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Short communication

# Comparison of emergence traps of different shape and translucency in the trapping of *Culicoides* (Diptera: Ceratopogonidae)

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ABSTRACT

Various types of emergence traps are available for investigations of the breeding habitats of *Culicoides* (Diptera: Ceratopogonidae). In order to assess the potential impact of the trap design on the trapping success, we compared the efficiency of opaque and white (more translucent) emergence traps and two trap shapes (cone-shaped and quadratic), to sample *Culicoides* emerging from cowpats. Significantly higher numbers of *Culicoides chiopterus* and *Culicoides dewulfi* were trapped with opaque traps, while there was no obvious effect of the trap shape. There were no distinct differences in the microclimate among different trap types.



## 1. Introduction

The haematophagous biting midges of the genus *Culicoides* transmit several arboviruses to livestock, e.g., bluetongue virus, Schmallenberg virus and African horse sickness virus (Mellor et al., 2000; Rasmussen et al., 2012). The immature stages of this genus occupy a variety of breeding sites, e.g., moorland, tree holes and animal dung (Kettle and Lawson, 1952; Murray, 1957). Emergence traps are a common tool in research on *Culicoides* breeding ecology. A variety of different trap designs have been applied in previous studies to sample emerging *Culicoides*, e.g., constructions of wooden boxes and tarred roofing paper (Dove et al., 1932; Davies, 1966; Braverman, 1970). Further designs include tent-like traps of white netting, plastic buckets, black cardboard cones and simple ice cream containers (Battle and Turner, 1972; Pajor, 1987; Dyce and Marshall, 1989; Bishop et al., 1996; Uslu and Dik, 2010).

It is not known whether different trap designs are comparably efficient in trapping *Culicoides*. Therefore, the aim of the present study was to evaluate the effectivity of four different trap designs. In order to estimate the potential impact of the trap shape on the trapping success, we compared cone-shaped and quadratic designs. To facilitate sampling, emergence traps are often used in combination with transparent collection containers in order to utilise the positive phototaxis of *Culicoides* (Megahed, 1956; Becker, 1960; Bidlingmayer, 1961). A dark or non-transparent trap body maximises the differences in light intensity between trap interior and collection beaker. It was therefore tested whether an opaque trap design increases the number of trapped *Culicoides* compared to white-coloured traps. The advantages and disadvantages of the tested trap types are discussed in comparison with alternative types proposed in previous studies.

## 2. Materials and methods

### 2.1. Culicoides *sampling*

Cowpats were sampled in June 2014 from a pasture of an organic cattle farm in north-western Germany (GPS coordinates: N53 9.985 E8 8.771). Two days in advance of the main experiment, small subsamples (approximately 10 g each) were collected from the edges of 25 cowpats for the extraction of *Culicoides* larvae with an adapted Berlese technique (see Steinke et al., 2014 for details) to ensure that only cowpats containing immature stages of *Culicoides* were included in the experiment. Ten colonised cowpats were randomly selected and sampled as a whole from the pasture along with the soil layer (down to 3–4 cm) underneath. A sample of each cowpat

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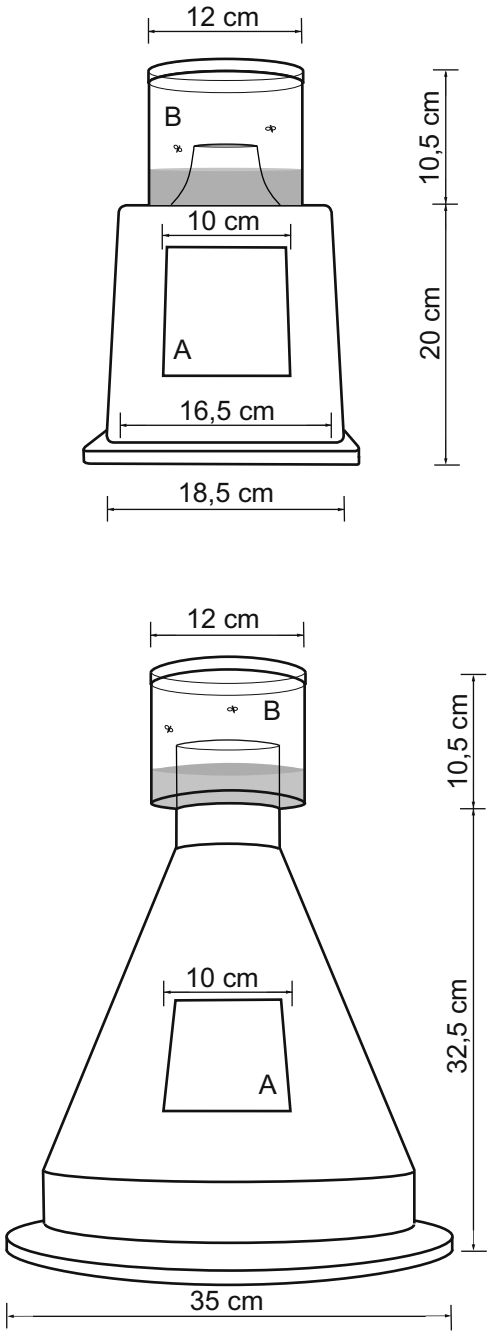


**Fig. 1.** Schematic drawing of the quadratic (top) and cone-shaped trap (bottom). Aeration windows (A) are covered with gauze (mesh size: 105 μm). Emerging insects are trapped and preserved in the salt solution in the transparent collection container (B).

