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Investigation of *Culicoides* spp. preference for light colour and source using light emitting diodes and fluorescent light

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Abstract
Light colour and source preference testing has been conducted for *C. brevitarsus* in Australia but have not been performed in South Africa. Data from the Australian trials show an increased affinity for light from Light Emitting Diodes (LEDs) rather than incandescent light (the Australian Standard). Locally, the collection standard is an 8W fluorescent ultra-violet (UV) blacklight. A new trap was used to compare midge attractiveness to fluorescent and LED light sources as well as the colours: white, green and UV. Results show a very high affinity for UV light. Catches from white and green light were not found to differ significantly and the interaction between light colour and source was not found to be significant. Possible trap development and action thresholds are discussed.

Keywords: *Culicoides* midge vector, African Horse Sickness, light colour, light emitting diodes
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Introduction
Midges of the genus *Culicoides* have long been implicated in the transmission of diseases afflicting both humans and livestock (Mellor *et al.*, 2000; Mullen, 2002; Whitman & Baylis, 2000). *C. imicola* and *C. Bolitinos*, the two main species known to transmit African Horse Sickness (AHS), have been described by many researchers as either crepuscular or nocturnal (Nevill, 1967; Walker, 1977; Boorman, 1993; Barnard, 1997; Wittman & Baylis, 2000). The successful use of light traps to catch *Culicoides* midges (Du Toit, 1944) initiated a lot of light trapping for research purposes. To date, the overwhelming trend in the collection of midges has been to use fluorescent black light as the main attractant (Walker, 1977; Van Ark & Meiswinkel, 1992; Venter & Meiswinkel, 1994; Barnard, 1997; Venter *et al.*, 2000; Musuka *et al.*, 2001; Meiswinkel & Paweska, 2003; Paweska *et al.*, 2003; Rawlings *et al.*, 2003). Venter & Hermanides (2006) conducted a comparative study between black and white light as an attractant medium and found black light to be far superior to white. Some have modified these traps to incorporate CO_2 as an added attractant (Holbrook & Bobian, 1989). Light traps have been modified to run off 12V batteries for added mobility (Rawlings *et al.*, 1998; Bishop *et al.*, 2000). In a recent study on *C. brevitarsis* in Australia, different light colours and sources were tested for their attractiveness to midges (Bishop *et al*., 2004). Results were compared to the catches of an incandescent bulb. It was found that there was a very significant increase in catch sizes when certain colours of Light Emitting Diodes (LEDs) were used to trap certain species of *Culicoides* midges. Green light emitted from LEDs at an intensity of 142% that of an incandescent globe was almost three times more effective at trapping *C. brevitarsis* than the current collection systems used in Australia. They concluded that a new type of LED based trap would be better suited at sampling areas of sparse population as they are more attractive and so stand a better chance of drawing in a thinly spread population.

No comparative light-source work has yet been done in South Africa. LEDs are an excellent light source as they are more efficient than typical fluorescent or incandescent lights (G. Dewar, Pers. Comm.) and so any trap developed using LEDs can be run on batteries for a far longer period than would otherwise be possible. Any new improvements can be used in both the out-trapping of vectors from stables and the trapping of midges for research purposes. Light traps capture insects intact and often unharmed and therefore can be used to create a breeding population on which further studies can be made (Nevill, 1967).

Materials and Methods
A revolving LED and fluorescent light trap (Jenkins, 2008) was set up at stables in Karkloof in the Midlands of KwaZulu-Natal (grid reference S29°22’47.9”; E30°14’43.3” GPS elevation 1116 m) during

February when previous downdraught trap collections (using an 8W blacklight as the attractant) had yielded large catches of midges. The light trap was turned on every evening an hour before dusk and was run until an hour after sunrise each morning, using LEDs and fluorescent lights alternately for eight repetitions. Each morning, the trap was "cleared". Midges that had adhered to the Perspex© sheets were removed using entomological tweezers (number 5). Samples were rinsed briefly in acetate to remove oil residues before being moved to 80% alcohol for preservation and storage. Midges were labelled and sent for identification to family and genus (Venter G.J., Pers. Com, Onderstepoort Veterinary Institute, Private Bag X5, Onderstepoort, 0110).

Catch numbers were log (X+1) transformed to normalise the skewed distribution. Analysis of variance (Genstat v9, 2006) of the transformed data was used to evaluate the interaction and main effects of type of light source and colour of light, with the expectation that the male and female midges would demonstrate a preference for coloured LED light.

Results and Discussion

The new revolving trap was very effective in catching midges (Figure 1). The ANOVA demonstrates that UV LEDs would be the best way of catching midges. As these are very expensive, white LEDs would be the next best choice. Ninety seven percent of the catch was female, of which 61% were nulliparous, 36% were parous, 0.1% were gravid and 2.9% were blood fed. Twenty different species were caught using the new trap.

