

## Blood feeding by black flies (Diptera: Simuliidae) on black grouse (*Tetrao tetrix*) in Finland

Ulriikka Ojanen, Osmo Rätti, Peter H. Adler, Kalevi Kuusela, Björn Malmqvist & Pekka Helle

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We investigated the species composition of blood-sucking black flies harassing black grouse (*Tetrao tetrix* L.) by exposing live black grouse to insects in field conditions. Fieldwork was conducted in northern and central Finland in 1995 and 1996. Among identified specimens ( $n = 493$ ) we observed five engorged black fly species: *Metacnephia lyra* (Lundström), *Simulium* (*Nevermannia*) *vernum* Macquart, *Simulium* (*Nevermannia*) *bicorne* Dorogostaisky, Rubtsov and Vlasenko, *Simulium* (*Parabyssodon*) *transiens* Rubtsov, *Simulium* (*Eusimulium*) *aureum* Fries, and *Greniera* sp. All observed species were present in northern Finland but only two of them, *Simulium vernum* and *S. aureum*, were observed in central Finland. *Metacnephia lyra* was the most common species harassing grouse in northern Finland. In central Finland the density was much lower, and *Simulium vernum* was the most prevalent. The black grouse is a novel host for all engorged species observed in this study. Also, black grouse is the first ever recorded host for *Metacnephia lyra* and for any member of the genus *Greniera*. The most likely vectors for *Leucocytozoon* and filarial nematodes parasitizing grouse in Finland are *Metacnephia lyra* and *Simulium vernum* in northern Finland and *S. vernum* in central Finland.

Ulriikka Ojanen, Finnish Game and Fisheries Research Institute, Tutkijantie 2 A, FIN-90570 Oulu, Finland

Osmo Rätti, Arctic Centre, University of Lapland, P.O. Box 122, FIN-96101 Rovaniemi, Finland; E-mail: osmo.ratti@uova.fi

Peter H. Adler, Department of Entomology, Clemson University, Clemson, South Carolina 29634-0365, U.S.A.

Kalevi Kuusela, Oulanka Biological Station, University of Oulu, Liikasenvaarantie 134, FIN-93999 Kuusamo, Finland

Björn Malmqvist, Department of Ecology and Environmental Science, Umeå University, SE-90187 Umeå, Sweden

Pekka Helle, Finnish Game and Fisheries Research Institute, Tutkijantie 2 A, FIN-90570 Oulu, Finland

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## 1. Introduction

The first major study of Finnish black flies (Simuliidae) was conducted by Lundström (1911). Thereafter the knowledge on Finnish black flies and their distribution has been accumulating (Carlsson 1962, Kuusela 1971, 1979, 1984, 1992, Itämies & Kuusela 1976). In two recent checklists the number of species observed in Finland is 33 (Crosskey & Howard 1997, Jensen 1997). The species lists are not identical and the combined total number of species is 39. In Sweden, the number of recorded species is 61 (Adler *et al.* 1999) and in Norway 51 (Raastad 1996). The black fly fauna of Finland is presumably still poorly known, since the number of species observed is low compared to that in adjacent areas.

Blood-sucking insects may have both direct and indirect effects on their hosts, causing itchiness and irritation. In addition to irritation black flies transmit haematzoan parasites (e.g. Desser *et al.* 1975, Desser & Bennett 1993, Anderson 2000). The combined effects of physical harassment, blood parasite infection and direct loss of blood may even kill nestlings or fledglings (Hunter *et al.* 1997, Smith 1998). Black flies are a nuisance for various bird species, and many black fly species are specialized to feed on birds (Crosskey 1990). However, it is not well known what species of black flies are feeding on what species of birds. Also, the impact of black flies on birds and the knowledge of different host species of black flies are far from complete.

Different species of birds are often infected with haematzoan parasites (e.g. Eide *et al.* 1969, Greiner *et al.* 1975, Peirce 1981). The two most common blood parasites occurring in the black grouse (*Tetrao tetrix* L.) in Finland are *Leucocytozoon lovati* and filarial nematodes (Höglund *et al.* 1992, pers. obs.). All, except one species of *Leucocytozoon*, are transmitted exclusively by black flies (Desser & Bennett 1993). Filarial nematodes are transmitted by different haematophagous insects including black flies (Anderson 2000). Since black grouse are not migratory but are still infected with blood parasites transmitted by black flies, we expected that ornithophilic black flies feed on them during summer.

