Limits of grazing area use by feral Greylag Geese *Anser anser* during moult

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Abstract

Use of grazing areas by feral Greylag Geese *Anser anser* was studied from May–September 2010 to compare grazing pressure at two feeding sites during and after moult. Grazing pressure was determined from weekly counts of goose droppings within random 5 m^2 plots; vegetation height and composition were measured to determine whether variation in food supply influenced the extent to which geese used the two sites. Distance from the water's edge explained much of the variation in goose grazing across sites, with birds less likely to use areas furthest from open water during moult.

Key words: distance to open water, grazing pressure, vegetation cover.

Foraging decisions can affect an animal's chances of survival (Alcock 1993) and reproductive success (Black *et al.* 2007). Geese tend to select food plants high in nutrients and low in fibre (Prop 1991; Black *et al.* 2007) and food quality is a major factor determining where they feed (Owen 1971; Van der Graaf 2006). When choosing a feeding site, geese balance their need for nutrients against the probability of disturbance and predation (Fox & Kahlert 2000; Kahlert 2006). Optimal feeding areas therefore need to be sufficiently open to detect approaching predators (Madsen 1985). The main reasons for geese leaving a feeding area are usually disturbance by a real predator (foxes or hunters), a quasi-predator stimulus (*e.g.* noise, helicopter or car) or a false alarm (Madsen 1985; Kahlert 2006). Disturbance that leads to physical escape is an energetically costly process, and additionally reduces the time available for feeding (Kahlert 2006).

In cities such as Stuttgart, disturbances are plentiful; people walk up to the geese, children try to catch them and dogs, cars or helicopters can cause the birds to retreat to the safety of an open water body. Geese usually flee by walking quickly or flying to water, which provides safety from most terrestrial predators (Schwarz 2010). During moult, geese are flightless for up to five weeks (Cramp & Simmons 1977; Taylor 1995) making them more vulnerable to interference and predation at this time. In principle, geese should prefer to graze at the water's edge when flightless, enabling retreat to safety from predators. If all geese were to do this, however, the vegetation close to the water would quickly become depleted or of reduced nutritional quality, and under these circumstances the geese may experience more agonistic behaviour as they compete for limited resources. Thus areas close to the water need not necessarily be preferred during the moult.

Detailed studies of habitat use by moulting geese have been carried out mostly in the birds' natural environment, for instance in Alaska for Black Brant *Branta bernicla nigricans* (Weller *et al.* 1994; Lewis *et al.* 2011), in Greenland for Pink-footed Geese *Anser brachyrhynchus* and Barnacle Geese *Branta leucopsis* (Madsen & Mortensen 1987) and on the Danish island of Saltholm or in the Oostvaarderplasen, the Netherlands, for Greylag Geese *Anser anser* (Fox & Kahlert 2000; Loonen *et al.* 1991). There have, however, been few studies of habitat use by geese in urban areas (Käßmann & Woog 2008), and to the best of our knowledge there have been no such studies to date made during the moulting period. Urban habitats may differ from more natural settings in that geese are more used to people, show lower flight distances, perceive predation risk differently and are exposed to other forms of disturbances. This study therefore analyses grazing pressure in relation to vegetation height, vegetation cover and distance to water at two feeding sites used by Greylag Geese in an urban environment (Stuttgart, Germany), and investigates whether the birds' use of these sites – particularly their proximity to water – varies depending on whether or not the birds are in moult.

Methods

Study area and study population

Since first breeding successfully in 1995, a population of feral Greylag Geese *Anser anser* has become established in Stuttgart, southwest Germany (48°46'N, 9°10'E; Woog *et al.* 2008). Numbers increased to 282 individuals by 2010 (Schwarz 2010; Woog *et al.* 2012), and birds also moult in the area, mostly from late May – late June. Woog *et al.* (2011) provide a more detailed description of this population.

