Urinary excretions of Purine Derivatives (PD) as a predictor of nutritional status of local Zebu cattle and their crosses

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Abstract

The objective of the present study was to evaluate the nutritional status of Indian X indigenous Sri Lankan zebu cattle by using the Purine derivative excretion technique (PD). In the preliminary phase of the study, the voluntary intake (VI) was estimated as 3.11 DM/day for local cattle (body weight 100 kg). In the main experiment four male zebu cattle were used to determine the response of PD excretion at four levels of intake (95%, 80%, 60%, 40%). Digestibility of dry matter and organic matter were not affected (P>0.05) but nitrogen retention was increased with increasing levels of feed intake, The endogenous PD excretion rates were 1.91, 1.46, 1.21 and 0.66 mmol/kg $^{0.75}$/day for 95%, 80%, 60% and 40% intake levels respectively. The proportion of allantoin from total PD accounts 82.6% and was comparable to the range previously observed for other breeds of cattle. The excretion of creatinine was 1.05, 1.04, 0.92 and 0.84 mmol/kg $^{0.75}$/day, respectively. Daily output of total PD showed a positive response to the level of feed intake while creatinine(CR) excretion was independent of dietary treatments. The correlation between PD excretion rate and digestible organic matter intake (DOMI) was significant (r^2=0.70). Nevertheless PDC index was affected (P>0.05) by the level of feed intake and the correlation of PDC index and DOMI was significant as well (r^2 =0.63). A preliminary banding system was developed based on the above results. Results suggest that it is possible to use the average PDC index as a tool to estimate the nutritional status of local cattle.

Introduction

Low intake particularly during the dry season when feed availability is low is one of the major factors limiting animal production from native feed resources in many regions of Sri Lanka. Therefore, the strategy for improving production has been to maximize the efficiency of utilization of available feed resources in the rumen by providing optimum conditions for microbial growth.

Ruminants meet 50% to 100% of their total crude protein requirements from ruminal microbial synthesis[1]. The catabolism purine bases usually yields purine derivatives (PD), which are principally allantoin, uric acid, xanthene and hypoxanthene. While allantoin is quantitatively the most abundant, the other three in the urine of ruminants vary from one species to another[2]. It is therefore not surprising that a close relationship exists between urinary excretion of PD and duodenal supply of purines[3-5]. Osuji *et al.*[6] and others[7-8] demonstrated the potential of PD concentration in total urine as a predictor of intake and nutrient status of sheep.

The objective of the present study was to determine the urinary excretions of PD in indigenous Sri Lankan cross - bred animals at 4 levels of feed intake. The diurnal variation in the excretion of PD by means of spot urine samples who also examined.

Materials and Methods

Examine the urinary excretions of PD at four levels of feed intake

Animals and diets

Four mature animals (Indian x indigenous Sri Lankan breed) of average live weight (100 kg) were kept individually in metabolic cages for about one month and being maintained on a diet of natural grasses and concentrates. Diet per animal consisted of (on dry matter basis) 70% grass (mixture of *Bracharia brizantha, B. rusisiensis* and *Panicum maximum*) and 30% of commercial cattle feed (95%DM) to obtained. Diet containing 12.5% CP (on DM basis) was fed *adlibitum* twice daily in equal parts to achieve an intake of at least 3% live weight. *Adlibitum* intake was estimated as 3.105 kg DM /head/day. Fresh water was available freely. After the preliminary period, animals were fed at 4 fixed levels as 95, 80, 60 and 40% of the *adlibitum* intake using a 4 x 4 Latin Square design. Each feeding period lasted 3 weeks.

Sample collection

Samples were collected during last the 10 days of each feeding period. Daily feed intake was monitored with total collection of feces and urine during the first seven days of the experimental period. During the last three-days, spot urine samples were collected between 08 – 12 hrs, 17 – 20 hrs and 21 – 08 hrs the next morning within 24 hrs.

Measurements

Feces and feed were analyzed[9] for dry matter, organic matter and nitrogen (Kjeldhal method) to calculate of dry matter digestibility (DMD) and organic matter digestibility (OMD) and nitrogen intake. The urine was analyzed for total nitrogen (Kjeldhal method); creatinine and purine derivatives (allantoin and uric acid) were determined following the procedures of IAEA TECDOC 945[10].