We investigated the species composition of blood-sucking insects harassing black grouse by

exposing live black grouse to insects in field conditions. Studies on black flies feeding on a particular host are important to demonstrate possible specific black fly — host relationships and also to reveal potential haematzoan vectors for a host species. The knowledge on black fly — avian host relationships is based largely on old studies (see Crosskey 1990). Thereafter the taxonomy has developed and some earlier identifications are suspect. This study is one of the few recent studies that clearly demonstrate a black fly–avian host relationship.

## 2. Methods

We conducted the fieldwork at the Meltaus Game Research Station, Finnish Game and Fisheries Research Institute (66°55'N, 25°15'E) and the Konnevesi Research Station, University of Jyväskylä (62°37'N, 26°20'E) in 1995 and 1996. In 1995, the fieldwork was conducted from 20 July to 7 August in Meltaus and from 31 July to 4 August in Konnevesi. In 1996, the dates were from 27 June to 22 August in Meltaus and from 18 June to 7 August in Konnevesi.

In collecting insects we used the method developed by Bennett (1960) and Anderson & DeFoliart (1961). Black grouse were exposed to blood-sucking insects in a cage (56 cm × 29 cm × 28 cm) for 30-min periods. The cage was placed on the ground. At the end of each presentation, the cage was covered by a dark opaque sack. At one side of the cage there was an opening that led to a transparent container. When the cage was put at a well-illuminated place for 20 min, the insects flew to the container after completing their blood meal. Thereafter the insects were collected from the container and preserved in 70% alcohol. The number of trials in Meltaus and Konnevesi were 57 and 60 in 1995, respectively, and 54 and 36 in 1996. In Meltaus we used six different black grouse individuals and respectively 12 individuals in Konnevesi. Trials were conducted in various habitats including spruce swamp, pine bog, and spruce, pine and birch forests. In both areas there was one large river with rapids and several smaller rivers within a radius of 10 km from the study site. The distances to the large river was 1 km in Konnevesi and 6 km in Meltaus.

In the laboratory we identified the insects and determined whether they were engorged or not. In this article we present a report on the black fly fauna only. Black flies were identified morphologically using keys by Ussova (1964), Rubtsov (1969), Yankovsky (1979) and unpublished keys of PHA. Taxonomic classification of black flies follows that of Crosskey & Howard (1997). In the first stage, UO identified a sample of black flies collected in 1995 ( $n = 87$ ) and samples of engorged black flies from three days in 1996 ( $n = 122$ ) from Meltaus. All specimens from Konnevesi were identified ( $n = 35$ ). In the second stage, we wanted to

confirm the identifications and PHA identified 249 additional black flies of which 181 were engorged. The total number of identified black flies was thus 493.

### 3. Results

The total number of insects collected during the study was 4342. Ninety-nine percent ( $n = 4303$ ) of blood-sucking insects were black flies. In addition, we observed some mosquitoes (Culicidae,  $n = 36$ ) and biting midges (Ceratopogonidae,  $n = 3$ ). Here we report the black fly fauna based on a sample from the total material. The rest of the material will be used to study seasonal variation in black fly harassment and the influence of black flies on the grouse behaviour. There were up to 300 black flies harassing the exposed grouse during a 30-minute exposure at times when black fly density was highest.

Among identified specimens we observed five different engorged black fly species: *Metacnephia lyra* (Lundström), *Simulium (Nevermannia) vernum* Macquart, *Simulium (Nevermannia) bicorne* Dorogostaisky, Rubtsov and Vlasenko, *Simulium (Parabyssodon) transiens* Rubtsov, *Simulium (Eusimulium) aureum* Fries, and *Greniera* sp. (Tables 1 and 2).

The following combination of characters indicated the unmistakable assignment of our material to the genus *Greniera*: the costal vein has fine light-colored setae without dark spinules, the radial vein has hair dorsobasally, the radial sector is not forked, the calcipala is small and pointed, the pedisulcus is represented by nothing more than superficial wrinkles, and the claws each have a basal thumblike lobe.

