肉用種繁殖雌牛が放牧されるバヒアグラス(Paspalum notatum Fluegge)草地の生産と利用

誌名	日本草地学会誌
ISSN	04475933
著者名	平田,昌彦 小倉,振一郎 福山,喜一 黒木,志郎 井上,俊春 日高,利治 弓削,嗣彦 高橋,政男 野村,憲司
発行元	日本草地学会
巻/号	48巻6号
巻号補足	
掲載ページ	p. 477-484
発行年月	2003年2月

農林水産省 農林水産技術会議事務局筑波産学連携支援センター
Tsukuba Business-Academia Cooperation Support Center, Agriculture, Forestry and Fisheries Research Council Secretariat

AgriKnowledge

Grassland Science 48 (6) : 477-484 (2003)

Herbage Production and Utilization in a Bahiagrass (*Paspalum notatum* Flügge) Pasture Grazed by Breeding Beef Cows

Masahiko HIRATA, Shin-ichiro OGURA, Kiichi FUKUYAMA*, Shirou KUROKI*, Toshiharu INOUE*, Toshiharu HIDAKA*, Tsuguhiko YUGE*, Masao TAKAHASHI* and Kenji NOMURA*

Division of Grassland Science, Faculty of Agriculture, Miyazaki University, Miyazaki 889-2192, Japan
* Sumiyoshi Livestock Farm, Faculty of Agriculture, Miyazaki University, Shimanouchi, Miyazaki 880-0121, Japan

Received : April 18, 2002/Accepted : August 23, 2002

Synopsis

HIRATA, M., S. OGURA, K. FUKUYAMA, S. KUROKI, T. INOUE, T. HIDAKA, T. YUGE, M. TAKAHASHI and K. NOMURA (2003) : Herbage production and utilization in a bahiagrass (*Paspalum notatum* Flügge) pasture grazed by breeding beef cows. *Grassland Science* 48, 477-484.

Herbage production and utilization in a bahiagrass (*Paspalum notatum* Flügge) pasture rotationally grazed by breeding Japanese Black cows were quantified in a cow-calf system in coastal Miyazaki, southwestern Japan. Herbage mass (range=20-421 g DM/m^2) increased during the pre-grazing season (mid-April to late May), and thereafter repeated a decrease during a grazing period and an increase during a rest period in the grazing season (late May to late October). Dry matter digestibility and nitrogen concentration of herbage (range=471-593 and 13-26 g/kg DM, respectively) decreased from May to October. The rate of herbage production (range=2.4-8.8 g DM/m^2/day) tended to peak in early July, with the potential rate (range=3.0-13.7 g DM/m^2/day) being high until early July and decreasing thereafter. The rate of herbage consumption and dry matter intake by cows ranged from 19.9-59.2 g DM/m^2/day and 14.8-42.9 g DM/kg LW/day, respectively. Total herbage production and consumption from mid-April to late October (≈growing season) were respectively 1025-1033 (mean=1029) g DM/m^2 and 892-941 (mean=916) g DM/m^2, with degrees of utilization of 0.86-0.92 (mean=0.89). The study shows that a bahiagrass pasture, which is intermediately productive among sown pastures in Japan, is highly utilized by breeding Japanese Black cows, providing sufficient digestible energy and protein.

Key words : Bahiagrass, Breeding beef cow, Digestibility, Nitrogen, Production, Utilization.

Introduction

Quantifying herbage production and utilization in grasslands is an important theme in studies on grazing systems, because it enables us to characterize the systems in terms of biotic (*e.g.* plants and animals) and abiotic factors (*e.g.* climate, soil, topography) and management by human (*e.g.* fertilizer application, grazing intensity). A number of studies have therefore quantified herbage production and utilization in various types of grazed grasslands, as shown by examples in Japan[2,17,18,20-23,25,27,28].

Bahiagrass (*Paspalum notatum* Flügge), a sod-forming, warm-season perennial, is widespread in the southern USA and Central and South America[24]. It is also grown in the low-altitude regions of southwestern Japan and used for both grazing and hay. Some previous studies for quantifying herbage production and/or utilization in grazed grasslands in Japan have dealt with bahiagrass pastures in grazing systems with such animals as beef steers[27], dairy heifers[6] and lactating dairy cows[17]. However, it seems that few studies dealt with a bahiagrass pasture grazed by breeding beef cows, despite the fact that bahiagrass pastures in the low-altitude regions of southwestern Japan are mainly used for feeding this type of animal. It is widely recognized that bahiagrass is more suitable to animals having low energy and nutrient requirements such as breeding beef cows than to animals with high requirements for growth and production, because of low herbage quality particularly in summer-autumn. In fact, grazing systems rearing young growing animals (*e.g.* heifers and steers) on a bahiagrass pasture are often characterized by low pasture utilization[6,27] and low liveweight gain of animals[5,21,26,27].

In the present study, herbage production and utilization in a bahiagrass pasture rotationally grazed by breeding Japanese Black cows were quantified for 2 growing seasons (inclusive of 2 grazing seasons) in a cow-calf system in coastal Miyazaki, southwestern Japan. Digestibility and nitrogen (N) concentration as measures of herbage quality were also quantified. The aim of the study was to characterize the system mainly in terms of herbage production and utilization and energy and nutrient intake by cows, by comparing the results with those in the literature.

