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# Does covering of farm-associated *Culicoides* larval habitat reduce adult populations in the United Kingdom?

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ABSTRACT

*Culicoides* biting midges (Diptera: Ceratopogonidae) are the biological vectors of a range of internationally important arboviruses of livestock, including bluetongue virus (BTV) and the recently emerging Schmallenberg virus (SBV). *Culicoides* species in the subgenus *Avaritia* (in the UK: *Culicoides obsoletus* Meigen, *Culicoides scoticus* Downes & Kettle, *Culicoides dewulfi* Goetghebuer and *Culicoides chiopterus* Meigen) have been implicated in BTV transmission in northern Europe and to a varying degree utilise cattle dung as a larval development substrate. The collection of cattle dung into heaps on farms provides a localised source of *Culicoides* emergence in close proximity to livestock. This study assesses the impact of covering dung heaps prior to the onset of adult *Culicoides* activity with the aim of reducing recruitment to the local adult populations at four livestock farms in England. Light suction trap catches of adult *Culicoides* from these farms were compared with those from four untreated control farms from a wide geographic range across the UK. It was demonstrated that implementing control of emergence from dung heaps did not have a significant impact upon the local adult subgenus *Avaritia* abundance at the treated farm holdings and that the onset of *Culicoides* activity was similarly unaffected. Use of this method in isolation is unlikely to have an effect in reducing the risk of BTV and SBV transmission. The implications of these results for control of farm-associated *Culicoides* in Europe are discussed.



## 1. Introduction

*Culicoides* biting midges (Diptera: Ceratopogonidae) are the biological vectors of a range of internationally important arboviruses of livestock, including bluetongue virus (BTV), Schmallenberg virus (SBV) and African horse sickness virus (AHSV) (Elbers et al., 2013; Mellor et al., 2000). In northern Europe, putative BTV and SBV vector species have been identified in the *Avaritia* subgenus, represented in the UK by *Culicoides obsoletus* (Meigen), *Culicoides scoticus* Downes & Kettle, *Culicoides dewulfi* (Goetghebuer) and *Culicoides chiopterus* (Meigen). Within the subgenus, *C. dewulfi* and *C. chiopterus* develop directly in cattle dung (Campbell and Pelham-Clinton, 1960; Kettle and Lawson, 1952; Kremer, 1965), although other alternative habitats including bogs rich in decaying vegetation (Dzhafarov, 1964; Goetghebuer, 1936) and sap running from wounds in elm trees (Edwards et al., 1939) require further confirmation. In contrast, larvae of *C. obsoletus*

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and *C. scoticus* have been frequently recorded as occupying a wide-range of habitats including marshes, swamps, acid grassland, leaf litter, rotting vegetable matter, maize silage residues, organically enriched soil and fungi (Boorman, 1986; Buxton, 1960; Campbell and Pelham-Clinton, 1960; Dzhafarov, 1964; Glushchenko and Mirzaeva, 2008; Goetghebuer, 1936; González et al., 2012; Harrup et al., 2013; Hill, 1947; Kettle and Lawson, 1952; Kremer, 1965; Trukhan, 1975; Zimmer et al., 2008, 2012). The relative contribution of each of these habitats to emerging adult populations of *C. obsoletus* and *C. scoticus* is currently unknown.

Control measures aimed at reducing or destroying available larval *Culicoides* habitats may be broadly divided into three main categories: (1) conventional larvicidal applications; (2) biorational applications and (3) habitat modification and destruction (see Carpenter et al., 2008a for review). All of these measures require detailed knowledge of the distribution and abundance of *Culicoides* larval habitat, which to a great degree determines the efficacy of procedures applied (Kettle, 1962). Larval habitat modification and eradication has historically been most effective when practiced against *Culicoides* with a localised distribution inhabiting areas that can be straightforwardly manipulated in a cost-effective manner. A key example is *Culicoides sonorensis* Wirth and Jones, the principle vector of BTV in the USA, which primarily develops in dairy wastewater lagoons (Mullens, 1989; O Rourke et al., 1983; Schmidtmann et al., 1983, 1998). Waste and water management strategies, focusing on the efficacy of draining water trough overflows and dairy waste water evaporation beds, have been shown to be effective for controlling *C. sonorensis* in certain contexts (Jones, 1977; Mullens and Rodriguez, 1988).

