. I applied a natural logarithmic transformation on the flock size variable to account for right-skewed distribution, with many small values and few large ones, and to improve the interpretability of the relationship between vigilance and flock size in the model.

From the data used in the foraging model, I excluded the observation sessions done on the beach, as there are many zero observations of foraging from those sites. Nonetheless, the focal observation data from areas with greater opportunities for foraging also had many observations without the foraging or relaxed active behaviours occurring (Foraging:106/478, 22%; Relaxed active: 257/532, 54%). Because of that I chose to use a Hurdle approach to model foraging and relaxed active behaviours. First, I investigated how the explanatory variables affected the occurrence of behaviour by using GLMM with binomial error distribution. Then I excluded the zero observations and explored, how the variables affect the duration of behaviour when it is happening. For that I used GLMM with beta binomial error distribution for proportional data, where I had proportions of time engaged in the behaviour as response variable.

For the behaviour type of geese moving away, I only investigated the probability of this behaviour to occur using GLMM with binomial error distribution. Moving away often resulted in the goose disappearing from the view, making the durations of the behaviour biased.

For all the above focal goose behaviour models, I used the same model selection approach as for other models, but with a difference that before testing all the possible combinations of variables I conducted a covariate model for weather and time variables. Based on that model I excluded covariates that did not seem to have an effect ($p < 0.05$) on the behaviour. The reason for that approach was to reduce the number of possible variable combinations that would make the computing time unnecessarily time-consuming. The models selected are in Table 3.

2.4.3 Flight initiation distance

To investigate which variables influence FID I built two models. The first model was for environmental and time related variables: the activity of people, wind, cloud, date and time. I did not include temperature as a variable as it correlated with date. The second model was for flock and goose related variables: flock size, distance to the nearest goose and behaviour of the approached goose. For both models, I transformed the FID using the natural logarithm, to meet the normality assumption. The models had observation site as a random effect. Model selection for environment model is in Table 3. For the second model the null model was the best model explaining the data.

2.4.4 Flock size model

In addition to investigating the effect of flock size on vigilance behaviour and FID, I also wanted to test does the activity of people affect the flock size. To test this, I built a flock size model with the same three activity categories as in geese presence model: people, vehicles and people walking dogs (Table 2). The flock size used in the model was the size measured in the beginning of the observation. To better fit the assumption of normality I did natural logarithmic transformation to the flock sizes.

3. RESULTS

I visited the parks 170 times, during which geese were present 97 times. From these flocks of geese I made 534 focal goose observations (Figure 2).

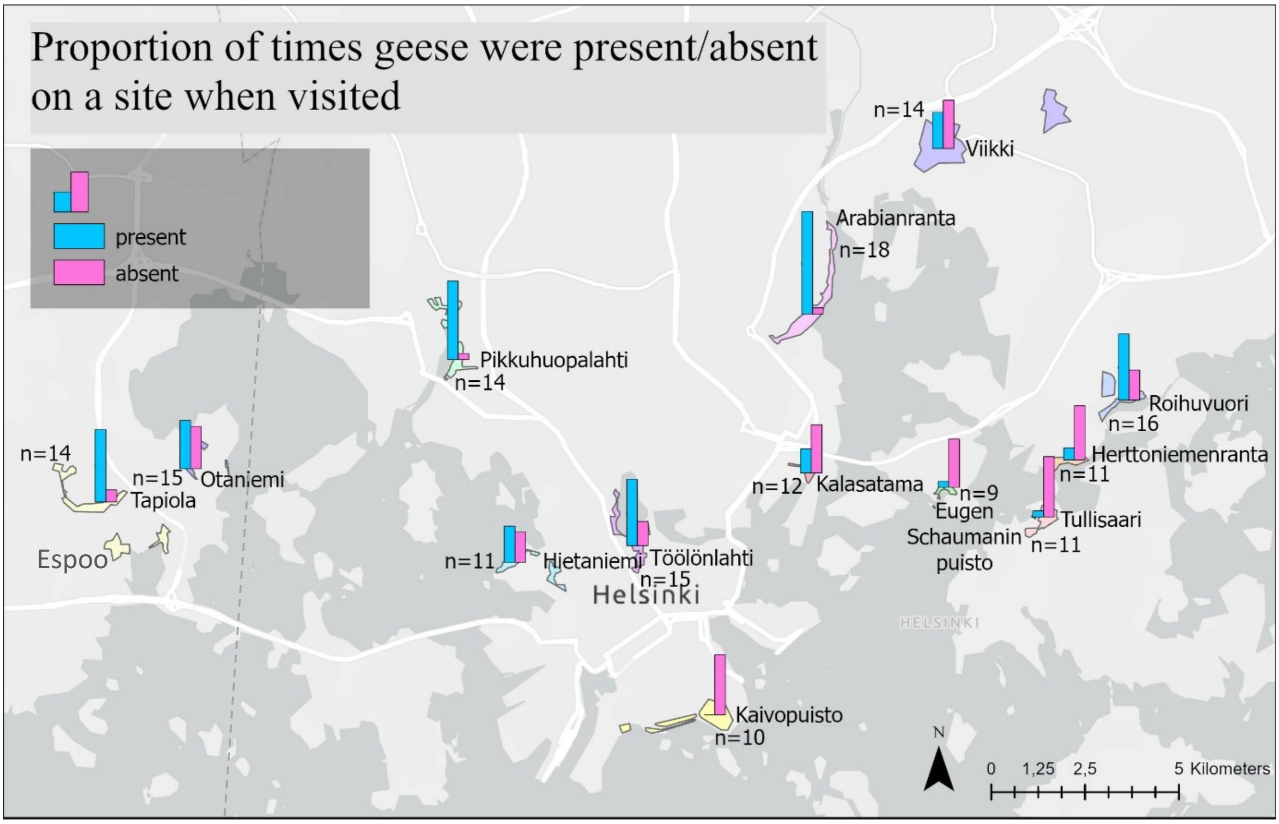

Figure 2. Map of the study sites and distribution of flock observations, where n is the number of times I visited the site, and bars represent the proportion of times geese were present (blue bar) or absent (pink bar).

