Temporal activity of biting midges (Diptera: Ceratopogonidae) on cattle near Darwin, Northern Territory, Australia

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Summary

The activity of nine species of biting midges aspirated from cattle was recorded in the late afternoon, evening and early morning at a site near Darwin, Northern Territory, between March and June in 1999 and 2001. There were no significant differences between the temporal activity patterns for nulliparous and parous females of any species. Nulliparous females dominated collections of all species except *Culicoides marksi*. *C. actoni* and *Forcipomyia (Lasiohelea) sp.*, were mostly active during daylight hours while *C. peregrinus*, *C. bundyensis* and *C. brevipalpis*, were nocturnal. Differences in the peak activity of *C. brevitarsis* were noted between years and occurred slightly earlier than that observed at other sites. *C. fulvus*, *C. marksi* and *C. oxystoma* were generally crepuscular but differed in the length and peak period of activity. *C. actoni* was four times more active in the evening than in the morning while *C. marksi* and *C. peregrinus*, were respectively 2.6 and 3.4 times more active in the morning than in the evening. Numbers of the other six species were not significantly different in the evening and morning. All nine species were collected at least once from cattle shortly after dawn.

Keywords

Australia – Biting midges – Bluetongue – Cattle – *Culicoides* – *Lasiohelea* – Onchocerca – Temporal activity – Vector.

Introduction

Biting midges (Diptera: Ceratopogonidae) are recognised pests of bovids in northern Australia and elsewhere, chiefly through their ability to transmit diseases and parasites (1, 2, 11, 13). Species often differ in their temporal activity on hosts and this information can be important for those interested in collecting insects for laboratory studies, sampling the biting fauna or protecting valuable stock from attack.

When collecting biting midges from cattle in Malaysia, Buckley (2) concentrated on the period between 7.30 am and 9.30 am and in the two hours prior to sunset as he had observed maximum activity at these times. He noted that midges were 'extremely scarce during the heat of the day'. His nocturnal collections were conducted between 11 pm and 2 am. However, midges collected during these hours were thought to be attracted to the light used to facilitate collecting rather than being attracted to the animals to feed. Of the species he collected, only *Culicoides actoni* Smith (listed as *C. pungens* (14), *C. oxystoma* Kieffer and *C. peregrinus* Kieffer are also present in the coastal Northern Territory of Australia.

In south-east Queensland, *C. brevitarsis* Kieffer exhibited very low activity during daylight hours which sharply increased at sunset, peaked 30 min thereafter and gradually reduced to zero over the next 6 h, followed by a minor period of activity at sunrise (3). Standfast and Dyce (12) also noted a peak in activity of this species at dusk. Beveridge *et al.* (1) collected *C. marksi* Lee and Reye, *C. brevitarsis*, *C. bundyensis* Lee and Reye *C. actoni* and two species of *Forcipomyia* (*Lasiohelea*) from cattle before sunset and after sunrise but made no attempt to collect at night.

Pathogens are usually transmitted biologically by biting midges. Consequently, the epidemiologically important part of the population is the older females that have had the opportunity to take a blood meal and become infective for the pathogen. Protecting valuable stock from infection therefore relies on protecting against attack by old females. If protection is to be achieved by reducing exposure to attack during peak midge activity, the activity of old female midges needs clarification. Few studies of the relative activity of nulliparous and parous female midges have so far been published although the proportion of parous female *C. sonorensis* Wirth and Jones (as *C. variipennis sonorensis*) collected in a CO_2-baited trap was reported to be higher 'in the middle of the night', prompting the suggestion that crepuscular oviposition patterns may explain the difference in temporal activity between parous and nulliparous midges (10).

The authors report on the temporal activity of nulliparous and parous biting midges collected from cattle on the sub-coastal plains of the Northern Territory.

