

The fauna of Diptera visiting tethered heifers in Danish pastures

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The dipterous fauna of tethered heifers in several Danish pastures was studied during the day and in the evening in order to isolate potential insect transmitters of summer mastitis. More than 50,000 Diptera representing 18 *Culicoides*-species (Ceratopogonidae), 5 species of Simuliidae, 6 species of Tabanidae and 15 species of Muscidae were recorded. *Hydrotaea irritans*, *Haematobosca stimulans*, *Haematobia irritans*, *Simulium ornatum* (species complex), *Culicoides scoticus* and *C. obsoletus* contributed >85% of all Diptera recorded.

The face fly (*Musca autumnalis*) was few in number; *Trichopticoidea decolor* was recorded for the first time from Danish cattle.

During the day the dipterous fauna of the heifers was dominated by *H. irritans*, *Hae. irritans*, *H. stimulans*, *Morellia* species and *S. ornatum* (species complex), in the evening mainly by the former three species and biting midges. In late afternoon and early evening the feeding activity of black flies and biting midges and that of *H. irritans* overlap.

Species composition of the dipterous fauna recorded in the pastures investigated differed considerably. Especially, relative abundance and density of *H. irritans* varied regionally, contributing from 1-2% to >80% of the fauna. A relation between the abundance of *H. irritans* and the incidence of summer mastitis is discussed.

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Introduction

During the last decades the incidence of summer mastitis, i.e., an inflammation of the udder of heifers and dry cows, has increased in Western Europe. In Danish animal husbandry an annual loss of 80-100 million kr. due to slaughtering of attacked heifers and dry cows has been estimated. It is generally assumed that insects are involved in the transmission of the disease.

Throughout the summer pasturing heifers are visited by several species of Diptera feeding on blood and secretions. Studies on cattle-

visiting biting midges (Ceratopogonidae, *Culicoides* Latr.), black flies (Simuliidae), and Muscidae in Denmark were carried out by Petersen (1924), Ussing (1925), Thomsen (1938), Hammer (1941), Bahr (1955), Nielsen (1971), Nielsen *et al.* (1971, 1972), Nielsen & Christensen (1975), and Jensen (1982), but no comprehensive study on the dipterous fauna of cattle is available. In Sweden, Britain, and Germany investigations on some taxa of cattle-visiting flies have been carried out, but many of the results obtained abroad cannot be directly applied to Danish pastures. In 1979 an ento-

mological research project was initiated in Denmark, with the main purpose of isolating potential insect transmitters of summer mastitis. This paper reports on the dipterous fauna recorded from heifers during the day and in the evening in different types of Danish grassland. In order to record as many species of cattle-visiting Diptera as possible - including biting midges (*Culicoides*) - all sampling was carried out on tethered heifers acting as stationary baits. The seasonal activity and distribution of species of Diptera over the bodies of heifers are presented in future papers (in preparation).

Localities and Methods

The majority of the insects was collected from heifers in the pastures of Store Vildmose (NWJ), 1979 and 1980. The northern pastures (Ørnefæner) are sheltered by shelter-belts at a distance of about 200 m, whereas the southern ones (Ringfæner and Damfæner) are open and exposed to the wind. The data presented in this paper are from the northern part. In Store Vildmose (area about 775 ha) an annual stock of about 3000 heifers is pasturing.

Throughout the summer of 1980 the insect fauna of heifers in a pasture near Funder (EJ) was recorded. This pasture is situated in a forest-bordered valley where marshland and several watercourses and springs are found.

Finally in early August 1979 and 1980 insects were occasionally collected from heifers in several other pastures (Fig. 1) representing sites of different topography, viz. inland and coastal pastures, being dry or moist, sheltered or wind-exposed, etc. (for details, see Jespersen 1981). The main sampling was carried out in the peak season of summer mastitis, viz. in July-August; in this period the species composition of the fly fauna in each locality was rather constant.

The insects of heifers were collected by standardized sweeping (diameter of net: 30 cm, sample unit: 20 strokes) just above the

head and the back, and another sample was collected along the belly of heifers. Vacuum cleaning of head, back, flanks, belly, udder, and front legs separately for 3 minutes each was done with a vacuum cleaner (Nilfisk) fitted with a fine-meshed bag. Details on sampling methods, number of flies collected, etc. are presented by Jespersen (1981) and Nielsen *et al.* (1984).

Nearly all heifers in this investigation belonged to the Frisian race, i.e., the Black and White Dairy cattle race (SDM).