Statistical analyzes

Statistical analyzes of the experimental were done using the soft ware packages EXCEL 2000 and SAS windows system

Results and Discussion

Feed intake and nutrient digestibility

Feed intake, DMD and OMD and digestible organic matter intake (DOMI) of the diet (70% grass and 30% cattle feed) are given in Table I. DMD and OMD ranged from 69.94 to 65.02 and 71.08 to 68.22 for highest and lowest levels of intakes respectively. The reported DMD and OMD in this study were higher than that of the reported values under Sri Lankan conditions, presumably due to feeding of concentrates in addition to grass[11]. Dry matter intake and DOMI ranged from 1.31 to 2.95 and 0.85 to 2.04 kg/d respectively. Although there were significant differences in the level of feed intake and DOMI, the digestibilities of dry matter (DMD) and organic matter (OMD) were not affected ($P<0.05$) by the level of feed intake. These differences were intentional in an attempt to maximize differences in the production of ruminal microbial nitrogen. Mean body weights were not significantly different with in the experiment (Table II). Therefore, it can be suggested that the PD excretion rate depended mainly on the DOMI rather than DMD or OMD.

Table 1. Feed intake, DM and OM digestibilities and DOMI (kg/day) of the diet fed to local Zebu cattle at different levels of intake

Level of feed intake (%)	95	80	60	40	Sig.
Feed intake(Kg/day)	02.95 ± 0.25	2.42 ± 0.35	01.91 ± 0.24	01.31 ± 0.23	0.001
DMD (%)	69.05 ± 2.97	69.94 ± 2.54	66.06 ± 2.57	65.02 ± 2.25	NS
OMD (%)	71.08 ± 4.44	70.34 ± 4.09	68.68 ± 3.33	68.22 ± 3.00	NS
DOMI (kg/day)	02.04 ± 0.20	01.69 ± 0.29	01.26 ± 0.36	00.85 ± 0.32	0.001

Response of PD excretion to feed intake

Urinary PD excretion in local cattle fed at different levels of intake is shown in Table 2. The excretion of allantoin and total PD ranged from 15.49 to 52.48 and from 21.30 to 60.07 (mmol per day) for the lowest (40%) and highest (95%) levels of intake respectively. As expected the daily outputs of allantoin and uric acid in local cattle showed a positive response to the level of feed intake. However, the excretion of creatinine was independent of the dietary treatments. It was also observed that the profile of PD excretion in the urine of local zebu cattle was similar to the other breeds of cattle [12,13]. Allantoin was found to be the principal PD in the urinary samples and was within the range previously observed in cattle by Verbic *et al* [14].

The PD excretion (Y) of local cattle was correlated to the digestible organic matter intake (DOMI =X) according to the following equation

$$Y = 22.595\,X + 10.794 \quad (R^2 = 0.70, n = 16)$$

The mean value for the intercept of above equation indicated an excretion of 22.59 mmol PD /day. Therefore, it can be suggested that the calculated PD excretion per unit digestible organic matter. Intake of local cattle is comparable to the values obtained for Keda-Kelantan[12] and Ongole[13] cattle.
Moreover, the correlation of PDC indexes to digestible organic matter intake with the following equation (Figure 1.).

$$Y = 24.428x + 1.9323 \quad (R^2 = 0.6365, n = 16)$$

It was also evident that, endogenous PD excretion rate of zebu cattle (Table 3) in this study was comparable but somewhat higher (1.91-0.66 mmol/ kg $^{0.75}$) than that of Bali cattle (0.46 mmol /kg$^{0.75}$) and Ongole cattle (0.54 mmol /kg$^{0.75}$) in Indonesia respectively. These findings provided satisfactory variation upon which to test the predictability of intake using urinary PD.

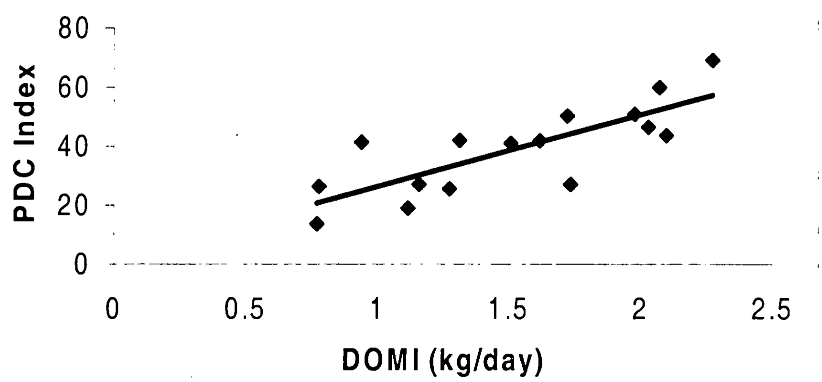

Figure 1. Relationship between PD/C index and digestible organic matter intake (DOMI) in local Zebu cattle.