3.1 How often do barnacle geese and people interact in the parks and what type of interactions do they have?

During the 534 focal goose observations, I recorded 3029 (mean 5.67, min:0, max: 63, SD: 7.85) interactions, specified as people within less than a 40 m radius from geese. Most interactions between people and geese were neutral (2893 interactions). During the focal goose observations I recorded 39 positive and 7 negative interactions, and overall there was 44 positive interactions and 23 negative interactions (focal observations and other observations done during the observation session). According to the two-sided binomial test, positive interactions were more common than negative interactions than expected by chance (p-value = 0.014). All positive interactions were people stopping to look or take a picture of the geese. Negative interactions included people running towards the focal geese (n = 10), people bringing their dog in close contact with the goose so that the dog could chase it (n = 9), child chasing the goose with a vehicle (n =2) and child throwing goose with a frisbee or football (n = 2). Four times dog chasing the geese resulted the whole observation session to end as the geese flock flew away.

There was no evidence that vehicles or dogs affected the presence of geese on the site as the best model did not include these terms (Table 3), and only weak evidence that the activity of people may influence geese (included as a term in the best model but not statistically significant, Table 4). As the autumn progressed, the likelihood that geese were present at a site declined significantly (Days: $p<0.001$, Table 4).

Table 3. Models of geese presence on a site, focal goose behaviour, FID and flock size on a site according to the following selection criteria (Richards *et al.* 2011): 1. Include the models within six delta AICc units but 2. exclude models that are more complex versions of the models with lower AICc. Null models are included for comparison (note that "FID goose model" the null model was the top-ranking model and therefore the only model in the set and for "flock size model" the null model is included in the model set). df = degrees of freedom. delta = difference in AICc to the lowest AICc model. weight = Akaike weight. log = natural logarithmic transformation for the variable.

Model response	Model parameters	n	df	AICc	delta	weight
Geese presence model						
Presence of goose	day + people average	170	4	188.9	0	0.137
	day	170	3	188.9	0.02	0.135
	null model ~1	170	2	200.8	11.91	0.000
Focal goose behaviour models						
Proportion of time vigilant	car + dog + flock size (log)	532	7	5288.66	0	0.123
	dog + flock size (log)	532	6	5291.81	3.14	0.025
	car + flock size (log) + jogger	532	7	5293.61	4.94	0.010
	car + flock size (log)	532	6	5293.83	5.16	0.009
	null model ~1	532	4	5305.95	17.3	0.000
Foraging/Not foraging	car + day	477	5	428.248	0	0.081
	day	477	4	429.917	1.67	0.035
	null model ~1	477	3	454.320	26.07	0.00
	car + dog	371	6	3806.09	0.00	0.125

Proportion of time foraging	dog	371	5	3806.09	0.32	0.106
	null model ~1	371	4	3813.92	7.83	0.002
Relaxed active/ Not relaxed active	car + day + people	532	6	716.683	0	0.166
	car + day	532	5	719.330	2.65	0.045
	day + people	532	5	720.755	4.07	0.022
	null model ~1	532	3	729.318	12.63	0.000
Proportion of time relaxed active	car + day + dog	266	7	2558.7	0	0.287
	null model ~1	266	4	2584.00	25.3	0.000
Moving away/ Not moving away	dog + people + jogger + vehicles	532	7	450.884	0	0.151
	dog + people + jogger	532	6	451.001	0.12	0.143
	dog + people + people around + vehicles	532	7	454.777	3.89	0.021
	dog + people + vehicles	532	6	454.999	4.11	0.019
	dog + people + people around	532	6	455.802	4.92	0.013
	dog + people	532	5	455.923	5.04	0.012
	null model ~1	532	3	493.349	42.43	0.000
FID						
FID environment (log)	cloud + day	94	5	163.72	0	0.235
	day	94	4	165.24	1.51	0.110
null model	null model ~1	94	3	189.42	25.70	0.000
FID flock (log)	null model ~1	110	3	234.4	0	0.301
Flock size model						
flock size (log)	dog + people	92	5	366.66	0	0.156
	people	92	4	367.90	1.24	0.084

	dog	92	4	368.79	2.13	0.054
	null model ~1	92	3	369.36	2.71	0.040

Table 4. The model estimates for the best model for goose presence at a site. CI = confidence interval. Bolded values indicate statistical significance (p-value < 0.05).

Geese presence model			
Variable	Estimate	95% CI	p-value
Intercept	**1.8**	**0.32, 3.2**	**0.017**
Days	**-0.05**	**-0.08, -0.02**	**0.001**
People activity	-0.06	-0.16, 0.03	0.176

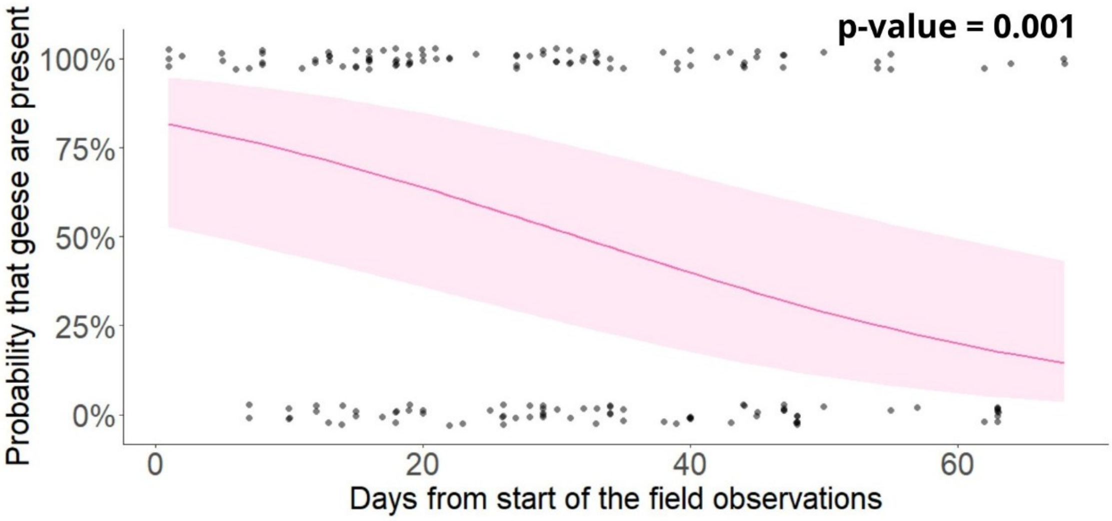

Figure 3. Predicted effect of date on probability that geese were present on a site. Fitted line and 95% confidence intervals are from the GLMM with the lowest AICc presented in Table 4. The date in x-axis starts from 1 = August 22 and ends to 68 = October 28. The points show the raw data, scattered with "jitter" for easier interpretability. Bolded p-value indicates statistical significance.

