Protection of cattle from *Culicoides* spp. in Australia by shelter and chemical treatments

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Summary

Trials were conducted in three regions of Australia to investigate the potential for improvised shelters and chemical treatments to reduce feeding by *Culicoides* on cattle and thereby minimise the risk of bluetongue transmission during transport of cattle to ports. Various designs and combinations of roofs and walls were placed around penned cattle. Chemical treatments were applied to other penned cattle. *Culicoides* were collected from the cattle by vacuum samplers or by light traps in the pens. Roofs alone did not consistently reduce the numbers of *Culicoides brevitarsis* or *C. fulvus* and increased the numbers of *C. actoni* collected. Walls alone reduced the numbers of *C. wadai* but not *C. brevitarsis*. Roofs and walls in combination reduced the numbers of *C. brevitarsis* and *C. wadai*. The chemical treatments 'Flyaway' (a blend of repellents) and fenvalerate reduced the numbers of *C. brevitarsis* and *C. wadai* up to 52 h post treatment.

Keywords

Arbovirus – Australia – Bluetongue – Cattle – *Culicoides brevitarsis* – *Culicoides wadai* – *Culicoides actoni* – *Culicoides fulvus* – Repellent – Shelter – Risk reduction.

Introduction

Australia exports live cattle to a number of countries. Arbovirus-sensitive markets require the cattle to be free from bluetongue (BT) viruses (BTV). Suitable cattle can be sourced from inland and southern areas. The export of such cattle from inland northern Australia could be enhanced if the animals could be sent from ports in northern Australia. However, to reach these ports, the cattle must be transported through areas in which *Culicoides* vectors may be active. The risk of BT transmission could be minimised if the cattle could be protected from *Culicoides* during transport.

Several species of *Culicoides* in northern Australia are capable of transmitting BTV to cattle (9). *C. brevitarsis* Kieffer (Diptera: Ceratopogonidae) is the most widespread of the vector species in Australia and occurs at least seasonally through northern Western Australia, northern Northern Territory, Queensland and northern and central coastal New South Wales. *C. wadai* Kitaoka and *C. actoni* Smith are restricted to the northernmost Northern Territory and coastal Queensland although *C. wadai* also occurs sporadically in northern coastal New South Wales. *C. fulvus* Sen and Das Gupta is restricted to northernmost Northern Territory but has previously been recorded in coastal north Queensland. However, a current review is likely to redefine the Queensland population as *C. dumdumi* Sen and Das Gupta (A.L. Dyce, personal communication). A previous study has suggested that *C. brevitarsis* is exophagic (8). It is most prevalent in open pasture and the numbers of *C. brevitarsis* that attack cattle can decrease in wooded areas (1). However, this is not true of all *Culicoides* species. A variety of other *Culicoides* species will attack livestock in shelters (4, 6). The habits of the other BT vector species in Australia are unknown and the effects of shelter on any Australian *Culicoides* have yet to be tested experimentally. Improvised covers on livestock transport compartments may afford cattle some protection from exophagic *Culicoides*. The cover provided by the slatted construction of cattle road transport vehicles and rail wagons may already provide some protection. It may also be possible to enhance this effect by adding extra covers to form roofs and partial walls.

A number of chemical treatments have proved to be effective against the vector species in Australia. Bishop *et al.* (3) collected reduced numbers of *C. brevitarsis* in light traps covered in mesh treated with 'Flyaway', fenvalerate, deltamethrin or 'pyrethroid-T'. Melville *et al.* (7) found fenvalerate, deltamethrin and permethrin reduced the numbers of *C. actoni*, *C. brevitarsis* and *C. fulvus* in cattle 8 h-60 h post treatment. Doherty *et al.* (5) found cypermethrin and deltamethrin reduced *C. brevitarsis* numbers in cattle 8 h-53 h post treatment. However, no tests have been conducted against *C. wadai*.

These trials aimed to investigate the potential of improvised shelters and chemical treatments to protect cattle against the vectors of BTV so that cattle may be transported through areas where vectors may be active.

Materials and methods

Trials were conducted in 2001 and 2002 in three areas, Beatrice Hill in the Northern Territory (12.39°S, 131.20°E), Tocal in New South Wales (32.38°S, 151.35°E) and Mena Creek in Queensland (17.62°S, 145.91°E). In the Northern Territory, a shelter trial against *C. actoni*, *C. brevitarsis* and *C. fulvus* was conducted (Trial A). In New South Wales, shelter trials against *C. brevitarsis* were conducted (Trials B and C). In Queensland, shelter (Trial D) and chemical (Trial E) trials against *C. brevitarsis* and *C. wadai* were conducted.

Trial A

Four pens, each 2.5 × 2.5 m and 1.9 m high, were constructed. Two pens had tarpaulin roofs and two were uncovered. Four uniform steers were held in each pen. Collections were made from the cattle with a vacuum sampler. Covered and uncovered pens were sampled simultaneously. Five collections were made at approximately hourly intervals starting at 17:00 on each of eight evenings in March and a further eight evenings in May/June. Unfed and blood-fed *C. actoni*, *C. brevitarsis* and *C. fulvus* were identified and counted. Data were analysed with a generalised linear model using S-plus. Models were fitted using a Poisson error distribution with a log link.