Materials and Methods

1. The site, pasture and animals

The study was conducted in a 1.06-ha paddock of a Pensacola bahiagrass pasture at the Sumiyoshi Livestock Farm (31°59′N, 131°28′E), Miyazaki University, Japan. The paddock was one of 5 paddocks (total area=6.3 ha) rotationally grazed by Japanese Black cows and calves during the grazing season from late May to late October-early November.

In 1998 and 1999, the paddock was mown to a height of about 10 cm above ground level in mid-April, to remove spring weeds. Then, during the grazing season, the paddock was grazed 6 times by 30–34 cows (mean liveweight≈450 kg) and 9–13 calves (mean liveweight≈70–100 kg) for 4–7 days (0900–1600 h each day) at intervals (rest periods) of 11–38 days (Table 1). The total duration of grazing was 30–32 days.

Calves consumed negligible amounts of herbage in the paddock, because they were at a pre-weaning stage (<4 months old) and separately fed with concentrate (TDN=74%, CP=20%) and roughage (mainly Italian ryegrass hay). The mean amounts of concentrate and roughage were 0.4 and 0.3 kg/head/day as fed, respectively. Cows were rarely supplemented when they grazed the paddock (inclusive of the previous day of each rotational grazing period). Except these periods, cows were supplemented with Italian ryegrass, guineagrass, rhodesgrass and/or bahiagrass hay (2–14 (mean=5.4) bales/month ; 270–280 kg each as fed) in a barn where they spent night. In addition, they were supplemented with corn silage in early June (5 days ; 600 kg as fed at each time) and early to mid-October (3 days ; 800–1200 kg as fed at each time) in 1998, and with Italian ryegrass silage in mid-August (2 bales ; 400 kg each as fed) and early October (1 bale ; 400 kg as fed) in 1999.

Table 1. Outlines of grazing management.

Year	Grazing period	Duration (day)	Number of cows[a)]	Mean liveweight (kg/cow)
1998	21–25 May	5	32	444
	17–23 Jun.	7	32	444
	18–24 Jul.	7	32	458
	12–16 Aug.	5	32	455
	20–23 Sep.	4	31	444
	23–26 Oct.	4	34	453
1999	22–25 May	4	33	440
	21–25 Jun.	5	30	448
	3–7 Aug.	5	32	438
	13–18 Sep.	6	32	440
	22–25 Oct.	4	32	455
	6–11 Nov.[b)]	6	32	455

a) With 9–13 calves (mean liveweight≈70–100 kg).
b) Not included in the study.

The paddock received compound fertilizer and urea. The fertilization rates in 1998 were 97 kg N (60 kg in April and 37 kg in September), 26 kg P (April) and 40 kg K (April) per ha. The rates in 1999 were 70 kg N (30 kg in April and 40 kg in August), 17 kg P (April) and 20 kg K (April) per ha.

2. Measurements

Herbage mass (dry matter (DM) per m^2 above a 3-cm height) was estimated in mid-April and at the beginning and the end of each rotational grazing period (Table 1), using an electronic capacitance probe (PastureProbe™, Mosaic Systems Ltd., New Zealand). In mid-April, herbage mass was quantified for 8 permanent quadrats (20 cm×20 cm) in the paddock. Pre- and post-grazing herbage masses during the grazing season were quantified for 182 fixed locations (50 cm×50 cm) along 2 permanent 90-m line transects crossing the paddock. Details of the measurements and estimation for mid-April and grazing season are described in HIRATA and PAKIDING[12)] and HIRATA[11)], respectively.

Dry matter digestibility (DMD) and N concentration of herbage were quantified 5 times between mid-May and mid-October in 1999. On each occasion, 8–10 locations (50 cm×50 cm) whose herbage mass covered the range of herbage mass in the paddock at approximately constant intervals were sampled to a 3-cm height, and the samples were oven-dried, weighed and ground to pass a 1-mm screen. DMD was determined with a pepsin-cellulase technique, and corrected by a calibration equation to give predicted *in vivo* DMD[4)]. N concentration was determined according to AOAC[30)]. More details of the measurements are described in OGURA *et al.*[19)]. Because of the non-random sampling, the mean DMD and N concentration of herbage in the paddock on each occasion were estimated as a mean value over 2–3 locations which showed closest herbage masses to the mean herbage mass over the 182 locations along the transects on the nearest measurement date.

3. Calculation of rates of herbage production and utilization, potential rate of herbage production and digestible energy intake

Herbage production during the pre-grazing season (mid-April to late May) and during each rest period in the grazing season (between grazing periods in Table 1) was calculated as net accumulation in herbage mass during the period. Herbage consumption during each grazing period was calculated as : apparent herbage consumption (difference between pre- and post-grazing herbage masses) plus herbage production during grazing, *i.e.* disturbed herbage accu-

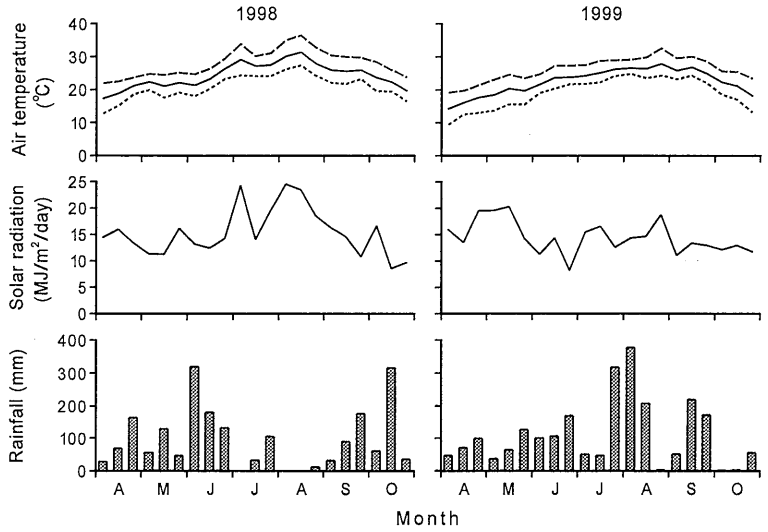


Fig. 1. Meteorological conditions during the study. Ten- or 11-day means of maximum (------), mean (——) and minimum (·····) daily air temperatures, daily total short-wave solar radiation, and 10- or 11 -day totals of rainfall.