Results

Species recorded and sex ratio

More than 50,000 Diptera representing 44 species were recorded from tethered heifers, viz. 18 species of biting midges (Ceratopogonidae, *Culicoides*), 5 species of black flies (Simuliidae), 6 species of horse flies (Tabanidae), and 15 species of Muscidae (Table 1). Nine species of *Culicoides*, 3 species of Tabanidae, 4 species of Muscidae, among others *Trichopticoides decolor*, were recorded associated with cattle for the first time in Denmark (Table 1). Due to the sampling methods used, all mosquitoes collected were in a bad condition, and no identification to species level was possible. Twelve species of biting midges and 4 species of black flies were represented by blood-fed individuals (Jespersen 1981).

Of all Diptera recorded during the day and in the evening, the following contributed more than 85%: the sheep head fly (*H. irritans*) (>40%), black flies of the *S. ornatum* species complex (>25%), the biting midges *C. scoticus* (c. 8%) and *C. obsoletus* (c. 5%), and the biting flies *H. stimulans* (c. 4%) and *Hae. irritans* (4%). It is noteworthy that in the whole research period only 43 individuals of the face fly *M. autumnalis* were collected.

Observations on the tabanids of the St. Vildmose pastures are presented by Nielsen *et al.* (1988).

In Simuliidae, Ceratopogonidae (*Culicoides*

des), and Tabanidae only females were collected from the heifers, whereas in nearly all

species of Muscidae also males were recorded (Table 1). In *Hae. irritans* and *H. stimu-*

