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Brief report

Between the Herring Gull *Larus argentatus* and the bulldozer: Black-headed Gull *Larus ridibundus* feeding sites on a refuse dump

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Flock composition and interspecific dominance were studied in Black-headed Gulls and Herring Gulls wintering at an inland refuse dump in Germany. Herring Gulls were the dominant species and forced the much more numerous Black-headed Gulls to forage close to operating bulldozers. This supports the hypothesis that dominance governs the relationship between gulls feeding on refuse dumps and that this relationship is mediated through operating bulldozers favouring the smaller gull species.

1. Introduction

For several bird species domestic waste on refuse dumps forms a man-made food resource which is clumped in space and time and subject to human activities like bulldozer operations which may be disturbing or even harmful to birds. Feeding on refuse by large flocks of gulls is a conspicuous example and also known to be highly competitive (Monaghan 1980, Greig *et al*. 1983), at least where refuse is immediately levelled out and covered with inedible waste or sand. The importance of dominance for exploiting food resources is well studied in gulls. Among Herring Gulls *Larus argentatus* feeding on refuse dumps the subordinate sex or age-classes were forced to forage on depleted refuse where competition and foraging success both remained low (Monaghan 1980, Greig *et al*. 1984). Within a mixed feeding flock the birds with higher competitive abilities should then be more numerous at sites with a higher food gain as was the case for adult Herring Gulls displacing immatures from the more profitable primary feeding (Monaghan 1980). Subordinate species and individuals in feeding flocks may also be forced to forage at sites where the risk of predation is higher (Krams 1996) while the dominant birds concentrate at safer sites even if food is less abundant there (Krams *et al*. 2001). In this case the dominant birds should concentrate at sites with a lower risk even if food gain there remains lower as long as they can gather enough food there.

On refuse dumps bulldozers regularly operate in areas of high food gain for gulls, i.e. where fresh waste arrives or where operations themselves make previously covered food accessible (Monaghan 1980), but they can also be dangerous for ground foraging birds. Foraging close to operating

bulldozers may therefore include a trade-off between a higher food gain and a higher risk. Herring Gulls were often reported to avoid feeding until bulldozer operations stopped (Burger 1981, Greig *et al*. 1983, Horton *et al*. 1983, Burger & Gochfeld 1984) while smaller gulls frequently fed closer to operating bulldozers (Isenmann 1978, Burger 1981). Burger (1981) concluded that bulldozer operations were the ultimate factor allowing Laughing Gulls *L. atricilla* to feed successfully because when operations stopped Herring Gulls excluded the smaller species from ground feeding. These patterns have been explained either by dominance of the larger gulls (Monaghan 1980, Burger 1981, Greig *et al*. 1984) or with different feeding skills like higher manoeuvrability of smaller species (Isenmann 1978, Horton *et al*. 1983). Burger and Gochfeld (1984) suggested that American Herring Gulls *L. smithsonianus* lose their competitive ability when outnumbered by the usually subordinate smaller species. Isenmann (1978) assumed that large flocks of Black-headed Gulls could drive Yellow-legged Gulls *L. michahellis* away from feeding in the zone of dumping operations.

I studied preferences of Black-headed Gull and Herring Gull for different feeding situations on an inland refuse dump at Bochum (West Germany, ca 215 km south east of the North Sea coast), where large numbers of both species occurred in winter. Black-headed Gull and Herring Gull wintered in a ratio of five to one in most years (Bellebaum *et al*. 2000). Consequently, Black-headed Gulls formed the majority of gulls at refuse dumps in the whole region. Judging from the difference in body size Herring Gulls weighing 700–1,200 g (Cramp & Simmons 1983) should be clearly dominant over Black-headed Gulls weighing only 200–400 g (Cramp & Simmons 1983) and displace them from foraging in preferred sites if the feeding distribution of gulls is based on competition. Interspecific dominance should be measurable from the outcome of direct aggressive interactions.

2. Methods

2.1. Study area

During the study the central refuse dump at Bochum was a typical "gull-feeder" with continuous operations of up to three bulldozers on a main dumping area mainly in the morning and an adjacent secondary feeding area where no dumping operations take place and no fresh waste is delivered (categories after Monaghan 1980). The size of these areas varied from day to day, the other parts of the refuse dump offered no food to the gulls. Because most of the refuse dumped was inedible (Bellebaum *et al*. 2000) and household waste was quickly covered accessible food was probably not always superabundant. At the nearest roost (Kemnade reservoir, ca 5 km south) a total of 12,600 black-headed and 2,600 Herring Gulls were present on January, 24th 1998 (J. Nowakowski, pers. comm.).