mulation. Disturbed herbage accumulation was estimated using Equation 1 (see below). Herbage utilization was defined as a proportion of consumption to production (not to standing herbage mass).

The rate of herbage production was calculated by dividing herbage production during the pre-grazing season or during each rest period by the duration (day) of the period. The rate of herbage consumption was calculated similarly by dividing herbage consumption during each grazing period by the duration (day) of the period.

HIRATA[11] measured the rate of herbage production (undisturbed accumulation) in the current system during May-October 1996, and showed that the rate (G, g DM/m^2/day) was quadratically related to herbage mass (M, g DM/m^2), *i.e.* herbage accumulation followed the logistic growth curve, with the potential or maximal rate (G_{max}, g DM/m^2/day) changing with season and the herbage mass for G_{max} being around 400 g DM/m^2 :

$$G=G_{max}(1-(M-400)^2/160000) \quad (1)$$

Using this equation, G_{max} during the study period was estimated from G and M quantified as above, in order to highlight the seasonal dynamics in the potential herbage production, *i.e.* removing the effect of herbage mass on the production rate.

DM intake by cows was calulated from the rate of herbage consumption, paddock size (1.06 ha) and the number and liveweight of cows (Table 1). Intake of digestible energy was estimated on assumptions that gross energy concentration of herbage equals 18.4 kJ/g DM and energy digestibility equals DMD.

Results and Discussion

1. Meteorological conditions

The meteorological conditions during the study are shown in Fig. 1. Compared with the long-term average (1961-1990), the growing season (May-October) of 1998 showed higher mean air temperature (25.2 *vs.* 23.3℃) and similar mean solar radiation (15.6 *vs.* 15.5 MJ/m^2/day) and total rainfall (1719 mm *vs.* 1761 mm). The growing season of 1999 showed similar mean air temperature (23.6℃), lower mean solar radiation (14.2 MJ/m^2/day) and higher total rainfall (2111 mm).

2. Herbage mass and herbage quality

Herbage mass (range=20-421 g DM/m^2) increased during the pre-grazing season (mid-April to late May), and thereafter repeated a decrease during a grazing period and an increase during a rest period in the grazing season (Fig. 2). Herbage mass in 1998 peaked in July, whereas that in 1999 in September-October. The later peak in herbage mass in 1999 than in 1998 may be attributed mainly to different seasonal patterns of air temperature and rainfall. In 1998, air temperature peaked in mid-August with relatively low rainfalls in July-August (Fig. 1). By contrast, in 1999, air temperature peaked in late August and decreased slowly until mid-September with relatively high rainfalls in August-September.

DMD and N concentration of herbage (range=471-593 g/kg DM and 13-26 g/kg DM, respectively) decreased from May to October (Fig. 3). Such a decreasing trend of seasonality in DMD broadly accords with previous observations on herbage digestibility

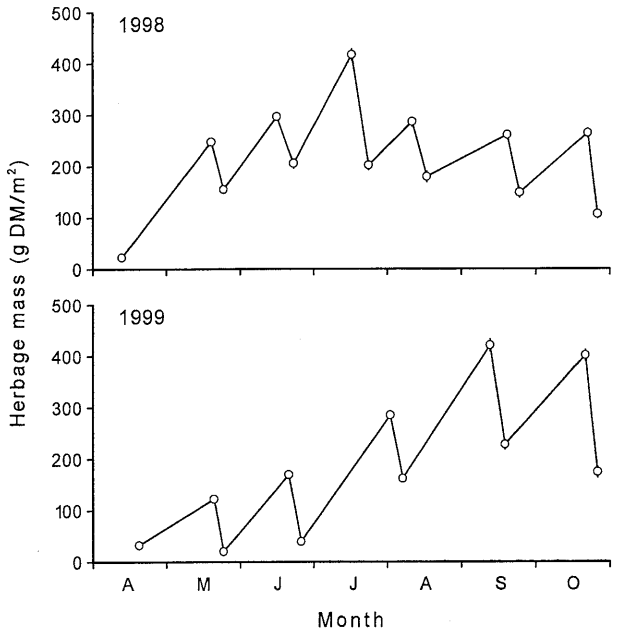


Fig. 2. Changes in herbage mass. Vertical bars indicate SE of mean (usually smaller than the symbol size). Periods for decreasing herbage mass correspond to rotational grazing periods (Table 1), and those for increasing herbage mass to the pre-grazing season (mid-April to late May) and rotational rest periods.