All observed species were present at Meltaus but only two of them, *Simulium (Nevermannia) vernum* and *Simulium (Eusimulium) aureum*, were recorded at Konnevesi. Our identifications of *S. vernum* also might have included some morphologically very similar species (e.g. *S. cryophilum* (Rubtsov)).

*Metacnephia lyra* was clearly the most common species harassing grouse in northern Finland (Tables 1 and 2). In 1995 we observed also one female of *Simulium (Simulium) truncatum* (Lundström) that, however, was not engorged. In Konnevesi, the density was much lower than in Meltaus: despite almost identical sampling effort, we collected only 36 individuals compared to more than 4000 in Meltaus. In 1995, we observed only one *Simulium vernum* individual, while in 1996 the species was the more prevalent of the two species in central Finland (33 individuals,

Table 1. Numbers and percentages of engorged species observed in 1995 and 1996 in Meltaus, northern Finland (UO).

	1995	1996
<i>Metacnephia lyra</i>	49 (90%)	72 (59%)
<i>Simulium (Nevermannia) vernum</i>	2 (4%)	39 (32%)
<i>Simulium (Parabyssodon) transiens</i>	1 (2%)	8 (7%)
<i>Simulium (Eusimulium) aureum</i>	1 (2%)	3 (2%)
<i>Simulium (Nevermannia) bicorne</i>	1 (2%)	0 (0%)
Total	54 (100%)	122 (100%)

Table 2. Black fly fauna harassing the black grouse in Meltaus, 22 July 1996 (PHA).

	Engorged / total	(%)	% of engorged
<i>Metacnephia lyra</i>	154 / 212	(85)	73
<i>Simulium (Nevermannia) vernum</i>	19 / 25	(10)	76
<i>Simulium (Parabyssodon) transiens</i>	7 / 10	(4)	70
<i>Greniera</i> sp.	1 / 2	(<1)	50
Total	181 / 249	(100)	73

94%; Table 4.). We observed only two individuals of *S. aureum*.

There were clear seasonal changes in the black fly fauna in 1996 in Meltaus. *Metacnephia lyra* dominated during the early season (July) while during the late season *Simulium venum* prevailed ( $\chi^2 = 55.23$ ,  $df = 2$ ,  $p < 0.001$ ) (Table 3). *Simulium transiens* and *S. aureum* were also more abundant in the late season. Also, in Konnevesi *S. venum* and *S. aureum* were more abundant in the late season (Table 4).

## 4. Discussion

### 4.1. Species

According to our results, black flies are the most important blood-feeding insects harassing grouse in Finland. All five engorged black fly species had tarsal claws typical of ornithophilic species (Shewell 1955, Bennett 1960).

*Metacnephia lyra* was the most numerous black fly species in the north and dominated especially in the early season in this study. Its distribution includes Norway, Sweden, Finland, northern Russia and western Siberia (Crosskey & Howard 1997). Larvae of *Metacnephia lyra* are found in great numbers in the rapids of free-flowing larger rivers in northern Sweden and Finland (Adler et al. 1999, pers. obs.), where they rapidly

develop during spring and subsequently emerge as adults in mid-June (Malmqvist 1999). The males form spectacular swarms over the river rapids. The very high densities in which they occur suggest that they have great ecological importance. This is true about the larvae, which can 'carpet' the substratum of rapids with aggregates having more than 100 000 larvae/m<sup>2</sup>. These might potentially be important food for salmonids, and they significantly alter particle transport in rivers (Malmqvist et al. 2001). Because of their high abundance, the adults are also likely to be ecologically significant not only as prey for insect eaters but also by attacking birds for blood. Interestingly, we observed high density far away (6 km) from their likely breeding river.

*Simulium venum* has a very wide distribution including Finland (Crosskey & Howard 1997). *S. venum* was found at both the Meltaus and Konnevesi study sites. It was not as abundant as *M. lyra* in Meltaus but prevailed clearly in the late season. In Konnevesi it was the most common species.

*Simulium transiens* has a Holarctic distribution (Crosskey & Howard 1997). *S. transiens* was most common in the late season in Meltaus. This species develops in the slowly flowing parts of large rivers, where the larvae are found on macrophyte vegetation and occurs later in the season than *M. lyra*.

*Simulium aureum* has a wide distribution in Europe and Russia (Crosskey & Howard 1997).