Observations were made from 24 May – 5 September 2010 at two sites in Stuttgart, used by the geese throughout their annual cycle: 1) a system of three small lakes in a park close to the inner city ("Park"), which has a small flock of *c.* 30 moulting geese, and 2) a lake 7 km to the north along the river Neckar (Max-Eyth Lake, "MES"), heavily used for leisure activities, but also the most important breeding site for geese in the area, which has a flock of about 200 geese during moult (Woog *et al.* 2008). Regularly mowed pastures around the lakes offer year-round high quality grazing (Schwarz 2010; Woog *et al.* 2012) as repeated mowing increases the protein content of many grasses and herbs (Ydenberg & Prins 1981; Gadallah & Jefferies 1995). In Stuttgart, geese are used to humans and, when able to fly, most individuals walk away for only a few meters to avoid them. They strongly react towards dogs, however, especially large ones (Schwarz 2010). Dogs and people account for 30% of known causes of goose mortality ($n = 17$) in the city (F. Woog, unpubl. data). There has been no evidence for predation by nocturnal foxes or mustelids in the past decade (2002–2012), which may be attributable to the geese being mostly diurnal and spending the night on water or on islands.

Data collection

Grazing pressure was expressed as dropping density per 5 m^2, which is considered a better measure than observational data of how markedly different areas are used for grazing (Ebbinge *et al.* 1975; Ydenberg & Prins 1981; Woog & Black 2001; Black *et al.* 2007). Ninety two circular plots each covering 5 m^2 were placed along randomly selected transects (Park: $n = 46$, MES: $n = 46$) at varying, measured, distances from the water. Droppings were counted and removed weekly from the plots. Resting piles of droppings produced by loafing geese where counted but later excluded from the analysis, as were plots close to points where people feed the birds.

Vegetation height was measured each month, by placing a ruler at three random points within each plot, and recording (to the nearest mm) the maximum height of the vegetation. As the grass was of uniform length, this gave a good measure of the height of the sward. Vegetation cover was also estimated at the start of the field season by assessing, to the nearest 5%, the percentage cover for herbs, grasses, moss and soil within each plot.

Data analyses

Generalized linear models (GLMs) in program "R", version 2.11.1. (R Development Core Team 2010), were used to determine factors that had a significant influence on grazing pressure. The number of droppings per plot was used as the dependent variable and a quasi-Poisson error distribution with logarithm link function was used to fit these data in the GLM. To reduce the effects of data dependency between weekly measures, the number of droppings accumulated (*i.e.* grazing pressure) were analysed for different time periods. Firstly, the complete study period (from 24 May – 5 September 2010) was considered. Secondly, to test the effects of moult, we summed droppings accumulated over the four weeks when most birds were flightless (24 May – 20 June) and compared this with droppings accumulated during four weeks when all birds were capable of flight (9 August – 5 September).

Explanatory variables included in the model were field number, distance to the water, vegetation height, total vegetation cover, grass cover and herb cover. All explanatory variables were categorical. The distance to the edge of the water was classed as: 1) < 30 m, 2) 30–60 m, and 3) > 60 m; vegetation height as: 1) < 6 cm, and 2) 6–9 cm; vegetation cover as: 1) ≤ 120%, and 2) > 120%; and grass cover and herb cover were each classed as: 1) < 40%, 2) 40–80%, and 3) > 80%.

Variation in the dropping data was explored initially by testing the effects of each explanatory variable, independently, in an ANOVA. All explanatory variables were then fitted to one model (GLM) sequentially. As the cover parameters were correlated (vegetation cover and grass cover, $r = -0.3$, $P = 0.003$; vegetation cover and herb cover, $r = 0.57$, $P < 0.0001$; grass cover and herb cover, $r = -0.96$, $P < 0.0001$), only total vegetation cover was included in the

GLM. Thirdly, various models were tested against each other using F-tests, as recommended by Bolker *et al.* 2009 for quasi-Poisson models. Model testing followed the procedure proposed by Korner-Nievergelt & Hüppop (2010), in which a model containing one explanatory variable (*e.g.* "site") is compared with a model containing the same and an additional variable (*e.g.* "site" + "distance to water"), and a significant F-test indicates that the second variable has an additional explanatory value. This was done for all explanatory variables separately. The most significant explanatory variable was then included in the next model (thus controlling for it in subsequent tests), which was again compared against models containing an additional variable (*e.g.* the first model "site" + "distance to water" was tested against a second model containing "site" + "distance to water" + "vegetation cover"), until inclusion of additional variables no longer improved the explanatory power of the model.