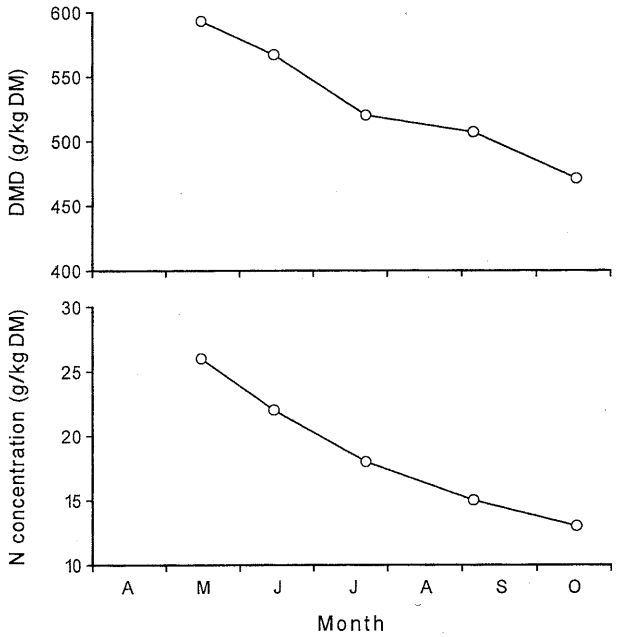


Fig. 3. Changes in dry matter digestibility (DMD) and nitrogen (N) concentration of herbage in 1999.

Table 2. Herbage production and consumption in individual periods.

Year	Period[a)]	Duration (day)	Production (g DM/m²)	Consumption (g DM/m²)
1998	13 Apr.–20 May (PGS)	38	225	—
	21–25 May (G)	5	33	126
	26 May–16 Jun. (R)	22	142	—
	17–23 Jun. (G)	7	48	139
	24 Jun.–17 Jul. (R)	24	212	—
	18–24 Jul. (G)	7	45	260
	25 Jul.–11 Aug. (R)	18	85	—
	12–16 Aug. (G)	5	23	130
	17 Aug.–19 Sep. (R)	34	81	—
	20–23 Sep. (G)	4	11	123
	24 Sep.–22 Oct. (R)	29	116	—
	23–26 Oct. (G)	4	4	162
	Total	197	1025	941
1999	20 Apr.–21 May (PGS)	32	89	—
	22–25 May (G)	4	14	116
	26 May–20 Jun. (R)	26	149	—
	21–25 Jun. (G)	5	25	155
	26 Jun.–2 Aug. (R)	38	246	—
	3–7 Aug. (G)	5	35	158
	8 Aug.–12 Sep. (R)	36	259	—
	13–18 Sep. (G)	6	33	226
	19 Sep.–21 Oct. (R)	33	174	—
	22–25 Oct. (G)	4	10	237
	Total	189	1033	892

a) Pre-grazing season (PGS), rotational grazing period (G) and rest period (R).

in bahiagrass[5,8–10,17,26], though there may be some recovery in digestibility in autumn[9,10,17,26]. Furthermore, the ranges of DMD and N concentration almost agree with previous values of 480–675 g/kg DM[5,8–10] and 13–24 g/kg DM[17], respectively, though the spring DMD in the present study is lower than previous values.

3. Herbage production and utilization

Herbage production and consumption during the pre-grazing season and individual grazing and rest periods were estimated as shown in Table 2. Herbage production during grazing accounted for 2–34% (mean=16%) of herbage consumption, showing a tendency of higher contributions in spring and summer than in autumn. This indicates that herbage accumulation under grazing (disturbed accumulation) is too large to neglect in estimating herbage consumption particularly in summer, as already well pointed out[16]. Total herbage production and consumption for the period of mid-April to late October (≈growing season ; 189–197 days) were respectively 1025 and 941 g DM/m² in 1998 (utilization=0.92), and 1033 and 892 g DM/m² in 1999 (utilization=0.86),

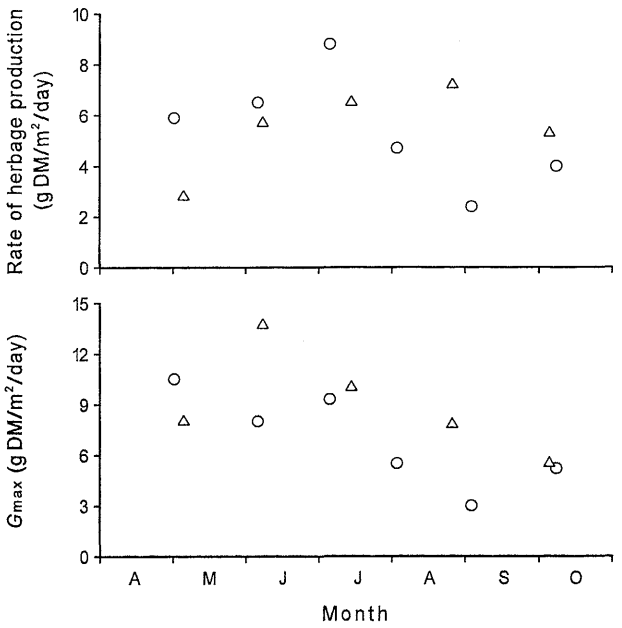


Fig. 4. Changes in rate of herbage production and potential rate of herbage production (G_{max}) in 1998 (○) and 1999 (△). Rates are for the pre-grazing season and individual rest periods (Table 2). Refer to Equation 1 for G_{max}.