Table 3. Seasonal changes in black flies feeding on the black grouse in Meltaus in 1996 (UO).

	2 JUL	22 JUL	6 AUG
<i>Metacnephia lyra</i>	32 (80%)	37 (88%)	3 (7%)
<i>Simulium (Nevermannia) venum</i>	8 (20%)	4 (10%)	27 (68%)
<i>Simulium (Parabyssodon) transiens</i>	0 (%)	1 (2%)	7 (18%)
<i>Simulium (Eusimulium) aureum</i>	0 (%)	0 (%)	3 (7%)
Total	40 (100%)	42 (100%)	40 (100%)

Table 4. Seasonal changes in black flies harassing the black grouse in Konnevesi in 1996 (UO).

	18 JUN	4 JUL	26 JUL	6 AUG
<i>Simulium (Nevermannia) venum</i>	1 (100%)	7 (100%)	18 (95%)	7 (88%)
<i>Simulium (Eusimulium) aureum</i>	0 (0%)	0 (0%)	1 (5%)	1 (12%)
Total	1 (100%)	7 (100%)	19 (100%)	8 (100%)

It was another species observed at both of our study sites, though the density was low at both.

The distribution of *Simulium bicornne* is Holarctic (Crosskey & Howard 1997). Neither Crosskey & Howard (1997) nor Jensen (1997) included Finland into its distribution range. However, Kuusela (1992) has reported the species from northeastern Finland. In our study, the species was very rare: only one individual was observed in Meltaus.

Species of the genus *Greniera* have never been observed in Finland before (Crosskey & Howard 1997). The closest observation comes from Karelia, Russia (*G. brachiata*) (Crosskey & Howard 1997). Our observation of *Greniera* from Meltaus is also the first legitimate published record for a Nordic country. However, it has recently been observed also in northern Sweden (Malmqvist unpubl.). Larvae develop in small trickles and are, therefore, easily overlooked in stream sampling. Adults may be easier to observe.

There was a marked seasonal change in species composition. *Metacnephia lyra* outnumbered other ornithophilic species in northern Finland, since it is the most prevalent species in the early season when the density of black flies peaks. Interestingly, the density and the number of species were low in Konnevesi. Still, the blood parasite prevalence has been observed to be rather high in central Finland (Höglund *et al.* 1992, pers. obs.). This observation may suggest that a low density of vectors is able to sustain reasonably high prevalence of blood parasites. Alternatively, there is high local variation in black fly density depending on the occurrence of suitable streams for larval development. The landscape in Konnevesi is rather flat with many lakes, and relatively few and small streams.

#### 4.2. Black grouse as a host species

This is the first study of the black fly fauna feeding on the black grouse. Thus, the black grouse is a novel host for all engorged species observed in this study.

Black grouse was the first-ever recorded host for *Metacnephia lyra* and for any member of the genus *Greniera*. All the species have a bifid claw typical of ornithophilic black flies and their

mouthparts are not reduced. This study confirms that they really are ornithophilic species.

Ornithophily is a prevalent bloodsucking habit in both *Simulium aureum* and *S. venum* (Davies *et al.* 1962, Crosskey 1990). Also Kuusela (1979) discovered *S. aureum* on the goshawk and the golden eagle. Our observations support that view.

*Simulium transiens* has been reported to be one of the most vicious bloodsuckers of humans, but it has not been observed near animals (Rubtsov 1969). *Simulium bicornne* rarely attacks humans or animals (Rubtsov 1969). Thus, black grouse is the first recorded avian host for *Simulium transiens* and *S. bicornne*. Their bifid claws suggest that earlier feeding observations on humans are only occasional, due to misidentification, or that these species are feeding upon both mammals and birds.

Interestingly, in our study the percentages of the different species engorging were nearly identical. We suggest that the most likely vectors for *Leucocytozoon* and filarial nematodes parasitizing grouse in Finland are *Metacnephia lyra* and *Simulium venum* in northern Finland and *Simulium venum* in central Finland. The contribution of other black fly species seems to be low. Additionally, blood-sucking insects influence the behaviour of the black grouse (Rätti *et al.* unpubl.). In the presence of insects, birds shake their heads, peck and scratch their feathers and move more often. This may expose individuals to predation. Clearly, more studies are needed on the role of black flies in northern ecosystems.

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