2.2. Observations

Foraging gulls were observed between January, 14th and February, 20th 1998. Proportions of Herring Gull among feeding flocks were measured out of scan samples (Altmann 1974) of 40–100 gulls feeding on the ground under different dumping conditions. Common *L. canus* and Lesser Black-backed Gulls *L. fuscus* occurred irregularly in the feeding flocks and were not counted. Aerial feeding Black-headed Gulls ("dipping"; Burger 1981) were rarely seen and also not included in the counts. The proportion of immatures among feeding Herring Gulls was measured in the same way from scan samples of 30–100 Herring Gulls. To measure the duration of feeding bouts previous to each count I supposed that a feeding bout continued, when most birds flushed (e. g. caused by a bulldozer) but immediately returned to the feeding site. This happened regularly when flocks were feeding during operations. During long-lasting bouts consecutive samples were separated by at least 3 minutes time and treated as independent because of the high turnover of individuals in a feeding flock. Feeding conditions were classified after Monaghan (1980) as disturbed primary foraging close to an operating bulldozer, undisturbed primary foraging on recently delivered refuse without bulldozer operations and secondary foraging on old refuse without bulldozer operations.

Interspecific dominance was measured using continuous observations of focal Herring Gulls feeding in mixed flocks. Observation lasted until

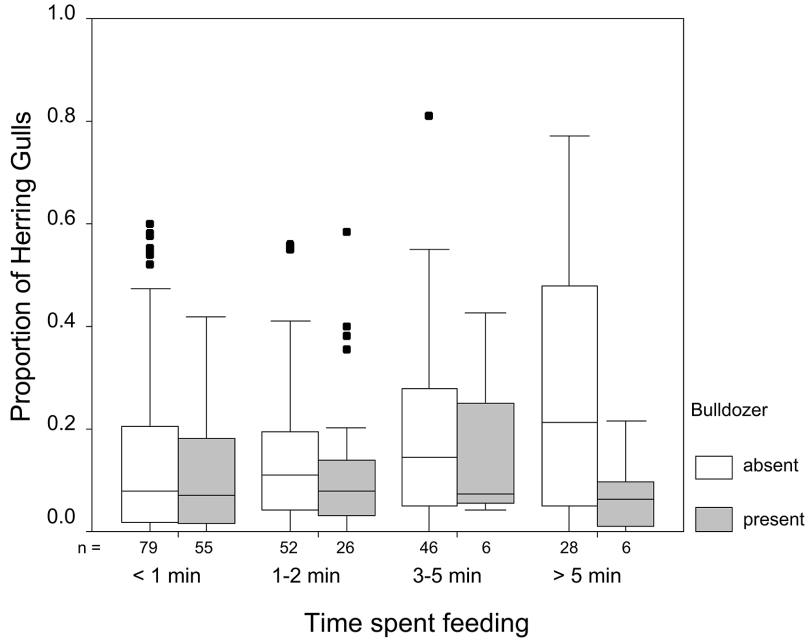

Fig. 1. Proportions of Herring Gulls in foraging flocks increased with feeding time when bulldozers were absent (open boxes), but not when bulldozers were present (filled boxes). Box-and-whiskers plot where the box represents quartiles with the median indicated by the horizontal line in the box, and the bars depicting the range with dots as outliers.

the first aggressive encounter with another gull, i.e. attacks or aggressive upright-postures directed to an individual gull. Encounters were counted as successful if the other gull moved away.

In order to examine foraging success under different conditions peck rates were measured on old refuse with and without bulldozer operating, recently levelled refuse and freshly delivered domestic refuse. I also recorded whether pecking birds were successful, i.e. swallowing food or flying off with a larger item.

2.3. Statistics

The influence of feeding time and bulldozer operations was tested using logistic regression. Peck rates of both species were normally distributed (Kolmogorov-Smirnov test, Black-headed Gull: $Z = 0.757$, $n = 129$, $P = 0.62$; Herring Gull: $Z = 0.695$, $n = 75$, $P = 0.72$) as was the proportion of immature Herring Gulls ($Z = 0.7$, $n = 34$, $P = 0.7$) and therefore were analysed using ANOVA with post-hoc Scheffé-tests. Differences were otherwise tested with Wilcoxon matched pairs test or a t-test, where appropriate.

