Regional Communication

Forage production and quality of *Urochloa decumbens* cultivar 'Basilisk' in Okinawa, Japan

Producción y calidad del forraje de Urochloa decumbens *cultivar 'Basilisk' en Okinawa, Japón*

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Abstract

Two studies were conducted to assess forage growth and nutritive value of *Urochloa decumbens* (syn. *Brachiaria decumbens*) cultivar 'Basilisk' in comparison with other grass species grown in Okinawa during 2002–2005 and 2006–2008. Harvests were performed every 40 days from April to October and every 55 days from November to March. In Experiment 1, from 2002 to 2005 total dry matter (DM) yield of 'Basilisk' (119.5 t/ha) was significantly higher than that of *Digitaria eriantha* cultivar 'Transvala' (87.4 t/ha; P = 0.01), one of the most popular recommended grass varieties in Okinawa Prefecture. Mean DM digestibility of 'Basilisk' was 56.7 %, significantly higher than that of other recommended grass varieties (54.5–51.4 %). In addition, total digestible DM yield (64.8 t/ha) and crude protein (CP) yield (13.7 t/ha) of 'Basilisk' were significantly higher than those of other varieties including 'Transvala' (P<0.01). In Experiment 2, total DM yield of 'Basilisk' during 2006–2008 was 93.0 t/ha and significantly higher only than that of *Urochloa mutica* (syn. *Brachiaria mutica*) (78.6 t/ha; P<0.01), whereas mean DM digestibility (54.8 %) was significantly higher only than that of *Chloris gayana* cultivar 'Katambora' (52.8 %; P<0.05). Total digestible DM yield (48.8 t/ha) of 'Basilisk' was significantly higher only than that of *U. mutica* (40.3 t/ha; P<0.01) while its total CP yield (10.4 t/ha) was similar to those of other *Urochloa* cultivars (P>0.05). As a result, in 2016 'Basilisk' was approved to be added to the list of grasses recommended for sowing in Okinawa Prefecture for improving beef production in the area. A suitable supply of seed to allow this cultivar to be sown widely is essential if its potential for improving beef production in the region is to be realized.

Keywords: *Brachiaria decumbens*, crude protein, dry matter digestibility, seasonal production, tropical forage.

Resumen

Se realizaron dos estudios para evaluar el crecimiento y el valor nutritivo del cultivar 'Basilisk' de *Urochloa decumbens* (syn. *Brachiaria decumbens*) en comparación con otras especies de gramíneas cultivadas en Okinawa durante 2002–2005 y 2006–2008. Las cosechas se realizaban cada 40 días desde abril a octubre y cada 55 días desde noviembre a marzo. En el Experimento 1, de 2002 a 2005 el rendimiento total de materia seca (MS) de 'Basilisk' (119.5 t/ha) fue significativamente mayor que el del cultivar 'Transvala' de *Digitaria eriantha* (87.4 t/ha; P = 0.01), una de las variedades de pasto más popularmente recomendadas en la prefectura de Okinawa. La digestibilidad media de la MS de 'Basilisk' fue del 56.7 %, significativamente más alta que la de otras variedades de gramíneas recomendadas (54.5-51.4 %). Además, el rendimiento total de MS digestible (64.8 t/ha) y el rendimiento de proteína cruda (PC) (13.7 t/ ha) de 'Basilisk' fueron significativamente más altos que los de otras variedades, incluida 'Transvala' (P<0.01). En el Experimento 2, el rendimiento total de MS de 'Basilisk' durante 2006–2008 fue de 93.0 t/ha y solo significativamente mayor que el de *Urochloa mutica* (sin. *Brachiaria mutica*) (78.6 t/ha; P<0.01), mientras que la digestibilidad media de la MS (54.8 %) fue solo significativamente mayor que la del cultivar de 'Katambora' de *Chloris gayana* (52.8 %;

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P<0.05). El rendimiento total de MS digestible (48.8 t/ ha) de 'Basilisk' fue solo significativamente mayor que el de *U. mutica* (40.3 t/ha; P<0.01) mientras que su rendimiento total de PC (10.4 t/ha) fue similar al de otros cultivares de *Urochloa* (P>0.05). Como resultado, en 2016 se aprobó que 'Basilisk' se agregara a la lista de pastos recomendados para la siembra en la prefectura de Okinawa para mejorar la producción de carne en el área. Un suministro adecuado de semillas que permita sembrar ampliamente este cultivar es esencial si se quiere aprovechar su potencial para mejorar la producción de carne en la región.

Palabras clave: *Brachiaria decumbens*, digestibilidad, forraje tropical, producción estacional, proteína cruda.

Introduction

In Okinawa, the southernmost part of Japan, the beef industry accounted for 24.5 % of gross agricultural production in 2019 and sales of calves during the past 10 years ranked fourth throughout Japan. According to the official figures of the Okinawa prefectural government, more than 3 million foreign tourists visited Okinawa in 2018, the highest number recorded in any year at that stage, and 10 million of domestic and international tourists were recorded in 2019. There is an urgent need to boost the production of Okinawa's famous unique beef brands such as 'IshigakiGyu', 'YamashiroGyu' and 'MiyakoGyu' to cope with this increase. To ensure breeding cows are healthy with high reproductive rates and high growth rates are achieved in growing animals, feeding of high-quality grass plays an important role.

