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Systems Modelling in Dairy Development under Coconut

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ABSTRACT. Systems modelling is a useful tool in farming system research to study the system behaviour and to analyse the sensitivity of the system to various interventions. This paper explores the potential of using livestock models for assessing the dairy development strategies under coconut. The 'Java' feed allocation model used in this study, has the capacity of estimating the potential animal production in an area in reference to feed availability and to assess the impact of various innovations developed through research and development. Using modelling approach, potential of milk production in two coconut growing areas in Pannala Divisional Secretariat (DS division) in Kurunegala district was assessed. Each DS division comprised of 3 Grama Niladari Divisions (GNDS). GNDS of Ihala Makandura, Pahala Makandura and Elivila GNDS (Paddy dominant area) had higher potential for milk production (99750 l per year) in reference to the quality of feeds available compared to the GNDS of Irriyagolla, Pathigodagethera and Paragammana (Coconut dominant area) (85125 l). In both areas, the energy level of nearly 50% of the available feeds were below the maintenance requirement (512 kJ $kg^{-0.75}d^{-1}$). At present the availability of Gliricidia (<u>Gliricidia sepium</u>) at least in live fences is found to be comparatively low (10 plants/100 m of fence) in both areas. Indications are that the incorporation of Gliricidia in live fences would be a good option for increasing the potential of milk production without disturbing the existing farming system.

INTRODUCTION

'Systems approach' or 'Total system view point' has been widely accepted in the recent era in solving problems in complex farming systems. The objectives of systems research are to predict the behaviour of a system or more commonly to improve control over an existing system or to design new systems.

Systems research relies to a considerable extent on the use of models because it is often impossible or impractical to study the real system. Systems can be visualised by models. Modelling offers the possibility of examining large numbers of alternative practices/systems, through simulation whereas only limited number of production systems/practices can be examined experimentally. Mathematical modelling for livestock production systems is a research tool that can be used effectively to organise and collate existing research information for application and to study future impact of different interventions to the existing system. Various modelling approaches and software packages

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have been used for simulation of livestock systems and feed allocation (Udo and Brouwer, 1993; Zemmelink *et al.*, 1992). Maximisation of animal production in mixed farming systems where there is a high variation of quality and quantity of available feeds can be simulated by employing feed allocation models.

Domestic milk production in 1999 was estimated as 347 million litres which meets only 20-25% of the demand whereas the volume of milk products imported to Sri Lanka in 1999 amounted to Rs. 7118 million (Anon, 1999). This emphasises the importance of boosting the domestic milk production in Sri Lanka. The coconut triangle has been identified as one of the potential areas for increasing milk production in the country. The poor quality of natural pasture under coconut in terms of digestibility and crude protein, low dry matter production along with large seasonal fluctuations have limited the development of livestock for milk production in the coconut triangle (Perera, 1996). Much work have been done on strategies to overcome feed shortages and number of technological packages have been developed to improve the intake of poor quality feeds and to solve the issue of fluctuation of feed supply. Above technological innovations includes, establishment of pasture under coconut (Santhirasegaram, 1966), supplementation of Gliricidia (Liyanage *et al.*, 1993), feeding urea treated straw (Schiere *et al.*, 1988) and combination of these methods. Impact of those innovations on livestock production has not been assessed. Possibility of feed allocation models to assess the various interventions to feed resource base on livestock production is a valuable research and policy tool for development of livestock under coconut. Apart from that, feed allocation models are also useful in predicting potential animal production in certain areas in reference to feed availability. Therefore, this paper explore the potential of using livestock model (Java) to assess the milk production in two areas in the coconut triangle in relation to feed availability.

