WEATHER REGULATED CATTLE BEHAVIOUR ON RANGELAND

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Abstract. Cattle behaviour depends both on internal factors (breed, age, oestrus, hierarchy, body homeostasis) and external factors (air temperature, humidity, wind speed, paddock size, grass quality and quantity). In our study we present how weather conditions modify behaviour and daily walked distance. Direct observations of Hungarian grey cows and calves were carried out in Eastern Hungary on a rangeland called Hortobagy. Meteorological, spatial and behavioural data were collected using weather stations, GPS collars and ethogram recordings. Data showed a positive correlation between daily walked distance and atmospheric pressure ($r=0.389$, $P<0.05$). Animals consistently used the same daily routes and resting sites. Moreover, frequency of metabolic behaviour (grazing, rumination, drinking, defecation, and urination) depended significantly on type of weather fronts experienced on the day following the examined day ($r=0.445$, $P<0.05$). These weather fronts were classified according to the system developed by Peczely. In summary, our study suggests that Hungarian grey cattle show specific behavioural patterns during low-pressure conditions. Therefore, understanding their behavioural responses to different environmental factors may help to improve the handling techniques of extensively farmed beef cattle. As behavioural adaptation is usually driven by the neuroendocrine system, we suggest that this type of regulation could also depend on environmental changes, therefore, this relationship needs further research.
Keywords: *atmospheric pressure; front; GPS; serotonin; zoometeorology*

Introduction

Zoometeorology is an interdisciplinary science, merging the principles of ethology and meteorology. The effects of environmental factors, such as temperature, humidity and wind speed, which all impact on the animals, need to be examined in a broad context (Anda et al, 2010; Lovelock, 2010; Yin and Zheng, 2011). Previous zoometeorological observations pointed out that grazing cattle react differently to various weather conditions (Malechek and Smith, 1975). Abiotic environment, animal physiology and behaviour are significantly correlated.

Atmospheric pressure / Weather front effect

Depending on their nature, weather fronts have various effects on both behaviour and physiology. Warm fronts have pre-frontal effects, and amplify parasympathetic nerve reactions, like higher heart and respiratory rate (Krueger and Smith, 1960; Soyka, 1977; Kalmar, 1987; Kovacs, 2010). Whereas cold fronts usually cause reactions in

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sympathetic system (e.g. higher blood pressure and adrenalin level), which appear post-frontal. According to the literature, Hungarian cattle breeds are well adapted to cold fronts (Kovacs, 2010). The Hungarian Grey cattle population lives at a relatively low altitude, where atmospheric pressure, under weather front-free conditions, is between 1000 and 1010 hPa. This value can decrease or increase rapidly throughout the day. The receptors of the inner ear and the pressure-sensitive mechano-receptors (Kovacs, 2010) of the upper skin notify both the neuro-endocrine and the autonomic nervous systems about atmospheric pressure changes. Weather fronts also deliver differently charged air, and through ionized oxygen-concentration, they determine the animal's blood-serotonin level (Krueger, 1960; Kerdo et al., 1972; Soyka, 1977; Sulman, 1980; Pfeifer and Sulman, 1982; Adams et al, 2012). Serotonin is a neurotransmitter, responsible for controlling mood (behaviour), appetite, sleep and also has important role in exploratory behaviour (Sánchez, 1995). Under warm or cold weather fronts the atmospheric pressure is erratic, and air electricity (ionization) also changes dramatically. This has direct influence on serotonin hormone synthesis (Phelps, 2005).

Our objective was to observe the complexity of the grazing cattle/pasture/weather system. We present correlations between cattle behaviour and grass supply just as with individual weather factors.