The Prefecture of Okinawa consists of many small islands where cattle are raised on pasture, and droughts are experienced on some islands. Okinawa experiences a subtropical climate so tropical perennial grasses can be grown successfully. Growing highly productive grasses would remove the need for farmers to depend on imported forage. Introduction of new species suitable for grazing by cattle would be a significant advance and drought tolerance would be an added benefit. *Urochloa decumbens* (Stapf) R.D. Webster (syn. *Brachiaria decumbens* Stapf) cultivar 'Basilisk', originally from Uganda, is known for its drought tolerance (Oram 1990; Miles et al. 1996). Actually, 'Basilisk' is sown in Queensland, Australia and since the 1970s has been grown in Brazil, well-adapted to infertile acid soils in the Brazilian savanna, while showing high productivity and persistence (Kissmann 1977).

It was considered that 'Basilisk' could be possibly more productive than grasses currently grown in Okinawa so we investigated yield of dry matter, digestible dry matter and crude protein of Basilisk in comparison with those of recommended grass varieties of Okinawa Prefecture and other species of the genus *Urochloa.*

Materials and Methods

Research location and period

The research was conducted during 2 periods (2002–2005 and 2006–2008) at Okinawa Livestock Research Center (Nakijin, Okinawa, Japan) (26º68' N, 127º94' E; 90 masl). Soils of the experimental area were Kunigami Merge, a red acidic Acrisol (Miyagi and Kondo 1990) and are composed of 32.8 % clay (<0.002 mm particle size), 63.7 % silt (0.002–0.2 mm) and 4.6 % sand (>0.2 mm) (Oshiro 2007). Chemical characteristics are: pH 4.7, total carbon, 1.33 %; total nitrogen, 0.12 %; organic matter, 2.2 %; cation exchange capacity, 13.5 meq/100 g soil; Ca, 74.4 meq/100 g soil; Mg, 40.6 meq/100 g soil; and K, 14.0 meq/100 g soil. Specific gravity is relatively high. Main clay mineral is kaolinite. Climatic conditions during the 2 experimental periods (2002–2005 and 2006–2008) are illustrated in Figures 1 and 2, indicating a cold and dry winter season from November to March.

In Experiment 1, between June 2002 to April 2005 performance of 'Basilisk' was compared with that of the other *Urochloa* species and cultivars as well as cultivars from other genera, while in Experiment 2 from December 2006 to December 2008 comparisons were made with other species within the genus *Urochloa* as well as *Chloris gayana* cultivar 'Katambora'.

Experiment 1

The design was a complete randomized block with 7 grasses and 3 replications. Seeds of selected grasses were sown at 27.8 kg/ha on 11 October 2001, except for *Digitaria eriantha* cultivar 'Transvala' and *Cynodon nlemfuensis* (Table 1), which were planted vegetatively using stolons at 4 stolons/m^2 on 29 October 2001. Seed of *Ch. gayana* cultivar 'Katambora' was sown on 22 April 2002 to increase the number of cultivars involved. Plot size was 2 × 3 m = 6 m^2. Basal fertilizer