3. Results

Feeding bouts were regularly started by flocks of Black-headed Gull and the proportion of Herring Gull in the feeding flock remained low during the first two minutes (Fig. 1). Without bulldozer oper-

Table 1. Parameter estimates for the logistic regression model explaining the proportion of Herring Gulls in the feeding flock. Modelfit: $\chi^2 = 107{,}4$, 3 d.f., $P < 0.001$

Parameter	Estimate	s.e.	t	P
Constant	–1.705	0.024	–71.39	<0.001
Time spent feeding	0.052	0.004	12.93	<0.001
Bulldozer	–0.343	0.046	–7.40	<0.001
Time * Bulldozer	–0.051	0.017	–3.01	0.003

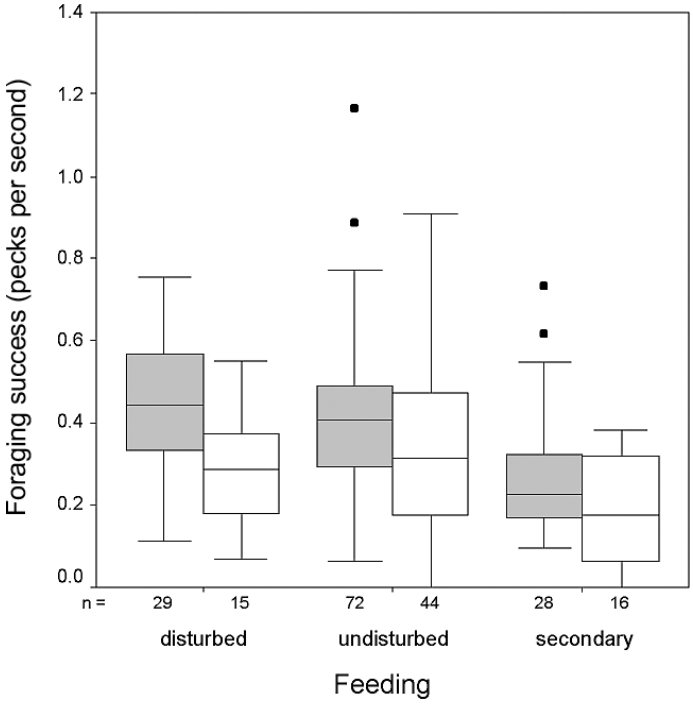

Fig. 2. Foraging success measured as peck rates per second of Black-headed Gulls (filled boxes) and Herring Gull (open boxes) were lowest during secondary feeding as compared to disturbed or undisturbed primary feeding. Plot type as described in Fig. 1.

ations the proportion of Herring Gulls in the flock increased when the feeding bout continued while around the operating bulldozer it remained low. The logistic regression model for the proportion of Herring Gulls as dependent variable (Table 1) showed significant influences of the time the flock had spent feeding before, the presence of an operating bulldozer and the interaction between time and bulldozer. Furthermore, the daily mean percentage of Herring Gull was lower in flocks close to the bulldozer (Wilcoxon matched pairs test: n = 12, Z = –2.35, P = 0.019). As expected from Monaghan (1980), the proportion of immature Herring Gulls was slightly higher during secondary feeding (0.61 $\pm$ 0.11, n = 23) than during disturbed and undisturbed primary feeding (0.54 $\pm$ 0.12, n = 11; one-tailed t-test: t = 1.83, P = 0.038).

Out of 62 Herring Gulls observed, 17 attacked successfully a Black-headed Gull and gained food in 6 cases. There were no unsuccessful attacks on Black-headed Gulls. The success rate of attacks directed towards conspecifics was significantly lower with 14 successful out of 18 attacks (exact binomial test: P < 0.001), three of these resulting in a food gain. None of the focal Herring Gulls was attacked by a Black-headed Gull and on 11 occasions a Black-headed Gull avoided the Herring Gull under observation although no aggressive behaviour could be noticed, so this was not regarded as an encounter although in three cases the Herring Gull took over food. Only four Herring Gulls seemed to ignore an approaching Black-headed Gull, allowing it to feed in their close vicinity.

In both species peck rates were significantly lower during secondary feeding than during undisturbed primary feeding (Fig. 2; ANOVA: Black-headed Gull $F_{2, 126} = 8.6$, $P < 0.001$, Scheffé-test P = 0.002; Herring Gull $F_{2, 72} = 4.6$, P = 0.013, Scheffé-test P = 0.014). Black-headed gulls also showed higher peck rates during disturbed feeding (Scheffé-test P = 0.001).

4. Discussion

The results of this study are in accordance with what would be expected if Black-headed Gulls are constantly the subordinate species irrespective of flock composition, and Black-headed Gulls may take a greater risk by starting feeding earlier and feeding closer to the bulldozer in order to avoid attacks by the dominant Herring Gull. Displacement

attacks by dominant individuals are a usual form of kleptoparasitism in this species (Greig *et al*. 1984). Thus the results give further evidence that dominance connected with differences in body size governs the relationship between gulls feeding on refuse dumps (Greig *et al*. 1984) and that it is mediated by bulldozer operations which favour the smaller gulls (Burger 1981).