Results

When testing single terms, grazing pressure varied most with site ($F_{1,90}$ = 18.68, $P < 0.001$; Fig. 1), with the Max-Eyth Lake having much higher dropping densities than the Park. Geese preferred plots with high grass cover (> 80%; $F_{2,89}$ = 11.45, $P < 0.001$), low herb cover (< 40%; $F_{2,89}$ = 7.0; $P < 0.01$) and that were close to the water's edge ($F_{2,89}$ = 13.78, $P < 0.001$; Fig. 2). Total vegetation cover and vegetation height tested as single factors had no influence on grazing pressure. There was little variation in vegetation height (of the 95

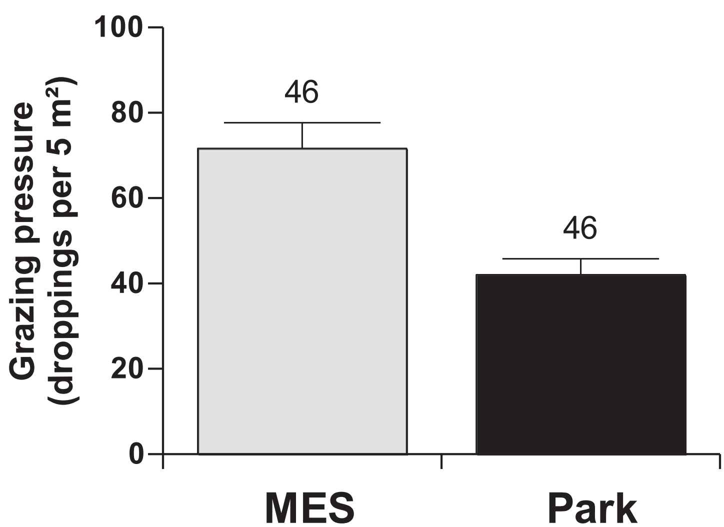

Figure 1: Mean grazing pressure (± s.e.) at the two study sites, measured as cumulative droppings from 24 May – 5 September 2010. "MES" = Max-Eyth Lake, "Park" = park close to the inner city, Stuttgart. Sample sizes indicate the number of plots per pasture.

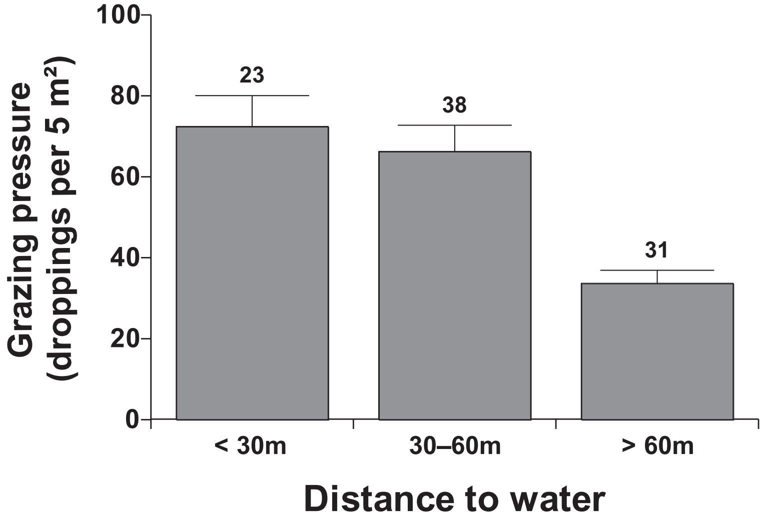

Figure 2: Mean grazing pressure (± s.e.) by Greylag Geese in Stuttgart (cumulative number of droppings between 24 May – 5 September 2010), in relation to the distance of the dropping plots from the water's edge. Sample sizes indicate the number of plots surveyed.

plots, 56% were < 6 cm and 34% were 6–9 cm).