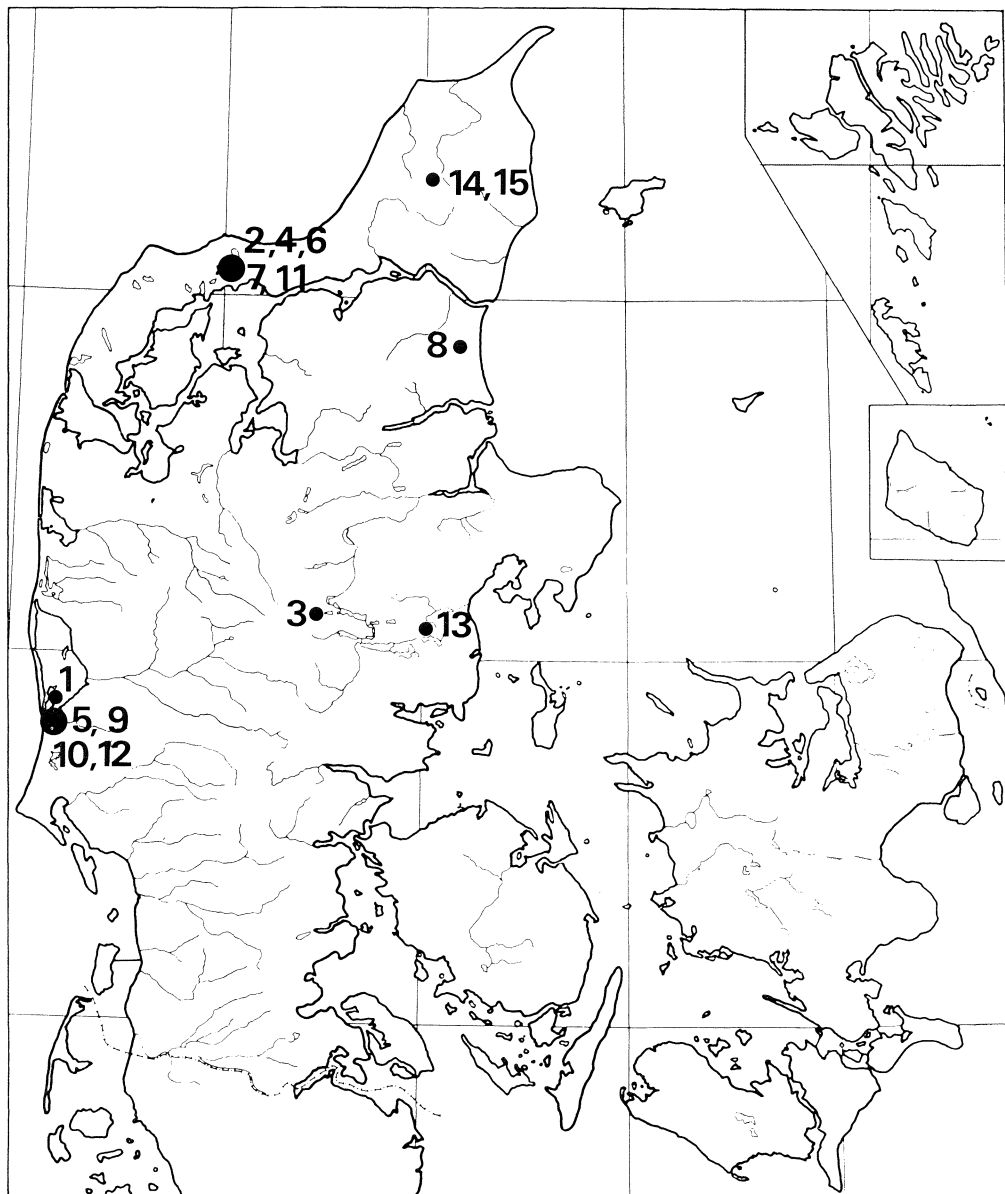


Fig. 1. Location of pastures investigated. Numbering of localities refers to the order of pastures presented in Fig. 2. 1 = Værn Enge; 2, 4, 6, 7, and 11 = pastures in Vejlerne; 3 = Funder; 5, 10, and 12 = pastures south of Ringkøbing Fjord; 8 = Lille Vildmose; 9 = Anerbjerg Plantage; 13 = Dørup; 14 and 15 = Store Vildmose (1980 and 1979 respectively).

Fig. 1. Beliggenhed af undersøgte græsningsarealer. Nummerering af lokaliteterne refererer til den rækkefølge, hvori græsningsarealerne præsenteres i Fig. 2. 1 = Værn Enge; 2, 4, 6, 7 og 11 = græsningsarealer i Vejlerne; 3 = Funder; 5, 10 og 12 = græsningsarealer syd for Ringkøbing Fjord; 8 = Lille Vildmose; 9 = Anerbjerg Plantage; 13 = Dørup; 14 og 15 = Store Vildmose (henholdsvis 1980 og 1979).

lans the percentages of males were 40% and 42% respectively (sex ratio 1:1.50 and 1:1.38) and in *M. hortorum* and *M. simplex* 9.8% and 20.9% (sex ratio 1:9.22 and 1:3.79) respectively. In the predominant *Hydrotaea* species, viz. *H. irritans*, *H. albipuncta* and *H. meteorica*, males contributed 1.6%, 1.7%, and 1.9% respectively. In late June about 50% of all *H. irritans* were males, however, from mid July onwards the male activity on heifers was negligible; consequently, the seasonal activity pattern of male *H. irritans* on cattle was unimodal.

Diurnal and regional variation in the fly fauna of heifers

During the day the species composition of the dipterous fauna of heifers differed considerably from that recorded during the evening (Fig. 2). All *Culicoides* species - except *C. heliophilus* - were primarily recorded on the heifers at sunset and sunrise (Fig. 3), but in some cases the cattle was also attacked by biting midges during the day.

Species of the *S. ornatum* species complex were active on the cattle all day long, but mainly in late afternoon and early in the evening; during the night the activity was negligible, increasing to a peak in the morning (Fig. 3).

Hae. irritans is present on the heifers day and night, and *H. stimulans* and *H. irritans* are active from early morning to late evening; consequently, the relative abundance of these species was often high during the day as well as in the evening (Fig. 2). *Morellia* species were only recorded from the heifers during the day (Fig. 2), viz. from late morning to late afternoon (Jespersen 1981).

Table 1. Species of Diptera recorded from tethered heifers in Danish pastures 1979-1980. * = Species not previously recorded from pasturing cattle in Denmark.

Tabel 1. Arter af myg og fluer indsamlet på tøjrede kvier på græsningsarealer i Danmark 1979-1980. * = Arter, der ikke tidligere er registreret fra kvæg på græs i Danmark.