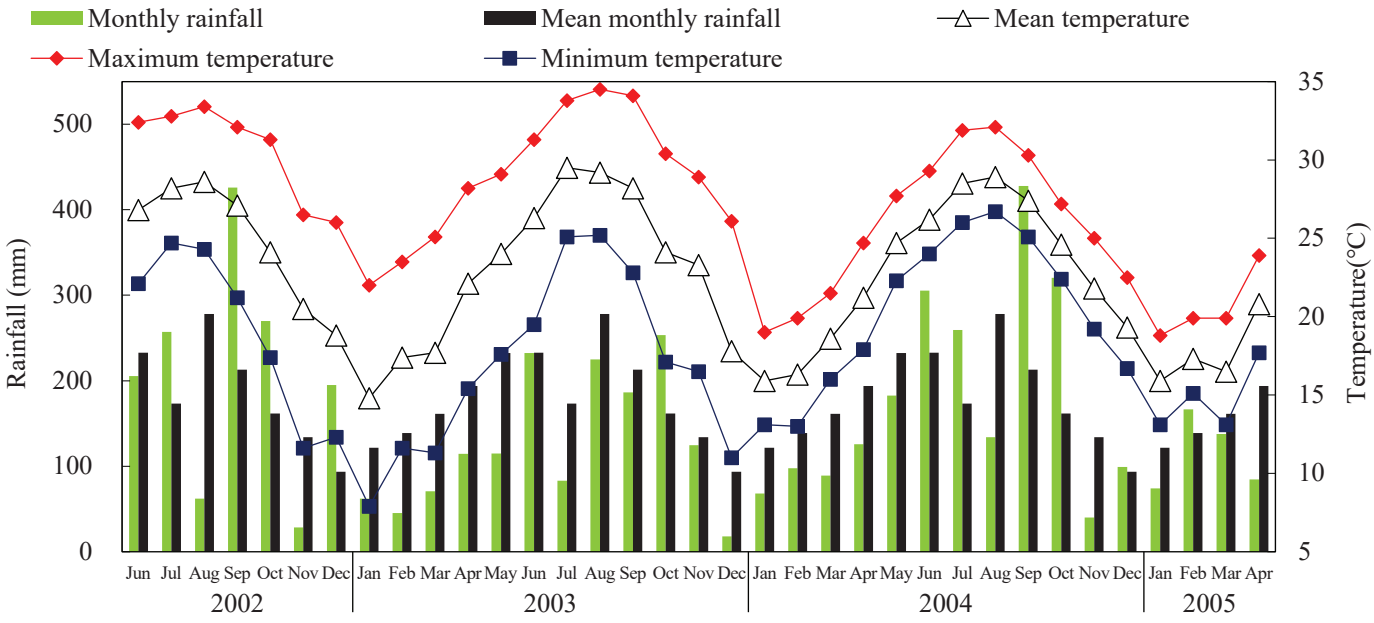

Figure 1. Average, maximum and minimum temperatures, monthly rainfall from June 2002 to April 2005 and mean monthly rainfall.

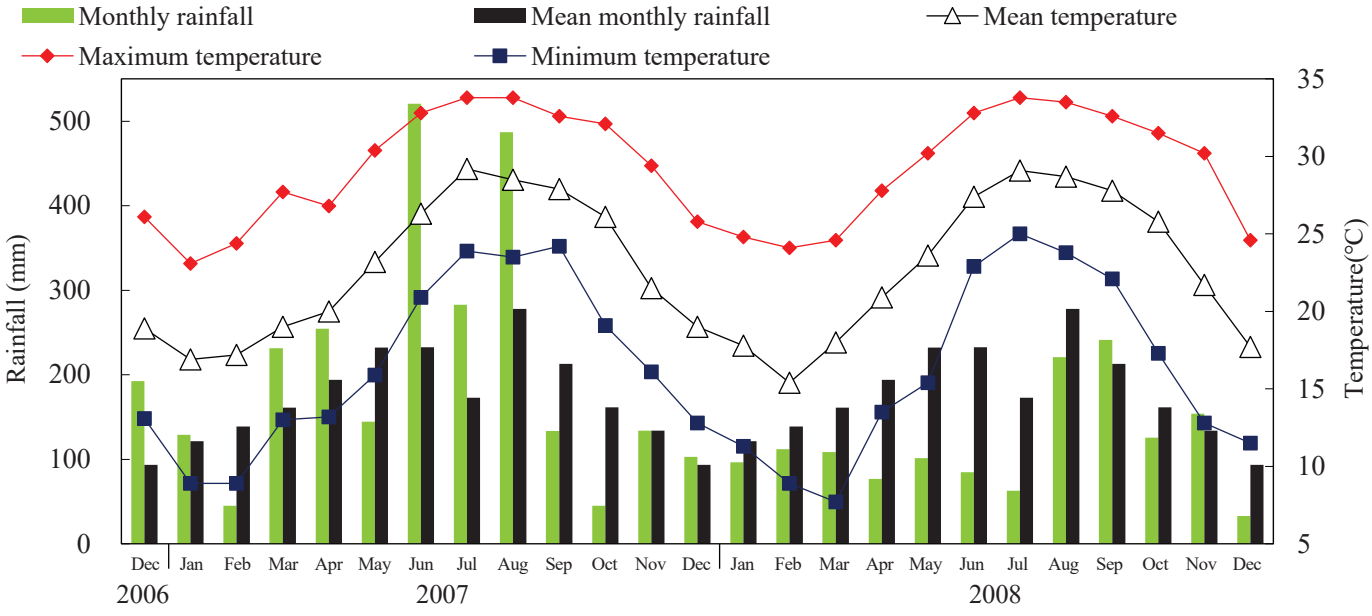

Figure 2. Average, maximum and minimum temperatures, monthly rainfall from December 2006 to December 2008 and mean monthly rainfall

of N:P:K at 50:13:25 kg/ha was applied at planting and further N:P:K at 70:17:45 kg/ha was applied as maintenance fertilizer after each harvest. Measurement of species performance commenced in June 2002, when original plantings had become established following a few preliminary harvests. The previous harvest was in April 2002, while 'Katambora' was harvested for the first time in June 2002. Harvesting occurred at locally used intervals, i.e. approximately every 40 days from April to October (summer season) and approximately every 55 days from November to March (winter season) in each year, ceasing in April 2005.

Table 1. List of grass varieties investigated in Experiments 1 and 2.