Materials and methods

Insect collections

The method used to collect, preserve and sort midges on cattle are fully described elsewhere (8, 9). Briefly, midges were collected from a group of ten cattle which were not treated with insecticides and which were housed in open pens while collections were being made. Midges were aspirated using a commercially available garden leaf blower (Makita RBL250) modified to allow insect collections into a gauze bag. Midges were aspirated from the back-line and flanks for one five-minute period per half hour on each day collections were made. Collections made between 30 March and 3 June 1999 began as early as 3 h prior to sunset and continued as late as 3.75 h after sunset and recommenced as early as 3 h prior to sunrise continuing as late as 2.5 h after sunrise. Collections made between 12 March and 14 June 2001 began as early as 1.75 h prior to sunset and continued until as late as 2.75 h after sunset. Collections were sorted into species and parity was assessed based on abdominal pigmentation (5).

Statistical analyses

The time between the collection of a sample and the closest dawn or dusk time was calculated for each sample. The distribution of activity times for most species were highly skewed so the measure of peak activity was characterised by the median, with 25th and 75th quartiles used to describe dispersal around the median (Figs 1, 2 and 3).

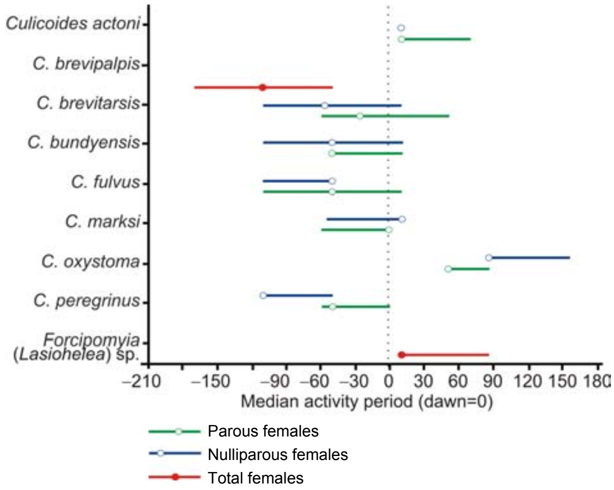

Figure 1
Temporal activity with respect to sunrise of nine biting-midge species on cattle near Darwin, Northern Territory, March, April, May and June 1999
Lines delineate the 25th to 75th quartiles around the median

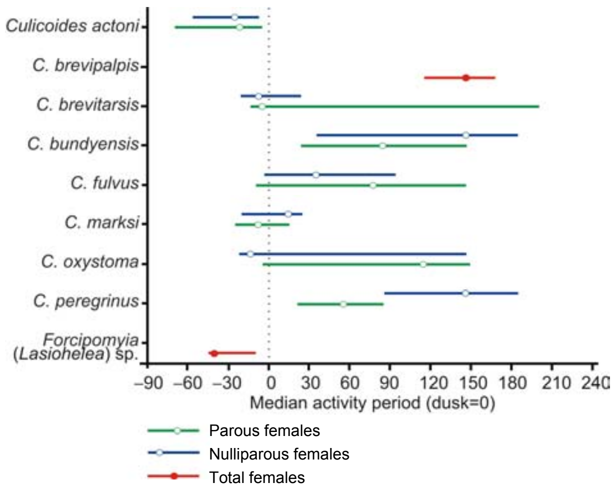

Figure 2
Temporal activity with respect to sunset of nine biting midge species on cattle near Darwin, Northern Territory, March, April, May and June 1999
Lines delineate the 25th to 75th quartiles around the median

To compare numbers of biting nulliparous and parous females of each species trapped at dawn (early morning) and dusk (afternoon and evening), the sample data were analysed using a generalised linear model (6). The model used tested the main effects of time of day (dawn or dusk), and parity type (nulliparous and parous females) and the interaction of time and type. Models were fitted using a Poisson error distribution with a log link.

All statistical tests were calculated at the 5% significance level (α=0.05) using S-Plus statistical software (7).