	♂♂	♀♀
Nematocera		
Ceratopogonidae		
<i>Culicoides chiopterus</i> (Mg.)		288
* <i>C. cubitalis</i> Edw.		85
* <i>C. dewulfi</i> Goetgh.		3
* <i>C. duddingstoni</i> Kettl & Laws.		1
<i>C. fascipennis</i> (Staeg.)		26
* <i>C. griseocens</i> Edw.		77
* <i>C. heliophilus</i> Edw.		8
* <i>C. impunctatus</i> Goetgh.		338
* <i>C. lupicaris</i> Down. & Kettl.		1
<i>C. nubeculosus</i> (Mg.)		4
<i>C. obsoletus</i> (Mg.)		2,681
* <i>C. pallidicornis</i> Kieff.		17
<i>C. pulicaris</i> (L.)		1,006
<i>C. punctatus</i> (Mg.)		1,654
<i>C. riethi</i> Kieff.		10
* <i>C. scoticus</i> Down. & Kettl.		4,141
<i>C. stigma</i> (Mg.)		29
<i>C. subfascipennis</i> Kieff.		26
Simuliidae		
<i>Simulium (Wilhelmia) lineatum</i> (Mg.)		30
<i>S. (Boophthora) erythrocephalum</i> (D.G.)		209
<i>S. (Odagmia) ornatum</i> Mg.		13,180
<i>S. (Simulium) posticatum</i> MG.		8
<i>S. (Simulium) morsitans</i> Edw.		2
Brachycera		
Tabanidae		
* <i>Chrysops relictus</i> Mg.		1
<i>Hybomitra bimaculata</i> (Macq.)		29
* <i>H. tropica</i> (L.)		21
<i>Heptatoma pellucens</i> (Fabr.)		2
* <i>Haematopota crassicornis</i> Wahlb.		7
<i>H. pluvialis</i> (L.)		249
Cyclorrhapha		
Muscidae		
<i>Stomoxys calcitrans</i> (L.)	4	20
<i>Haematobia irritans</i> (L.)	754	1,131
<i>Haematobosca stimulans</i> (Mg.)	867	1,199
* <i>Morellia aenescens</i> Rob.-Desv.	1	
<i>M. hortorum</i> (Fall.)	58	535
<i>M. simplex</i> (Loew.)	33	125
<i>Musca autumnalis</i> D.G.	12	31
<i>M. domestica</i> (L.)	1	2
<i>M. tempestiva</i> Fall.		3
* <i>Trichopticoides decolor</i> (Fall.)		274
<i>Hydrotaea albipuncta</i> (Zett.)	17	966
* <i>H. borussica</i> Stein		2
<i>H. irritans</i> (Fall.)	344	20,937
* <i>H. meridionalis</i> Portschi.	5	15
<i>H. meteorica</i> (L.)	9	462
	2,105	49,835

In the evening biting midges were recorded from heifers in nearly all sites investigated (Fig. 2), however, the abundance varied according to the exact hour and weather conditions. In pastures at Funder, biting midges contributed about 75%, at Dørup and Nyværn Dige about 60%, and at Anerbjerger Plantage about 54% of the dipterous fauna recorded in the evening (Fig. 2).

The species composition of the dipterous fauna recorded in the pastures investigated differed considerably. At Funder (N = 4459) and Dørup (N = 818), the fauna of biting midges on the heifers was dominated by *C. scoticus* (60-65%), *C. obsoletus* (10-20%), and *C. pulicaris* (c. 10%), whereas in the Mols area (EJ; N = 611), at Anerbjerger Plantage (N = 230), and in Store Vildmose (N = 1082), *C. punctatus* and *C. obsoletus* were predominant (70-90%). In Lille Vildmose, *C. impunctatus* contributed >70% of the biting midges attacking heifers.

In two sites in Central Jutland (Funder, Dørup), black flies (Simuliidae) contributed 10-60% of Diptera attacking heifers during the day (in the evening 15-20%), but in the majority of the pastures visited in this study, black flies were not recorded or only very few specimens were collected (Fig. 2). Allowing for the intensive sampling done in Store Vildmose, the number of black flies recorded in this area was relatively low compared with the results from Funder (Fig. 2).

The horn fly (*Hae. irritans*) was recorded in all 15 sites, but the regional variation in relative abundance was considerable, viz. <1% at Funder and Skårupodde, 5-10% in Store Vildmose and at Dørup, and 50-80% in Værn Enge and at Vust (Fig. 2). In August, when the activity of *H. stimulans* was relatively low, this fly was recorded in all sites, contributing 1-40% of the fly fauna of heifers (Fig. 2).

Generally, *M. hortorum* and *M. simplex* only made up a small proportion of the total dipterous fauna, but in Vejlerne these species contributed about 20% (Fig. 2).

The sheep head fly (*H. irritans*) was recorded in all sites and in 7 of the pastures investigated,

e.g., the inland sites of Store Vildmose (1979, 1980), Lille Vildmose, and Dørup, as well as some sheltered coastal areas, this fly contributed c. 50% - >80% of the insect fauna recorded from tethered heifers (Fig. 2).