Following the incursion of BTV serotype 8 (BTV-8) into northern Europe some eighteen months passed before the implementation of inactivated vaccination schemes (Carpenter et al., 2009). During this time a range of *Culicoides* control techniques were recommended across affected countries as mitigation against infection with BTV (Carpenter et al., 2008a). In the UK the traditional method for dealing with manure and waste bedding material from livestock farms is to store it in piles (Nicholson and Brewer, 1997), colloquially known as muck heaps (Fig. 1). Muck heaps are usually located at a designated point on the farm property, often close to livestock housing, before being spread on fields as a natural fertiliser.

Prior to the BTV-8 incursion, muck heaps had been suggested as a major development site of ruminant associated *Culicoides* (Campbell and Pelham-Clinton, 1960; Harrup et al., 2013; Kettle and Lawson, 1952; Kremer, 1965; Schwenkenbecher et al., 2009). Due to this, covering of muck heaps prior to *Culicoides* emergence in spring was recommended to farmers as a method to ameliorate potential BTV transmission (Defra, 2009). Little quantitative data, however, existed regarding the impact of covering muck heaps upon *Culicoides* abundance, although the technique has been employed with variable success in small scale field-trials to target larval development sites of stable flies (*Stomoxys calitrans* (L.)) (Meyer and Shultz, 1990; Todd, 1964), house flies (*Musca domestica* L.) (Gerry et al., 2005; Meyer and Shultz, 1990), coastal flies (*Fannia femoralis* (Stein)) (Gerry et al., 2005) and the black dump fly (*Hydrotaea aenescens* (Wiedemann)) (Gerry et al., 2005). This study therefore aimed to assess both the logistics and the impact of covering dung heaps on the local abundance of adult *Culicoides*.

## 2. Materials and methods

### 2.1. Study area and Culicoides collection

Using a trapping network run by volunteers at eight livestock farms in England between 2006 and 2009 (Fig. 2), estimates of *Culicoides* abundance were made using Onderstepoort Veterinary Institute (OVI) type 8W ultraviolet (UV) down-draught suction traps (Agricultural Research Council, South Africa). Traps were suspended at a height of 1.5–2.0 m above the ground and insects collected into a 500 ml beaker suspended below the trap that contained approximately 100 ml of water with a small drop of detergent (Hederol, Procter and Gamble Professional, UK). Traps were run for one night each week at each farm from dusk until dawn to coincide with crepuscular peaks in *Culicoides* activity (Hill, 1947; Kettle, 1957; Parker, 1949; Service, 1969). The contents of each collecting pot was passed through a fine mesh sieve (aperture of <0.25 mm) and the retained insects washed using 70% ethanol into a 250 ml straight-side wide-mouth polypropylene sample jar. Sufficient 70% ethanol was then added to cover the sample for storage prior to postage to The Pirbright Institute for identification. *Culicoides* were separated from other insects collected and identified to species or subgenus level (Campbell and Pelham-Clinton, 1960) using a stereomicroscope (10–40× magnification). Male subgenus *Avaritia* species were identified from their genitalia which is species diagnostic, while females were identified to subgenus level only.

### 2.2. Habitat modification control measure

All muck heaps present at farms one to eight were created by owners predominately from a mixture of cattle waste and straw bedding, with the exception of farm two where sheep rather than cattle waste formed the principle component. The muck heaps at the farms included in this study are not normally covered and range in volume from approximately 60 $m^3$ to 280 $m^3$, with new material added on average biweekly. During winter 2009, four of the eight farms (farms one, two, three and four: Fig. 2) from which weekly estimates of *Culicoides* abundance were available were randomly selected for implementation of the control measure. Farms one, two and four all had one muck heap each, while farm three had two muck heaps, each of these muck heaps were covered with a 200 $g/m^2$ (14 by 14 per square inch weave) green tarpaulin (Bradshaws Direct, York, UK), which excluded both light and water from the surface of the muck heap (Fig. 1). Tarpaulins were weighted and secured with 8 mm polypropylene rope (Wickes, Northampton, UK) and 440 mm by 215 mm by 100 mm medium density blocks (Wickes, Northampton, UK) (Fig. 1). The muck heaps at farms one, two, three