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Brief report

Increasing group size dilutes black fly attack rate in Black Grouse

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Black flies (Simuliidae) have been observed to harass Black Grouse (*Tetrao tetrix*) in northern Finland during summer. We studied experimentally whether group size affects the attack rate of black flies on Black Grouse. The increase in flock size diluted the rate of the black fly attacks in the Black Grouse, thereby demonstrating a clear encounter–dilution effect. This study is – to our knowledge – the first in demonstrating an insect harassment dilution effect due to group living in an avian host, but our result are in agreement with previous studies carried out in various mammalian vertebrates. Joining other individuals during summer when black flies are actively feeding should benefit Black Grouse. A reduction in insect harassment may at least partly explain why Black Grouse are often gregarious during summer, but does not exclude other reasons (e.g. a reduction in predation risk) for staying in groups.

1. Introduction

Many animal species are gregarious during some stage of their life. Living in groups may benefit an individual in many ways. One benefit is that group living dilutes the impact of some harmful or lethal events (Krebs & Davies 1993). In addition to predation, insect harassment is thought to be diluted by living in a group (Mooring & Hart 1992). The probability of detecting a group may not increase proportionally to the increase in group size (the encounter effect), and harassment will be diluted if insects do not attack more members of a large group than of a small group (the dilution effect)(Mooring & Hart 1992). Individuals benefit from this encounter-dilution effect by reduced per capita attack rate as the group size increases. Some primates (Freeland 1977), feral horses (Duncan & Vigne 1979), ponies (Rutberg 1987), and reindeers (Helle *et al.* 1992) have been shown to benefit from grouping or herding in terms of reduced insect harassment. However, there are no studies, to our knowledge, on the effect of group size on insect harassment in birds (see also Mooring & Hart 1992, Hart 1994).

Black flies (Simuliidae) have been observed to be a nuisance for Black Grouse (*Tetrao tetrix*) in northern Finland during summer (Ojanen *et al.* 2002). In the aviary, up to 300 black flies may harass a single Black Grouse during an experimental period of half an hour. In addition to irritating the birds, black flies transmit haematozoan parasites (e.g. Desser *et al.* 1975, Desser & Bennett 1993, Anderson 2000). The two most common blood parasites occurring in the Black Grouse are *Leucocytozoon lovati* and microfilarial nematodes (Höglund *et al.* 1992, pers. comm.). Both of them are transmitted by black flies (Desser & Bennett 1993, Anderson 2000). To reduce the harm caused by blood feeding insects Black Grouse utilize different kinds of fly repelling behaviour when attacked by blood feeding insects including scratching, head shaking, pecking and restless movements (pers. comm., see Hart 1994.)

Black Grouse form large mixed-sex flocks in winter time (Koskimies 1957, Hanson & Soikkeli 1984). During summer, flock formation is less common but especially males are then often observed in small groups (Koskimies 1957, Hanson & Soikkeli 1984). Females stay together with their chicks, from hatching until the end of summer. Even though the broods presumably stay together for other reasons, dilution of insect harassment may be a contributing factor for staying in a group. Unsuccessful breeders, which typically are about 40% of all females, have a tendency to join in groups (Rajala 1974). If the effect of blood sucking insects dilutes with increasing group size, group living is beneficial and individual should prefer to aggregate. Contrary, if a group attracts proportionally more insects than a single bird, insect harassment is a cost of group living and individuals are presumed to prefer to dwell alone. In the latter case, increased insect harassment may represent a cost of reproduction for grouse females.

Here, we studied experimentally whether group size affects the attack rate by black flies in the Black Grouse and use an existing data base of wildlife count data to analyze Black Grouse flocking behaviour during summer.

2. Material and methods

We conducted the field work near the Meltaus Game Research Station, Finnish Game and Fisheries Research Institute (66°55'N, 25°15'E) during 7–10 August 1995. Young Black Grouse, bred in captivity, were exposed to blood-sucking insects in a cage (56 cm x 29 cm x 28 cm) for 30 min period. This was done out in the open at a nearby spruce swamp. At the time of the experiment, Black Grouse were about six weeks old and they weighed on average 408 g (SD = 34 g). At the end of each presentation, cages were covered by a dark opaque sack. At one side of the cage there was an opening which led to a transparent container. When the cage was put at a well illuminated place for 20 min, insects flew to the container after completing their blood meal. Thereafter the insects were collected from the container and preserved in 70% alcohol. In the laboratory we counted and identified the insects and determined whether they were engorged or not.

