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SHORT REPORT

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Gull-human interactions in an urban population of Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *Larus fuscus*

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ABSTRACT
Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *Larus fuscus* were involved in more nuisance events with humans as the breeding season progressed, although human provisioning was negatively associated with gull nuisance events.

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Herring Gulls *Larus argentatus* and Lesser Black-backed Gulls *Larus fuscus* frequently nest in urban areas on rooftops and other structures. This behaviour has led to an expansion of their range and has allowed some populations to grow. In some areas, urban gull populations have reached a point where their numbers are so great that they are considered a nuisance (Rock 2005). However, in many parts of their range, particularly in coastal nesting areas, there has been a decline in their breeding populations. Consequently, despite being versatile and opportunistic, both gull species are now considered of conservation concern in the UK; Herring Gull is Red-listed and Lesser Black-backed Gull is Amber-listed on the Birds of Conservation Concern assessment (Stanbury *et al.* 2021).

Historically, Herring Gulls have only lived inland in small numbers, but there appears to be a positive trend in the number of urban roof-nesting Herring Gulls throughout the UK (Rock 2005) and other parts of Europe (Huig *et al.* 2016). Herring Gull is not the only *Larus* species to settle more permanently in urban areas. In recent decades there has been a shift in the migratory patterns of Lesser Black-backed Gulls, with many individuals remaining in the UK year-round (Rock 2002). An increase in urban food supply (e.g. open air rubbish tips, human provisioning behaviour) may be contributing to this shift in behaviour and migratory pattern (Rock 2002), although there are likely to be many other potential contributing factors to the increase in urban gull populations that are still unknown.

This study focused on interactions between gulls and humans. Previous studies have demonstrated that behaviour is relevant to the management of animal populations from a conservation biology perspective (Moore & Huntington 2008, Shier 2006, Wallace & Buchholz 2001) and when managing nuisance populations. To date, the majority of urban gull studies have described rooftop colonies and foraging at landfills (Coulson & Coulson 2015, Rock 2005), although there is a growing body of literature focusing upon the behaviour of urban gulls and their direct interactions with humans (Goumas *et al.* 2020, 2019, Pais de Faria *et al.* 2021, Spelt *et al.* 2021, Raghav & Booghert 2023)

The city of Bath (51°22′53.02″N 2°21′36.51″W) in Somerset, UK, was chosen as the field site for this study. The urban gull population has been increasing throughout the whole of the south-west of England, including Bath (Winsper 2014), and there is a confirmed population of roof-nesting gulls in the city that have been closely studied by researchers at the University of the West of England (pers. comm. Chris Pawson). A pilot study took place from 1 to 31 March 2017 to establish field sites and relevant behaviours. Six study sites were chosen on the basis of the abundance of gulls witnessed by the team and/or the likelihood that humans and gulls would interact in these locations (e.g. areas with outdoor eating options).

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Field observations were conducted between 1 April and 1 August 2017. The research period covered an entire breeding season from settling to fledging (following Huig *et al.* 2016). Phases in the breeding season were divided as follows: settling (23 March–19 April), laying (20 April–17 May), incubation (18 May–14 June), rearing (15 June–12 July), and fledging (13 July–9 August). To assess any changes in gull nuisance events (producing, raiding, destruction and gull-human aggression; full description in Table 1), gull-human conflict (i.e. any aggressive interactions between humans and gulls, initiated by either gulls or humans), and human provisioning at the six study sites, continuous scan surveys were conducted for 30 min periods (258 periods in total) at each site using the behaviour catalogue in Table 1.

It should be noted that although producing is not a direct nuisance behaviour, some humans may still be unsettled by the mere presence of a foraging gull, and thus it may be considered as both a foraging and nuisance behaviour. Additionally, although it was outlined in our behaviour catalogue (Table 1), there were no observed instances of gull-human aggression throughout the study. We collected count data for all variables. Observations were conducted by the same observer every other day, between 09:00 and 18:45 GMT.

Due to the low number of Herring Gulls in the City of Bath during 2017 (the ratio of Herring to Lesser Black-backed Gulls was approximately 1:4; online Table S1) we aggregated Herring and Lesser Black-backed Gulls into an overall gull count variable. Behavioural data for gull nuisance events were also aggregated into an overall nuisance variable. Incidents of humans being aggressive towards gulls and feeding gulls were counted. Location and phase of the breeding season were all collected as nominal categorical data.