Experiment 1	Experiment 2
U. decumbens 'Basilisk'	*U. decumbens* 'Basilisk'
U. humidicola	*U. brizantha* 'Marandu'
Ch. gayana 'Callide'	*U. humidicola*
Ch. gayana 'Katambora'	*U. brizantha* 'MG5'
Cynodon nlemfuensis	*U. ruziziensis*
D. eriantha 'Transvala'	*U. mutica*
Megathyrsus maximus 'Gatton '	*Ch. gayana* 'Katambora'

Experiment 2

The design was again a complete randomized block with 7 grasses and 3 replications. On 18 October 2005 seeds of grasses were sown at 41.7 kg/ha, while *Urochloa mutica* was planted with 4 stolons/m^2 (Table 1). Basal fertilizer of N:P:K at 80:14:40 kg/ha was applied at planting and the same quantities were applied as maintenance fertilizer after each harvest. Again plants were allowed to establish before observations commenced on 18 December 2006. The previous harvest was on 7 November 2006. Harvests occurred approximately every 55 days from November to March and every 40 days from April to October as described above until December 2008.

Dry matter yield

In both studies, forage on each plot was harvested (6 m^2) at approximately 10 cm from ground level and forage samples (500 g) for each plot were collected and dried at 70 °C for 48 h to determine DM yield. The dried samples were ground with a mill and the powder was sieved through a 1 mm mesh for analyzing for nitrogen concentration for crude protein concentration and in vitro DM digestibility.

In vitro dry matter digestibility and crude protein analysis

Grass samples were analyzed for in vitro DM digestibility according to the pepsin-cellulase assay (Goto and Minson 1977). Crude protein (CP) concentration was determined by the microKjeldahl method using an Auto Analyzer.

Statistical analysis

One-way analysis of variance (ANOVA) was used for the statistical analysis of DM yield, in vitro DM digestibility, digestible DM yield, CP concentration and CP yield in each experiment using the RStudio Version 1.4.1717. Tukey's test was used to identify the differences between Basilisk and other grass varieties.

Results

Experiment 1

Dry matter. In Experiment 1 from 2002 to 2005, there was no significant difference in DM yield between 'Basilisk' and other varieties in 2002 (Table 2). However, in 2003 DM yield of 'Basilisk' (46.7 t/ha) was significantly greater than that of *U. humidicola* (33.1 t/ha; P = 0.02), *C. nlemfuensis* (33.8 t/ha; P = 0.03) and 'Transvala' (30.2 t/ha; P = 0.004). As a result, total DM yield of 'Basilisk' (119.5 t/ha) from 2002 to 2005 was significantly greater than that of 'Transvala' (87.4 t/ha; P = 0.01).

Digestibility. Mean DM digestibility of 'Basilisk' (56.7 %) from 2002 to 2005 was significantly greater than that of *U. humidicola* (54.3 %; P = 0.02), 'Callide' (54.5 %; P = 0.03), 'Katambora' (51.4 %; P<0.001) and *C. nlemfuensis* (52.9 %; P<0.001) (Table 3).

For digestible DM yield, there was no significant

Table 2. Dry matter yield (t/ha) of forage of a range of tropical grasses in Okinawa (Experiment 1).

Grass variety	2002 S4h[1]	2003 S7h	2004 S8h	2005 S2h	Total
Urochloa decumbens 'Basilisk'	21.6 ± 1.1	46.7 ± 1.4	45.7 ± 0.7	5.5 ± 0.2	119.5 ± 0.5
Urochloa humidicola	17.1 ± 1.6	33.1 ± 3.5*	43.4 ± 1.4	5.1 ± 0.5	98.7 ± 6.9
Chloris gayana 'Callide'	20.2 ± 0.7	36.9 ± 0.7	38.5 ± 1.8	5.3 ± 0.4	100.9 ± 3.3
Chloris gayana 'Katambora'	18.5 ± 0.5	35.4 ± 3.1	37.0 ± 3.6	4.4 ± 0.8	95.3 ± 7.6
Cynodon nlemfuensis	19.6 ± 0.8	33.8 ± 0.9*	38.6 ± 2.2	3.2 ± 0.3	95.1 ± 2.7
Digitaria eriantha 'Transvala'	16.7 ± 0.5	30.2 ± 1.7**	36.5 ± 1.5	4.1 ± 0.2	87.4 ± 3.0*
Megathyrsus maximus 'Gatton'	21.4 ± 0.9	42.2 ± 0.9	43.7 ± 0.6	4.9 ± 0.4	112.1 ± 1.0

Within columns, * and ** indicate significant differences (P<0.05) and (P<0.01) compared with 'Basilisk'; [1]Sum of *n* harvest. Source: Mochizuki et al. 2005.

Table 3. Mean dry matter digestibility (%) of forage of a range of tropical grasses in Okinawa (Experiment 1).