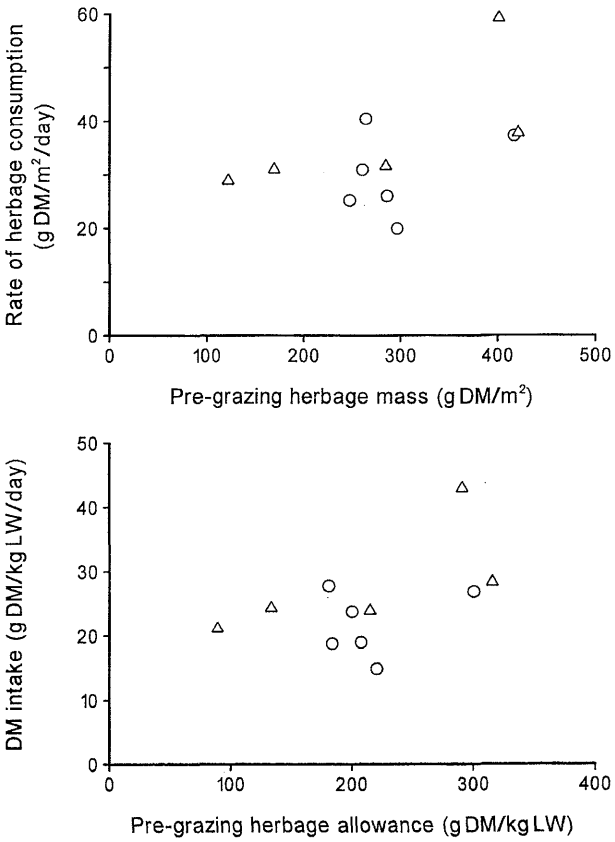


Fig. 5. Relationship between rate of herbage consumption and pre-grazing herbage mass, and between dry matter (DM) intake and pre-grazing herbage allowance in 1998 (○) and 1999 (△). Rates are for the individual grazing periods (Table 2).

averaging 1029 and 916 g DM/m² (utilization=0.89).

The rate of herbage production for the pre-grazing season and individual rest periods (range=2.4–8.8 g DM/m²/day) tended to peak in early July (Fig. 4). Such high rates of herbage production in summer are characteristic of tropical grasses. Removing the effect of herbage mass, the potential rate of herbage production (G_{max} ; range=3.0–13.7 g DM/m²/day) tended to be high until early July and decreased thereafter (Fig. 4). The high potential rates in April-May compared with the relatively low air temperatures (Fig. 1) are considered to reflect a spring flush. Consequently G_{max} was not significantly correlated with air temperature ($r=-0.365$, $P>0.1$). There was also no significant correlation between G_{max} and rainfall ($r=0.137$, $P>0.1$).

The rate of herbage consumption and DM intake by cows ranged from 19.9–59.2 g DM/m²/day and 14.8–42.9 g DM/kg LW/day, respectively (Fig. 5). None of these variables showed specific relationships to the amount of substrate, *i.e.* pre-grazing herbage mass and pre-grazing herbage allowance, respectively. Here, excluding one data set with a considerably overestimated intake of 42.9 g DM/kg LW/day, the range of DM intake was 14.8–28.3 g DM/kg LW/day, which agrees closely with intakes estimated in the current system in 1996 (14.9–25.4 g DM/kg LW/day)[11]. Furthermore, without the data set, the relation of DM intake to herbage allowance may be taken to form a part of a commonly observed curve where intake increases with a saturating trend as allowance increases (*e.g.* GIBB and TREACHER[3], LE DU *et al.*[15] and NRC[31]). In this case, the maximal intake (asymptote) is estimated at about 25 g DM/kg LW/day, which is common to grazing animals.

Compared with values from grazed grasslands in Japan, the total herbage production averaged over 2 years (1029 g DM/m² ; from Table 2) was almost intermediate among sown temperate and tropical pastures (Fig. 6). By contrast, the mean total herbage consumption (916 g DM/m²) and mean utilization (0.89) were relatively high (4th and 3rd highest, respectively) among the sown pastures. Although values of herbage production and consumption in grazed grasslands would vary with management such as fertilizer rate and grazing intensity, comparison of the values provides us with information on a rough position of the system in the present study.

4. Energy and nutrient intake by cow

Intakes of digestible energy and crude protein were almost equal to or above the requirements

