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BRIEF COMMUNICATION: Effect of Shelterbelts on Dairy Cattle Behaviour During Summer

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Abstract

Summer heat load can negatively affect dairy cattle welfare and productivity. This study assessed whether shelterbelts influence dairy cattle behaviour, microclimate, and spatial distribution using GPS tracking, motion sensors, and cow-level temperature–humidity loggers across four New Zealand dairy farms. Cattle time budgets did not differ between shelterbelt and non-shelterbelt paddocks, although lying time increased at one site. Hotspot analysis showed strong clustering of cows near shelterbelts. Cow-level THI exceeded NIWA station THI, suggesting that ambient weather data underestimates heat load experienced by cattle. Shelterbelts influenced spatial distribution but had limited effect on overall behavioural time budgets.

Keywords: dairy cattle; heat stress; shelterbelts; behaviour; GPS tracking

Introduction

Pasture-based dairy systems dominate New Zealand primary sector production (DairyNZ, 2020) and allow cows to perform natural behaviours (Arnott et al., 2017), but animals remain exposed to climatic variation, including summer heat stress (Kadzere et al., 2002). High-producing cows generate considerable metabolic heat (Hansen, 2019)), and elevated temperature–humidity index (THI) values reduce milk yield, fertility, and overall welfare (Schuller et al., 2014; Silanikove et al., 2000; Summer et al., 2019). To mitigate adverse environmental conditions, cattle can modify their behaviour by seeking shade and changing the time they spend performing specific behaviours such as resting and grazing (Olson and Wallander, 2002; Schütz et al., 2010). These behavioural changes also include variations in posture to reduce exposure to solar radiation, shade seeking, crowding over water, bunching and time spent standing (Gaughan et al., 2002; Bryant et al., 2007; Polsky and von Keyserlingk, 2017). Shelterbelts provide shade and shelter for cattle (Gregory, 1995), creating a microclimate with lower air temperatures (Brandle, 2015). This study investigated the effect of shelterbelts on cattle behaviour, heat load, and spatial distribution during summer.

Materials and methods

Trials were conducted on four commercial dairy farms (Hiwinui (40°16'44.6"S 175°41'58.6"E), Palmerston North (40°23'31.4"S 175°36'30.7"E), Glen Oroua (40°19'47.1"S 175°23'59.7"E) and Table Flat (39°57'12.7"S 175°56'06.8"E)) in Manawatū–Whanganui during February–March 2020. A crossover design was used in which twenty Holstein-Friesian cows per site grazed a shelterbelt paddock and a comparable non-shelterbelt paddock for three consecutive days. Global Positioning System (GPS) collars (DataCarter Ltd., Palmerston North, NZ) log cow position every 60 seconds or whenever the cow had moved ≥ 5m; Icetag3D sensors (IceRobotics Ltd., Edinburgh, Scotland) measured lying, standing, and active behaviour; and Watchdog loggers (B-Series, Spectrum technologies, Illinois, USA) recorded temperature and humidity at cow level. THI was calculated using both NIWA weather-station data and cow-level measurements. Behavioural variables were compared using a two-way Student's t test or Mann–Whitney U tests ($p < 0.05$) using Minitab® 19 software for Windows (Minitab Inc., State College, Pennsylvania). Hot Spot analysis (z-score) was performed using ArcGIS Pro® software to find differences in cow distribution patterns in shelterbelt and non-shelterbelt paddocks.

Results and Discussion

Cow-level temperature and humidity data were consistently higher than NIWA records. THI calculated from cow-level data exceeded NIWA-derived THI at all farms (Table 1), which is expected because sensors were positioned close to the animals' bodies. The sensors were attached to the top of the GPS collars and fluctuations in animal temperature could have affected sensor data. THI calculated from cow-level data exceeded NIWA-derived THI at most farms, confirming that ambient weather data underestimate heat load experienced by cattle. These findings support previous work (Schutz et al., 2009) demonstrating that microclimate at animal height differs from standard meteorological recordings.

Table 1. Air temperature, relative humidity, Temperature-Humidity index (THI) data from NIWA weather station and cow body level weather data measured with Watchdog® sensor during six consecutive days on four different farms during 2020.

	Palmerston North		Glen Oroua		Table Flats		Hiwinui	
NIWA station	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Air temperature (°C)	11.8-26.4	18.0	6.3-23.5	16	10.4-19.8	13.8	12.0-29.0	18.7
Relative Humidity (%)	44.0-96.0	71.0	42.0-98.0	73.3	37.0-81.0	60.6	35.0-96.0	67.6
THI* (Environment)	54.3-74.5	64.1	45.0-71.8	61.1	52.9-64.8	57.7	54.7-75.7	64.6
Shelterbelt								
Cow temperature** (°C)	12.0-49.1	24.2	6.1-41.6	22.7	6.6-44.1	15.2	11.6-46.1	23.5
Cow relative humidity (%)	45.8-68.8	71.2	45.9-81.2	60.5	50.2-74.7	58.6	45.8-59.7	53.1
THI* (Cow level)	54.6-104.4	71.2	46.2-95.8	69.6	47.0-99.4	59	54.1-100.2	69.9
Non-shelterbelt								
Cow temperature** (°C)	11.6-41.1	22.8	6.6-47.6	22.6	6.1-47.1	15.2	10.0-47.6	23.4
Cow relative humidity (%)	47.7-66.2	56.0	32.8-94.1	61.9	46.6-73.0	57.4	48.0-58.0	52.9
THI* (Cow level)	54.0-93.8	69.3	47.0-101.8	69.5	46.0-101.9	59	51.4-101.8	69.7

*THI= Temperature–humidity index
**Cow temperature= Temperature measured at cow body level with Watchdog sensors

Time budgets were similar between treatments (Table 2). Across farms, cows spent most of the day active, followed by lying and standing. No consistent shelterbelt effect on behaviour was observed, although lying time increased in the sheltered paddock at Hiwinui (2020). Behaviour patterns varied inconsistently across farms, likely reflecting differences in weather, pasture availability, and herd management rather than a shelterbelt effect.

