Interindividual Differences and Their Consistency in Grazing Cattle Behavior across Seasons

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Abstract
Interindividual differences and their consistency in behavior were investigated for cattle (*Bos taurus*) grazing a bahiagrass (*Paspalum notatum*) and centipedegrass (*Eremochloa ophiuroides*) dominated pasture as a herd of about 30 breeding cows with their calves. Behavior of the cows was monitored directly by observers and also using GPS and accelerometer data loggers attached to focal cows for a period of 1–5 days every month during the grazing seasons (from May to October) in 2018 and 2019. The data were converted into behavioral variables (e.g. time spent grazing, ruminating and resting, time spent in particular areas, and selectivity for grass species). Time budget of the maintenance behavior, spatial use pattern, preference for grass species on a daily basis were different among cows consistently across the seasons although the behavior varied daily and seasonally in accordance with sward and weather conditions, i.e. some individuals showed a particular tendency in some behavioral traits compared with others across various environmental situations. The consistent individual behavioral characteristics found in this study can be partly explained by age, body size and nutritional and physiological states; otherwise considered as personal traits of animals, which may affect their ecological fitness to the environment and production performances as livestock and be transmitted to their offspring. Further studies are warranted to reveal associations of behavioral traits with fitness or productivity and their transmissibility.

Introduction

Large herbivores such as cattle form a herd. Their behavior often synchronizes and coincides, but varies among individuals within a herd. Individual animals exhibit different behavioral tendencies due to differences in traits such as age, sex, body size, physiological and emotional states, social dominance, past experiences and personality. Animal personality and similar concepts such as temperament, behavioral syndrome and coping style have been found to be associated with fitness (Smith and Blumstein, 2008) and energy metabolism (Biro and Stamps, 2010), which support growth, survival and breeding success of individuals (Rauw et al. 2017). To associate individual behavioral differences with personalities, the consistency among individuals must be confirmed across multiple times, contexts or situations (Mackay and Haskell, 2015). In behavioral experiments under control, the interindividual consistency across times (i.e. repeated trials at certain intervals), or repeatability, has been often tested and confirmed. In field behavioral observations under natural or semi-natural conditions, the interindividual consistency across years has been confirmed (e.g. Howery et al. 1996). In addition, the interindividual consistency across contexts (i.e. correlations among different behavioral traits) have also been reported (e.g. confinement vs. rangeland pasture, Wesley et al. 2012; aggressive responses to conspecifics vs. to predators; dominance vs. leadership, Šárová et al. 2010). However, although situations such as pasture (sward height and herbage mass and quality) and meteorological conditions alter from day to day through a year, most of these studies collected behavioral data during a relatively short season (less than a month in many cases). Few studies have confirmed the consistency of behavioral differences under grazing across the situations (Hirata et al. 2010). Thus, the objective of the present study was to evaluate the interindividual consistency of behavioral differences in selection for grass species, time budget, spatial use pattern and activity intensity in grazing cattle across seasons. Associations between consistent behavioral differences and individual attributes (age, body size and nutritional and physiological states) were also tested.

Methods and Study Site

The study was conducted in 2018 and 2019 at a 1.1-ha paddock of a pasture dominated by bahiagrass (BG) and centipedegrass (CG) at the Sumiyoshi Livestock Science Station (31°59’N, 131°28’E), Faculty of Agriculture, University of Miyazaki, southern Kyushu. The pasture also contained a low cover of Japanese lawngrass (*Zoysia japonica*; JL). In the grazing seasons (May–October) of the study years, the pasture was grazed monthly by a herd of 27–33 Japanese Black cows and their 9–15 calves for 3–5 days (0900–1600 hours each day). The total duration of grazing was 28 days for each year. During grazing time, animals had free access to a 0.4-ha resting area that had a drinking place and shade trees and were connected with the pasture by a single entrance point. Animals spent the remainder of the day in a barn connected with the resting area.

All experimental procedures were approved by the Animal Care and Use Committee of the university (#2017–004–2 and 3).

Measurements were conducted during each monthly grazing period from May to October for the two years. Botanical composition and sward height of the paddock were measured on the previous day of each monthly grazing period at 522 fixed points. Meteorological data were obtained from the observation records at the Miyazaki Meteorological Office (31°56'N, 131°25'E; about 7 km from the study site) (Japan Meteorological Agency, 2020). For behavioral measurements, focal cows were randomly selected from three different age groups excluding cows of which estimated calving dates were within the grazing season. The cows were identified by marking with nontoxic paint spray (Tell Tail Aerosol, FIL, Mount Maunganui, New Zealand) on their flanks.