In some coastal grassland areas, e.g., Værn Enge, the relative abundance of the sheep head fly was extremely low (1-2%); in some pastures at Vejlerne and Ringkøbing Fjord this fly made up 20-30% of the fauna of Diptera. In the pastures at Funder, the contribution of *H. irritans* to the total fly fauna of heifers was comparable to the latter results, however, during the day the actual role of the sheep head fly was veiled by the predominance of black flies, and during the evening by the high relative abundance of biting midges (Fig. 2).

Discussion

A total of 44 species of Diptera was recorded from tethered heifers. Very few specimens of the face fly (*M. autumnalis*) were recorded (Table 1). This is remarkable; apparently this fly was formerly abundant on Danish cattle (Thomsen 1938, Hammer 1941), and at least in some districts in Sweden *M. autumnalis* is still so. *T. decolor* was not previously recorded from Danish cattle. This may be explained by the fact that at least under field conditions, *T. decolor* and *H. irritans* are hardly distinguishable. Also in Britain *T. decolor* was until recently a rather unnoticed species, although it is actually a regular element of the fly fauna of cattle in many sites (Ball 1984). Unlike *M. aenescens* (1 specimen, Table 1), *M. hortorum* and *M. simplex* are sweatflies (Skidmore 1985).

The sex ratio of *Hae. irritans*, *H. stimulans*, and *M. hortorum* observed is comparable to that recorded in North America and Britain (Hoelscher & Combs 1971, Ball 1984). The percentage of males in *M. simplex*, *H. irritans*, *H. albipuncta*, and *H. meteorica* is somewhat lower than that recorded from cattle in Britain (Ball, *op.*

cit.), however, the sex ratio varies seasonally. Apparently, the seasonal pattern of the percentage of males in *H. irritans* on cattle in Denmark and Britain is nearly identical, i.e., males are most abundant early in the fly season but are rather rare after the start of the mating period (cf. Tarry & Kirkwood 1974, 1976, Titchener *et al.* 1981, Ball 1984). This suggests that *H. irritans* is univoltine in Denmark.

During the day the dipterous fauna of tethered heifers was dominated by *H. irritans*, *Hae. irritans*, *H. stimulans*, *Morellia*- and *Simulium* species, in the evening mainly by the former three species and biting midges. In the evening the abundance of *H. irritans* on the heifers varied; however, especially in warm, damp, and calm weather a high feeding activity was often observed, even after dark. For instance, high evening activity of sheep head flies was observed when the weather cleared up after a cool, wet and windy day. This demonstrates that *H. irritans* is able to utilize even a short spell of good weather for feeding.

In late afternoon and early evening the feeding activity of black flies and biting midges and that of *H. irritans* overlap. In this period the blood-feeding of *H. irritans* is facilitated, at least in sites where the cattle is heavily attacked by black flies.

Many species of biting midges are associated with specific breeding habitats; thus, the difference in species composition observed

between pastures may reflect the availability of adequate breeding sites. For instance, *C. scoticus* is considered as a woodland species (Dzhafarov 1964); this might explain the abundance of this species on heifers pasturing near forest edges at Funder and Dørup. *C. impunctatus*, which was abundant on heifers in the pastures of Lille Vildmose, mainly breeds in *Sphagnum*; thus, this species may be a nuisance in the neighbourhood of *Sphagnum* bogs (Nielsen 1963). Finally, *C. obsoletus*, *C. punctatus*, and *C. pulicaris* breed in a number of widespread habitats, e.g., freshwater mud-flats.