Grass variety	2002 M4h[1]	2003 M7h	2004 M8h	2005 M2h	Overall mean
U. decumbens 'Basilisk'	54.4 ± 0.2	56.5 ± 0.5	54.3 ± 0.2	72.8 ± 1.0	56.7 ± 0.1
U. humidicola	53.2 ± 0.1	53.8 ± 0.7*	51.3 ± 0.2*	71.6 ± 0.2	54.3 ± 0.3*
Ch. gayana 'Callide'	52.8 ± 0.2	54.0 ± 0.3	50.9 ± 0.2**	74.7 ± 0.1	54.5 ± 0.2*
Ch. gayana 'Katambora'	48.3 ± 0.3***	50.7 ± 0.1***	48.1 ± 0.5***	74.4 ± 0.4	51.4 ± 0.3***
C. nlemfuensis	50.7 ± 0.7*	53.0 ± 0.5**	48.8 ± 0.8***	74.6 ± 0.4	52.9 ± 0.7***
D. eriantha 'Transvala'	51.3 ± 0.4	56.5 ± 0.5	53.5 ± 0.3	76.5 ± 0.6*	56.1 ± 0.1
M. maximus 'Gatton'	51.0 ± 1.0*	54.8 ± 0.2	53.7 ± 0.5	76.2 ± 0.6*	55.5 ± 0.5

Within columns, * and *** indicate significant differences (P<0.05), (P<0.01) and (P<0.001) compared with 'Basilisk'; [1]Mean of *n* harvest. Source: Hanagasaki et al. 2006.

difference between 'Basilisk' and other varieties in 2002 and 2005, while in 2003 that of 'Basilisk' (25.5 t/ha) was significantly greater than those of *U humidicola* (17.4 t/ha; P = 0.006), 'Katambora' (17.7 t/ha; P = 0.008), *C. nlemfuensis* (17.0 t/ha; P = 0.004) and 'Transvala' (16.1 t/ha; P = 0.001) (Table 4), and in 2004 that of 'Basilisk' (23.8 t/ha) was significantly greater than those of 'Katambora' (17.1 t/ha; P = 0.01) and *C. nlemfuensis* (18.1 t/ha; P = 0.03). Over the complete study, total digestible DM yield of 'Basilisk' (64.8 t/ha) was significantly higher than that of *U. humidicola* (51.2 t/ha; P = 0.04), 'Katambora' (46.8 t/ha; P = 0.006), *C. nlemfuensis* (47.2t/ha; P = 0.007) and 'Transvala' (46.3 t/ha; P = 0.005).

Crude protein. Mean CP concentration (13.1 %) of 'Basilisk' was significantly higher than that of 'Callide' and 'Katambora' (P<0.05) (Table 5).

Regarding CP yield, that of 'Basilisk' (5.1 t/ha) was significantly higher than that of *U. humidicola* (3.6 t/ha; P = 0.03) and 'Transvala' (3.3 t/ha; P = 0.01) in 2003, while in 2005 that of 'Basilisk' (1.0 t/ha) was significantly higher than that of 'Katambora' (0.6 t/ha; P = 0.04) and *C. nlemfuensis* (0.5 t/ha; P = 0.02) (Table 6). Total CP yield of 'Basilisk' (13.7 t/ha) was significantly higher than that of 'Katambora' (10.1 t/ha; P = 0.02) and 'Transvala' (9.5 t/ha; P = 0.008).

Experiment 2

Dry matter. In Experiment 2 from 2005 to 2008, DM yield of 'Basilisk' (2.6 t/ha) was significantly lower than that of *U. brizantha* 'MG5' (3.9 t/ha; P = 0.007) in 2006 but was significantly higher than that of *U. mutica* (46.3 vs. 37.9 t/ha; P = 0.01) in 2007 and overall (93.0 vs.78.6 t/ha; P = 0.008) (Table 7).

Digestibility. Mean DM digestibility of 'Basilisk' (54.8 %) from 2006 to 2008 was significantly higher than that of 'Katambora' (52.8 %; P = 0.02) (Table 8).

Digestible DM yield of Basilisk in 2007 and 2008 (23.6 and 23.5 t/ha) was significantly greater than those of *U. mutica* (19.4 t/ha; P = 0.03 and 19.6 t/ha; P = 0.01) (Table 9). Total digestible DM yield of 'Basilisk' (48.8 t/ha) was also significantly greater than that of *U. mutica* (40.3 t/ha; P = 0.004).

Crude protein. Mean CP concentration (12.7 %) and total CP yield (10.4 t/ha) of 'Basilisk' were not significantly different from those of other *Urochloa* cultivars (Tables 10 and 11).

Table 4. Digestible dry matter yield (t/ha) of forage of a range of tropical grasses in Okinawa (Experiment 1).