Using this approach, we presented Black Grouse alone and in groups of two or four. In group presentations each bird was placed in its own cage, and the distance between the cages in a group was about 1 m. We circulated the birds so that each of the seven birds was presented once alone and several times in a group of different size (Table 1). Each of the trials including whole set of different group sizes (1, 2 and 4) were conducted within three hours to reduce the influence of changing environmental factors, like temperature and wind. One of the birds died (B) during the study period and was replaced by another bird (H). This setup did not allow true replication since one individual was present in more than one trial in group presentations (see Hurlbert 1984). However, each group had a unique combination of indi-

Table 1. Experimental set-up. Letters denote individual Black Grouse.

	Group size		
Trial	1	2	4
1	A	B, C	D, E, F, G
2	B	C, D	E, F, G, A
3	C	D, E	F, G, A, H
4	D	E, F	G, A, H, C
5	E	F, G	A, H, C, D
6	F	G, A	H, C, D, E
7	G	A, H	C, D, E, F

viduals reducing the dependence between trials.

Grouse population density in Finland has been estimated by yearly wildlife triangle counts since 1989 (Lindén *et al.* 1996). In these line transect counts all grouse observations were recorded in each of 15 game management districts in August. To study flocking behaviour, we used data for the Lapland game management district, northern Finland, from years 1989–1997, including 1,182 observation totalling 1,505 Black Grouse individuals. We excluded observations on females with broods.

Two-tailed significance values of statistical tests are reported throughout.

3. Results

Most of the insects collected during trials were black flies (Simuliidae; n = 138, 93%). Additionally there were four biting midges (Ceratopogonidae, 3%) and six insects which do not feed on blood at all (4%). In total 55% of black flies had fed on blood. The proportion of engorged black flies remained constant with increasing total number of black flies (Regression analysis: a = 0.10 ± 0.13 (SE), b = 0.59 ± 0.02 (SE), $F_{1,47}$ = 602.3, P<0.001, R^2 = 0.93).

The number of black flies attracted by groups of different size did not differ significantly (Kruskal-Wallis test, H = 1.54, d.f. = 2, P = 0.46) suggesting that bigger groups did not attract significantly more black flies. However, the main interest for us was to assess whether individuals can reduce insect harassment by joining a group. The number of black flies attracted by a single grouse decreased as a function of group size (Mean ± 1SD of black flies per individual – Group size 1: 5.5 ± 6.8, n = 7; Group size 2: 4.9 ± 6.6, n = 14; Group size 4: 1.1 ± 1.4, n = 28; Fig. 1). This comparison involved pseudoreplication since one individual is included several times in the bigger groups (Table 1). As there may be differences in attractiveness of blood sucking insects between individuals (see Schofield & Sutcliffe 1996, 1997), we tested this by comparing mean number of black flies attracted by an individual in different group size categories. There was no difference in the number of black flies attracted by an individual between group size one and two (Fig. 1; Wilcoxon paired-sample test, Z = –0.42, P = 0.67, n = 7). However, individuals attracted significantly fewer black flies when they were in a group of four than in a group of two birds (Fig. 1; Wilcoxon paired-sample test, Z = –2.37, P = 0.02, n = 7).

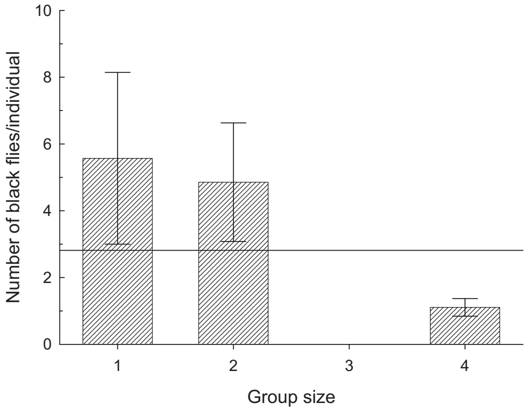

Fig 1. The mean number of black flies harassing an individual Black Grouse when exposed in groups of different size. Error bars show standard error. Horizontal line denotes grand mean.

The wildlife triangle data showed that mean flock size among observed Black Grouse was 1.27 (± 0.72) in August. Flock size ranged up to 11 individuals. However, most of the observed individuals (81%) were dwelling alone.