3.2 How interactions with people, vehicles and dogs affect the barnacle geese behaviour?

3.2.1 Behaviour of barnacle geese in the parks.

I scanned total amount 15 144 geese during the observation sessions. Almost half (48%) of the scanned geese were foraging (Figure 4). Other common behaviours were vigilant behaviour (23%) and relaxed active behaviour (18%). Inside vigilant behaviour the category 'standing while being vigilant' (HU and EHU) was more common than 'sitting' (HUsit and EHUsit), and 'head up' (HU) posture was more common than 'extreme head up posture' (EHU). Resting accounted for 8% and walking 1% of scanned geese behaviours. Swimming, drinking, aggressive behaviour (chasing another geese) and running away (behaviour captured when another goose started the chase) were rare behaviours totalling 1% of scanned geese.

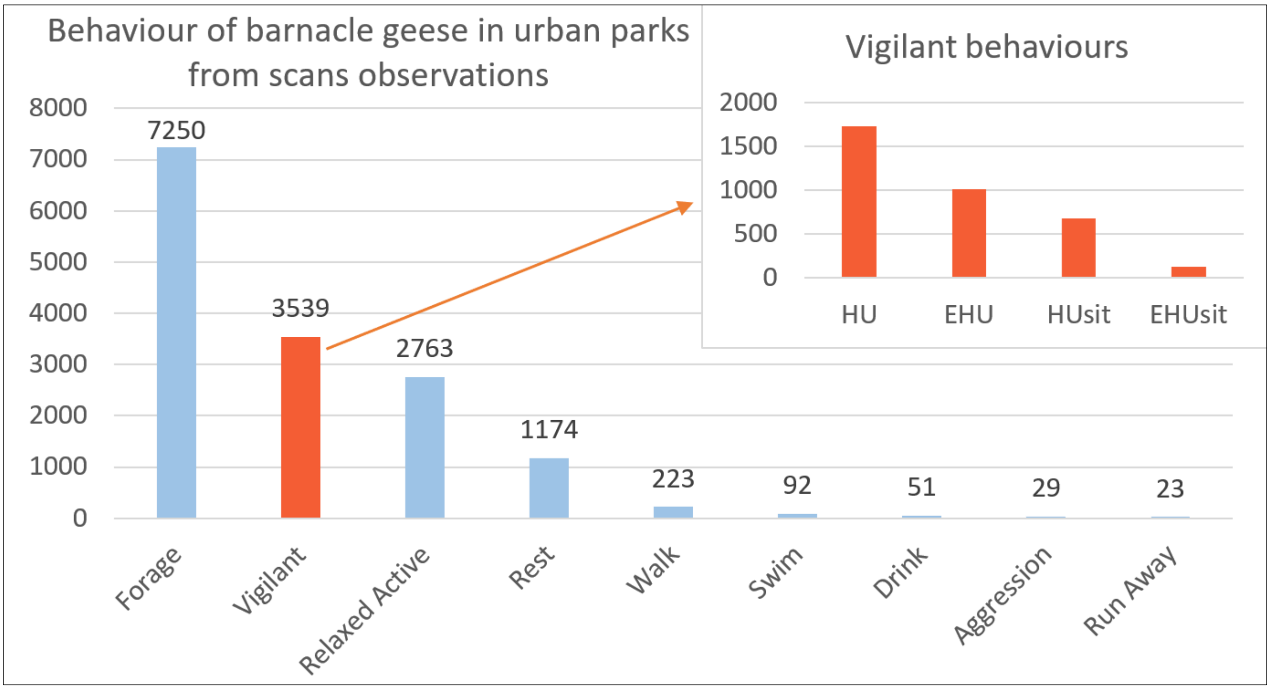

Figure 4. Goose behaviour in the urban parks. The y-axis is a total count of behaviours recorded in flock scans. Vigilance behaviours are head up (HU), extreme head up (EHU), head up sitting (HUsit) and extreme head up sitting (EHUsit) postures. Relaxed Active behaviour includes preening and stretching**.**

3.2.2 Focal goose behaviour in relation to people activities

Dogs and cars significantly increased time focal goose spent vigilant (Dogs: p-value = 0.004, cars: p-value = 0.021, Table 5). There was no evidence that people or vehicles affected the vigilance behaviour as those terms were not included in the best models. However, there was weak evidence that people jogging (joggers) may have influenced vigilance (included as a term in one of the models in the vigilance model set, Table 3).

Presence of dogs significantly reduced time focal geese spent foraging (Dog: p-value = 0.002, Table 5), but there was no evidence that they would affect if goose were foraging or not. There is weak but not statistically significant evidence that cars would affect foraging behaviour as it was present in both "Foraging/Not foraging" and "Proportion of time foraging" best models (Table 5). There was no evidence that people or vehicles affected the foraging behaviour as these terms were not present in the best models. The probability that geese were foraging during the focal observation increased significantly as autumn progressed (Days: p <0.001, Table 5).

Proportion of time geese spent relaxed active decreased significantly when there were dogs present (Dog: p-value =0.002, Table 5 & Figure 7c). Also, when there were more people walking, geese were significantly less likely to be relaxing during the focal observation (People: p-value = 0.037, Figure 7a), but there was no evidence that more people would affect the time the goose spent relaxed active. The probability of goose being relaxed active (p = 0.015, Table 5) and the time spent relaxed active (p = 0.003) decreased significantly when there were cars during the observation (Figure 7d). There was no evidence that vehicles would affect this behaviour as the term was not present in the model set. When the autumn progressed, the geese were relaxing significantly less time (Days: p-value = 0.001, Table 5)

Probability that the focal goose moved away increased significantly with dogs and people walking past the goose (Dog: p-value < 0.001, people: p-value < 0.001, Table 5). The dogs had large effect of the probability of moving away changing from 10 % to almost 40 % when there were dogs present during the focal observation (Figure 6b). The probability that goose moved away decreased in the presence of joggers significantly (p-value = 0.020, Table 5). There was also weak but not statistically significant evidence that vehicles and people staying around the geese would affect the moving away probability as the terms are present in the model set (Table 3).

Table 5. The models with lowest AICc for all the behaviour types tested: vigilance, foraging, relaxed active and moving away. Bolded estimate and p-value indicate statistical significance (P < 0.05). CI = confidence interval, (bin) = binary variable, (log) = natural logarithm transformation.