Trial B

Six pens each 6 m × 6 m and each containing two uniform steers were used. Tarpaulins were placed 3.2 m above three of the yards and three were left uncovered. The covers were relocated between pens at random for each of four serial replicates. *C. brevitarsis* were collected by vacuuming the backs, sides, neck/heads and rumps of the cattle in each pen for 5 min, 2 h before sunset and 1 h and 2 h after sunset. *C. brevitarsis* were identified and counted. Data were analysed by restricted maximum likelihood (REML) analysis following a square root transformation to normalise the data. Wald tests were used to test the significance of the fixed effects.

Trial C

Five treatments were replicated three times on each of four nights. The treatments were as follows:

1) High walls (>2 m high) and high roof. Three similar-sized pens (approximately 3 × 3 m) were used. The first was a closed wooden stable. The second a steel shed enclosed on three sides with the open side covered to 2.5 m high with a tarpaulin. The third was a cattle yard covered on each side and above with tarpaulins.
2) Low walls (<2 m high) and low roof. These used tarpaulins to cover each side of three pens (each 3.3 × 3.3 m × 1.5 m high). A tarpaulin roof was added to each pen
3) Low walls only (as for treatment 2 without the roof)
4) Low roof only (as for treatment 2 without the walls)
5) Uncovered (larger pens were used in this treatment) (30 m × 30 m).

Two uniform cattle were placed in each pen. A light trap was placed in each pen at a height of 1.5 m to 2.0 m so that minimal light was visible beyond the pen and only *Culicoides* within the pen would be trapped. The light traps were operated overnight and *C. brevitarsis* collected were identified and counted. Statistical analysis used a mixed model that allowed for random effects as the errors were not correlated between times.

Trial D

Two steers were placed into each of three 1.1 m × 3.0 m pens. Three treatments were included, namely: slatted walls, slatted walls and a tarpaulin roof and an unmodified pen as a control. The walls copied those found on cattle transport compartments. Plywood was fixed to panels of steel tubing in horizontal strips to produce a slatted wall with 35% of its area uncovered. The walls were erected around two pens creating outer pens 4.2 m × 2.1 m and 1.9 m high. One was covered with a tarpaulin. The experiment was replicated four times on four consecutive nights. Each treatment was allocated to a different pen each night in a randomised pattern. Collections were made by vacuuming the backs, sides, neck/heads and rumps of the cattle in each pen for 5 min. Collections occurred at intervals of at least 30 min to give 9-13 collections for each night. The numbers of blood-fed and unfed female *C. brevitarsis* and *C. wadai* were identified and counted. Mean nightly fed and total numbers were analysed using analysis of variance and least significant difference (LSD) on the natural log transformed means (mean + 1) using Genstat 5 ($P<0.05$).

Trial E

The cattle and three unmodified pens from Trial D were used. Three treatments were included: fenvalerate, 'Flyaway' and untreated. Fenvalerate was applied as a spray of 200 ml per steer of 1% active ingredient aqueous solution to the back, rump, flanks and head. 'Flyaway', (12 g/l permethrin, 50 g/l diethyltoluamide, 25 g/l n-octyl bicycloheptene dicarboximide, 25 g/l piperonyl butoxide, 20 g/l dibutyl phthalate and 10 g/l lavender oil) was applied as an undiluted spray to a similar area at 20 ml-25 ml per steer. Treatments were applied at 16:30. *C. brevitarsis* and *C. wadai* were collected as in Trial D. Collections were made at 25 min intervals from 17:30-20:25 for each of the three nights following treatment giving eight collections each night covering the periods 1 h-4 h, 25 h-28 h and 49 h-52 h post treatment. Four serial replicates were performed in successive weeks. Analysis was similar to Trial D.

Results

In Trial A, the tarpaulin roofs did not reduce the numbers of fed or unfed *C. brevitarsis* and *C. fulvus* collected from the cattle. Significantly more fed and unfed *C. actoni* were collected from the cattle in the covered pens (Table I).

In Trial B, the high roof reduced the numbers of *C. brevitarsis* collected from the cattle (Table II).

In Trial C, the lowest number of *C. brevitarsis* was collected in the pens with walls and roof, with fewer in the high walls and roof pens than the low walls and roof pens (Table II). Fewer *C. brevitarsis* were collected in pens with walls only than in pens with roof only. The pens with walls or roof only collected more *C. brevitarsis* than the uncovered pens but comparisons with the uncovered pens may be complicated by the different pen sizes. The light traps may have been less effective in the larger uncovered pens as they may not have been as close to the cattle at all times.