Table 2. Urinary PD and creatinine excretion in local Zebu cattle

	Level of feed intake (%)				
	95	80	60	40	Sig
Allantoin (mmol/day)	52.48 ± 4.69	39.08 ± 4.84	27.31 ± 4.75	15.49 ± 4.75	0.001
Uric acid (mmol/day)	07.27 ± 0.17	06.55 ± 0.17	06.31 ± 0.18	05.81 ± 0.18	0.001
Creatinine (mmol/day)	32.85 ± 4.65	32.59 ± 4.09	28.15 ± 4.43	25.48 ± 4.06	NS
PDC Index	56.00 ± 4.02	41.77 ± 4.06	35.04 ± 3.99	26.61 ± 3.87	0.001
AL % from TPD	87.40 ± 2.87	85.50 ± 2.49	81.30 ± 2.89	76.10 ± 3.80	NS
Total PD(mmol/day)	60.07 ± 5.68	45.71 ± 5.36	33.59 ± 5.43	21.30 ± 4.82	0.001

Table 3. Urinary PD and creatinine excretion in local Zebu cattle

	Level of feed intake (%)				
	95	80	60	40	Sig.
Body weight (kg)	100	100	100	100	100
Allantoin (mmol/kg $^{0.75}$)	1.68 ± 0.034	1.25 ± 0.037	1.01 ± 0.038	0.51 ± 0.038	0.001
Uric acid (mmol/ kg $^{0.75}$)	0.23 ± 0.005	0.21 ± 0.005	0.20 ± 0.004	0.15 ± 0.005	0.001
Creatinine (mmol /kg $^{0.75}$)	1.05 ± 0.100	1.04 ± 0.090	0.92 ± 0.090	0.84 ± 0.090	NS
Total PD (mmol /kg $^{0.75}$)	1.91 ± 0.170	1.46 ± 0.180	1.21 ± 0.170	0.66 ± 0..170	0.001

Nitrogen balance

Nitrogen balance of local zebu cattle was affected by the level of feed intake is shown in Table 4. The nitrogen balance was 40.30, 29.95, 19.74 and 11.27 g/day for 95%, 80%, 60% and 40% intake levels respectively. All the treatments had positive nitrogen balance, although it was affected by the level of feed intake (Table 4). It was also observed that the nitrogen balance and intake of digestible organic matter were linearly related.

Table 4. The effect of level of feed intake on nitrogen balance on local Zebu cattle

	Level of feed intake (%)				
(g/day)	95	80	60	40	Sig
Nitrogen intake	62.42 ± 0.50	53.22 ± 0.48	40.09 ± 0.34	26.73 ± 0.40	0.001
Faecal nitrogen	10.93 ± 0.82	11.19 ± 0.74	08.59 ± 0.75	06.18 ± 0.77	0.05
Urinary nitrogen	11.18 ± 0.78	12.07 ± 0.74	11.75 ± 0.73	09.29 ± 0.72	0.05
Nitrogen balance	40.30 ± 2.96	29.95 ± 2.09	19.74 ± 1.84	11.27 ± 1.28	0.001

As suggested by Chen *et al* [16] following banding system can be used for Sri Lankan cross bred cattle to predict the nutritional status.

Table 5. The corresponding values for the daily PD excretion and microbial N supply in indigenous Sri Lankan crossbred cattle at five different ranges of PDC index.

Band	PDC Index ($kg^{0.75}$)	PD excretion (mmol/day)	Estimated microbial N (g/day)	Nutritional status
1	< 19	< 11	08 – 15	Under feeding
2	19 - 27	20 – 24	15 – 22	Under feeding
3	27 - 44	29 – 44	22 – 32	Sufficient
4	44 - 59	44 – 58	32 – 43	Good
5	> 69	58 – 78	43 – 57	Very good

PDC index and corresponding microbial N supply are divided into 5 bands. The corresponding microbial N values to PDC index of groups II and I are 8-22 g/day. This is an indication of insufficient feeding and the value matches with 40% feeding level (Table 5). Experimentally estimated DOMI at 40% feeding level was 0. 85 kg/day.

In order to use of PDC index to estimate DOMI (kg/day) of Sri Lankan crossbred cattle, DOMI values obtained from experiment I were plotted against PDC index that were obtained from spot urine analyzes. By using the equation derived in figure I, DOMI (kg/day) were estimated as 1.05±0.3 and1.253±.0.34 for band II and I respectively. Results suggest that the feeding values estimated experimentally and by using the equation was did not differ much. Therefore, it is possible to use the average PDC index as a tool to estimate the nutritional status of local cattle.