Proportion of time vigilant						
Variable	Estimate		95% CI		p-value	
Intercept	-0.06		-0.41, 0.29		0.7	
Dog (bin)	**0.38**		**0.10, 0.65**		**0.004**	
Car (bin)	**0.51**		**0.08, 0.94**		**0.021**	
Flock size (log)	**-0.14**		**-0.22, -0.06**		**<0.001**	
	Foraging/ Not foraging			**Proportion of time foraging**		
Variable	Estimate	95% CI	p-value	Estimate	95% CI	p-value
Intercept	-0.43	-1.2, 0,33	0.3	**0.38**	**0.21, 0.55**	**<0.001**
Days	**0.07**	**0.05, 0.10**	**<0.001**	-	-	-
Car (bin)	1.1	-0.09, 2.3	0.070	-0.33	-0.74, 0.09	0.120

Dog (bin)	**-**	-	**-**	**-0.48**	**-0.77, -0.18**	**0.002**
	Relaxed/ Not relaxed			**Proportion of time relaxed**		
Variable	Estimate	95% CI	p-value	Estimate	95% CI	p-value
Intercept	**0.81**	**0.33, 1.3**	**<0.001**	0.10	-0.26, 0.47	0.6
Days	**-0.02**	**-0.04, -0.01**	**<0.001**	**-0.02**	**-0.03, -0.01**	**<0.001**
Car (bin)	**-0.93**	**-1.7, -0.18**	**0.015**	**-1.0**	**-1.7, -0.35**	**0.003**
People	**-0.16**	**-0.32, -0.01**	**0.037**	-	-	-
Dog (bin)	-	-	-	**-0.59**	**-0.96, -0.22**	**0.002**

Moving away/ Not moving away			
Variable	Estimate	95% CI	p-value
Intercept	**-2.2**	-2.7, -1.8	**<0.001**
Dog (bin)	**1.7**	1.1, 2.3	**<0.001**
People	**0.4**	0.20, 0.59	**<0.001**
Jogger (bin)	**-1.0**	-1.9 -0.16	**0.020**
Vehicles	-0.13	-0.32, 0.05	0.2

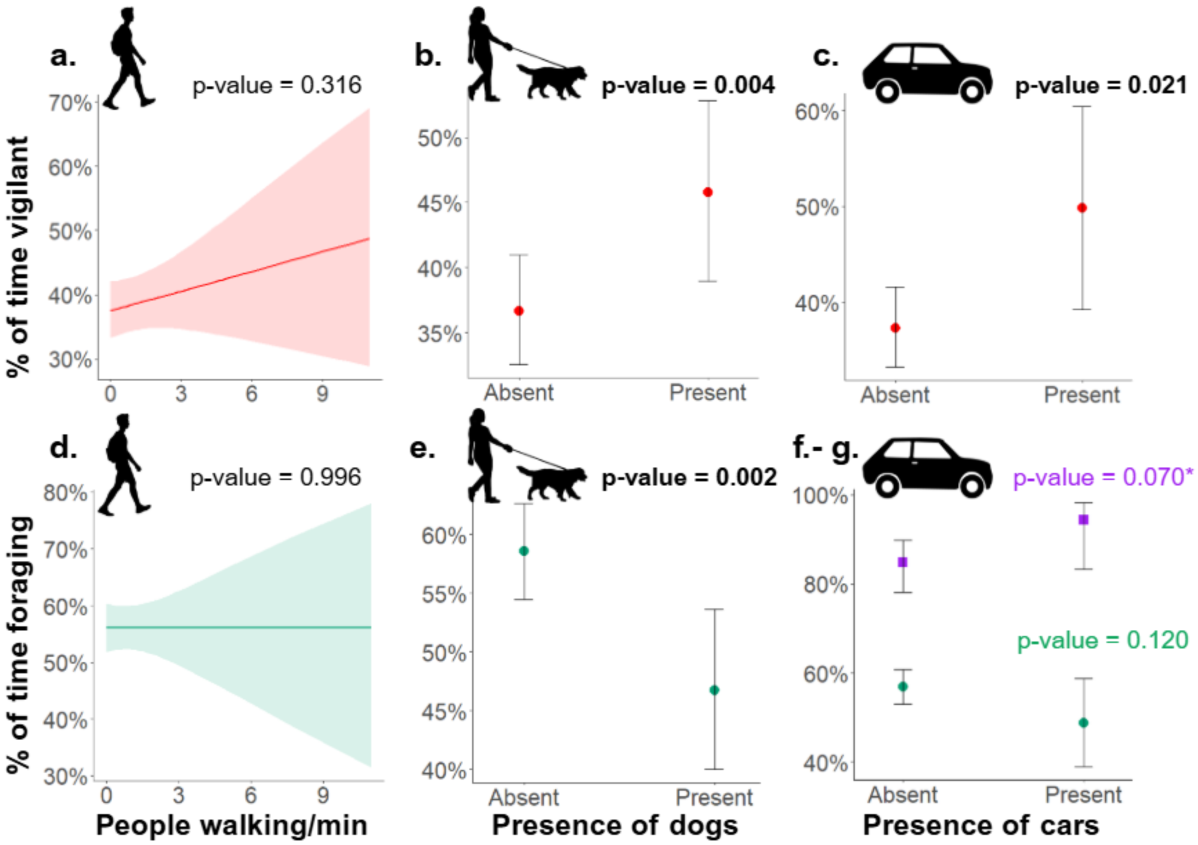

Figure 5. Proportion of time barnacle geese spent a.- c. vigilant (top row) and d.- f. foraging (bottom row) in the presence of people (people per minute), dogs and cars (presence/absence), when the behaviour was occurring during the focal observation. Coloured dots represent the estimated means (with 95% confidence intervals) from a GLMM with the lowest AICc in the candidate model set, or in the case of the term "people", which was not present in any of the best models (Table 3), the estimates are from the model with lowest AICc including the term. *In the bottom right figure g. presents the probability that the geese foraged during the focal observation in the presence of cars from "Foraging/Not foraging"-model (Table 5) presented with purple colour squares (instead of green dot for figure f.). Bolded p-value indicates statistical significance.