Grass variety	2002 S4h[1]	2003 S7h	2004 S8h	2005 S2h	Total
U. decumbens 'Basilisk'	11.4 ± 0.6	25.5 ± 0.4	23.8 ± 0.1	4.2 ± 0.1	64.8 ± 0.3
U. humidicola	8.9 ± 0.8	17.4 ± 1.9**	21.2 ± 0.5	3.8 ± 0.3	51.2 ± 3.5*
Ch. gayana 'Callide'	10.3 ± 0.5	19.8 ± 0.3	18.9 ± 1.0	4.2 ± 0.3	53.2 ± 1.9
Ch. gayana 'Katambora'	8.6 ± 0.1	17.7 ± 1.6**	17.1 ± 1.8*	3.5 ± 0.6	46.8 ± 4.0**
C. nlemfuensis	9.6 ± 0.5	17.0 ± 0.6**	18.1 ± 0.7*	2.5 ± 0.3	47.2 ± 1.2**
D. eriantha 'Transvala'	8.3 ± 0.2	16.1 ± 0.8**	18.7 ± 0.7	3.2 ± 0.2	46.3 ± 1.5**
M. maximus 'Gatton'	10.6 ± 0.6	21.7 ± 0.5	22.2 ± 0.4	3.8 ± 0.3	58.3 ± 0.9

Within columns, * and ** indicate significant differences (P<0.05) and (P<0.01) compared with 'Basilisk'.
[1]Sum of *n* harvest.

Table 5. Mean crude protein concentration (%) of forage of a range of tropical grasses in Okinawa (Experiment 1).

Grass variety	2002 M4h[1]	2003 M7h	2004 M8h	2005 M2h	Overall mean
U. decumbens 'Basilisk'	13.0 ± 0.2	12.8 ± 0.1	12.2 ± 0.1	17.9 ± 0.7	13.1 ± 0.1
U. humidicola	13.3 ± 0.4	12.8 ± 0.4	11.2 ± 0.2	16.6 ± 0.6	12.7 ± 0.3
Ch. gayana 'Callide'	11.9 ± 0.3	11.5 ± 0.2	10.7 ± 0.0	13.9 ± 0.2**	11.5 ± 0.1*
Ch. gayana 'Katambora'	11.6 ± 0.3	11.6 ± 0.3	10.6 ± 0.5*	13.5 ± 0.5***	11.4 ± 0.3*
C. nlemfuensis	14.0 ± 0.4	13.6 ± 0.4	12.0 ± 0.3	17.1 ± 0.1	13.5 ± 0.3
D. eriantha 'Transvala'	13.4 ± 0.3	12.6 ± 0.3	10.9 ± 0.2	15.2 ± 0.2*	12.4 ± 0.1
M. maximus 'Gatton'	13.6 ± 0.4	13.7 ± 0.1	11.4 ± 0.2	16.5 ± 0.5	13.1 ± 0.1

Within columns, *, ** and *** indicate significant differences (P<0.05), (P<0.01) and (P<0.001) compared with 'Basilisk'.
[1]Mean of *n* harvest.

Table 6. Crude protein yield (t/ha) of forage of a range of tropical grasses in Okinawa (Experiment 1).

Grass variety	2002 S4h[1]	2003 S7h	2004 S8h	2005 S2h	Total
U. decumbens 'Basilisk'	2.6 ± 0.2	5.1 ± 0.1	4.9 ± 0.1	1.0 ± 0.0	13.7 ± 0.2
U. humidicola	2.2 ± 0.1	3.6 ± 0.4*	4.3 ± 0.1	0.8 ± 0.1	10.9 ± 0.7
Ch. gayana 'Callide'	2.2 ± 0.2	3.8 ± 0.1	3.8 ± 0.2	0.7 ± 0.1	10.5 ± 0.4
Ch. gayana 'Katambora'	2.0 ± 0.1	3.8 ± 0.4	3.7 ± 0.5	0.6 ± 0.1*	10.1 ± 1.1*
C. nlemfuensis	2.5 ± 0.2	4.1 ± 0.2	4.3 ± 0.1	0.5 ± 0.0*	11.5 ± 0.4
D. eriantha 'Transvala'	2.0 ± 0.1	3.3 ± 0.2*	3.6 ± 0.1	0.6 ± 0.0	9.5 ± 0.4**
M. maximus 'Gatton'	2.6 ± 0.2	5.0 ± 0.1	4.5 ± 0.1	0.8 ± 0.1	12.9 ± 0.2

Within columns, * and ** indicate significant differences (P<0.05) and (P<0.01) compared with 'Basilisk'; [1]Sum of *n* harvest.

Table 7. Dry matter yield (t/ha) of forage of *Urochloa* cultivars and *Chloris gayana* cultivar 'Katambora' in Okinawa (Experiment 2).

Grass variety	2006 1 harvest	2007 S8h[1]	2008 S8h	Total
U. decumbens 'Basilisk'	2.6 ± 0.1	46.3 ± 2.4	44.1 ± 1.4	93.0 ± 3.7
U. brizantha 'Marandu'	3.1 ± 0.2	42.1 ± 0.9	40.3 ± 0.2	85.5 ± 1.3
U. humidicola	2.9 ± 0.0	44.7 ± 0.4	43.0 ± 0.3	90.5 ± 0.4
U. brizantha 'MG5'	3.9 ± 0.2**	46.8 ± 0.6	46.6 ± 1.3	97.2 ± 0.9
U. ruziziensis	2.1 ± 0.2	44.4 ± 1.4	47.4 ± 0.9	94.0 ± 2.2
U. mutica	2.0 ± 0.2	37.9 ± 0.6*	38.7 ± 0.6	78.6 ± 0.9**
Ch. gayana 'Katambora'	2.8 ± 0.1	44.1 ± 0.6	48.3 ± 1.2	95.3 ± 1.7

Within columns, * and ** indicate significant differences (P<0.05) and (P<0.01) compared with 'Basilisk'; [1]Sum of *n* harvest. Source: Kudaka et al. 2020.