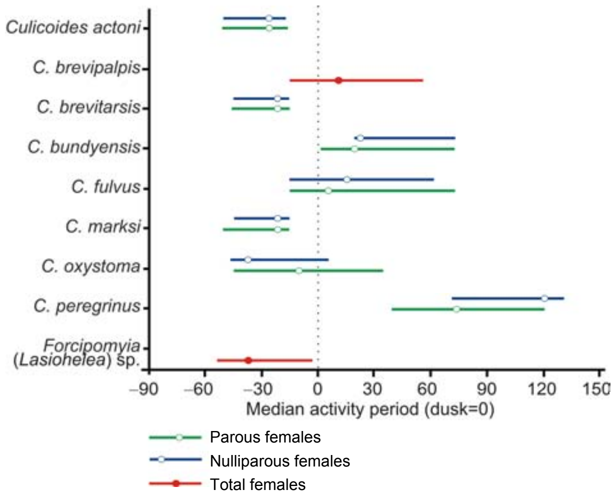

Figure 3
Temporal activity with respect to sunset of nine biting midge species on cattle near Darwin, Northern Territory, March, April, May and June 2001
Lines delineate the 25th to 75th quartiles around the median

Results

A total of 39 886 and 38 536 biting midges comprising 18 species were collected from cattle in 1999 and 2001, respectively. The most dominant species that attacked cattle were *C. actoni* and *C. peregrinus,* comprising 27% and 60%, respectively of the total in 1999 and 48% and 25%, respectively, of the total in 2001. Sufficient data to measure temporal activity was obtained for species and these are presented in Figures 1, 2 and 3.

The parity of *C. brevipalpis* Delfinado and an as yet unidentified species of *Forcipomyia* (*Lasiohelea*) could not be reliably assessed using abdominal pigmentation so data on these species is presented as total females and were excluded from results comparing activity of parous and nulliparous females.

There were notable differences in the periodicity of these nine species on cattle. Three of these species, *C. brevipalpis*, *C. bundyensis* and *C. peregrinus*, were nocturnal although they were also collected after sunrise. *C. actoni* and *F.* (*Lasiohelea*) sp. were mostly diurnal with significant numbers collected after sunrise and both exhibited a sharp drop in activity following sunset. *C. fulvus* Sen and Das Gupta was crepuscular with significant activity extending for at least 1 h after dusk and 2 h prior to dawn. *C. marksi* and *C. oxystoma* were also crepuscular but were generally active earlier than *C. fulvus*. *C. marksi* had a much narrower period of activity than either *C. oxystoma* or *C. fulvus*. Despite the significant nocturnal activity of *C. oxystoma* in the evening, peak morning activity of this species was not until well after dawn.

Evening activity of *C. brevitarsis* peaked before dusk and was significantly earlier in 2001 than in 1999 (median test, Chi-square=109.004, $p<0.0001$).

Numbers of *C. actoni* were about four times higher at dusk than those at dawn. Numbers of *C. marksi* and *C. peregrinus* were respectively about 2.6 and 3.4 times higher in the morning than in the evening. No significant differences were observed between morning and evening totals for the other species (Table I). Nulliparous females dominated collections of all species excepting *C. marksi* (Table II). There were no significant differences in the temporal pattern of activity of nulliparous and parous females of any of the species studied (Table III).

Table I
Mean (standard error) and associated p-values of female biting midges aspirated from cattle during morning or afternoon and evening periods at Beatrice Hill, Northern territory, between March and June 1999

Species	Morning	Afternoon and evening	p-value
Culicoides actoni	18.3 (9.29)	76.3 (15.46)	0.0036
C. brevitarsis	0.8 (0.17)	1.8 (0.43)	0.0729
C. bundyensis	6.5 (1.75)	6.4 (1.49)	0.9668
C. fulvus	4.8 (1.51)	2.9 (0.60)	0.0807
C. marksi	1.6 (0.47)	0.6 (0.12)	0.0020
C. oxystoma	23.7 (15.48)	16.1 (3.44)	0.3589
C. peregrinus	291 (107.9)	265 (70.2)	0.0009

Table II
Mean (standard error) and associated p-values of nulliparous and parous female biting midges aspirated from cattle at Beatrice Hill Northern territory, between March and June 1999