Table 1. Behavioural catalogue used to specify the behaviour of humans, Herring Gulls and Lesser Black-backed Gulls in this study. Producing, raiding and destruction were aggregated under a gull nuisance variable.

Behaviour	Description
Gulls	
Producing	A gull takes consumable material into its beak that it has found on the ground, anthropogenic or natural
Raiding	A gull takes food directly from a human's hands or from a table where a human is eating or previously was eating
Destruction	A single gull or multiple gulls causing damage to human property by biting, ripping, clawing, or defaecating on said property
Gull→human aggression	A gull, or multiple gulls, makes physical contact with a human, unprovoked
Humans	
Feeding gull(s)	A human, or multiple humans, directly feed or throw food in the direction of a gull or multiple gulls
Human→gull aggression	A human, or multiple humans, physically interact with a gull, unprovoked

We had four research questions: (1) how does the abundance of gulls in the city change throughout different phases of the breeding season, (2) is there a change in nuisance events across the breeding season, (3) to what extent are the nuisance events associated with human feeding and human aggression, and (4) how does human behaviour change across the breeding season? Following what is known about the natural history of gulls and recent studies of urban populations of gulls, we made the following predictions: (i) the abundance of gulls would peak during the rearing phase and remain the same until the fledging phase; (ii) gull nuisance events would peak in the rearing and fledging phases; (iii) human aggression towards gulls would increase during the rearing and fledging phases, and (iv) human feeding and gull nuisance would be positively related.

All data were analysed using IBM SPSS v.27. In each model presented, where appropriate, we include the number of gulls and humans as fixed effect variables, and location as a random effect. The number of humans was included as it is possible that human group size might act as either a deterrent or an attractant for foraging gulls.

The gull abundance data were not normally distributed (Shapiro–Wilk = 0.671, df = 257, $P =$ 0.0001). To investigate question 1 we therefore ran a generalized linear mixed effect model with a log-linked negative binomial distribution. The response variable was gull abundance, with phase in the breeding season and the number of humans as the fixed effects, and location as a random effect. This model revealed significant effects for phase ($F_{2,251} = 3.625$, $P = 0.007$, with alpha set at 0.05) but not for the number of humans ($F_{1,251} = 0.047$, $P = 0.829$) indicating that gull abundance was unevenly distributed across the phases of the breeding season. An inspection of the exponential coefficients associated with each phase showed that only the rearing phase significantly predicted an increase in gull abundance from the baseline population at settling, which conformed to our prediction (Exponential Beta = 1.681, $t = 2.704$, $P =$ 0.007; see online Table S2 for full analysis). Location had no significant effect on gull abundance (Z = 1.533, $P = 0.125$).

Gull nuisance events were not normally distributed (Shapiro–Wilk = 0.166, df = 257, $P = 0.0001$). We approached questions 2 and 3 using a single generalized linear mixed model. Our initial analysis demonstrated a high level of collinearity between phases 1 and 2 and also phases 4 and 5. Consequently, we reorganized the data into three broad phases. Broad phase 1 was Settling, broad phase 2 (eggs) incorporated laying and incubation from the previous schema. Broad phase 3 (chicks) incorporated rearing and fledging. We then ran a generalized linear mixed model with an identity-linked Poisson distribution. The response variable was all gull nuisance events, and the fixed effect predictors were the broad phase in the breeding season ($F_{2,68} = 28.489$, $P = 0.0001$), human feeding ($F_{1,68} = 44.304$, $P = 0.0001$), human aggression ($F_{1,68} < 0.001$, $P = 0.990$), the number of gulls ($F_{1,68} < 0.001$, $P = 0.998$), and the number of humans ($F_{1,68} < 0.001$, $P = 0.992$). Location was introduced as a random effect variable ($Z = 1.438$, $P = 0.150$). Table 2 displays the exponential coefficients for predictors of all gull nuisance events.

We found that the gull nuisance events happened from the broad phase eggs period onwards, although there were few nuisance events in total (producing = 1564, raiding = 46, destruction = 14 and gull-human aggression = 0; see online Table S3 for breakdown by location). No nuisance events were recorded during settling and laying phases. Human feeding was associated with a lower number of nuisance events.