Table 8. Mean dry matter digestibility (%) of forage of *Urochloa* cultivars and *Chloris gayana* cultivar 'Katambora' in Okinawa (Experiment 2).

Grass variety	2006 1 harvest	2007 M8h[1]	2008 M8h	Overall mean
U. decumbens 'Basilisk'	62.7 ± 1.0	54.4 ± 0.6	54.2 ± 0.1	54.8 ± 0.4
U. brizantha 'Marandu'	61.2 ± 0.9	55.3 ± 0.2	53.5 ± 0.8	54.8 ± 0.4
U. humidicola	61.2 ± 0.5	53.7 ± 0.3	54.2 ± 1.0	54.4 ± 0.5
U. brizantha 'MG5'	54.9 ± 0.5***	53.5 ± 0.1	52.4 ± 0.1	53.1 ± 0.1
U. ruziziensis	63.2 ± 0.2	56.6 ± 0.2*	55.2 ± 0.3	56.4 ± 0.1
U. mutica	63.7 ± 0.4	54.2 ± 0.2	51.5 ± 0.3	53.5 ± 0.2
Ch. gayana 'Katambora'	60.9 ± 0.8	53.3 ± 0.3	51.3 ± 0.1	52.8 ± 0.1*

Within columns, * and ** indicate significant differences (P<0.05) and (P<0.01) compared with 'Basilisk'; [1]Mean of *n* harvest. Source: Kudaka et al. 2020.

Table 9. Digestible dry matter yield (t/ha) of forage of *Urochloa* cultivars and *Chloris gayana* cultivar 'Katambora' in Okinawa (Experiment 2).

Grass variety	2006 1 harvest	2007 S8h[1]	2008 S8h	Total
U. decumbens 'Basilisk'	1.6 ± 0.1	23.6 ± 1.4	23.5 ± 0.8	48.8 ± 2.2
U. brizantha 'Marandu'	1.9 ± 0.1	22.2 ± 0.5	21.2 ± 0.2	45.3 ± 0.4
U. humidicola	1.7 ± 0.0	22.2 ± 0.2	22.9 ± 0.4	46.8 ± 0.2
U. brizantha 'MG5'	2.1 ± 0.1	23.9 ± 0.4	24.2 ± 0.7	50.3 ± 0.4
U. ruziziensis	1.4 ± 0.1	23.8 ± 0.8	25.3 ± 0.4	50.5 ± 1.1
U. mutica	1.3 ± 0.1	19.4 ± 0.4*	19.6 ± 0.3*	40.3 ± 0.6**
Ch. gayana 'Katambora'	1.7 ± 0.0	21.5 ± 0.2	24.0 ± 0.6	47.3 ± 0.7

Within columns, * and ** indicate significant differences (P<0.05) and (P<0.01) compared with 'Basilisk'; [1]Sum of *n* harvest. Source: Kudaka et al. 2020.

Table 10. Mean crude protein concentration (%) of forage of *Urochloa* cultivars and *Chloris gayana* cultivar 'Katambora' in Okinawa (Experiment 2).

Grass variety	2006 1 harvest	2007 M8h[1]	2008 M8h	Overall mean
U. decumbens 'Basilisk'	18.2 ± 0.5	12.5 ± 0.3	12.2 ± 0.2	12.7 ± 0.1
U. brizantha 'Marandu'	18.0 ± 0.7	13.9 ± 0.4	13.0 ± 0.3	13.7 ± 0.4
U. humidicola	17.1 ± 0.2	12.4 ± 0.3	11.7 ± 0.1	12.4 ± 0.2
U. brizantha 'MG5'	16.1 ± 0.3	13.2 ± 0.2	12.3 ± 0.2	12.9 ± 0.2
U. ruziziensis	18.9 ± 0.4	13.5 ± 0.3	12.3 ± 0.3	13.2 ± 0.1
U. mutica	20.6 ± 0.4	13.9 ± 0.1	11.1 ± 0.2	12.9 ± 0.2
Ch. gayana 'Katambora'	17.0 ± 0.3	12.3 ± 0.2	11.3 ± 0.2	12.1 ± 0.2

[1]Mean of *n* harvest. Source: Kudaka et al. 2020

Table 11. Crude protein yield (t/ha) of forage of *Brachiaria* cultivars and *Chloris gayana* cultivar 'Katambora' in Okinawa (Experiment 2).