Material and methods

This research was carried out between 2010 and 2013. During the four grazing seasons the distribution of precipitation varied greatly, as 2010 was an extremely wet year, whereas 2012 was an extremely dry year. The study area was 1191 ha of rangeland, and consisted of two major parts: the North (688 ha) and South (503 ha). The Hortobagy River and two local sweep-pole wells were the only water sources. The herd consisted of 200 mid-age (8-10 years) Hungarian Grey cows. We marked 10 cows of identical age (age 10 in 2010) using coloured calf rope for visual identification. The differently coloured pieces of rope were clearly visible on the neck, cows were not bothered by it during the behavioural observations. Observations were made regularly during the active day period. We recorded the behavioural status of marked individuals and the herd itself every 20 minutes. At the end of each day a descriptive behavioural report was made. The animals maintained a 50-100 m flight-zone. Only a gallery forest and the riverbank provided wind shelter. The herd did not receive supplementary feed along the year. In the winter housing period animals received only hay and salt. The cattle always returned to the herd-hut, equipped with a sweep-pole well and an elevated calving-mount. As Hafez (1968) and Stookey (1997) suggested, we also observed "home drift" every time the herd returned from their daily route. The marked cows had different ranks within the herd, and they represented every aspects of the hierarchy. We applied the Czako (1985) terminology to describe animal behaviour, and organized the behavioural traits into 4 main groups. We determined social actions (fighting, playing, communication, suckling, licking and scratching), grazing-metabolic actions (grazing, rumination, drinking, defecation, and urination), locomotion and sexual actions (copulation, oestrus).

Two types of GPS receivers were used (Snewi Trekbox, Bluetooth, GT-750 GPS data logger) to describe the spatial positions of the animals and calculate their speed and daily walked distances. The loggers were recording the daily route of animals for 5 days. Reviewing positional data, we verified Bailey's (1989) observation about the

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spatial memory of cattle. Animals consistently used regular daily routes and they found their way without the herdsman's control. The most typical behavioural patterns were logged. To find the labelled animals, we used a binocular. The problem of the "flight zone" (distance kept from strangers) was managed using a pick-up truck (Malechek and Field, 1975; Kilgour et al., 2012). The typical behavioural patterns (grazing, fighting, and nursing) were recorded with a digital video camera. Meteorological data were collected from the national weather survey database, and complemented with our own local measurements (atmospheric pressure, temperature). SPSS 19.0 software package (SPSS Inc., Chicago, IL, USA) was used for statistical analysis of collected data. Spearman non-parametric correlation was calculated ($P<0.05$ was considered statistically significant) between the examined weather conditions and cattle behaviour. For weather classification, we applied the Peczely-method (Peczely, 1961) standardized to sea level.

Results

Using Peczely-typification we categorized the weather fronts into two major groups. The first group included cyclonic fronts. One of their major characteristics is the low atmospheric pressure which results in air flow disturbance and unstable conditions. Anticyclonic fronts are accompanied by high atmospheric pressure (typically over 1010 hPa), and stabilize weather conditions for a longer period. Our findings show that in a high (normal) pressure environment, movement behaviour occurs more frequently (*Fig. 1*).