In 2018, behavior of five focal cows (age (mean ± s.e.): 11 ± 2.0 years; body weight: 455 ± 18 kg) was observed during 7 h daily grazing period on 11 days from May to October. When they grazed at the pasture, the plant species grazed was recorded every 6 min. Preferences for BG, CG and JL were evaluated by Ivlev's electivity index (Ivlev 1961).

In 2019, activities (grazing, ruminating, resting, walking and other behavior, e.g. drinking) of twelve focal cows (age: 10 ± 1.1 years; body weight: 485 ± 16 kg) were scanned every 5 min on 11 days from May to October. Proportion of time spent on each activity out of the 7 h daily grazing period was then calculated. A collar with a GPS logger (i-gotU GT-600, Mobile Action, Taipei, Taiwan) and a triaxial accelerometer (GDCD X16-4, Gulf Coast Data Concepts, MS, USA) was attached to the focal cows during grazing periods of July–October. Positional and acceleration data were respectively obtained at 30-sec intervals and at a frequency of 25 Hz. Positional and acceleration data for all of the focal cows were successfully obtained for 13 days in July, September and October and for 8 days in August and October, respectively. Proportion of time spent in the resting area was calculated from the positional data. Vectoral sum of triaxial dynamic acceleration was calculated as an indicator of activity intensity from the acceleration data. Body condition score (BCS) was rated monthly by three observers as an indicator of nutritional status using 10-point scale where 1 is emaciated and 10 is obese, and mean score was used. Data on age, body weight and days after calving were obtained from management records of the station.

Analysis of variance (ANOVA) was carried out to evaluate the effect of animal and day on each behavioral measure. Interindividual consistency in each behavioral measure was evaluated by Kendall's W. For further analysis, we averaged daily values of the behavioral measures by individual animal, and used the mean values. The associations between consistent behavior measured in 2019 and individual attributes (age, body weight, BCS and days after calving) were evaluated by Spearman's rank correlation (r_s).

Results

Sward vegetation and meteorological conditions

Proportions of BG, CG and JL across the paddock were respectively 0.45, 0.47 and 0.09 in 2018 and 0.42, 0.51 and 0.07 in 2019. Pre-grazing sward height was highest in June (mean: 12.6 cm) and lowest in October (7.3 cm) in 2018 and highest in August (13.6 cm) and lowest in October (8.5 cm). Average daily temperature during the survey periods ranged from 16.6 to 30.7°C in 2018 and from 22.7 to 30.7°C in 2019. Daily rainfall ranged from 0 to 45 mm in 2018 and from 0 to 31 mm in 2019.

Differences in behavior and correlation with individual attributes

All the behavioral measures were different among days (Table 1, $P < 0.05$, ANOVA). The behavioral measures also differed among individual cows ($P < 0.05$, ANOVA) except for Ivlev's electivity index of JL and proportions of walking and ruminating time. Interindividual differences were consistent across days through the single year ($P < 0.05$, Kendall's W) except for Ivlev's electivity index of BG and proportions of walking and ruminating time. In other words, some cows consistently preferred or avoided particular plant species more strongly, spent more time grazing, resting and in the resting area, and were more active than the others. For example, Cow 2622 showed the strong preference for CG out of the five focal cows on seven days out of the 11 days surveyed (Figure 1). Proportion of grazing time was negatively correlated with age and BCS (Table 2). Proportion of resting time was positively correlated with them because of its strong negative correlation with that of grazing time ($r_s = -0.965$). Proportion of time in resting area and activity intensity were not correlated with any other behavioral measures or individual attributes. BCS was positively correlated with age ($r_s = 0.619$) and days after calving ($r_s = 0.742$).