MATERIALS AND METHODS

Research area and feed availability

This study was done in Pannala Divisional Secretariat (DS division) in Kurunegala district. Pannala DS division comprised of 87 Grama Niladhari divisions (GNDS) of which two areas each with 3 GNDS were selected for comparison of milk production in relation to feed availability in each area. Area, which comprises of Irriyagolla, Patigodagedara and Paragammna GNDS was predominantly coconut growing area with lager coconut estates and for the sake of simplicity, hereafter it is referred as 'Coconut dominant area'. Other area selected comprises of GNDS, Ihala Makandura, Pahala Makandura and Elivila. It is predominantly paddy-growing area and hereafter it is referred as 'Paddy dominant area'. Data collection was done separately for each division. Available feeds identified in a Participatory Rural Appraisal (PRA) were used for quantification in this study. Quantification of available feeds was done by field measurements and the use of literature (Liyanage and Jayasundara, 1987; Gunasena *et al.*, 1996; Ferdinandez, 1978). Nutritive values were taken from previous studies (Ibrahim, 1988; Ibrahim and Jayatilake, 1999).

Livestock model

Optimum utilisation of feed resources was evaluated employing computerised calculation model; "Java programme" developed by Zemmelink *et al.*, 1992. The program was designed to calculate the effect of varying degrees of selection on the number of animals that can be fed *ad libitum*, corresponding production in terms of live weight gain (LWG) and the total production of the herd (TLWP).

The Java program assumes that voluntary intake is related to the quality of the feed offered. The input data required is the feed table giving amount and quality of each feed. Quality data required are dry matter digestibility (DMD) or organic matter digestibility (OMD), crude protein content (CP) and energy concentration in dry matter. The Java program is further based on the principle that maximum animal production could be obtained when the feed is spent as little as possible on maintenance (*i.e.*; when animals are fed *ad libitum*) and if only part of feed is used, those giving highest intake of metabolic energy (IME) are selected first. The first step of "Java program" is the ranking of feeds according to IME. This value is calculated in 2 steps. In the first step intake of organic matter (IOM) is calculated, using the equation developed by Ketelours and Tolkamp (1991) for sheep, *i.e.*;

$$IOM = -42.78 + 2.3039 * OMD - 0.0175 * OMD^2 - 1.8872 * N^2 + 0.2242 * OMD * N$$

IOM is expressed in g $kg^{-0.75}$ d^{-1} and both OMD and N (Nitrogen concentration in organic matter) as percentage (g/100g). IOM calculated, is multiplied by correction factor (1.33) to account for higher metabolism needs of cattle. Then IOM is multiplied by OMD to ascertain IDOM (intake of DOM) and it is converted into IME assuming that 1 g of DOM is equivalent to 15.8 kJ ME.

After ranking the feeds according to IME the program starts a stepwise procedure. In step 1, a certain fraction (*e.g.*, 1% to be decided by the user of program) of the total amount of feed DM available is taken. In step 2 the next 1% is added and so on, until all the feeds are included. At each step, the program calculates the following values.

a. Total amount of feed dry matter (DM) included
b. Weighted mean of OMD and N
c. IOM for sheep from DOM and N according to equation, multiplied with a correction factor (ICF) for other species and
d. IME as described above

And using these values the following are calculated:

e. The number of animal units (AU) that can be fed *ad libitum*; in principle (a)/(c), but taking into account the definition of the animal unit the period of time and ash content of the feeds,
f. Production (mean live weight gain, MLWG) per AU per day, and
g. Total live weight production (TLWP); (e) * (f)

LWG per animal per day (f) is calculated on the basis of the equation;

$$LWG = (IME - ME_m) / b$$

where, ME_m represents the maintenance requirement and 'b' the ME needed per gram of LWG. Values of 'b' and ME_m are chosen by the user.

RESULTS AND DISCUSSION

Feed availability and nutritive value

Total feed availability per year in 'coconut dominant area' and 'paddy dominant area' are given in Table 1 and the nutritive values of feeds are given in Table 2.

Table 1. Feed availability per year in 'coconut dominant' and 'paddy dominant' areas.