On considering the entire study period, regardless of whether or not the birds were in moult, only "site" and "distance to water" had a significant effect on grazing pressure (GLM: $F_{1,90}$ = 34.0 and $F_{2,88}$ = 37.67 respectively, P < 0.001 in each case); vegetation height and vegetation cover did not prove significant ($F_{1,87}$ = 2.64 and $F_{1,86}$ = 0.87, n.s.) when included in the model. When controlling for "site", only "distance to water" and "grass cover" were significant, but when controlling "for distance to water" then "site", "grass cover" and "herb cover" had an influence (Table 1). On controlling for "site" and "distance to water" at the same time, none of the vegetation parameters remained significant (Table 1).

The data were grouped into the four weeks during moult (when birds were flightless) and four weeks during the period when birds were able to fly to test the effects of moult, on the birds' use of the different sites. For this reduced dataset, "site" and "distance to water" again had a significant effect on grazing pressure (GLM: $F_{1,182}$ = 26.94 and $F_{2,179}$ = 21.21 respectively, P < 0.001 in each case), with "moult" also proving significant ($F_{1,181}$ = 6.17, P < 0.05), but not vegetation cover and vegetation height ($F_{1,178}$ = 0.48, n.s. and $F_{1,177}$ = 2.12, n.s.) when these terms were included sequentially in the model. Because grazing pressure was significantly higher at the Max-Eyth Lake than at the Park (Fig. 1), changes in feeding distribution at the two sites were tested separately in subsequent analysis. During moult, grazing pressure

Table 1. Significance of explanatory variables added to three initial models, to test the effects of site, distance to water, vegetation height and vegetation cover on Greylag Goose grazing pressure (expressed as droppings/5m^2 accumulated over the entire study period). Each of the three models in the left column was tested against that model plus one of explanatory variables on top (*i.e.* Droppings~Distance to water was tested against Droppings~Distance to water+ % grass cover *etc.*). The site and the distance from open water explained most of the observed variation in grazing pressure. Significant results are given in bold.

Initial model	Variables added to the model					
	Site	Distance to water	% Grass	% Vegetation	% Herbs	Vegetation height
Droppings~Site	X	**$F_{2,88}$ = 37.55 P < 0.001**	**$F_{2,88}$ = 3.20 P < 0.05**	$F_{1,89}$ = 0.85 P = 0.36, n.s.	$F_{2,88}$ = 0.88 P = 0.42, n.s.	$F_{1,89}$ = 0.19 P = 0.66, n.s.
Droppings~Distance to water	**$F_{1,89}$ = 62.74 P < 0.001**	X	**$F_{2,87}$ = 15.79 P < 0.001**	$F_{1,88}$ = 3.25 P = 0.07, n.s.	**$F_{2,87}$ = 12.13 P < 0.001**	$F_{1,88}$ = 0.27 P = 0.60, n.s.
Droppings~Site + Distance to water	X	X	$F_{2,86}$ = 0.76 P = 0.47, n.s.	$F_{1,87}$ = 0.86 P = 0.36, n.s.	$F_{2,86}$ = 0.60 P = 0.55, n.s.	$F_{1,87}$ = 2.23 P = 0.14, n.s.

decreased with distance to water at both sites, but this was more evident at Max-Eyth Lake (Fig. 3; Tables 2a,b). The geese used plots at distances of ≥ 30 m less during the moulting period. When birds were able to fly (*i.e.* not moulting), distance to water did not have a significant influence on grazing pressure ($F_{2.43}$ = 2.66, P = 0.08 and $F_{2,43}$ = 0.7, P = 0.5 for non-moulting geese at MES and the Park, respectively; n.s. in each case). Moreover, grazing pressure at the Max-Eyth Lake was much higher than at the Park during moult ($F_{1,90}$ = 70.1, P < 0.001), whereas outside the moulting period grazing pressure was similar between the two sites ($F_{1,90}$ = 0.21, P = 0.65, n.s.).