Species	Nulliparous females	Parous females	p-value
Culicoides actoni	96.6 (21.89)	26.0 (7.76)	0.0002
C. brevitarsis	2.4 (0.61)	0.7 (0.19)	0.0009
C. bundyensis	10.1 (2.28)	2.7 (0.19)	0.0001
C. fulvus	5.5 (1.12)	1.2 (0.24)	<0.0001
C. marksi	0.9 (0.19)	0.9 (0.23)	0.9999
C. oxystoma	28.4 (9.09)	7.7 (1.92)	0.0027
C. peregrinus	265 (70.2)	12.2 (2,86)	<0.0001

Table III
Interaction means (standard errors) and associated p-values for collection period (morning or afternoon and evening) of nulliparous and parous biting midge species aspirated from cattle at Beatrice Hill, Northern Territory, between March and June 1999

Species	Nulliparous females		Parous females		p-value
	Morning	Afternoon and evening	Morning	Afternoon and evening	
Culicoides actoni	34.2 (18.11)	118.4 (28.33)	2.5 (1.09)	34.1 (10.24)	0.4682
C. brevitarsis	1 (0.27)	2.9 (0.8)	0.6 (0.21)	0.7 (0.25)	0.3538
C. bundyensis	9 (3.24)	10.5 (2.86)	4 (1.17)	2.3 (0.51)	0.3756
C. fulvus	7.9 (2.85)	4.7 (1.14)	1.8 (0.66)	1 (0.24)	0.8887
C. marksi	1.2 (0.47)	0.8 (0.2)	2.1 (0.8)	0.5 (0.12)	0.0769
C. oxystoma	45.2 (30.61)	22.6 (6.35)	2.3 (1.26)	9.6 (2.51)	0.1052
C. peregrinus	550 (202.93)	167.4 (60.1)	32.5 (9.4)	5.2 (1.28)	0.7180

Discussion

Temporal activity is clearly a critical factor when assessing the biting midge fauna attacking hosts. For example, sampling only before sunset would overestimate the importance of *C. actoni*, *C. marksi*, *F.* (*Lasiohelea*) sp. and possibly also *C. brevitarsis* while underestimating *C. bundyensis*, *C. brevipalpis* and *C. peregrinus* and vice versa. The low activity of *C. actoni*, *F.* (*Lasiohelea*) sp. and to some extent *C. brevitarsis* after sunset, may also affect the ability of some sampling devices, for example light traps to representatively sample populations of these species. All of these species were still active after dusk and consequently still detectable in light traps. Indeed, Melville *et al.* (9) found that *C. brevitarsis* dominated light-trap collections made in the same time and place that the present study was conducted.

Temporal activity of *C. actoni*, *C. oxystoma* and *C. peregrinus* in Darwin was generally similar to that observed for these species in Malaysia (2). Debenham (4) noted that although few studies into the temporal activity of Australian species of *F.* (*Lasiohelea*) had been undertaken, the collection times of those specimens she studied indicated a diurnal, sometimes crepuscular, activity pattern.

The difference in the activity pattern of *C. brevitarsis* between 1999 and 2001 was unexpected. The pre-dusk peak observed in both years also differs from the post-dusk peak observed in this species in south-east Queensland (3). Early morning activity was more important relative to dusk activity in Darwin, which also contrasts with the predominantly evening activity observed in south-east Queensland. Environmental factors may contribute to the differences between the Darwin and south-east Queensland activity patterns although these are less likely to explain the difference between the 1999 and 2001 results, as these were both obtained at the same site during the same time of the year. The trigger for these changes in the activity pattern remains unclear.

Protection of stock from attack may be achieved by reducing exposure to potentially infective vectors during periods of peak activity. As no significant differences were observed between nulliparous and parous females of the seven species studied, this assessment is somewhat simplified. For those diseases with only one known vector, for example *Onchocerca sweetae* (11), protection may only be required during peak activity of the vector, *C. bundyensis*, i.e. after sunset and before dawn. For those diseases transmitted by a suite of vectors, for example bluetongue virus (13), the period over which all of the vectors are active in the area of concern needs to be taken into account.

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