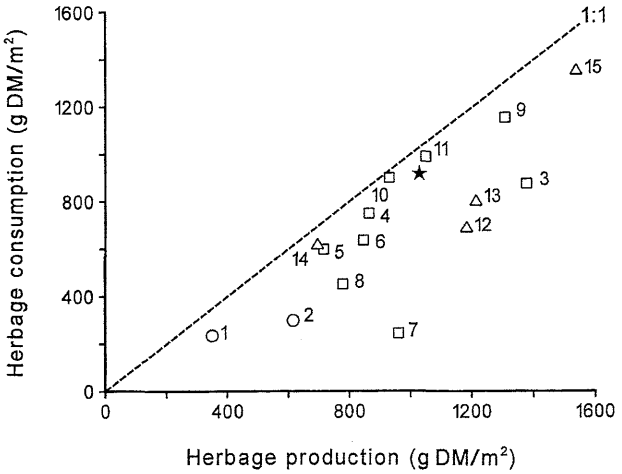


Fig. 6. Comparison of herbage production and consumption in the present study (★) with those in grazed pastures in the literature (○, native pasture ; □, sown temperate pasture ; △, sown tropical pasture). Values for the present study are for the period of mid-April to late October (≈growing season), and those for the literature are on a basis of annum, grazing season or growing season. Pastures in the literature are : (1, 2) Nezasa-type grasslands (YAMAMOTO *et al.*[28] and OKUBO *et al.*[22], respectively) ; (3) orchardgrass pasture (FUKUYAMA *et al.*[2]) ; (4) Italian ryegrass-orchardgrass pasture (OKUBO *et al.*[21]) ; (5, 6) redtop pastures (OKAJIMA *et al.*[20] ; conventional and high N fertilizer rates, respectively) ; (7, 8) mixed temperate-species pastures (TAKAHASHI *et al.*[25] ; light and heavy grazing intensities, respectively) ; (9) Italian ryegrass pasture (SHINDO *et al.*[23]) ; (10, 11) perennial ryegrass dominant pastures (NISHIMICHI *et al.*[18] ; pre-grazing sward heights of 20 cm and 30 cm, respectively) ; (12–14) bahiagrass pastures (on-and-off grazing and whole-day grazing without supplementation in TAKIMOTO *et al.*[27] and MIAKI *et al.*[17], respectively) ; (15) bahiagrass-*Vicia* pasture (OKUBO *et al.*[21]). Values for TAKAHASHI *et al.*[25] were calculated on an assumption that energy concentration of herbage equals 18.4 kJ/g DM. Values for TAKIMOTO *et al.*[27] were calculated on an assumption that dry matter concentration of herbage equals 0.26 g/g.

recommended in Japanese feeding standard for beef cattle[29] ; *i.e.* requirements for maintenance of a 450 kg LW cow with and without additional requirements during the last 2 months of pregnancy or for daily milk production of 6.5 kg (Fig. 7). It is reported that the daily milk production by a Japanese Black cow during the lactation period peaks 1 week after parturition with a value of 6–7 kg and decreases thereafter[13,14]. This indicates that allowing 6.5 kg milk production gives close estimates of the maximal requirements by a lactating cow. The present study estimated DMD and N concentration of the whole herbage above a 3-cm height in locations representative of the mean herbage mass over the paddock. Because all grazing animals are selective in their diet, actual intakes of digestible energy and crude protein are considered to be higher than the estimations in this study. Supporting these, cows maintained their liveweight throughout the grazing season in both years (Table 1). FUKUYAMA *et al.*[1] reported that calf productivity by cows in the current cow-calf system was similar during the grazing season and the non-grazing season.

Conclusions

Bahiagrass is well adapted to the low-altitude regions of southwestern Japan and forms an important feed resource mainly for breeding beef cows. The results of the present study show that a bahiagrass pasture, which is intermediately productive among sown pastures in Japan, is highly utilized by breeding Japanese Black cows, providing sufficient digestible energy and protein.

A major goal of the management of a grazing system is to maximize pasture production and utilization quantitatively and qualitatively without adverse effects on persistence of the pasture. In the grazing system of this study, pasture production may be maximized by maintaining herbage mass at 400 g DM/m^2 (Equation 1). However, this greatly delays the beginning of the grazing season (Fig. 2). At the same time, herbage quality (*e.g.* DMD and N concentration) decreases with progressing season (Fig. 3) and increasing herbage mass in summer-autumn[19]. In terms of herbage intake by cows, herbage allowance of 100–200 g DM/kg LW is needed for ensuring an intake of 25 g DM/kg LW/day (2.5% of LW) (Fig. 5). This allowance corresponds to variable herbage masses depending on the paddock size and the number and liveweight of cows (*e.g.* 127–255 g DM/m^2 when thirty 450 kg cows graze a 1.06-ha paddock). Sufficient allowance needs to be maintained throughout each rotational grazing period, taking account of daily herbage production and consumption. Thus, search of an optimal management is not simple, and may need a modeling and simulation approach. For this purpose, further accumulation and analyses of data are needed, particularly to model G_{max}, DM intake and quality of herbage.

HIRATA *et al.*[7] estimated that a bahiagrass pasture is persistent when utilization (proportion of herbage consumption to net primary production) is below 0.93. Considering the fact that the utilization in the present study is defined as a proportion to herbage

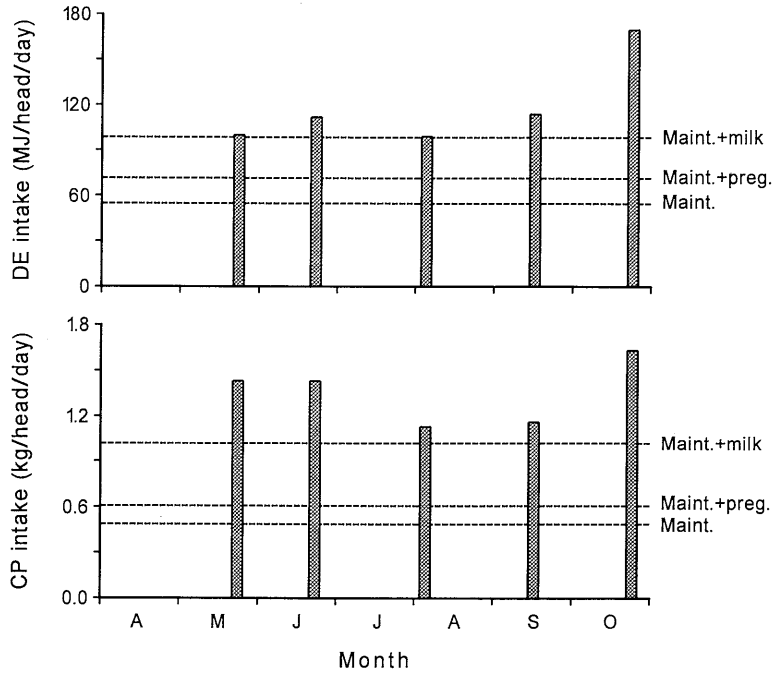


Fig. 7. Changes in intakes of digestible energy (DE) and crude protein (CP) in 1999, as compared with requirements in Japanese feeding standard for beef cattle[29]. Requirements are for maintenance of a 450 kg LW cow with and without additional requirements during the last 2 months of pregnancy or for daily milk production of 6.5 kg. See text for estimation of DE intake.

production, *i.e.* not including production of stubble, belowground plant parts and litter, the utilization values of 0.86–0.92 (Table 2 and Fig. 6) are regarded to be well below the critical value.