Source of feeds	Total feed availability (tons/year)	
	Coconut Dominant area	Paddy Dominant area
Gliricidia	26.4	13.3
Natural grasses		
Under coconut	1166.0	468.0
Paddy fields	644.0	1194.0
Roadside grasses	188.0	217.0
Creepers	4.2	2.8
Banana wastes	196.0	214.0
Jack		
Leaves	6.3	5.1
Fruit wastes	36.0	29.4
Brachiaria mutica	16.0	-
Brachiaria brizantha	3.0	-
Rice straw	1626.0	3008.0
Rice bran	45.0	84.0

Effect of selective utilisation of feed

The feeds rice bran, *Gliricidia*, and *B. mutica* had highest energy intake levels 750–850 kJ $kg^{-0.75}$ d^{-1} (1.5–1.7 times maintenance). Grasses in paddy fields had energy intake level 1.3 times of maintenance while the energy intake levels of grasses under coconut which are supposed to be the major feed sources for livestock in coconut based farming systems, is just enough to meet the maintenance requirement (*i.e.*, 512 kJ $kg^{-0.75}$

d^{-1}). Energy intake level of rice straw tends to be below the maintenance requirement 350 kJ kg$^{-0.75}$ d^{-1}. The dotted line of Fig. 1 (1–5) shows the degree of selection of different feed resources in coconut dominant area. For example when 2% of the available feeds including whole amount of rice bran, Gliricidia and 45% of the available *B. mutica* were used, a higher quality ration (15% CP*, 70% OMD) is obtained. This resulted in IDM of 85 g kg$^{-0.75}$ d^{-1} and highest MLWG, 872 g AU^{-1} d^{-1} which is equivalent to 6.5 l of milk (1 kg of LWG is equivalent to 7.5 l of milk in terms of metabolic energy).

Table 2. Crude protein, organic matter and organic matter digestibility of feeds.

Feeds	CP (%)	OM (%)	OMD (%)
Gliricidia (whole leaves)	21.8	85.6	61.4
Natural grasses			
Under coconut	8.2	87.9	47.8
Paddy field	12.1	87.4	57.2
On roadside	7.9	89.2	46.3
Banana leaves and stems (Petioles, leaves and psuodostems)	9.5	91.0	59.5
Jack			
Leaves	15.3	90.3	49.3
Fruit skin and refuse of fruit	7.6	84.8	42.7
Creepers	14.9	86.4	49.4
B. mutica	12.5	89.1	70.1
B. brizantha	10.8	91.6	53.2
Paddy straw	4.9	85.4	39.8
Rice bran (No. 1 and No. 2)	11.1	86.0	76.0

Sources: Ibrahim, 1988; Ibrahim and Jayatilake, 1999

As a result the TLWP is 8.8 tons and the herd size at this production level is only 35 AU. In the study area nearly 50% of cattle and buffalo population is female of more than two years of age (Ibrahim and Jayatilake, 1999). Therefore, corresponding total milk production is equivalent to 33000 l of milk. However, when more of feeds are included in the ration, quality of the ration decreases so as the intake. However, decrease in LWG with the increase in inclusion of lower quality feed stuffs is compensated by the increase in herd size resulting in higher total live weight production. However, this is only until 23% of DM is offered. At this level total live weight production is 22.7 tons with MLWG of 129 g AU^{-1} day^{1}, which is the maximum TLWP with available resources. The corresponding herd size is 484 AU. When this is expressed in terms of milk, it is 1 l AU^{-1} d^{-1} and maximum milk production is equivalent to 85125 l per year. However, the actual milk collection in the coconut dominant area is approximately 30000 l per year (Pers.

Comm. with milk collectors). Further the priority given for milk production in coconut dominant area is low, as the number of farmers keep cattle for secondary benefits such as for manure, weeding, financial security and preparation of paddy lands.