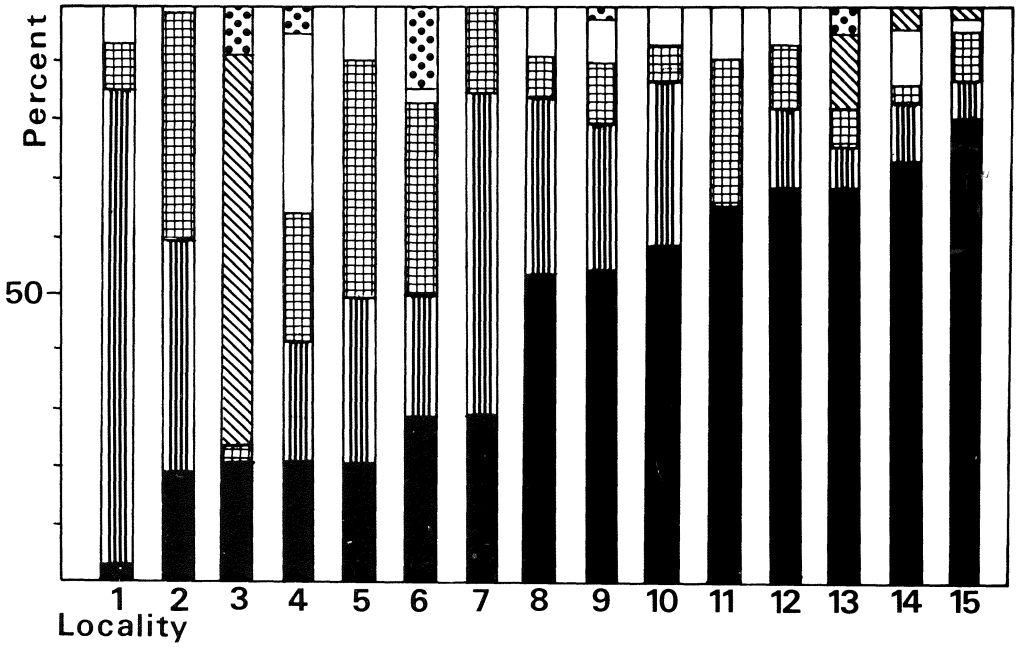
In three sites, viz. near Funder and Dørup, the heifers were often heavily annoyed by black flies (Jespersen 1981, Nielsen *et al.* 1986). These pastures are sheltered and situated near watercourses where the breeding conditions for black flies are excellent. In 1978-1986 severe attacks by black flies on pasturing cattle were observed in several pastures all over the country (Nielsen *et al.* 1988).

In many sites the sheep head fly was extremely abundant on the heifers. For instance, the extensive pastures of Store Vildmose are the habitat of a huge number of *H. irritans*. However, especially in some coastal, wind-swept grassland sites, e.g., Værn Enge, *H. irritans* is scarce. In these sites *Hae. irritans* is predominant. However, since tethered heifers were used as bait, the results obtained might be somewhat biased. For in-

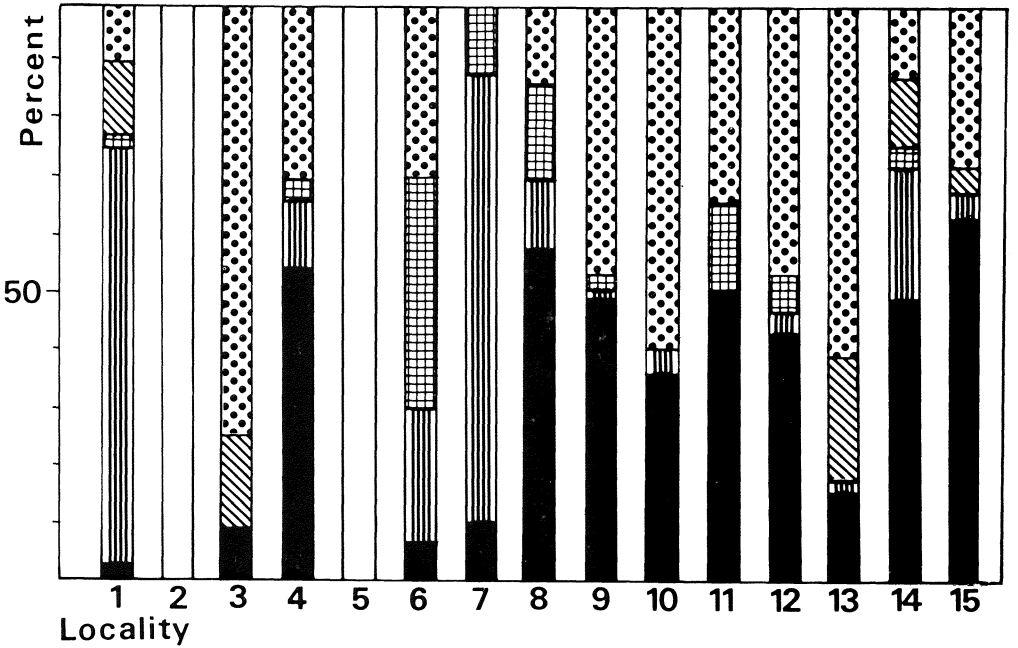
Fig. 2. The relative abundance of taxa of Diptera on tethered heifers in Danish grassland sites during the day and in the evening. The localities 1-15 (see Fig. 1) are arranged according to increasing relative abundance of the sheep head fly (*Hydrotaea irritans*) during the day. In the localities 2 and 5, no samples from the evening were available. H.i. = *Hydrotaea irritans*; Hae.i. = *Haematobia irritans*; H.s. = *Haematobosca stimulans*; Mor. = *Morellia* spp.; Sim. = *Simulium* spp.; Cer. = Ceratopogonidae, *Culicoides* spp. Number of Diptera recorded in pastures 1-15 (day/evening): 1. 633/129; 2. 69/0; 3. 15,032/6,545; 4. 207/122; 5. 272/0; 6. 519/24; 7. 400/152; 8. 2,741/847; 9. 389/363; 10. 1,394/235; 11. 1,571/247; 12. 590/799; 13. 701/2,872; 14. 2,979/817; 15. 8,417/3,060.