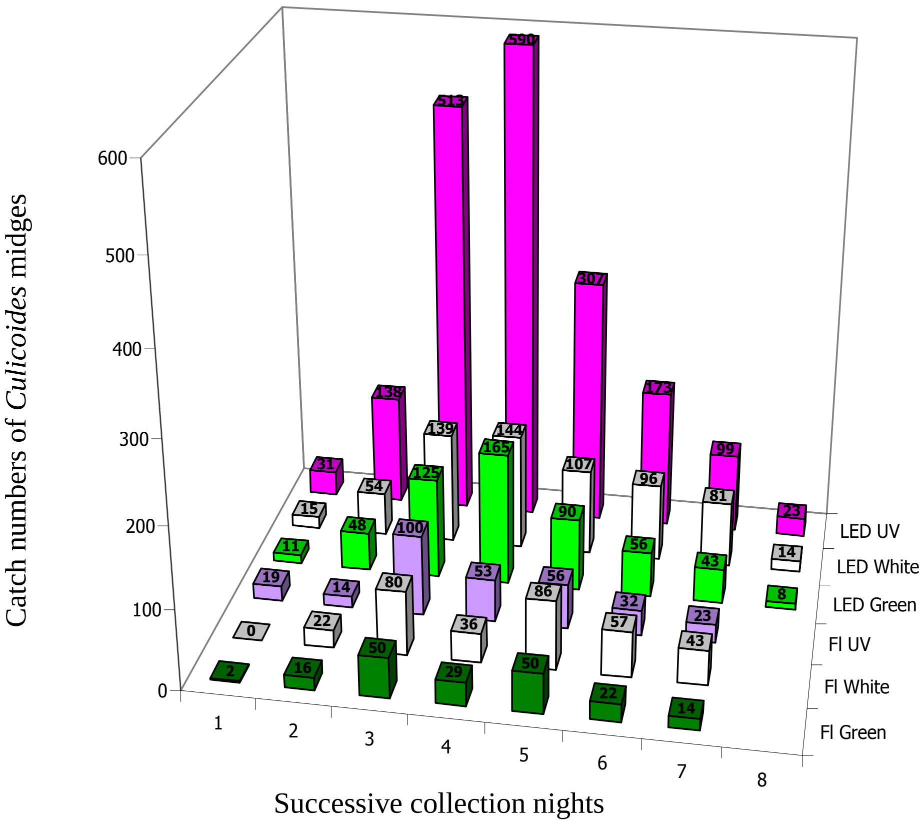

Figure 1 Catch numbers of *Culicoides* spp. male and female midges using six colour/light source combinations in a revolving light trap (after Jenkins, 2008).

ANOVA showed highly significant variation between the different sources and colours of light (P <0.001), but no interaction (P = 0.865). The log (x+1) transformed means shown in Table 1 highlight the usefulness of UV light as an attractant wavelength for midge collection. There is also significant difference

(P <0.001) between LEDs and fluorescent lights as a light source. By percentage, this trend is seen across all species collected with all 20 species showing a higher percentage caught on the LEDs than on fluorescent lights. UV light has been shown to be highly attractive to night flying insects and is excellent for midge collection. Partially agreeing with the findings of Bishop *et al*. (2004), green light was not significantly different from white light but, in this instance, fell well below the attractive capacity of UV. The *Culicoides* genus is highly speciose and results pertaining to one specific species cannot be extrapolated to another from a geographically different location. In all instances, the use of a light source was better than no light source at all. It is therefore important to turn lights off in the stables at night, as an AHS control measure.

Table 1 Log (x+1) transformed means of *Culicoides* spp catches using UV and coloured light combinations in a revolving light trap (after Jenkins, 2008).

Main effect	Treatment	Mean	LSD
Colour**	UV	1.874[a]	0.3403
	White	1.636[ab]	
	Green	1.503[b]	
	Control	0.710[c]	
Light Source**	LED	1.630[a]	0.2412
	Fluorescent	1.203[b]	

** main effects significant at P <0.001.
Means with different superscripts differ significantly from one another (P <0.001).
LSD - least significant difference.

This may be a very useful consideration in the design of small, cheap monitoring devices. LEDs are cheap, hardy and can be run on very low voltage systems. Thus the development of a battery or solar powered system may be possible through the use of LEDs. The technique of an "action threshold" is currently enjoying widespread use in the control of Orange Wheat Blossom midge (*Sitodiplosis mosellana)* (Manitoba Agriculture, 2008). Small, yellow, sticky cards are set at various intervals throughout the crop. These attractive cards are checked periodically and when the critical number of insects caught within a period of time is exceeded, a spray regime is initiated to effectively control the pest population. Similarly, a battery operated LED panel with a removable sticky surface could be a good monitoring device for the control of *Culicoides* midges. A threshold number of midges caught per unit time can be calculated and this can initiate a control program involving larviciding possible breeding sites, fogging with an adulticide and an increase in pour-on prophylactics (Simpkin, 2008).

Conclusion

In addition to the development of early warning system indicators for midge numbers, the revolving trap design, in testing light/colour combinations, also offers improvement value to the standard downdraught traps that are used in insect traps, by informing choices of light source and colour for geographically relevant control of particular midge species. In conjunction with a stringent vaccination program, the use of UV and LED light traps provides a practical intervention in the reduction of *Culicoides* midge populations to protect equids against African Horse Sickness, by attracting the midges away from the horses and trapping them to reduce the bite load on the horses.

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