4. Discussion

Our experiment showed that a larger group size did not attract more black flies in the Black Grouse. Instead, an individual in a larger group attracted proportionally fewer black flies. Thus, increasing group size dilutes the adverse effects of biting black flies. The result is in agreement with previous studies on various mammalian vertebrates (Freelend 1977, Duncan & Vigne 1979, Rutberg 1987, Helle *et al.* 1992). In this respect, it should be beneficial for Black Grouse to join other individuals during summer when black flies are actively feeding. The benefit of joining a group is realised especially in the largest group size, since the difference in the number of insects attracted between a single individual and a group of two was rather small. However, due to small sample sizes, the standard errors of the mean were large, and thus, no clear conclusions could not be drawn from that difference.

Black flies are locating their host using olfactory, visual and thermal cues (Sutcliffe 1986, Gibson & Torr 1999). Olfactory cues, carbon dioxide and body odour, are important long range locating cues (Sutcliffe 1986, Gibson & Torr 1999). Black flies most often feed on large or abundant hosts (Malmqvist *et al.* 2003). Large hosts may be easier to locate since they emit more CO_2 and odour. The smaller abundant hosts instead are encountered more frequently. Although a group of individuals emits more CO_2 and odour, our results show no linear increase in the number of black flies with increasing host group size. A clumped distribution of hosts may therefore not increase the risk of being found by black flies relative to a single host. This effect might arise from the search pattern of black flies, and may depend on how CO_2 and odours are dispersing around host as they diffuse.

Studies on humans have shown that both the attractiveness and the ability to elicit a biting response from black flies varied among individuals and were mediated by especially carbon dioxide production rate (Schofield & Sutcliffe 1996, 1997). The differences in attractiveness between individuals were consistent over time. If there are such consistent differences in attractiveness also in Black Grouse, there might be implications for the formation of groups and flock dynamics. Would it be better to associate with very attractive grouse which may draw black flies away from you or not to associate with very attractive grouse in order to be exposed to fewer black flies?

The mean observed flock size in the Black Grouse in August was low and most of the individuals were dwelling alone. The dominant black fly species in our study area is *Metacnephia lyra* showing peak density in early July and thereafter the density declines (Malmqvist 1999, Ojanen *et al.* 2002). Our results show that Black Grouse typically do not dwell in flocks in August. However, the black fly density in August is already rather low. Therefore, the wildlife count data collected in August may not reveal the real response magnitude by Black Grouse to black fly harassment. If black flies are important in driving flocking behaviour, the prediction would be (all else being equal) that Black Grouse are most inclined to form groups in the peak black fly season. A test of this prediction would need monitoring of both group size of Black Grouse and population numbers of bird-feeding black flies over time.

One of the main causes for the group dynamics in Black Grouse probably is related to predation. In winter, Black Grouse are conspicuously feeding up in the trees (Koskimies 1957). Therefore, it might be beneficial for them to form bigger flocks, because that increases probability to observe predators early enough to be able to escape. In summer, Black Grouse are feeding on the ground and they may not be as vulnerable to predation as in winter due to cover provided by vegetation. Mortality among females is highest during spring when they are living alone without the shelter of a flock, and moreover are regularly moving between their breeding area and lek sites (Valkeajärvi & Ijäs 1994). During summer, mortality is relatively low which suggests that predation is not such an important mortality factor even though Black Grouses are living in much smaller groups than in winter.

The increase in the flock size reduces the per capita attack rate of the black flies in the Black Grouse. The black fly–Black Grouse interaction shows clear encounter-dilution effect. To our knowledge this is the first time when this has been shown in avian host. Insect harassment may at least partly explain why Black Grouse are often gregarious during summer, although this does not exclude other reasons to stay in groups.

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Ryhmäkoon vaikutus mäkärien aiheuttamaan kiusaan teerellä

Mäkärien on havaittu ahdistelevan teeriä (*Tetrao tetrix*) Pohjois-Suomessa kesällä. Ryhmäkoon vaikutusta mäkärien aiheuttamaan kiusaan tutkittiin kokeellisesti ensimmäistä kertaa linnuilla. Teerien ryhmäkoon suurentuessa mäkärien määrä

ei kasvanut vastaavasti, vaan havaittiin laimentumisvaikutus. Tämä havainto on samansuuntainen kuin aiemmin tutkituilla nisäkäslajeilla. Mäkärien määrän ollessa suurimmillaan kesällä teeret hyötyisivät parveutumisesta. Hyönteisten aiheuttama kiusa saattaa osaltaan selittää teerien kesäparveutumista, mutta ei sulje pois muita syitä, kuten saalistuksen vaikutusta.

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