Discussion

During moult, feral Greylag Geese in Stuttgart preferred to graze closer to the water and this was not influenced by vegetation height or vegetation cover. Moulting geese used areas at greater distances from the water less, and this reduced the area available for foraging. Fox & Kahlert (2000) found a reduced feeding range of moulting Greylag Geese on the Danish island of Saltholm. This is a pattern also found for feral Greylag Geese in

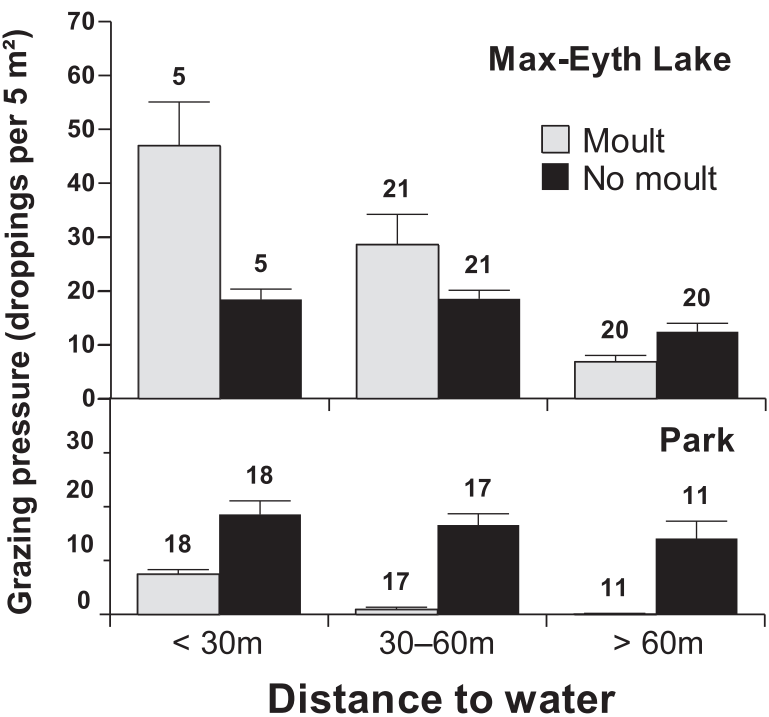

Figure 3: Mean grazing pressure (± s.e.) by Greylag Geese during moult (grey bars; 24 May –20 June) and after moult (black bars; 9 August – 5 September) at the Max-Eyth Lake and the "Park", in relation to the distance of the dropping plots from water. Sample sizes indicate the number of plots surveyed.

Table 2. Significance of explanatory variables added to two initial models, to test the effects of distance to water, moult, vegetation height and vegetation cover on Greylag Goose grazing pressure (expressed as droppings/5m^2) at: (a) Max-Eyth Lake, and (b) the Park. Each of the models in the left column was tested against that model plus one of explanatory variables listed (*i.e.* Droppings ~ Distance to water was tested against Droppings~Distance to water+Moult, *etc.*). Moult status explained most of the observed variation in grazing pressure, with distance to the water also proving significant. None of the vegetation parameters were significant.

Initial model	**Moult**	**Distance to water**	**% Grass**	**% Vegetation**	**% Herbs**	**Vegetation height**
(a) Max-Eyth Lake						
Droppings~Distance to water	$\boldsymbol{F_{1,88} = 5.68}$ $\boldsymbol{P < 0.05}$	x	$F_{2,87} = 0.12$ $P = 0.89$	$F_{1,88} = 1.78$ $P = 0.19$	$F_{2,87} = 0.69$ $P = 0.51$	$F_{1,88} = 3.17$ $P = 0.08$
Droppings~Moult	x	$\boldsymbol{F_{2,88} = 28.22}$ $\boldsymbol{P < 0.001}$	$F_{2,88} = 2.76$ $P = 0.07$	$F_{1,89} = 0.22$ $P = 0.64$	$\mathrm{F}_{2,88} = 1.41$ $P = 0.25$	$F_{1,89} = 0.05$ $P = 0.83$
(b) Park						
Droppings~Distance to water	$\boldsymbol{F_{1,88} = 5.68}$ $\boldsymbol{P < 0.05}$	x	$F_{2,87} = 0.12$ $P = 0.89$	$F_{1,88} = 1.78$ $P = 0.19$	$F_{2,87} = 0.69$ $P = 0.51$	$F_{1,88} = 3.17$ $P = 0.08$
Droppings~Moult	x	$\boldsymbol{F_{2,88} = 28.22}$ $\boldsymbol{P < 0.001}$	$F_{2,88} = 2.76$ $P = 0.07$	$F_{1,89} = 0.22$ $P = 0.64$	$\mathrm{F}_{2,88} = 1.41$ $P = 0.25$	$F_{1,89} = 0.05$ $P = 0.83$