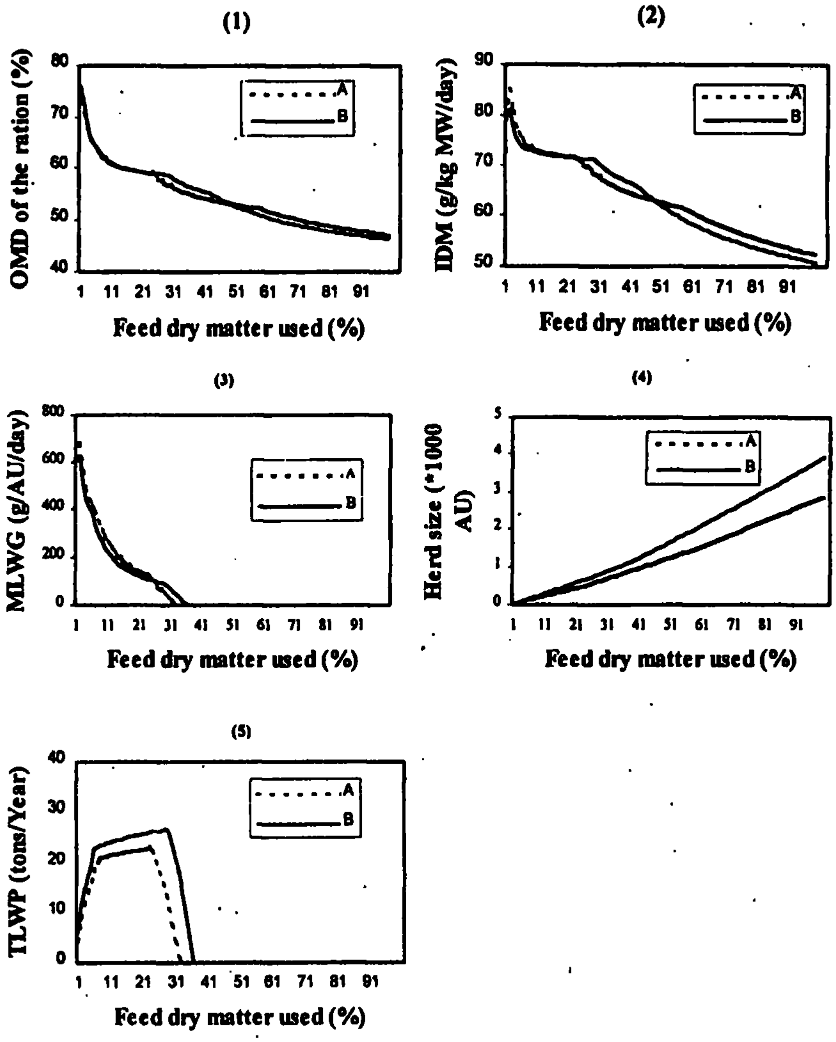

Fig. 1. Effect of using various proportions of feed dry matter on (1) OMD of the ration, (2) IDM, (3) MLWG per animal, (4) herd size and (5) TLWP in coconut dominant area (A) and paddy dominant area (B).

The solid line of Fig. 1 (1–5) shows the degree of selection of different feed resources in paddy dominant area. Highest MLWG (840 g AU^{-1} d^{-1}) is obtained when 2% of the total available feeds including whole amount of rice bran, *Gliricidia* and 4% of the

Banana wastes are included in the ration (73% OMD, 12.5% CP[3]). Herd size which can be fed *ad libitum* with this ration is equivalent 50 AU, resulting in 11.1 tons of TLWP. In terms of milk production this is equivalent to 6.3 l AU^{-1} d^{-1} and 41625 l of total milk production per year. As more feeds are included MLWG decreases while herd size, which can be fed *ad libitum* increases resulting in higher total live weight production. However, this trend goes only when up to 28% of total dry matter is used. At this level the maximum total production of 26.6 tons is achieved with MLWG of 103 g AU^{-1} d^{-1} and the herd size of 784 AU. In terms of milk, this is equivalent to 0.8 l AU^{-1} d^{-1} and 99750 l of total milk production per year. However, the actual milk collection in this area is approximately 60000 l per year (Pers. Comm. with milk collectors).