Although regularly being outnumbered, Herring Gulls remained dominant over Black-headed Gulls throughout the observations and were able to displace individual Black-headed Gulls in the feeding flock. Because feeding bouts were started by single-species Black-headed Gull flocks the increasing proportions of Herring Gull must at least to some extent be due to arrival of Herring Gulls and not simply a consequence of Black-headed Gulls leaving the feeding area. Flocks of Black-headed Gull often did not start feeding immediately after refuse arrived but waited until the bulldozer started operating. Feeding flocks were, however, not necessarily initiated by the bulldozer because even without operations feeding bouts were started by Black-headed Gulls and it took 3–5 minutes until most Herring Gulls started foraging. After this delay Herring Gulls fed successfully among large flocks of Black-headed Gulls in the absence of bulldozer operations. It was therefore the bulldozer which prevented Herring Gull from intruding the flock, not the flock itself as supposed by Burger and Gochfeld (1984) for Laughing Gull flocks. Also the behaviour of Herring Gulls towards conspecifics followed the findings of Monaghan (1980) with more subordinate immature birds during secondary foraging, giving no indication for a change in behaviour when outnumbered which was observed by Burger and Gochfeld (1984).

Foraging during dumping and bulldozer operations is heavily disturbed with regular flushes of hundreds of gulls (Monaghan 1980 and pers. obs.) which should result in higher energy expenditure for both species. Primary feeding is also more profitable and may result in higher energy intake (Monaghan 1980) because the frequency of large prey items which are most favourable especially for Herring Gulls should be highest when refuse is freshly delivered and decrease during subsequent feeding bouts unless the bulldozer uncovers new items. In fact freshly delivered refuse was most attractive for gulls as is supported by the observed decrease of peck rates from disturbed primary to secondary foraging for both species.

When refuse arrives, food supply is probably best, but Herring Gulls can take advantage from their dominance under undisturbed conditions when foraging is dominated by competitive interactions, which is not the case when the bulldozer is working (Greig *et al*. 1984). Bulldozer operations may therefore support utilization of refuse by Black-headed Gulls through preventing competition from Herring Gull (Burger 1981) but the results did not indicate that Black-headed Gull became the dominant species.

A greater sensitivity of Herring Gulls to disturbance could help to explain why they avoid the operating bulldozer. At the loafing water close to Bochum refuse dump Herring Gulls also preferred the less disturbed part while Black-headed Gulls did not (Jebram & Bellebaum 1996), and in coastal habitats Black-headed Gulls nest closer to roads than Herring Gulls do (Hüppop & Hüppop 1995). During the observations gulls were never seen to be injured or killed by dumping operations but on the refuse dump at Rheinberg (c. 45 km west of Bochum) three first-winter Black-headed Gulls were killed and one injured during 18 hours of observation (B. Engfeld, pers. comm.). This illustrates that foraging close to bulldozers involves a real risk.

Feeding on discarded fish at fishing vessels is another case of primary foraging regularly reported for several gull species. Like on refuse dumps the larger species are usually dominant over the smaller ones and have higher indices of foraging success and kleptoparasitism (Garthe & Hüppop 1998). Arcos *et al*. (2001) showed that although Yellow-legged Gulls were dominant over Audouin's Gulls *L. audouinii* the latter had a similar success index for capturing discards. But when competition increased Audouin's Gulls shifted to food resources less attractive for Yellow-legged Gulls. In contrast, the foraging success index of Black-headed Gulls feeding on discard was much lower than for Herring Gulls (Garthe & Hüppop 1998) and there is no evidence for a measurable advantage for Black-headed Gulls feeding close to fishing vessels or bulldozers.

Body size differences between gull species are also connected with preferred prey size (Götmark

1984, Arcos *et al*. 2001, Rome & Ellis 2004) and the Black-headed Gull takes much smaller prey than the Herring Gull (Götmark 1984). This difference might enable the Herring Gulls to wait until bulldozer operations cease because the Black-headed Gull should be unable to swallow larger prey items profitable for Herring Gulls. It might be hypothesized that Herring Gulls also would be forced to approach bulldozers when an even larger gull species was present in considerable numbers, e. g. the great Black-backed Gull *L. marinus* which prefers slightly larger food items (Rome & Ellis 2004).

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Harmaalokin ja puskutraktorin välissä

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