Fig. 2. Den relative hyppighed af arter eller slægter af Diptera på tøjrede kvier på danske græsningsarealer om dagen og om aftenen. Lokaliteterne 1-15 (se Fig. 1) er ordnet efter stigende relativ hyppighed af plantagefluen (*Hydrotaea irritans*) i dagtimerne. Fra lokaliteterne 2 og 5 foreligger ingen indsamlinger fra aften-timerne. H.i. = *Hydrotaea irritans*; Hae.i. = *Haematobia irritans*; H.s. = *Haematobosca stimulans*; Mor. = *Morellia* spp.; Sim. = *Simulium* spp.; Cer. = *Ceratopogonidae*, *Culicoides* spp. Antal Diptera indsamlet på græsningsarealerne 1-15 (dag/aften): 1. 633/129; 2. 69/0; 3. 15.032/6.545; 4. 207/122; 5. 272/0; 6. 519/24; 7. 400/152; 8. 2.741/847; 9. 389/363; 10. 1.394/235; 11. 1.571/247; 12. 590/799; 13. 701/2.872; 14. 2.979/817; 15. 8.417/3.060.

Day (9.00 - 19.00)



Evening (19.00 - 24.00)



H.i
 Hae.i
 H.s
 Mor.
 Sim.
 Cer.

stance the spontaneous avoidance reactions of the heifers were hampered and further, the behaviour of some fly species, especially that of the sheep head fly, might be influenced by the presence of the collector. Consequently, the activity and density of *H. irritans* and other flies on untethered heifers were recorded in a large number of pastures by means of binoculars. In a future paper (in prep.) the results of the latter studies are presented and the abundance of flies on tethered and untethered heifers compared.

The investigation demonstrates that the species composition of the fly fauna of tethered heifers varies between pastures; above all the relative abundance and density of *H.*

irritans vary regionally. Since this fly in particular is under suspicion of being the transmitter of summer mastitis (Nielsen *et al.* 1987), the relation between the regional variation in the density of the sheep head fly on pasturing heifers and the incidence of the disease is an important aspect. For instance in Værn Enge, where the abundance of *H. irritans* was extremely low (Fig. 2), the incidence of summer mastitis was negligible. In Store Vildmose, however, where the sheep head fly was very abundant (Fig. 2), summer mastitis has been a recurring problem. These observations suggest that some relation between the abundance of *H. irritans* and the incidence of summer mastitis in a site may exist.