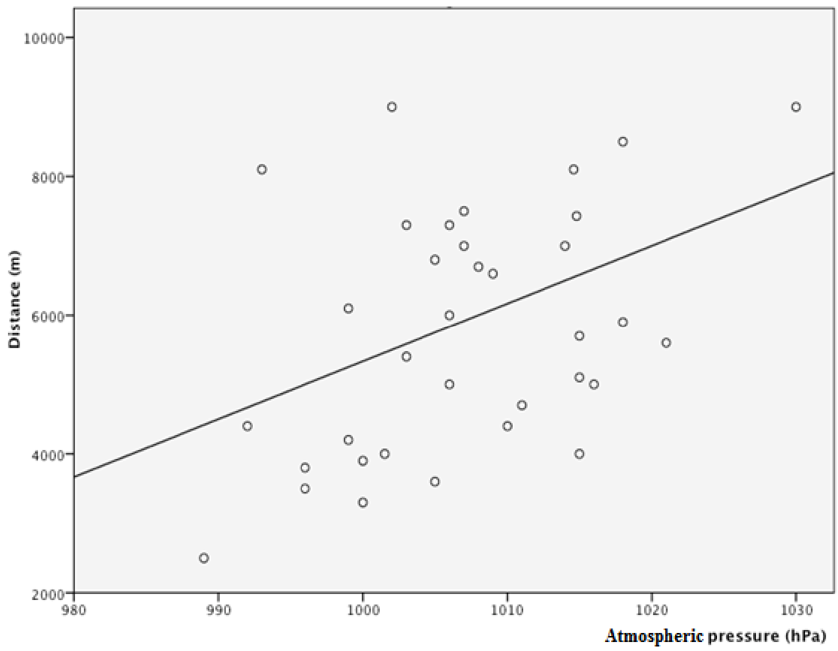

Figure 1. *Correlation between atmospheric pressure and daily walked distance of the herd*

Both front-free and cold-front weather systems create high atmospheric pressure ($P \geq 1005$ hPa). We found moderate correlation ($r=0.445$, $p=0.007$) between metabolic behaviour and the dominant weather front type on the following day (*Table 1*).

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Table 1. *Average number of events within the main behavioural groups based on the 5 most frequent Peczely-front types.*

Behavioral trait / **Front type**		**Feed intake-metabolic**		**Moving**		**Social**		**Sexual**	
		Avg. no. of event ±SE [1]	p [2]	**Avg. no. of event ±SE**	p	**Avg. no. of event ±SE**	p	**Avg. no. of event ±SE**	p
Front today	10-An[3]	46.3±6.7	0.716	22.4±3.7	0.271	5.4±2.5	0.950	0.4±0.3	0.467
	1-mCc [4]	42.9±6.1		16.9±6.0		3.9±1.7		0.1±0.1	
	5-Ae [5]	49.2±15.4		8.2±4.3		4.6±2.4		0	
	8-Aw [6]	50.2±11.2		10.8±4.7		5.0±1.9		0	
	12-A [7]	53.5±15.1		18.3±3.4		4.8±2.0		0	
Front tomorrow	1-mCc	38.7±8.3	**0.049**	3.8±2.3	0.004	2.3±1.0	0.039	0	0.164
	10-An	50.3±6.4		21.7±2.9		3.0±0.7		0.43±0.3	
	12-A	**71.2±4.5**		17.3±3.1		7.5±1.4		0	
	5-Ae	39.3±15.8		11.8±3.0		6.5±3.0		0	
	8-Aw	51.3±3.2		9.3±3.5		1.7±0.3		0	

[1]standard error; [2]Kruskal-Wallis test (level of significance: $p \leq 0.05$); [3]Anticyclone north of the Carpathian Basin; [4]rear flow system of meridional cyclon; [5]Anticyclone above Ukraine; [6]Anticyclone stretching from west; [7]Anticyklone above the Carpathian Basin

As rising atmospheric pressure has a calming effect on cattle, cows walk their normal daily route and spend about 8 hours feeding, and walk about 6 km on normal, non-stressed days. However, as the pressure starts to decline, the herd shortens its daily walked distance significantly or does not move at all if a stress-causing warm front is above them ($r=0.389$, $P<0.05$, *Figure 1.*). It is possible that differences in precipitation might slightly change the behavioural trait distribution (*Fig. 2*). The year 2010 was extremely wet with 1000 mm of annual rainfall – average annual rainfall in Hungary is about 500-750 mm. This caused serious floods in the Hortobagy region in early summer, but there was an abundance of water that covered the ground in August and September also, which refreshed the vegetation. The social and moving behaviour ratio was similar in 2010-11 and 2012-13 as well. There were no significant differences between the studied years. This suggests although animals walk slightly more for the less available, tasty (high carb) grass, but the four main behavioural traits ratios did not change significantly in the period. Results did not present significant connections between behaviour trait appearance and individual meteorological factors (temperature, precipitation). The difference between years was not significant.

During data processing we also found an obvious negative correlation between wind speed and walking direction ($r= -0.371$, $p= 0.026$). Movement and social activity are also appearing together frequently ($r= 0.347$, $p= 0.007$) such as playing behaviour. We discovered a promising connection between metabolic-grazing behaviour and the dominant Peczely-front type on the next day ($r= 0.445$, $p= 0.007$) (*Table 2*).