The spatial analysis identified areas with significant spatial clustering of dairy cattle when in shelterbelt and non-shelterbelt paddocks (Figure 1 only data from Palmerston North is presented as an example). Overall, the cows had similar spatial distribution between all farms, spending significantly ($P<0.05$) more time close to the shelterbelts when compared to the rest of the paddock. While in non-shelterbelt paddocks, cattle showed significant clustering around fences along the edges of the paddocks. Spatial cow distribution indicated that cows increased their use of areas immediately adjacent to shelterbelts. This confirms that cattle preferentially seek shade during warm conditions even when time budgets remain unchanged. In contrast, cows in non-shelterbelt paddocks often clustered along fence lines or showed dispersed distributions, indicating the use of different behavioural strategies performed by cows to cope with heat stress (Gaughan et al., 2002; Bryant et al., 2007; Polsky and von Keyserlingk, 2017).

These results support previous studies documenting cattle preference for shade during periods of heat load. The lack of strong treatment effects on lying or standing time aligns with earlier New Zealand research where shade reduced peak heat load without dramatically altering total daily behaviour. Taken together, findings suggest that shelterbelts primarily influence where cows perform behaviours rather than how much time they spend performing them.

Table 2. Mean h/d-1 (±SD) time spent performing three different behaviours (Active, Lying and Standing) on the different study sites in summer 2020.

Study site	Behaviour	Summer 2020			
		N	Shelterbelt	Non-shelterbelt	P-Value
Hiwinui	Standing	36	3.0 (±1.1)	2.6 (±1.1)	0.066
	Lying		9.8 (±1.2)	9.1 (±1.0)	0.019
	Active		10.6 (±1.0)	11.8 (±1.1)	0.001
Glen Oroua	Standing	34	3.5 (±0.8)	3.2 (±1.3)	0.161
	Lying		9.3 (±1.5)	8.8 (±1.4)	0.228
	Active		11.2 (±1.3)	12.0 (±0.9)	0.004
Apiti	Standing	18	1.2 (±0.7)	2.0 (±1.0)	0.006
	Lying		9.9 (±1.0)	9.5 (±1.0)	0.221
	Active		11.7 (± 0.6)	10.3 (±0.8)	0.001
Palmerston North	Standing	34	1.6 (±0.9)	1.3 (±0.7)	0.267
	Lying		9.7 (±1.6)	9.7 (±1.6)	0.946
	Active		12.5 (±1.4)	12.8 (±1.4)	0.377

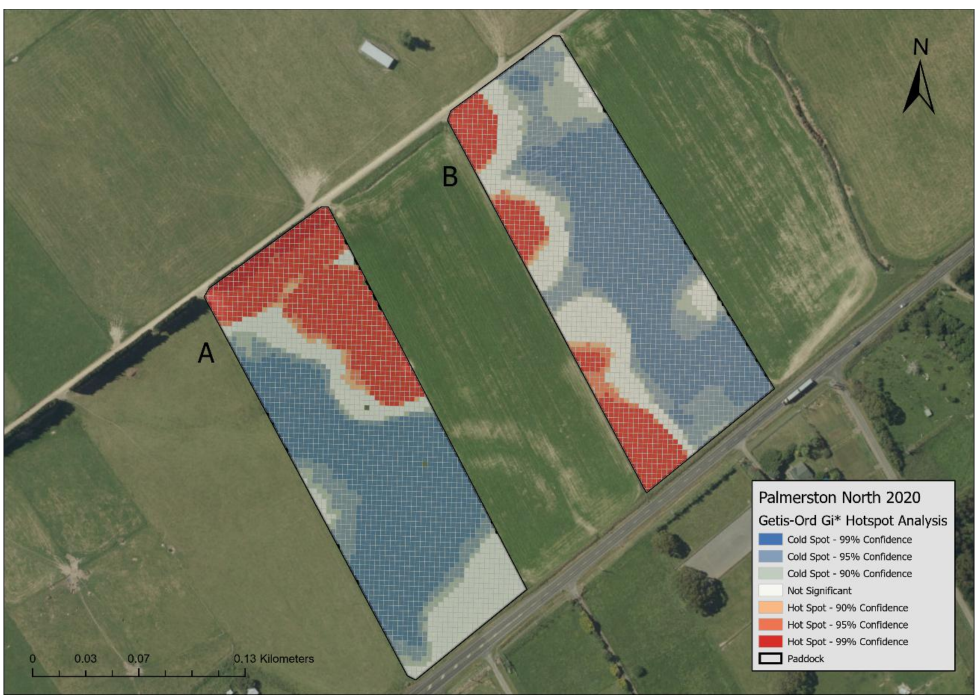

Figure 1. Maps showing the spatial distribution (magnitude per unit area) of cows in the paddock (A - shelterbelt & B – non-shelterbelt) using optimised hot spot analysis in Palmerston North farm. The blue areas represent low cow density, and red areas high cow density. Hotspot (red areas) indicates statistically significant (p<0.05) spatial clusters of high values (larger positive z-score) while cold spot (blue areas) indicates statistically significant (p<0.05) spatial clusters of low values (smaller negative z-score), and white indicates random distribution with no spatial clustering.

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