Table 1 Descriptive statistics, significance of ANOVA and Kendall's *W* of behavioral measures

Variables	*n*	Mean	SE	Min.	Max.	Significance (ANOVA)		*W*
						Animal	Day	
2018								
Ivlev's electivity index of BG	5	0.015	0.026	−0.083	0.065	*	*	0.130 NS
Ivlev's electivity index of CG	5	−0.042	0.029	−0.093	0.070	*	**	0.211*
Ivlev's electivity index of JL	5	−0.306	0.062	−0.467	−0.144	†	***	0.259*
2019								
Proportion of grazing time	12	0.868	0.011	0.807	0.911	***	***	0.378***
Proportion of resting time	12	0.057	0.007	0.024	0.096	***	***	0.415***
Proportion of walking time	12	0.039	0.002	0.030	0.050	NS	***	0.128 NS
Proportion of ruminating time	12	0.017	0.002	0.005	0.028	NS	***	0.103 NS
Proportion of time in resting area	12	0.124	0.006	0.087	0.158	***	***	0.274***
Activity intensity (g)	12	0.716	0.024	0.571	0.896	***	***	0.771***

Descriptive statistics were calculated based on values averaged across days by cow.

SE, standard error; BG, bahiagrass; CG, centipedegrass; JL, Japanese lawngrass.

NS, $P \geq 0.1$; †, $P < 0.1$; *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

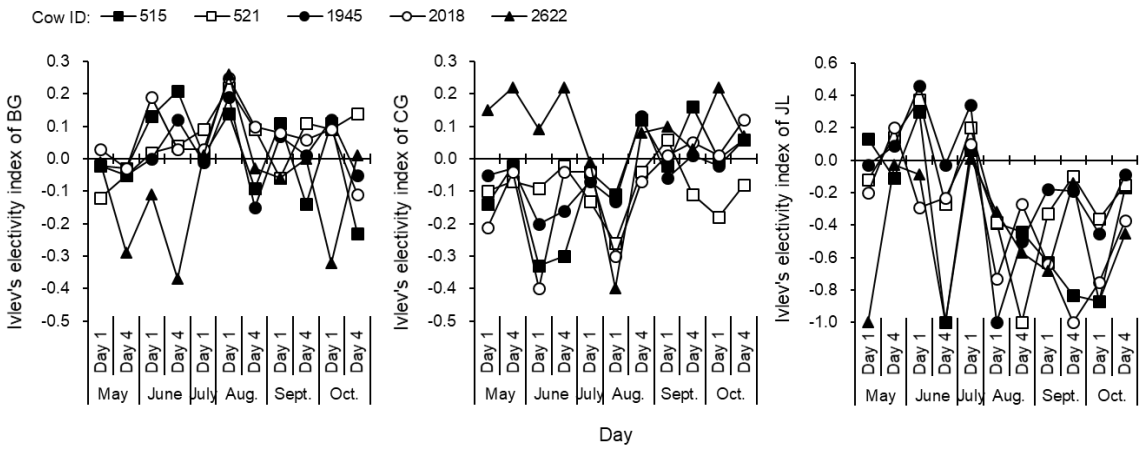

Figure 1 Daily preference for BG (bahiagrass), CG (centipedegrass) and JL (Japanese lawngrass) by individual cows.

Table 2 Spearman's rank correlation coefficients of consistent behavior measured in 2019 with individual attributes

Variables	Age	Body weight	Body condition score	Days after calving
Proportion of grazing time	−0.622*	−0.245 NS	−0.636*	−0.476 NS
Proportion of resting time	0.615*	0.336 NS	0.734**	0.490 NS
Proportion of time in resting area	−0.336 NS	−0.133 NS	−0.190 NS	−0.378 NS
Activity intensity	−0.455 NS	0.168 NS	−0.210 NS	−0.273 NS

$n = 12$. NS, $P > 0.1$; *, $P < 0.05$; **, $P < 0.01$.

Discussion

Since sward and meteorological conditions varied daily and seasonally, all behavioral measures also differed among days. Nevertheless, preference for centipedegrass, time spent grazing and resting during stocking, time spent in pasture or resting area on a daily basis differed among cows consistently across seasons in the single year, i.e. some individuals showed a particular tendency in behavior compared with others across various environmental situations. These consistent differences in behavior among cows indicate that even if stocking conditions are equal, energy and nutrition budgets also consistently differ among cows, resulting in differences in breeding success, or production efficiency. The consistent individual tendencies in time spent grazing and resting were correlated with age and BCS. The correlation between behavior and BCS indicates that these behavioral measures can be utilized as indicators of nutrition, health and welfare statuses of individual animals (Matthews et al. 2012). The consistent behavioral differences that cannot be explained by these individual attributes may be considered as personal traits of animals. These interindividual behavioral differences can affect their ecological fitness to the environment and production performances as livestock and be transmitted to their offspring (Garcia et al. 2020). Further studies are warranted to reveal associations of behavioral traits with fitness or productivity and their transmissibility.

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