Acknowledgments

We thank Miss Mizuho FURUSE, Miss Reiko SATO, Miss Hitomi HASEGAWA, Miss Yuki NAGAKURA, Miss Maki NOMURA and Mr. Tomotsugu TAKAHASHI for field assistance.

References

1) FUKUYAMA, K., K. IMAMURA, S. KUROKI, T. INOUE, T. YUGE and T. HIDAKA (2001) Calf production by Japanese Black cows grazing a bahiagrass pasture in southern Kyushu. *Grassland Science* **47** (ext), 210–211.**

2) FUKUYAMA, M., M. SHIMAMURA, M. USHIYAMA and M. OIKAWA (1980) Matter production and energy efficiency in pasture. I. Plant productivity in orchardgrass pasture under rotational grazing. *J. Japan. Grassl. Sci.* **26**, 26–35.*

3) GIBB, M.J. and T.T. TREACHER (1976) The effect of herbage allowance on herbage intake and performance of lambs grazing perennial ryegrass and red clover swards. *J. Agric. Sci., Camb.* **86**, 355–365.

4) GOTO, I. and D.J. MINSON (1977) Prediction of the dry matter digestibility of tropical grasses using a pepsin-cellulase assay. *Anim. Feed Sci. Tech.* **2**, 247–253.

5) HIGASHIYAMA, M. and M. HIRATA (1995) Analysis of a Japanese Black cattle rearing system utilizing a bahiagrass (*Paspalum notatum* Flügge) pasture. 1. Variations in the factors considered to affect animal production. *Grassland Science* **41**, 104–113.

6) HIRATA, M., Y. SUGIMOTO and M. UENO (1986) Energy and matter flows in bahiagrass pasture. III. Herbage consumption by grazing cattle in relation to canopy structure. *J. Japan. Grassl. Sci.* **32**, 267–277.

7) HIRATA, M., Y. SUGIMOTO and M. UENO (1990) Productivity and energy efficiency of bahiagrass (*Paspalum notatum* Flügge) pasture. IV. Relations between energy flows through the producer. *Bull. Fac. Agric., Miyazaki Univ.* **37**, 109–114.

8) HIRATA, M. (1993) Response of bahiagrass (*Paspalum notatum* Flügge) sward to cutting height. 2. Yield and *in vitro* digestibility of herbage. *J. Japan. Grassl. Sci.* **39**, 183–195.

9) HIRATA, M. (1996) A new technique to describe canopy characteristics of grass swards with spatial distribution, dry-matter digestibility and dry weight of small-size canopy components. *Grass Forage Sci.* **51**, 209–218.

10) HIRATA, M., M. HIGASHIYAMA and K. FUKUYAMA (1996) Evaluation of nine cultivars of bahiagrass, bermudagrass and kikuyugrass as alternatives to Pensacola bahiagrass in the low altitude region of Kyushu. *Bull. Fac. Agric., Miyazaki Univ.* **42**, 1–12.

11) HIRATA, M. (2000) Quantifying spatial heterogeneity in herbage mass and consumption in pastures. *J. Range Manage.* **53**, 315–321.