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Development and evaluation of a New Cage Wheel for power tiller

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Abstract

In Sri Lanka, land preparation for the cultivation of paddy is done mainly using the power tiller. The moisture content of paddy soil is usually very high. Therefore, power tillers that are operated in the saturated or flooded condition often require special devices called "Cage Wheels" in place of wheels. Rotation ring type Cage Wheels with retractable lugs for power Tillers were designed and developed to provide easy road transportation and to improve performance in wetland operations. A pair of cage wheels was constructed after testing the first wheel and implementing necessary modifications. The developed wheel consists of an inner ring and an outer cage. The 12 lugs were hinged on the inner ring resting on cross bars of outer cage those guide the lugs when the wheel was expanding or retracting. The 4 pulleys were provided on the inner side of the inner ring to rotate it smoothly when the wheel diameter was changed.

Two experiments were conducted in tow locations (dry and wet soil conditions) to compare the performance of the developed wheels with conventional cage wheels. Effective field capacity, time per hectare, traveling speed, travel reduction, the pull developed at 100% slip and wheel costs were considered in evaluation.

From the result, it was observed that the performance of designed cage wheels were significantly higher in both locations. Increase in pull and power of the developed cage wheel over conventional was about1.5 and 1.6 in both soil conditions, respectively.

Background and Objectives

Agricultural tractors are normally operated under difficult soil conditions, especially in rice fields. The efficiency of field operations is limited due to very adverse traction performance of pneumatic wheels under wet soil conditions. Therefore Power Tillers that are operated in the saturated or flooded conditions often require special devices called "Cage Wheels" attached to the tyres (Datta and Ojha 1970, Devnani and Ojha 1970 and Bangali, 1976). Main objective of this study was to design and develop a suitable mechanism for a Cage Wheel with retractable Lugs for tow wheel tractor and to compare the performances of the above wheel with conventional cage wheel.

Materials and Methods

A pair of Cage Wheels was constructed after testing the first wheel and implementing necessary modifications. The developed wheel consists of an inner ring and an outer cage (Figures 1 and 2). The 12 lugs were hinged on the inner ring resting on cross bars of outer cage those guide the lugs when the wheel was expanding or retracting. The four pulleys were provided on the inner side of inner ring to rotate it smoothly when the wheel diameter was changed.

Tow experiments were conducted in two locations (dry and wet soil conditions) to compare the performance of the development wheels with conventional cage wheels. Effective field capacity, time per hectare, traveling speed, travel reduction, the pull developed at 100% slip and wheel cost were considered as criteria for the evaluation of cage wheels.

In order to evaluate the uniformity of the soil throughout the field, bulk density, true density, Atterberg limits, soil texture, soil compaction, cone index, cone depth and hardpan depth of paddy soil were tested.

Results

The field test performance of different traction aids was compared by obtaining number of parameters. Test results were obtained for two traction aids, each having three replicates. Mean values of these results are tabulated in Table 1.

Table 1: Comparative test result of Design Cage wheel and conventional Cage wheel for puddling.

Traction aids	Maximum pull (kg)	Theoretical forwarded speed (m/s)	Actual forwarded Speed (m/s)	Travel reduction (%)
Conventional Cage Wheel	164.70	1.52	1.25	17.70
Designed Cage Wheel	237.00	1.52	1.37	9.70