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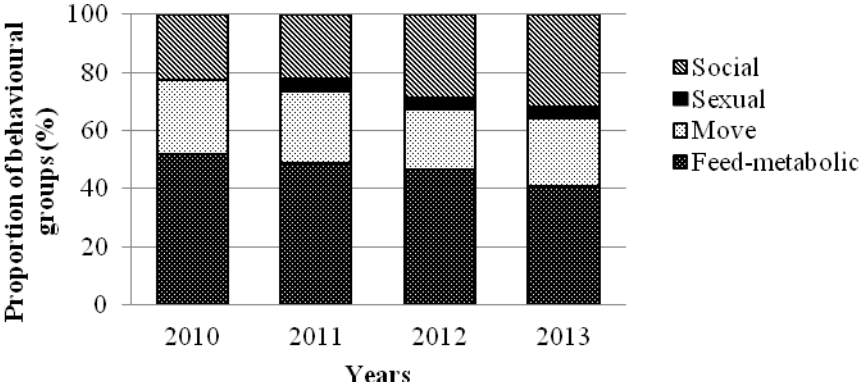
a)



b)

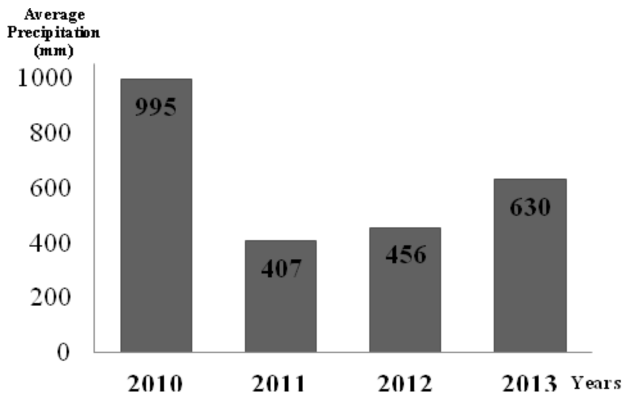


Figure 2. *Distribution of the four major behavioural groups (a) and average precipitation (b) between 2010-2013*

Table 2. *Significant correlating factors on behaviour*

Correlating factors	Spearman Correlation
Atmospheric pressure-daily walked distance	r= 0.374, p= 0.025
Wind speed-metabolic-grazing behaviour	r= -0.371, p= 0.026
Movement-social behaviour	r= 0.347, p= 0.038
Peczely-front type on the next day-metabolic-grazing behaviour	r= 0.445, p= 0.007

Examining the relationship between grass supply and animal behaviour (*Table 3*), significant association was found between the event number of feed intake-metabolic group and grass supply of the area (p=0.033).

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Table 3. *Associations between grass supply and the most frequent behavioural tratits and – groups.*

Behavioural trait / Grass supply category	Feed intake-metabolic						Moving			Social			
	SG ①	MG ②	LR ③	SR ④	Avg. no. of events (S.E.)	p⑤		Avg. no. of events (S.E.)	p	Watch	Scratch	Avg. no. of events (S.E.)	p
No	0	10	0	0	30.3±11.8		20			0	0		
Low	109	158	63	7	29.7±8.1	0.033*	156	15.1 ±2.2	0.964	24	9	30.83 ±2.3	0.304
Appropriate	255	173	121	47	52.8±5.3		226			30	31		

① Graze (standing) ② Graze (in motion) ③ Ruminate (lying) ④ Ruminate (standing)
⑤ Kruskal-Wallis test (level of significance: $p \leq 0.05$)

Every time when the herd stopped for ruminating we recorded the exact positions (*Figure 3.*). With the help of Trotter's (2010) Livestock Residence Index (LRI) we can illustrate the favourite camping spots (e.g. riverbank at the south-eastern corner). Favourite routes – along the river – are clearly visible as well. Cattle avoided dense reeds (dark green spots on map).