12) HIRATA, M. and W. PAKIDING (2002) Dynamics in tiller

weight and its association with herbage mass and tiller density in a bahia grass (*Paspalum notatum*) pasture under cattle grazing. *Trop. Grassl.* **36**, 24–32.
13) KYUMA, T., T. KIKUCHI, M. TAKAHASHI and S. TAKIZAWA (1976) Ingestive behavior and nutrient intake of suckling beef calves on pasture. *Bull. Tohoku Natl. Agric. Exp. Stn.* **52**, 145–159.*
14) KYUMA, T., S. TAKIZAWA, M. TAKAHASHI and T. KIKUCHI (1979) Effect of dam's milk production on the growth of suckling beef calves on pasture. *Bull. Tohoku Natl. Agric. Exp. Stn.* **60**, 73–90.*
15) LE DU, Y. L. P., J. COMBELLAS, J. HODGSON and R. D. BAKER (1979) Herbage intake and milk production by grazing dairy cows. 2. The effects of level of winter feeding and daily herbage allowance. *Grass Forage Sci.* **34**, 249–260.
16) MEIJS, J. A. C., R. J. K. WALTERS and A. KEEN (1982) Sward methods. *In* Herbage Intake Handbook (Ed. J. D. LEAVER). British Grassland Society. Berkshire. pp. 11–36.
17) MIAKI, T., S. TANAKA and O. KAWAMURA (1981) Grazing capacity and seasonal changes in nutritive value of bahiagrass pasture on sand dune. Based on observations of feeding conditions at Sumiyoshi livestock breeding station. *Bull. Fac. Agric., Miyazaki Univ.* **28**, 71–84.*
18) NISHIMICHI, Y., M. YAYOTA, C. YAYOTA, H. NAKATSUJI, S. KONDO and M. OKUBO (2002) Effect of pre-grazing grass height on herbage production and utilization under rotational grazing of lactating dairy cows on perennial ryegrass dominant pasture. *Grassland Science* **47**, 594–598.*
19) OGURA, S., H. HASEGAWA and M. HIRATA (2002) Effects of herbage mass and herbage quality on spatially heterogeneous grazing by cattle in a bahia grass (*Paspalum notatum*) pasture. *Trop. Grassl.* **36**, 172–179.
20) OKAJIMA, T., T. OKUBO, R. KAYAMA and M. KIKUCHI (1985) Dry matter production in the grazed pasture of *Agrostis alba* L. (redtop). 1. Seasonal change of dry matter production and the effect of heavy rate application of nitrogen. *J. Japan. Grassl. Sci.* **31**, 297–307.*
21) OKUBO, T., M. HIRAKAWA, T. OKAJIMA, R. KAYAMA, H. TANO and N. KIHIRA (1985) Energy efficiency of primary and secondary production in grazed pasture of *Dactylis glomerata* as compared with those of *Paspalum notatum*. *Proc. 15th Int. Grassl. Congr.*, 736–738.
22) OKUBO, T., N. WATANABE and S. ITANO (2001) Matter production of *Pleioblastus chino* var. *viridis* under grazed and ungrazed conditions. *Grassland Science* **47**, 262–268.*
23) SHINDO, K., N. KOYAMA and Y. OGAWA (1996) Characteristics in dry matter production of Italian ryegrass pastures under grazing and harvesting. *Grassland Science* **42** (ext), 362–363.**
24) SKERMAN, P. J. and F. RIVEROS (1989) Tropical Grasses. FAO. Rome.
25) TAKAHASHI, S., T. AKIYAMA, M. SHIYOMI and T. OKUBO (1989) The energy dynamics of grazed grassland. 2. Energy flow at the herbivore level. *Bull. Natl. Grassl. Res. Inst.* **42**, 41–48.
26) TAKIMOTO, Y., I. KUROHIJI, H. IWANARI and T. MINO (1972) Studies of nutrition and beef production of fattening young steers grazing on pasture —Effects of bahiagrass pasturing on nutrient intake, energy expenditure and beef production of fattening young steers. *Ann. Rep. Kyushu Agric. Exp. Stn. (1970),* 59–65.**
27) TAKIMOTO, Y., I. KUROHIJI, Y. NAKANISHI, T. MINO and M. FURUSAWA (1975) Studies of nutrition and beef production of fattening young steers grazing on pasture — Effect of intensive utilization of a sown pasture on fattening of young steers. *Ann. Rep. Kyushu Agric. Exp. Stn. (1973),* 59–62.**
28) YAMAMOTO, Y., N. KOYAMA, K. SHINDO and K. HAGINO (2000) Growth characteristics of Nezasa dwarf bamboo (*Pleioblastus variegatus* Makino). 3. Seasonal changes in dry matter production and crude protein content in Nezasa-type grassland under cattle grazing. *Grassland Science* **45**, 360–366.*
29) AGRICULTURE, FORESTRY AND FISHERIES RESEARCH COUNCIL SECRETARIAT, MAFF (Ed.) (1995) Japanese Feeding Standard for Beef Cattle (1995). Central Association of Livestock Industry. Tokyo.**
30) AOAC (1984) Official Methods of Analysis of the Association of Official Analytical Chemists, 14th edn. Association of Official Analytical Chemists. Washington, DC.
31) NRC (1986) Predicting Feed Intake of Food-producing Animals. National Academy Press. Washington, DC.

*: In Japanese with English summary.
**: In Japanese only.

要　　旨

平田昌彦・小倉振一郎・福山喜一*・黒木志郎*・井上俊晴*・日高利治*・弓削嗣彦*・高橋政男*・野村憲司*（2003）：肉用種繁殖雌牛が放牧されるバヒアグラス（*Paspalum notatum* Flügge）草地の生産と利用．日草誌 **48**, 477–484．宮崎大学農学部草地環境科学講座（889-2192 宮崎市学園木花台西 1-1），*宮崎大学農学部附属自然共生フィールド科学教育研究センター住吉フィールド（880-0121 宮崎市大字島之内 10100-1）

黒毛和種繁殖雌牛が輪換放牧されるバヒアグラス（*Paspalum notatum* Flügge）草地の生産と利用について調査した。草量は 20–421 g DM/m^2 の範囲にあり，放牧季節以前（4 月中旬-5 月下旬）に増加し，放牧季節（5 月下旬-10 月下旬）中は放牧期間中の減少と休牧期間中の増加を繰り返した。乾物消化率（471–593 g/kg DM）と窒素含有量（13–26 g/kg DM）は 5 月から 10 月にかけて減少した。4 月中旬から 10 月下旬まで（≈生育期間）の生産量と被食量はそれぞれ 1,025–1,033 g DM/m^2 および 892–941 g DM/m^2 で，利用率は 0.86–0.92 であった。バヒアグラス草地は，我国の牧草地の中では中程度の生産力であり，黒毛和種繁殖雌牛により高度に利用され，十分な可消化エネルギーと粗蛋白質を供給することが示された。

キーワード：消化率，草地生産，草地利用，窒素，バヒアグラス，繁殖雌牛．