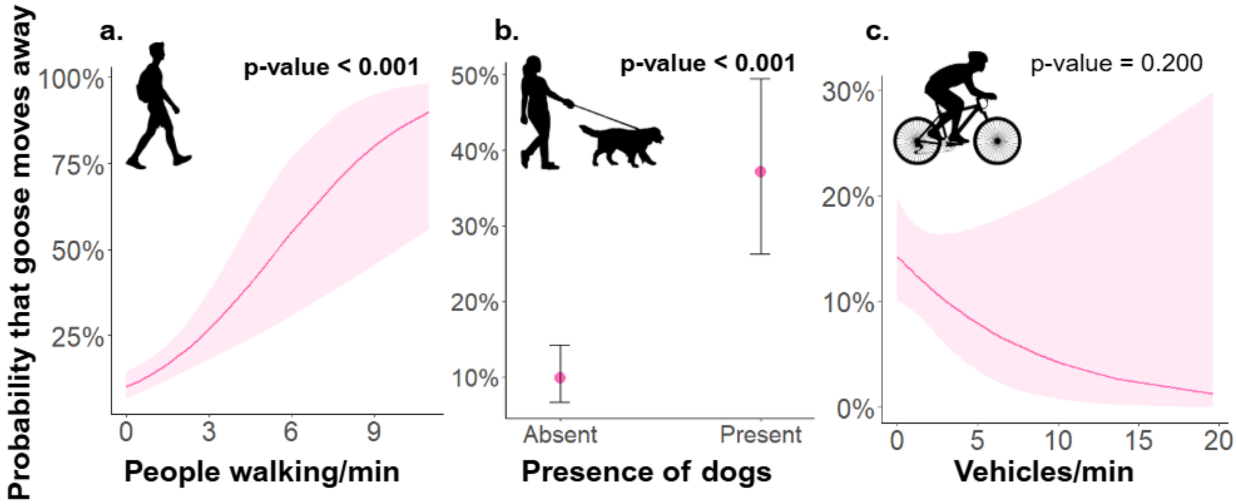

Figure 6. Probability that goose moved away (walking, running or flying) during the observation session when there were a. people (continuous), b. dogs (binary) or c. vehicles (continuous) present. For people and vehicles the fitted line and 95% confidence intervals are from the GLMM with the lowest AICc presented in Table 5. For Dogs coloured dots represent the estimated means (with 95% confidence intervals) from the same GLMM.

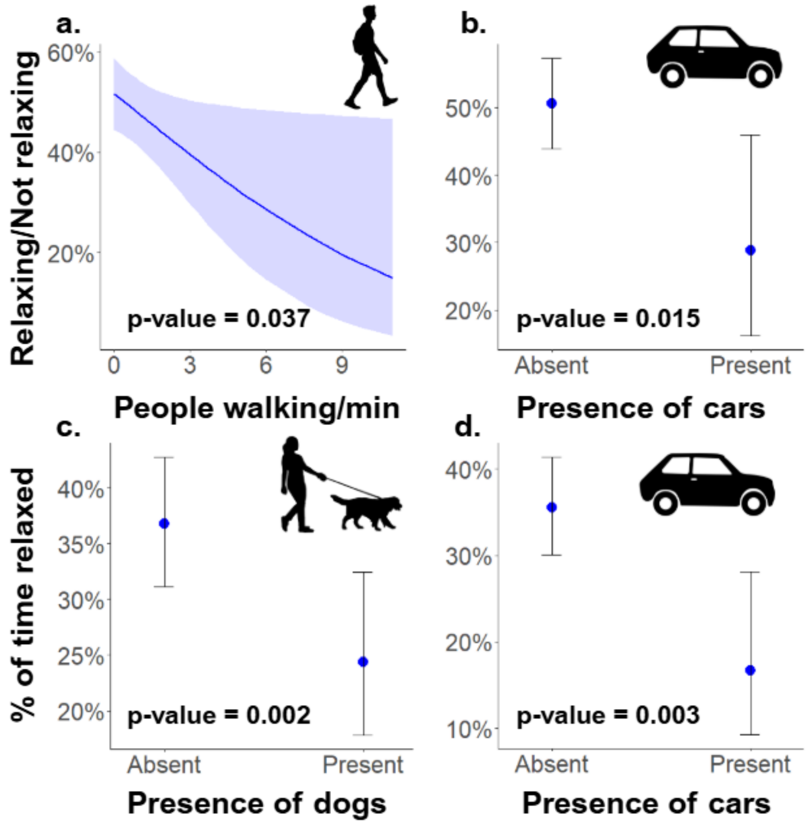

Figure 7. In the top row is the probability that geese engaged in relaxed active behaviour during the focal observation in a. the presence of people (people per min) and b. cars. In bottom row is the time spent in the behaviour when it was occurring in c. presence of people and d. cars. Fitted line and coloured dots represent the estimates (with 95% confidence intervals) from a GLMM with the lowest AICc in the candidate model set. Bolded p-value means statistical significance.

3.2.3 How people activity on a site affects flight initiation distance (FID)?

I measured the FID 116 times, out of which 94 ended up in the analysis because there was no people activity data for 22 of the observations. The mean distance for FID was 7.3 m ± standard deviation 6.1 m (n=94). There was no evidence that the activity of people ("activity of people" here: all the activity categories in Table 2 together) on a site would have affected barnacle goose FID, as the term was not in the best models (Table 3). The FID increased significantly during the season (Days: p-value < 0.001, Table 6). There was no evidence that flock size, distance to the nearest goose or behaviour of the approached goose would have affected FID, as the best model to describe the data was the null model (Table 3).

Table 6. Parameter estimates for model describing the environmental variables affecting flight initiation distance (FID) that had lowest AICc value.

FID Environment model			
Variable	**Estimate**	**95% CI**	**p-value**
Intercept	**0.94**	**0.61, 1.3**	**<0.001**
Cloud	0.06	0.00, 0.12	0.061
Days	**0.02**	**0.01, 0.03**	**<0.001**

3.3 How people activity affects the flock size on a site and what is role of flock size on barnacle goose behaviour?

Flock sized ranged from one individual goose to 1200 geese, with a mean of 101.1 geese counted in the beginning of the observation. A large flock of over 1000 geese was only observed once (Figure 9).

There was some evidence that increased number of people would have decreased the flock size on a site, the term was present but slightly above significance (Estimate = -0.09, SE = 0.046, p = 0.0513) in the smallest AICc model (Table 3) and in the second model of the model set the term showed significance (Estimate = -0.09, SE = 0.046, p = 0.048). There is no evidence that vehicle activity would have affected the flock size, but dog activity showed weak evidence as the term was present in the best models, however not significantly (Table 3). The flock size affected geese vigilant behaviour by geese in larger flocks spending less time vigilant during the focal observation significantly (p < 0.001, Table 5). Flock size did not show evidence of an effect on FID (the best model was the null model, Table 3).