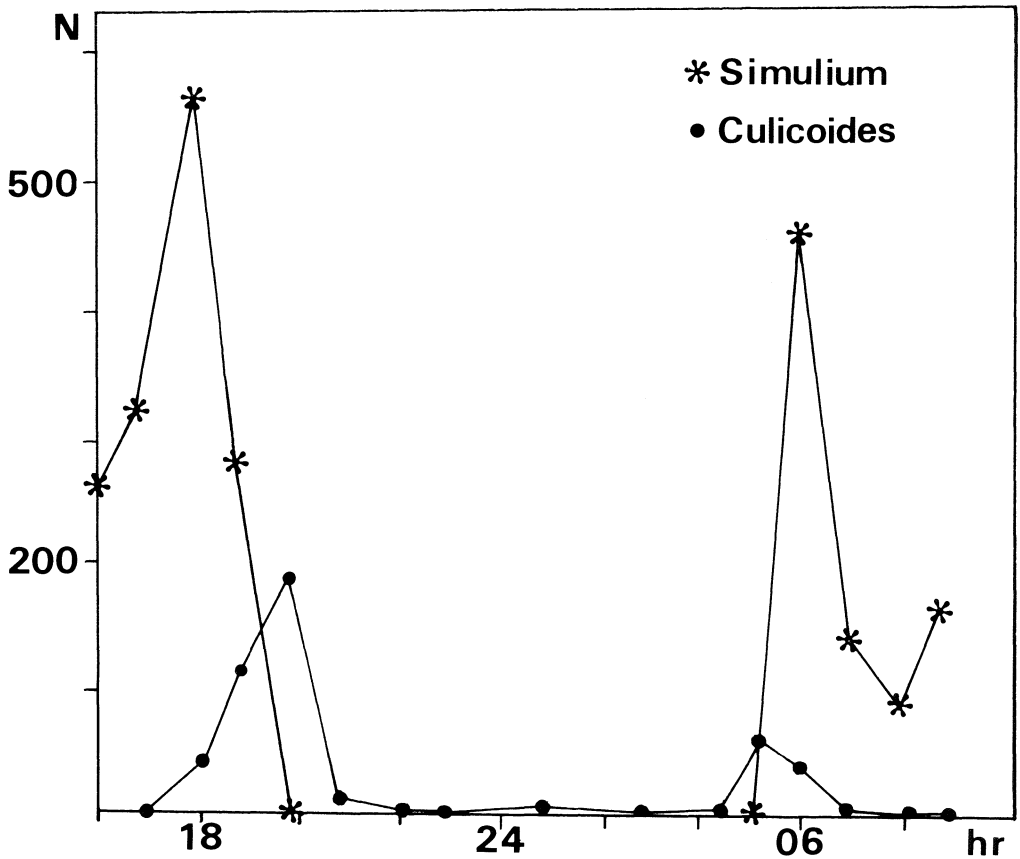


Fig. 3. Diurnal activity of black flies (*Simulium ornatum*) and biting midges (*Culicoides scoticus*) on a tethered heifer recorded by standardized sweeping.

Fig. 3. Døgnaktivitet af kvægmyg (*Simulium ornatum*) og mitter (*Culicoides scoticus*) på tøjret kvie. Indsamling ved hjælp af standardiseret ketsjning.

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Sammendrag

Dipterfaunaen på tøjrede kvier på danske græsningsarealer

Dipterfaunaen på tøjrede kvier blev registreret om dagen og i aften timerne på et stort antal græsningsarealer i Danmark med henblik på at indkredse arter, der kan overføre smitsom yverbetændelse (sommermastitis) til kvæg. Over 50.000 dipterer indsamledes, repræsenterende 44 arter, nemlig 18 mitte-arter (Ceratopogonidae, *Culicoides*), 5 kvægmyg-arter (Simuliidae), 6 klægarter (Tabanidae) og 15 arter af egentlige fluer (Muscidae). Plantagefluen (*Hydrotaea irritans*), efterårsstikfluen (*Haematobosca stimulans*), den lille stikflue (*Haematobia irritans*), kvægmyg tilhørende *Simulium ornatum*-artskomplekset samt mitterne *Culicoides scoticus* og *C. obsoletus* udgjorde >85% af alle registrerede dipterer. Kvægfluen (*Musca autumnalis*) var yderst fåtallig; *Trichopticoidea decolor* blev registreret for første gang fra kvæg i Danmark.

I dagtimerne var dipterfaunaen på kvierne domineret af plantagefluen, den lille stikflue, efterårsstikfluen, *Morellia*-arter og kvægmyg, om aftenen især af de tre førstnævnte arter samt mitter. Sidst på eftermiddagen og først på aftenen overlappede kvægmyggenes og mitternes fourageringsaktivitet med plantagefluens.

Dipterfaunaens artssammensætning på græsningsarealerne var ret forskellig. Især varierede plantagefluens relative hyppighed og tæthed; på nogle kystnære græsningsarealer, f. eks. Værn Enge, udgjorde denne flue kun 1-2% af dipterfaunaen, men på 7 andre

lokaliteter c. 50% - >80%. Det påpeges, at hos tøjrede kvier er afværgereaktionerne over for angribende insekter hæmmet; ligeledes kan tilstedeværelsen af indsamleren påvirke fluernes forekomst og adfærd. I et senere arbejde sammenlignes dipterfaunaen på tøjrede og fritgående kvier. Plantagefluen anses for at være involveret i spredning af smitsom yverbetændelse, der først og fremmest angriber kvier. Relationen mellem hyppigheden af *H. irritans* på græsningsarealerne og sygdomsfrekvensen diskuteres.

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