Grass variety	2006 1 harvest	2007 S8h[1]	2008 S8h	Total
U. decumbens 'Basilisk'	0.5 ± 0.0	5.1 ± 0.3	4.8 ± 0.2	10.4 ± 0.5
U. brizantha 'Marandu'	0.6 ± 0.0	5.2 ± 0.1	4.8 ± 0.0	10.6 ± 0.1
U. humidicola	0.5 ± 0.0	4.9 ± 0.1	4.4 ± 0.0	9.8 ± 0.1
U. brizantha 'MG5'	0.6 ± 0.0	5.4 ± 0.2	4.9 ± 0.2	10.9 ± 0.2
U. ruziziensis	0.4 ± 0.0	5.1 ± 0.3	4.5 ± 0.1	10.0 ± 1.4
U. mutica	0.4 ± 0.0	4.6 ± 0.0	3.9 ± 0.1	8.9 ± 0.1
Ch. gayana 'Katambora'	0.5 ± 0.0	4.7 ± 0.1	4.9 ± 0.2	10.1 ± 0.2

[1]Sum of *n* harvest.

Discussion

This study has provided valuable information on the relative performance of a range of tropical grasses including *U. decumbens* cultivar 'Basilisk' over a number of years in Okinawa. 'Basilisk' performed as well as all other cultivars evaluated in most years and outperformed some cultivars in some years. While rainfall in 2003 was well below the long-term mean for the area (Figure 1), 'Basilisk' maintained a high level of production and had higher DM yield than *U. humidicola*, *C. nlemfuensis* and *D. eriantha* cultivar 'Transvala', supporting claims that this cultivar has a good level of tolerance of drier conditions. However, even in this 'dry' year, rainfall received was 1,530 mm, which should be adequate to support good DM yields given that >100 mm was registered in 7 of the 12 months.

As well as having good DM production, 'Basilisk' showed CP concentration as high as all other cultivars tested with mean values of 13.1 and 12.7 % in the 2 experiments. The level of *U. decumbens* (14 %) was within the range expected for immature leaves in Costa Rica (Lascano and Euclides 1996). 'Basilisk' would provide an excellent diet for grazing ruminants,

especially given their ability to select a better quality diet than the mean of total feed on offer. DM digestibility of 56.7 and 54.8 % in the 2 experiments would ensure that there was an adequate supply of available energy.

In Okinawa, area of grass pasture covers more than 95 % of the total with 4 major grass varieties recommended, i.e. *Ch. gayana*, *D. eriantha*, *M. maximus* and *C. nlemfuensis* in the past 15 years. *D. eriantha* cultivar 'Transvala' has become the major grass sown in Okinawa and represented 27.9 % of total area sown to grass in Okinawa in 2020 because of its perceived excellent characteristics and its suitability for local conditions (Hanagasaki 2022). However, 'Basilisk' was obviously superior to 'Transvala' in Experiment 1, in terms of yields of DM, digestible DM and CP, suggesting that it could be an acceptable substitute. In addition, 'Basilisk' performed significantly better than *U. mutica*, which is also a recommended grass variety for sowing in Okinawa Prefecture. In fact, 'Basilisk' is a high yielding species, particularly if nitrogen fertilizer is provided. Up to 30 t DM/ha/yr can be obtained on fertile soils in Vanuatu, and the same biomass production is possible under coconut plantations in the Solomon Islands (Cook et al. 2020). The average yield is, however, generally lower at about 10 t DM/ha/yr. 'Basilisk' yielded 4 t DM/ha/yr without fertilizer in Colombia (FAO 2016). In studies in northeast Brazil (Rodrigues et al. 2014), total forage production of 'Basilisk' (8.94t DM/ha) over 2 years was significantly higher than Koronivia grass (*Brachiaria humidicola*) and Gamba grass (*Andropogon gayanus*). In addition, milk yield of cows grazing 'Basilisk' (8 kg/cow/d) was greater than on *Brachiaria dictyoneura* (now: *Urochloa humidicola*) (6 kg/cow/d) in Colombia (Lascano and Euclides 1996).

U. decumbens has an allelopathic effect, inhibiting germination of seeds of other plants (Barbosa et al. 2008). In our study it prevented invasion by other grasses throughout the 10 years since 'Basilisk' was planted (see bottom photo in Figure 3).

Consequently, if 'Basilisk' is introduced and sown widely in Okinawa, it should result in production of high-quality forage, which could reduce annual cost of keeping breeding cows (Kouki and Ebina 2009). Based on results of the current study it seems that *U. decumbens* cultivar 'Basilisk' could be added to the list of suitable species for sowing on these islands. In fact, in 2016 'Basilisk' was approved to be added to the list of grasses recommended for sowing in Okinawa Prefecture for improving beef production in the area and significant demand for seed has emerged.

Before it can be sown widely a reliable source of seed will be needed. However, 'Basilisk' seed production in Okinawa has been insufficient to meet demand (Kouki et al. 2009), despite the fact 'Basilisk' seed production is a success at 17–22 °S and elevations of 600–1,000 masl in Australia and Brazil (Hare et al. 2005). Unless seed production can be increased successfully in Okinawa, efforts will be needed to source supplies of seed from countries where seed is already grown successfully if its potential is to be realized in the area.

Figure 3. Appearance of *Urochloa decumbens* cultivar 'Basilisk' pasture in Okinawa.

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