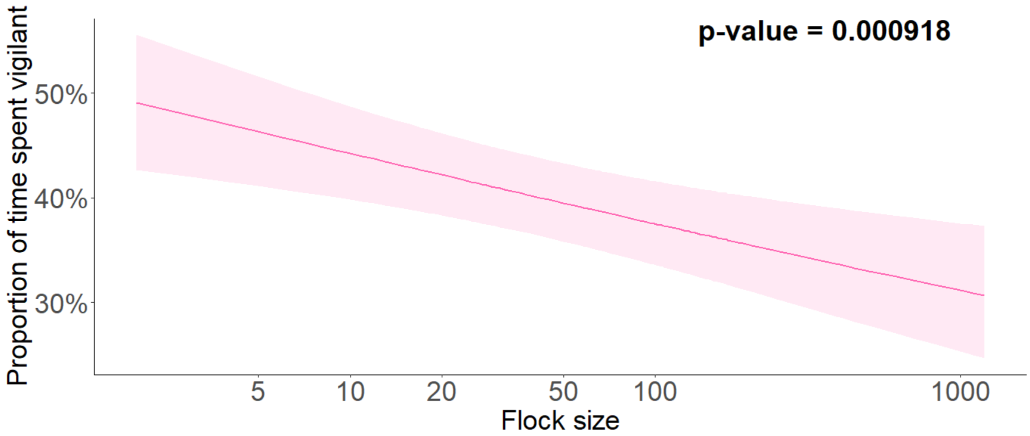

Figure 8. Proportion of time geese spent vigilant during the 3 min focal goose observation in relation to the flock size. Fitted line and 95% confidence intervals are generated from the output of the top model presented in Table 5. The x-axis shows flock size on a logarithmic scale, but to make the interpretation easier the axis labels indicate the original values.

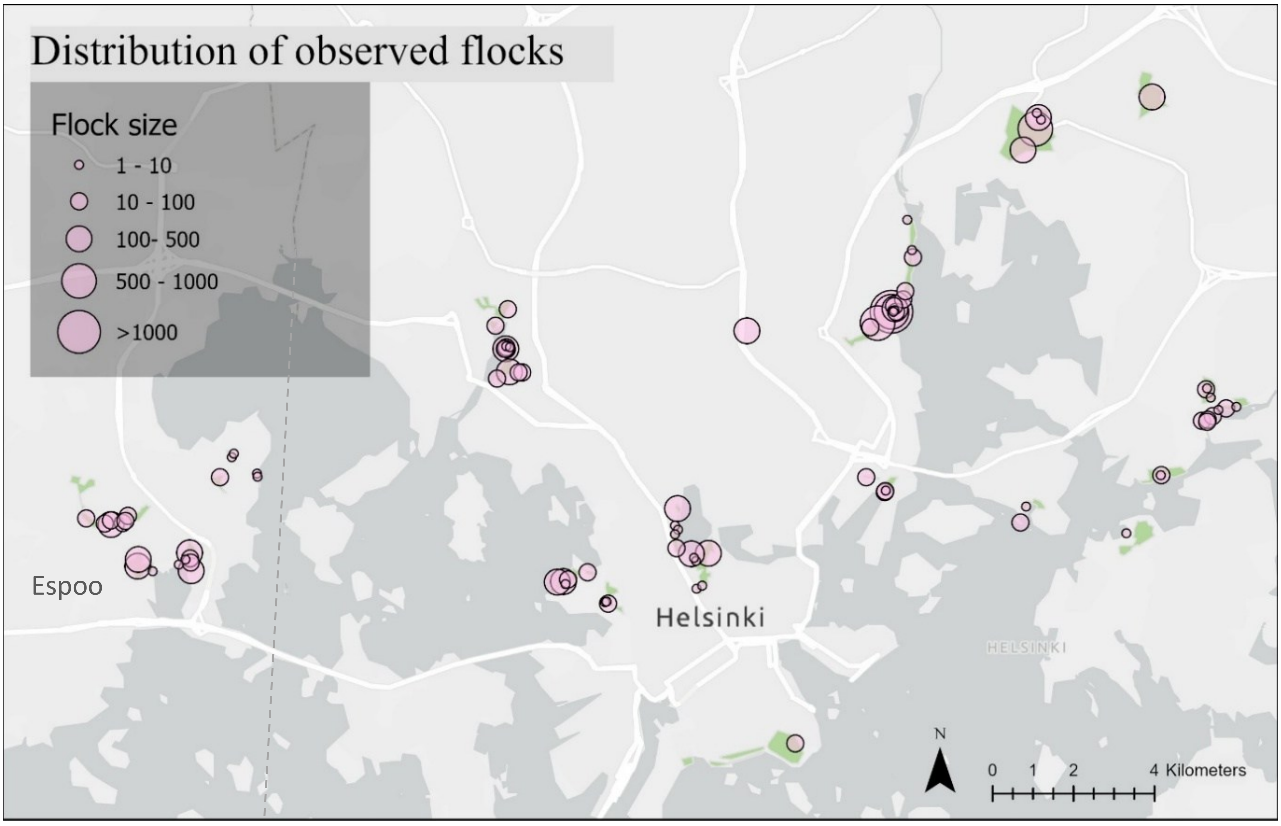

Figure 9. Observed flocks and their size. The size of the circle indicates how many birds were in the flock.

4. Discussion

Since the establishment of urban populations of barnacle geese in Helsinki and other cities in Finland, the presence of the geese in the parks has caused a lot of discourse. For example, citizens are complaining about large flocks of geese foraging in parks that leave large amounts of excrement behind, damaging the recreational value of the parks. Despite this, the findings of this study suggest that both the barnacle geese and people are mainly able to coexist. I found that the presence of a flock of geese was unrelated to the number of people, vehicles, and dogs on a site, and most of the interactions between geese and people were neutral. Also, geese were tolerant of most of the measured people activities, except reactions to dog walkers and the increased probability of moving away when there were more people walking. The flight initiation distance measurements did not show habituation between different levels of activity in observation sessions, but were overall short, indicating that the geese were habituated to the presence of people, which can be an important factor facilitating their use of urban habitats.

4.1 Human-barnacle geese coexistence in urban parks

In the Finnish media, the attitudes towards urban barnacle geese seem to have a negative tone (Kauppinen 2020). However, these attitudes were not as evident in the field. The fact that most of the interactions I observed were neutral indicates that people in Helsinki seem to have habituated to the geese. As the geese have been present in Helsinki for 36 years, they are nowadays a common sight in urban lawns for local people. At the end of the summer, when I conducted my fieldwork, people had already had the opportunity to observe them for the entire summer. Tourists, on the other hand, may show more interest and stop to look or take pictures of geese.