Figure 3. *Preferred areas on Malomhaza-pasture in 2011 September-Livestock Residence Index (6 days, 6 hours/day grazing time; by Trotter et al., 2011)*

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Discussion

Solar radiation, atmospheric pressure, maximum temperature, wind speed and relative humidity determine the outdoor comfort level, as Yin (2011) suggested that a strong relationship may exist between microclimatic and comfort conditions. In the present work, biometeorological observations were carried out on Hungarian Grey cattle. Because this breed is well adapted to unregulated semi-wild conditions in rangelands, therefore it is an ideal subject of such kind of examinations. Positive correlation between daily walked distance and atmospheric pressure ($r=0.389$, $P<0.05$) was found, and also a promising association between metabolic-grazing behaviour and the dominant Peczely-front type on the next day ($r= 0.445$, $p= 0.007$) was revealed by data analysis. Daily walked distance never exceeded 8 km which is in accordance with other authors (Haraszti, 1977; Holmes, 1986; Brosh et al., 2010; Napolitano et al., 2011; Popp and Scheibe, 2014), and typical riverbank route and camping spots strengthen Gerrish's observation (Gerrish et al., 1997), that water proximity define pasture utilization and grazing distribution. We suppose that the examined meteorological factors take effect through the neuro-endocrine network. The physiological processes (serotonin reuptake response, thermoregulation) create a particularly flexible bio-system (Phelps, 2005; Hainsworth et al., 2007), which may have a great influence on cattle behaviour. Results show that warm-weather fronts – low atmospheric pressure ($P\leq1005$hPa) – may cause more stress, because the changing (dropping) atmospheric pressure has an effect on the parasympathetic nervous system (Hainsworth et al, 2007; Kovacs, 2010). Warm-weather fronts are often accompanied by high temperature and humidity. Relaxed cattle spend more time by grazing (Grandin, 1980). Seeking fresh, nutritious grass is a natural herbivore behaviour (Gere, 1977), therefore a non-stressed herd's pasture- activity is 80 % grazing and ruminating. Stressed animals gather in one group and spend more time in shade at nearby water-sources (Tucker et al., 2007). It is well-known that ionized air is essential for a healthy respiratory system (Tchijewski, 1960; Soyka, 1977). Ions are charged particles, and because of their electrostatic nature, they connect to the functional groups of proteins. Through a complex process negatively charged air (oxygen) molecules are able to block serotonin production (Krueger, 1960), whereas positively charged carbon-dioxide causes a higher release of plasma serotonin. In the atmosphere positive and negative ions are both present, but radioactive minerals (radium, uranium), radioactive gases (e.g. radon), cosmic rays, lightning, wildfire and high voltage discharge may change their ratio (Wahlin, 1989; Lee, 1993; Cote, 2003; Komov, 2003; Serrano et al., 2006). Evaporating water produces negative ions, in contrast to the ionizing radiation which, interacting with air components, mostly produces positively charged particles. We suggest that the approaching weather systems through changing air ion concentration might result in serotonin neuro-transmitter stress. Throughout this process the animal gets more agitated (after the short serotonin induced calm period) and spends less time grazing and engaging in comfort behaviour. Furthermore, the changing weather may also have an effect on atmospheric pressure, which is easier to measure in real time. If we understood the deeper connections between behaviour and those structural changes of the prefrontal cortex which are caused by the characteristics of electromagnetic environment (Wang et al. 2014), we could explain certain behaviours through electrophysiology in the future.

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Conclusions

Our findings revealed connections between behaviour and grass supply and also presented evidence, how weather effects on cattle during low pressure conditions. This environmental relationship can help farmers to understand the reactions of grazing cattle and daily animal handling procedures would be more flexible. Vaccination in treating pens and cattle crush would be less stressful, if handlers consider weather fronts one day prior veterinary inspections. Hungarian grey cattle well adapted to the local pastures and its environment. In the future radically new treatments can occur if further research enlighten relationship between behaviour, environmental factors, neuroendocrine system and atmospheric conditions.

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