Stuttgart. Fox & Kahlert (2000) suggest that the decrease in area use with distance from the shore was caused mainly by the predator escape mechanism, which is heightened during the flightless moulting period. The Greylags on Saltholm showed more frequent escape responses during moult, including escapes from "quasi predator stimuli" (Kahlert 2006), indicating that being flightless made the geese more "nervous". This was also observed in Stuttgart but detailed data are missing.

Moult is an energy demanding process (Bezzel & Prinzinger 1990; Singer *et al.* 2012). Geese become flightless for up to five weeks and during this time need to balance their need for food with that of predator and disturbance avoidance (Fox *et al.* 1995; Kahlert 2006). The importance of these needs varies between goose species and sites. Some goose species put on fat prior to moult and can at least partly rely on their body reserves during moult whereas others need to feed (Ankney 1984; Fox & Kahlert 2005), or else they lose weight (Loonen *et al.* 1991; Fox & Kahlert 2005; Singer *et al.* 2012), and some deplete food at a site to the extent that it is no longer suitable for moulting (Loonen *et al.* 1991). Predator density, perceived predation risk and probability of disturbance also vary between areas. Because these data have not yet been recorded for Stuttgart, evaluation of the importance of the different factors – *i.e.* the need to maintain proximity to water as opposed to improve food intake during the moult – must remain speculative.

Compared to moulting Pink-footed Geese in Greenland (which feed 200–220 m from water; Madsen & Mortensen 2008), and the Greylags on Saltholm (which roam up to 150 m; Fox & Kahlert 2000), Greylags in Stuttgart rarely ventured more than 30 m from the water's edge. There are several potential explanations for this difference. Birds in Stuttgart may have more endogenous energy stores to rely on, or find food sufficiently rich enough in nutrients close to the water. Alternatively, real or perceived predation risk may be higher in the urban habitat than in the arctic, encouraging the geese to stay close to water, to which they can retreat quickly for safety. The landscape in the parks of Stuttgart consists of small grasslands divided by paths, hedges and trees and as such contrasts with the vast open areas of the arctic, where the birds can see predators and take evasive action at relatively long distances. Flight distances of wintering Pink-footed Geese in Denmark were lower in areas with obstructions to open view (Madsen 1984). The perceived predation risk in Stuttgart therefore may be much higher than in more open landscapes, with a corresponding reduction in the area available for feeding.

Moult migrations to sites with favourable feeding conditions, described for many migratory geese (Owen & Black 1990; Weller *et al.* 1994), occur only locally amongst Greylag Geese in southwest Germany (F. Woog unpubl. ring re-sightings data). Grasses and herbs around the selected moulting sites in Stuttgart are likely to be rich in nutrients, however, through the regular management of the parkland, as repeated mowing generally increases the protein content of vegetation (Ydenberg &

Prins 1981; Gadallah & Jefferies 1995). Grazing pressure was highest in plots with a high grass and low herb cover, a pattern also found by Käßmann & Woog (2007) during the winter. More detailed studies are needed on the food plant taxa selected by the geese, including nutrient content and biomass in relation to observed grazing patterns, to inform and improve habitat management regimes for the birds (Bos *et al.* 2005).

Future studies on moulting geese in urban habitats should concentrate on the study of individuals, their decisions and consequences for their survival and subsequent reproductive success. Is the behaviour of the Greylags in Stuttgart dependent on their condition before and during moult? To what extent do they lose body reserves during moult and is this affected by their reaction towards disturbances? Such studies could also guide management recommendations to set aside areas for undisrupted foraging, especially during moult.

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