Although rare, I did observe some negative interactions towards the geese. The negative interactions included people chasing geese, dogs chasing geese, and people throwing objects at geese. I did not witness any physical harm done to the geese. However chasing geese, which results in a pause in foraging or even a goose leaving the site, can impact its survival by reducing the energy gained that day. There is also a possibility that because there was at least one observer to witness people's actions towards geese could have affected their behaviour, as most people know it is not socially acceptable to bully animals. While this study investigated people's actions towards the geese on the field, it would also be important to investigate people's attitudes towards them with a questionnaire, as even though some do not necessarily show their feelings in their actions towards the animals, their attitudes may show more indirectly, for example, when voting about conservation decisions (Richardson et al. 2020).

The reason behind the negative tone in news reporting about the urban barnacle geese could be the fact that news sensationalising human-wildlife conflicts gets more views on social media than neutral ones (Nanni *et al.* 2024). This can amplify the negative feelings towards the animals as more people will see the negative news or posts. For example, news about spiders with sensational headlines talking about spider bites and other unpleasant interactions with them gets two to three times more shares on Facebook (Mammola *et al.* 2020). This way, opinions that are not even necessarily truthful, as the spider bites are extremely rare and often not as harmful as described, can shape public opinion (Mammola *et al.* 2020; Nanni *et al.* 2025).

Increasing people's knowledge of the barnacle goose behaviour could have a positive impact on people's attitudes. For example, one reasons for negative attitudes towards the barnacle geese is a fear that the geese attack people during the breeding season (Harjuntausta *et al.* 2013). People who are not familiar with the behaviour of the barnacle goose may perceive large flocks of geese in the late summer and autumn as frightening if they expect them to behave aggressively. During my observations, I did not encounter any attacks (chase or contact) from geese towards people, except on one occasion when a goose expressed mild aggression by lowering its head and hissing at a child walking towards it on a road. Knowing that the geese are not aggressive after the goslings have grown and being able to differentiate between different goose postures could help people to better tolerate their presence and share urban spaces.

One common interaction between birds and people in parks is people feeding them. Provisioning food for geese or other animals is a way for people to connect with wildlife, but it may also cause increased problems due to the animals losing their fear for humans (Fox 2019). Also, the food provided by people can be unhealthy for animals, especially ones with strict foraging requirements (Murray *et al.* 2016). During the field observations I encountered people giving food to barnacle geese twice, but this was not during the observation sessions. The people staying around geese had no effect on any of the geese behaviours measured, which indicates that barnacle geese have not changed their behaviour to expect food from nearby people. As the barnacle goose diet is specialised in grass, food that people provide to them may not interest them as a food source.

The barnacle geese seem to be habituated to the presence of people as well as people are to them. This is supported by the lack of evidence that the rate of people, vehicles or dogs observed in the parks would affect the probability of observing a flock of barnacle geese. The variation in probability to observe a barnacle goose flock between sites (Figure 2) could be better explained by other environmental factors, such as distance to water body, size of the foraging site or flight barriers, which have been found to affect the site attractiveness for many species of geese, including the barnacle goose (Groom *et al.* 2020). The barnacle goose also shows a foraging preference for grasses, implying that vegetation may influence site selection (Koski *et al.* 2019). The habituation of geese is also supported by the finding that people or vehicles moving past the goose did not affect the time it spent foraging or vigilant.

Measuring the flight initiation distance (FID) is a common way to measure the habituation of an animal to urban environments. Urban birds, such as the mallard (*Anas platyrhynchos)*, the Eurasian magpie (*Pica pica*) and the common starling (*Sturnus vulgaris*), tend to have reduced FID compared to rural ones, which is often explained by increased tolerance towards humans by habituation or decreased anti-predator behaviour due to the decreased predation in cities (Samia *et al.* 2017). In this study, I only had access to the urban population of the barnacle goose, and therefore, I measured the habituation to the temporal activity of people on a site. I did not find evidence that increased people activity would result in shorter FIDs in the urban barnacle geese. However, the observed mean FID of 7.3 meters is a lot lower than what is measured for barnacle geese in nature. Barnacle geese have a mean FID of 77 m in agricultural land in southern Sweden (Elmberg *et al.* 2025) and an even longer mean FID of 330 m for brood rearing barnacle geese in the Arctic Archipelago of Svalbard (Madsen *et al.* 2009). This could be seen as additional support for the other findings on the habituation of the barnacle geese to people. However, as the methodologies, for example, the starting distances between studies are different, direct comparisons between studies cannot be made.

The fact that the activity of people did not show an effect on FID implies that the geese don't temporally adjust their tolerance to humans when there are more people around. The reason for not finding this effect inside the urban area could be that in every site the geese interact with people daily, even though temporarily, the activity of people could be lower. The geese could also be moving between the parks with different levels of activity. In the study on song sparrows, repeated FID measurements decreased the FID in rural birds but did not influence the already lower FIDs of urban birds (Fossett & Hyman 2021). This implies that after a certain point of human exposure, the FIDs are not affected by human density but by other things, such as personal tolerance of the bird. There is also a possibility that the goose was habituated to the observer at the point of FID measurement, as the observer had spent some time near the goose in close distance (~40 m) already during other observations. This could also explain why there was no relation between FID and the behaviour of the goose, as most of the focal geese were already aware of the observer, regardless of their behaviour.

While habituation to human presence is key to successful colonisation of urban habitats, it can also lead to problems for both animals and people. The tolerance of barnacle geese towards vehicles (bicycles and electric scooters) could increase the risk of vehicle collisions, which are a common cause of injuries for wildlife (Soulsbury & White 2015). For other species of birds (e.g. magpie-lark (*Grallina cyanoleuca)* and little raven (*Corvus mellori)*), bicycles have evoked longer FIDs and more often resulted in birds flying than walking away from pedestrians (Bernard *et al.* 2018). The reason for the different findings between the studies could be that barnacle geese are more tolerant towards bicycles, but also from the direction of the movement of the bicycle. Unlike in this study, where the bicycles often stayed on the bicycle road and passed the geese at a similar distance, in Bernard *et al.* (2018) study, the bicycle drove towards the geese. However, in some cases I observed cyclist stopping their ride to go around geese that were not moving out of the way. Geese did not show similar tolerance towards cars, which probably are not as likely to avoid possible collision with geese, as it could cause accidents in the traffic.