Table I
Trial A (Northern Territory)
Mean numbers of *Culicoides* per vacuum sample from penned cattle

Treatment	*C. actoni*		*C. brevitarsis*		*C. fulvus*	
	Fed	Unfed	Fed	Unfed	Fed	Unfed
Pen with roof	61.4[a]	315.9[a]	1.4[a]	6.8[a]	0.9[a]	14.7[a]
Uncovered pen	32.8[b]	160.6[b]	1.2[a]	6.4[a]	1.0[a]	15.5[a]

Within each column, means with different superscripts are significantly different ($P<0.05$)

In Trial D, the pens with slatted walls and tarpaulin roof reduced both blood-fed and total numbers of *C. brevitarsis* and *C. wadai* collected (Table III). The pens with slatted walls only reduced the numbers of *C. wadai*, both blood-fed and total, but not the numbers of *C. brevitarsis*. The pens with walls and roof reduced total *C. wadai* numbers more than walls alone.

Table II
Trials B and C (New South Wales)
Back-transformed mean numbers of *Culicoides brevitarsis* per collection from penned cattle

Trial	Sampling method	Treatment	*C. brevitarsis*
B	Vacuum sampler	Pen with high (3 m) tarpaulin roof	3.1[a]
		Uncovered pen	14.9[b]
C	Light traps	1) Small pen with high roof and walls (>2 m)	4.6[c]
		2) Small pen with low roof and walls (<2 m)	13.7[d]
		3) Small pen with low walls only (<2 m)	103.6[b]
		4) Small pen with low roof only (<2 m)	475.8[a]
		5) Large uncovered pen	37.4[c]

Within each trial only, means with different superscripts are significantly different ($P<0.05$)

In Trial E, both 'Flyaway' and fenvalerate reduced both blood-fed and total numbers of *C. brevitarsis* and *C. wadai* collected (Table III). 'Flyaway' and fenvalerate were equally effective. The efficacy of both chemicals for both species did not vary significantly between the assessment periods, 1 h-4 h, 25 h-28 h and 49 h-52 h post treatment.

Discussion

The effect of roofs on *C. brevitarsis* varied between trials. There are many factors, which could interact with the response of *C. brevitarsis* and other species to shelters to produce this variability. For example, *C. brevitarsis* is crepuscular but its activity is also affected by temperature (2). If its response to shelters differed before and after dusk, different areas and times of year could give different results.

Table III
Trials D and E (Queensland)
Back-transformed mean numbers of *Culicoides* per vacuum sample from penned cattle

Trial	Treatment	*C. brevitarsis*		*C. wadai*	
		Fed	Total	Fed	Total
D	Pen with walls	1.6[b]	13.2[b]	0.1[a]	1.5[b]
	Pen with walls and roof	0.4[a]	2.6[a]	0.04[a]	0.27[a]
	Uncovered pen	2.3[b]	21.2[b]	0.5[b]	3.4[c]
E	Fenvalerate	0.74[a]	16.77[a]	0.06[a]	1.12[a]
	Flyaway	1.71[a]	30.82[a]	0.16[a]	1.87[a]
	Untreated	17.48[b]	172.47[b]	1.65[b]	10.63[b]

Within each column of each trial only, means with different superscripts are significantly different (P<0.05)

Culicoides actoni appears to be endophagic and so even more complete shelters may not afford protection against this species. *C. fulvus* was undeterred by roofs but may, like *C. brevitarsis*, be deterred by a more complete shelter. *C. wadai* can be deterred and it is likely that any shelter that is effective for *C. brevitarsis* will also be effective for *C. wadai*.

Improvised shelters consisting of only roofs or walls currently appear unlikely to give cattle reliable protection against all the Australian BT vectors. An unmodified cattle transport compartment typically consists of walls only and could not be relied on to reduce the risk of BT transmission in any area where *C. brevitarsis* is present. *C. brevitarsis* occurs wherever *C wadai* occurs so the effectiveness of walls against *C. wadai* is unfortunately of no practical value. Shelters with walls and roofs appear to offer useful protection for cattle against *C. brevitarsis* and *C. wadai*. The addition of tarpaulin roofs to transport compartments could be a useful risk reduction strategy if it does not compromise the welfare of the cattle.

Chemical treatments offer reliable protection for cattle. With the addition of this trial against *C. wadai*, to those mentioned above, fenvalerate has proved to be effective against all BT vectors in Australia. 'Flyaway' gives useful protection against *C. brevitarsis* and *C. wadai* but has not yet been tested against *C. actoni* and *C. fulvus* although another permethrin product was effective against these latter species (7).

Although neither shelter nor chemical treatments alone can currently entirely eliminate the risk of BT transmission to cattle during transport, they could be a valuable addition to other risk reduction strategies, such as uninterrupted travel to enable safe transport of cattle through areas of BT risk.

Acknowledgements

Biosecurity Australia provided funding for much of this work.

Harry McKenzie, Lorraine Spohr, Idris Barchia, Diana Pinch, Bill Albrecht and Angela Reid provided invaluable assistance.

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