(14 × 14 cm) was divided into four subsamples (7 × 7 cm), which were placed into four different emergence traps: (i) cone-shaped and white, (ii) cone-shaped and opaque, (iii) quadratic and white, and (iv) quadratic and opaque (Fig. 1). Ten traps of each type were used in the experiment. Cone-shaped traps were constructed from reversed plastic funnels and quadratic traps from reversed plastic buckets. The traps were combined with closed transparent collection containers at the top (material: polystyrene, e.g., LICEFA, Germany, Bad Salzuflen) and sealed with a closing plate at the bottom (Fig. 1). Both trap types had two lateral aeration windows (10 × 10 cm) covered with gauze (mesh size: 105 μm). The collection container was filled with approximately 50 ml of 20% NaCl saline, supplemented by a drop of detergent. Originally, all traps were of white colour. Ten traps of each shape were masked with a non-transparent black foil to create the opaque trap versions. The remaining white traps were not masked and were more translucent in comparison to the opaque traps. Data loggers (HOBO Pro v2, Onset, Bourne, MA, USA), fastened inside 12 emergence traps (three loggers per trap type), measured air temperature and humidity at hourly intervals. Additionally, miniature temperature loggers (iButton DS1921G, Maxim Integrated, Sunnyvale, CA, USA), carefully inserted into the centre of the 12 respective cowpat subsamples, recorded the substrate temperature. A weather station at a distance of 1.2 km from the test site (Oldenburg University, www.uni-oldenburg.de/wetter) provided information on the ambient temperature.

The traps were placed on a mowed lawn (without noteworthy sources of shadow) and secured with tent pegs for stabilisation. The light intensity at the bottom of all the traps was measured once during the experiment (12–3 pm, 7 August 2014) with a lux meter (PeakTech® 5025, PeakTech, Ahrensburg, Germany). Every second to third day, trapped insects were removed and the cowpat samples moistened with 20 ml of tap water using a spray diffuser. No insects were noted to escape the traps during this procedure. *Culicoides* biting midges were identified to the species level following the key of Campbell and Pelham-Clinton (1960). The experiment was stopped after 47 days, subsequent to two weeks without observed emergence of *Culicoides*.

### 2.2. Statistical analysis

All statistical analyses were carried out with the program R (R Core Team, 2014) using a confidence level of 5%. The relation between the number of trapped individuals (all *Culicoides*, *C. chiopterus* (Meigen, 1830) and *C. dewulfi* Goetghebuer, 1936 and the translucency and shape of the emergence traps was investigated by applying linear mixed-effects models (function *lme*, package "nlme", version 3.1-120, Pinheiro et al., 2015). The ID of each cowpat was included as a random effect ("pat") in the model to take variations of the *Culicoides* abundance in different cowpats into account. After respective exclusion of a fixed effect, i.e., "translucency" or "shape", the original and the new model were compared via ANOVA. The models were run with and without outliers to see whether the exclusions led to distinct changes in *p*-values or coefficient estimates. For evaluation of the final models, a conditional coefficient of determination ($R^2$) was calculated (Nakagawa and Schielzeth, 2013; Johnson, 2014) and residual plots were produced (histograms of Pearson residuals, fitted values vs. Pearson residuals) for model evaluation.

## 3. Results and discussion

A total number of 665 *Culicoides* midges were collected, i.e., 464 specimens of *C. chiopterus* (179 males, 285 females) and 201 *C. dewulfi* (33 males, 168 females). First individuals were collected between one and four days after the start of the experiment. The total numbers of trapped *Culicoides* varied greatly among cowpats from six individuals from all subsamples of one pat to 179 midges (66.5 ± 50.6). With quadratic translucent traps, 70 *Culicoides* specimens (7.0 ± 5.7) were trapped (Fig. 2), while 101 individuals (10.1 ± 9.0) were collected with cone-shaped translucent traps. Overall, more individuals were trapped with the opaque traps, i.e., 318 (31.8 ± 29.8) with the quadratic trap and 176 (17.6 ± 21.5) with the cone-shaped trap.

According to regression analysis, a significantly higher number of trapped *Culicoides* and *C. chiopterus* were correlated with the opaque traps whereas the shape did not significantly affect