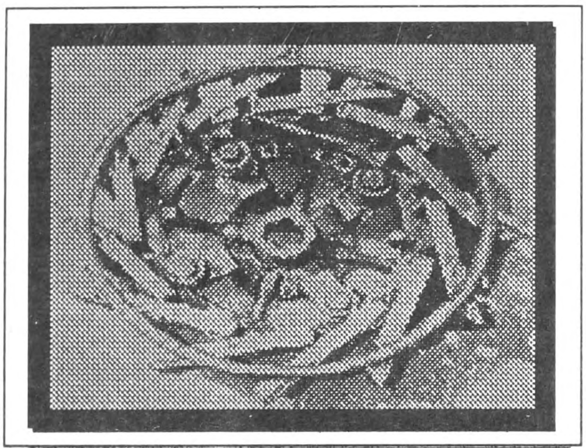

Photo 01 Designed Cage Wheel (Retracted

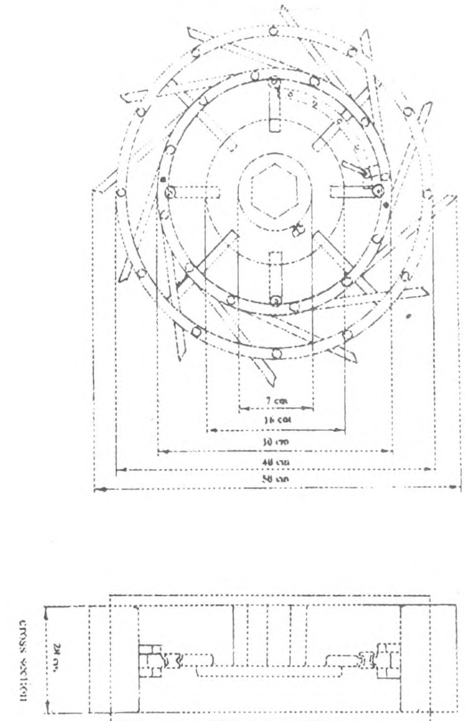

Figure 2 . The designed cage wheels (Retracted position)

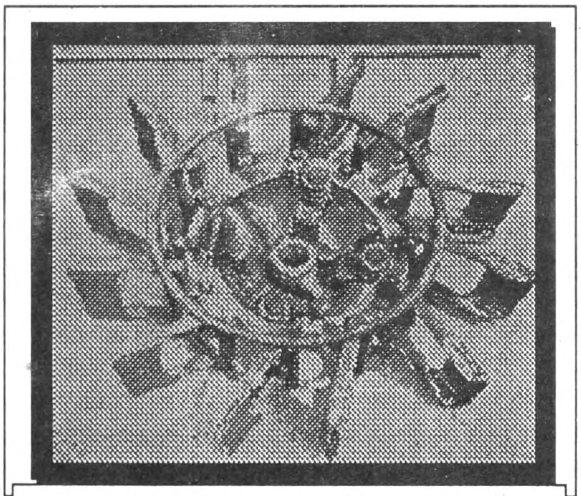

Photo.02 Designed Cage Wheel (Extended position)

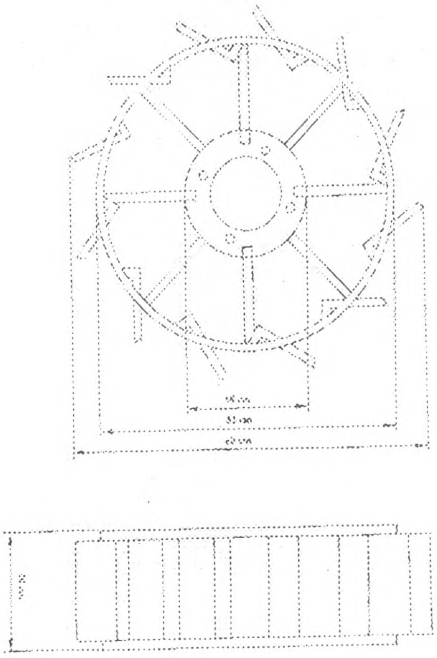

Figure [illegible] drawing of the conventional cage wheel

According to the results of the tests conducted in the research station it was found that the travel reduction of the developed cage wheel has significantly reduced compared to the conventional cage wheel. This was proven by using F-tests (Duncan's multiple range test) at different precision levels.

From the results, it was observed that the performance of designed cage wheels was significantly higher.

Increase in pull and power of the developed cage wheel over conventional was about 40%,

Following advantages of the developed cage wheel over the other traction aids can be identified:

1. It is capable of having a larger diameter than the tire in field operations and a smaller diameter for road transportation.
2. The hinged flat lugs penetrate to the hard pan properly compared to the triangular lugged mechanism and produce more traction
3. Retraction and extension of the lugs can be performed easily in wet or dry soil condition. Lug can be extended by driving the tractor in reverse direction with jerking action after disengaging a key in the retracted position.
4. Fabrication and maintenance of the cage wheel is simple. Maintenance of the wheel is easy since the lug bolts can be dismantled easily.
5. While reversing the tractor, angle of the lug changes from +30 to –30, due to swinging lug mechanism.

Conclusion

The performance of development cage wheel with retractable lugged was far batter than other tested traction aids. It can be clearly observed that the performance of the developed Cage Wheel was significantly higher in each soil condition. The relative improvement in performance of the developed cage wheel over Conventional Cage wheel was about 1.5 for pull and around 1.6 power in both soil conditions.

Finally it can be conclude that the principle of swinging flat lug retractable cage mechanism functioned well on road as well as in field. One of its main advantages is the capability of traveling in the reverse direction, as well as in forward direction without bogging down. Using the retracting lug principle, the Cage Wheel can be developed further.

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