4.2 Barnacle goose behaviour in the presence of dogs

The barnacle geese seem to be able to discriminate between disturbances. While geese seem to be tolerating people and smaller vehicles going past them, geese were more cautious of dogs and cars, as their presence increased time spent vigilant and decreased time spent foraging (Figure 5). This has also been observed in other species of urban geese, such as greylag geese (*Anser anser*) and Egyptian geese (*Alopochen aegyptiaca*), which showed stronger reactions to disturbance by dogs than pedestrians or bicycles (Hohmann & Woog 2021). Greylag geese have been shown to discriminate even between different sized dogs, showing longer reaction distances for larger dogs than smaller dogs (Woog & Schwarz 2024). As dogs resemble the natural predators of geese, such as foxes, and behave unpredictably, possibly even injuring geese occasionally, it may be that geese are not habituating towards them in the same way they do towards humans (Hohmann & Woog 2021). The barnacle geese in Helsinki may have had bad experiences with dogs, as dogs were used to deter geese from parks a couple of years ago, and nowadays people are still releasing their dogs from leash to scare geese without permission (SYKE, Valkoposkihanhiseuranta 2024; personal observation). The barnacle geese may also have aggressive encounters with dogs in their migration stopover sites or wintering grounds, however, I did not find evidence for this in the literature.

The behaviour changes related to dogs could have adverse effects on geese. Decreased time foraging, increased time vigilant, and moving away, especially by flying, means decreased energy gains for the geese. However, the finding that the presence of geese was not affected by the number of dogs in the parks reveals that using parks for foraging has most likely more benefits than costs for the geese. For example, geese could be chased away more from nearby agricultural fields than from parks.

4.3 Does flock size facilitate the coexistence between geese and humans?

The Dilution Effect Hypothesis states that in larger groups individuals experience a reduced probability of predation, resulting in decreased vigilance and flight initiation distance (FID) as animals feel safer (Stankowich & Blumstein 2005). Therefore, the formation of groups may be an important factor facilitating adaptation to live in urban areas, which is supported by a study by Ardila-Villamizar *et al.* (2022), which found that birds living in larger conspecific flocks show a more tolerant response to human approaches. The results of this study show that individual geese spend less time vigilant in larger flocks (Figure 8), which indicates that in larger groups the geese can tolerate the human presence better, as they do not have to spend as much time vigilant, even though there would be more distractions around (e.g. cars or dogs according to this study). Barnacle geese's tendency to form flocks could have been one of the reasons for the successful colonisation of urban areas of Helsinki, even though the flocks I observed here (mean of 101 geese) are smaller than in their natural breeding grounds in the Arctic (mean of 1 751 geese reported by Black & Owen 1989).

However, the flight initiation distance (FID) was not affected by flock size, as would have been expected due to the dilution effect (Ardila-Villamizar *et al.* 2022). The interaction between FID and flock size may be more complex, as studies have found varying results. For example, increasing flock size decreased FID in urban birds in Colombia (Ardila-Villamizar *et al*. 2022), whereas for European urban birds, FID increased with increasing flock size (Morelli *et al.* 2019). A previous study on the natural population of barnacle geese in Sweden did not find an effect between flock size and FID (Elmberg *et al.* 2025).

While for geese living in large groups may help them coexist with humans, the large flocks are also a reason behind some of the problems causing conflict, such as fouling of lawns with droppings, overgrazing, and taking more space from people's recreational activities. A study by Eriksson *et al.* (2023) shows that, although people generally have a positive attitude towards geese, they can still have a low acceptance capacity towards them. Tolerance towards large flocks of barnacle geese compared to smaller ones could be explored in future studies.

5. Conclusion

According to the findings of this study, both urban barnacle geese and people appear to be accustomed to coexisting in the parks of Helsinki and Espoo. For the geese, the results show that they do not avoid the presence of people in parks or change their vigilance or foraging behaviour in relation to more people walking near them. From the people's perspective, most of the recorded interactions were neutral towards the geese. However, there were still some negative interactions that could be harmful to the geese, one of which was people allowing dogs to chase the geese. The barnacle geese were more vigilant in the presence of dogs, which could be a result of these negative interactions or an innate response to canine predators. In this conclusion, I will give my recommendations for steps that could be taken for even more peaceful coexistence in the future.

First, future studies could further explore the attitudes of citizens with a questionnaire study to confirm the high degree of tolerance for the geese this study suggests, which contrasts with the sensationalistic reporting seen in the media. Understanding the public attitudes is crucial in making decisions about urban wildlife to prevent and mitigate possible urban wildlife conflicts (Fox 2019). For example, in the city of Helsinki citizens can participate to city planning through OmaStadi projects, which are projects planned by citizens and funded by the city. In 2024, a project towards mitigation of the geese droppings, by building a geese fence to control the geese movement in Kaivopuisto, was chosen in a public vote (Helsingin kaupunki, 2025). Currently the project is still on the implementation phase, but it will be interesting to see how it works and what are the effects on people's tolerance towards the geese.

Secondly, increase people's knowledge of barnacle goose behaviour. The information could, for example, include the behaviour changes of the barnacle geese during the summer season. In the early summer when geese are nesting, they can attack people coming too close to the nest or goslings. To avoid conflicts, and because the nesting birds are protected by the Nature Conservation Act (70 §), people should keep their distance and let the geese nest in peace. This knowledge is well passed by the Korkeasaari Zoo, where negative interactions between people and geese are mitigated by having informational signs and people working as goose guides to inform visitors on goose behaviour and coexistence (Korkeasaari, 2025; see also: Kisora & Driessen, 2025). Later in the summer, as seen in my results, geese are not aggressive towards people and are quite tolerant to their presence. Taking a similar approach to inform people outside the zoo about the barnacle geese behaviour in the parks can increase goose wellbeing and help people tolerate them even better. This information could include that geese need the lawns during summer and autumn to gather enough energy first for their young to grow up and then to migrate to their wintering grounds. As well as information about geese behaviours that can be threatening to people, such as an aggressive approach with the head down and neck outstretched, and that they are more likely to occur when the geese are with their goslings.

Thirdly, people should not use dogs to deter the geese from the parks. As this study shows, dog presence cause geese to be more vigilant, and them chasing the geese causes energetically costly flight responses, which could potentially affect the wellbeing of the geese. Dogs have been used for chasing the geese from parks in Espoo, Lahti and Helsinki with a special permit from Centre for Economic Development, Transport and the Environment (SYKE, Valkoposkihanhiseuranta 2024), but the effectiveness of measure is not clear and often the geese return to the site after some time. During my field observations I saw people use their own dogs to chase away the geese, which is illegal. Such behaviour could be because of lack of knowledge or because there are no consequences for the action.

This study is a new addition to the evidence showing that to live in urban environments species can tolerate high human disturbance levels. I also show how the rather recently increased urban population of barnacle geese in Helsinki can be a great study system to study human-wildlife coexistence and bird species' adaptation to the urban environment.

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