When coconut dominant area and paddy dominant area are compared for livestock production (primary), the potential of livestock production with only freely available feed resources is higher in paddy dominant area than in coconut dominant area. However, when total feed availability is considered, amount of feed available in coconut dominant area (5235 tons) is higher than that of paddy dominant area (3950 tons). In fact, natural grasses under coconut, the major feed resource in coconut based farming system is higher in coconut dominant area (30% of total DM) due to comparatively large extent of coconut (3347 ac) compared to the other area (8% of total DM). However, it's contribution to the primary production was (milk/meat) low, due to the poor feeding value in terms IME (550 kJ $kg^{0.75}$ d^{-1}) which is just enough to meet the maintenance requirement. *i.e.*, 512 kJ $kg^{0.75}$ d^{-1}.

Rice straw accounted nearly 50% of total feed resources in both the areas, which had IME below maintenance. However, the production (primary) level of paddy dominant area is higher than coconut dominant area due to the availability of higher amount of rice bran and natural grasses in paddy fields, which are comparatively higher in metabolic energy. Grass on bunds is available almost throughout the year for cut and carry during the time when the paddy is cultivated and grasses in the other areas in paddy fields (area excluding bunds) are available when paddy is harvested. Therefore, the technical potential of keeping livestock for primary production in paddy dominant area is higher.

Use of simulation models for testing livestock interventions

In order to illustrate the use of simulation models to assess the impact of interventions (sensitivity analysis), effect of increased availability of Gliricidia (*Gliricidia sepium*) was considered in this study. For example, when the coconut dominant area is considered, Gliricidia is mainly planted in the fences. Although, availability of Gliricidia even as live fence is comparatively low, (10 trees per 100 m of fence), if the availability of Gliricidia is increased by planting trees in the fence at least 2 m apart, use of Gliricidia as an animal feeds could be increased five fold. This results in increasing the max. TLWP by 12 tons (Fig. 2 - dotted line) (Corresponding milk production is 45000 l) compared to potential TLWP with present availability of feeds (solid line - Fig. 2). In the same manner other possible interventions such as expanding the area of pasture with proportionate

[3] Not shown in Fig. 1.

increase in the area of Gliricidia or supplementation of low cost concentrates could be simulated and impact of such innovations could be assessed beforehand.

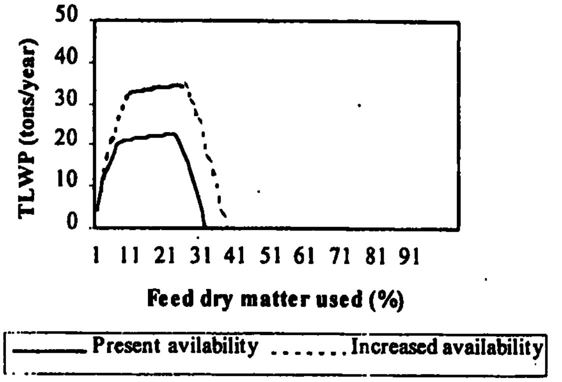

Fig. 2. Effect of increasing the availability of Gliricidia on total live weight production (TLWP).

CONCLUSIONS

Area comprised of Ihala Makandura, Pahala Makandura and Elivila GNDS (paddy dominant area) has higher biological potential for dairy farming (when only the quality of available feeds is taken into account) compared to the area comprised of Irriyagolla, Pathigodagethera and Paragammana GNDS (coconut dominant area). Gliricidia is found to be a promising low cost feed supplement, which could be popularised in the area under study without disturbing the existing farming system. The modelling approach used in this study is found to be a valuable research and policy tool that can be effectively used in assisting decision-making process. Models used to simulate feed utilisation in livestock research are useful tools for understanding present feeding practices and evaluation of proposed new technologies.

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