Given the adoption of the broad phase categories, we repeated our initial analysis for question 1 substituting phase in the breeding season with the new broad phase category. All else remained the same. Our overall predictions held firm with broad phase ($F_{2,253} = 6.811$, $P = 0.001$) significantly predicting the number of gulls, and the number of humans ($F_{1,253} < 0.001$, $P = 0.994$) having no significant effect. Location also had no significant effect ($Z = 1.533$, $P = 0.125$). An inspection of the exponential coefficients associated with each broad phase showed that only the chick phase predicted an increase in gull abundance (Exponential Beta = 1.541, 95% confidence intervals 1.098 and 2.164, $t = 2.510$, $P = 0.013$). This is consistent with the earlier, more detailed breeding phase analysis.

Table 2. Exponential coefficients (with 95% confidence intervals, CI) for predictors of all gull nuisance events. Note that settling (phase 1) is the baseline from which changes in nuisance behaviour are measured.

Variables	Exponential coefficient	t	P	Lower 95% CI	Upper 95% CI
Intercept	0.339	−3.15	0.002	0.171	0.6733
Settling (broad phase 1)	0	–	–	–	–
Eggs (broad phase 2)	1.237	1.982	0.052	0.999	1.534
Chicks (broad phase 3)	4.797	7.679	0.0001	3.193	7.214
Human feeding	0.946	−6.656	0.0001	0.930	0.961
Human aggression	1.000	−0.013	0.990	1.000	1.000
Number of gulls	1.000	−0.003	0.998	1.000	1.000
Number of humans	1.000	−0.010	0.992	1.000	1.000

To check for any relationship between the number of humans and phase in the breeding season, we ran a generalized linear model with a log-linked negative binomial distribution, with number of humans as the response variable and phase in the breeding season as the predictor. The model fit was a good (Pearson value/df = 141.154/252 = 0.560). The overall model effects were significant (Wald Chi-square = 9.636, df = 4, $P = 0.047$) but the individual phases were not (online Table S4). We can, therefore, conclude that the number of humans present did not change significantly across the phases of the season.

To test question 4, we used a generalized linear mixed model with a log-linked negative binomial distribution. The response variable was human aggression and the fixed effect predictors were phase in the breeding season ($F_{4,248} = 1.621$, $P = 0.169$), human feeding ($F_{1,248} = 0.002$, $P = 0.961$), all gull nuisance ($F_{1,248} = 0.061$, $P = 0.805$), the number of gulls ($F_{1,248} = 0.199$, $P = 0.656$) and the number of humans ($F_{1,248} = 2.069$, $P = 0.152$). Location was included as a random variable which proved redundant in the analysis. This model was not significant (online Table S5).

This study suggests that urban gull abundance was reasonably consistent across the phases of the breeding season, although there was a non-significant increase during the rearing phase. Nuisance events caused by urban gulls began during incubation but were only positively associated with phase of the breeding season and, surprisingly, were negatively associated with human feeding. We suggest that when gulls are actively provisioned they do not need to engage in other foraging practices that might cause nuisance, but this idea clearly requires further research. We were unable to predict human aggression towards gulls from our data, and this is no doubt due to the very low frequency of aggression in our dataset (153 instances across the whole breeding season, counted during 34 of the 257 observations). We suggest that data on direct experience of gull nuisance, as well as on the activities humans are engaged in at urban sites would be useful, but we also note that the low occurrence and bout-like nature of the human aggression recorded indicates individual differences in humans may be a better predictor of such behaviour. It should also be noted that there were no observed cases of gull aggression towards humans (online Table

S3). This was surprising considering that media discourse around gulls often centres around gull aggression and destructive behaviour.

Behavioural studies can provide important insights into urban gulls. Numerous studies have demonstrated that monitoring and studying behaviour is relevant to the management of animal populations from a conservation biology perspective (Wallace & Buchholz 2001, Shier 2006, Moore & Huntington 2008) and may be applied to help manage nuisance populations. This study contributes to the growing body of literature on urban gull behaviour and human-gull interactions. Our results indicate that human behaviour should be taken into consideration when implementing management plans.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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