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# A MATHEMATICAL MODEL AND COMPUTER PROGRAMME FOR THE ECONOMIC ASSESSMENT OF TRADITIONAL SYSTEMS OF PRODUCTION OF MILK AND WEANED CALVES

J A Herrero & S Berry[1,2]

*Universidad Católica Madre y Maestra, Santo Domingo, Dominican Republic*

A mathematical model of the traditional dual purpose system (production of milk and weaned calves) is described. Its use to identify limiting factors to the systems productivity is discussed.

On the basis of the model a computer programme is listed and the use of this programme described.

Key words: Cattle, duel purpose systems, computer programme, economic evaluation, mathematical model

## 1. *Introduction:*

The purpose of this article is to describe a simple, easily applicable mathematical model, designed for the analysis of the technical and economic parameters that exist within a determined dual-purpose herd (production of milk and weaned calves).

For the purpose of this work the definition of the word model is taken to be: a simplified abstraction of the reality under study. The model is described in algebraic terms as this is the only form in which one can arrive at numerical results that can be evaluated precisely.

The model has been divided into 5 sections that are described seperately, but at the same time are interelated one with another and together form the basis of the model. These sections are as follows:

1. The growth periods and the productive and non- productive periods during the life of a member of the herd.
2. The structure of the herd and stocking rate.
3. The productivity of the herd.
4. Income, costs and profitability

In its most simple form the model has 34 equations which define 34 fundamental variables that exist within the system.

## 2. *Description of the traditional dual-purpose (milk/weaned calves) production system:*

The model to be described is based on the dual-purpose production

[1] *Present address: CEDIPCA, CEAGANA, Aptd 1256/8, Santo Domingo, Dominican Republic.*

[2] *Technical Cooperation Officer, Overseas Development Administration, London, UK*

system widely used in tropical Latin America. For the purposes of the model the important characteristics of the system are as follows:

1. The production of: milk, weaned calves, cull cows and infertile heifers.
2. The milking of cows with calf at foot which implies the rearing of calves by restricted suckling and the virtual coincidence of the weaning of the calf and the end of lactation.
3. The grouping of the animals within the herd is:
   (i) suckling calves
   (ii) young replacement heifers
   (iii) bulling replacement heifers
   (iv) lactating cows
   (v) dry cows
4. The use of natural mating.

## 3. *The model*

### 3.1 *The definition of the growth periods and the productive and non-productive periods during the life of a member of the herd*

The life of a member of the herd can be divided into a period of growth followed by alternate productive and non-productive periods.

This simple division of the animals adult life into the periods of lactation and the dry periods is of fundamental importance in relation to the productivity and management of the herd. It is common policy for the care of the cow during her dry periods to be inadequate without a realisation of the consequences of this management in terms of the future development of the cows production. The management of the cow during the dry period has far reaching consequences in terms of the cows performance during its subsequent lactation. The importance of the lengths of lactation and dry period and their relation one with another will be manifested in many of the equations that follow.

It is necessary to distinguish between the non-productive period (dry period) in between lactations and the so called non-productive period from birth to first calving . In terms of milk production both of these periods are identical but with regard to the production of meat the non- productive period between calvings is substantially distinct from the period between birth and first calving.

The following equations describe the relationships between the age at first calving, the lactation length and the length of the dry period, with the growth rates of the non - adult animals and the level of fertility of the herd.

### 3.1.1 *Age at first calving*

(1) $C4 = C2 + C3 + 9$

where: C4 = age at first calving (months)
C2 = age of the heifer when it reaches bulling weight (months)
C3 = delay in conception after the heifer has reached bulling weight (months)

Equation 1 describes a well known process within meat and milk production systems. Distinct recommended bulling weights are recommended for the various cattle breeds, the age at which the animal reaches this weight is one of the determinants of age at first calving (C4). The other fundamental variable in determining the age at first calving is the delay in conception that the heifer exhibits after reaching the acceptable bulling weight (C3), the period of gestation being fixed (approximately 9 months).

The value of the variable C3 reveals the level of care and management that is dedicated to the herd replacements. The existance of the variable C3 in livestock production systems distinguishes these from other forms of production. In the livestock herd each unit of production requires special individual attention. The importance of the variable C3 in terms of its effect on the cost of production and income of the herd is often underestimated. The loss of a heat, given that the animal has reached bulling weight, will reduce the lifetime productivity of the animal.

For example, the missing of a heat signifies a delay of three weeks in the age of first calving and 3 weeks delay from then on in all the subsequent processes of reproduction . This signifies foregone income equivalent to the value of the production of milk and meat during the lost period. Furthermore the extension of the delay (C3) reduces the length of the useful life of the cow in relation to her entire life in terms of reproductive capacity of the animal in the herd. Thus in order to be able to produce the same quantity of calves per year, as C3 increases, it will be necessary to increase the number of adult cows in the herd (an increase in investment). The return on this additional investment will be negative as it will be necessary to carry it out only to recuperate lost production signified by an increase in the value of C3.

A prolonged period between bulling weight and conception, increases the length of time the heifers are with the bull. This in turn means that in order to obtain the number of calving heifers necessary to replace the cull

cows and thus to maintain herd size it will be necessary to have a larger number of bulling heifers. This signifies an increase in the costs associated with the maintenance of the herd and furthermore increases the investment that exists in livestock (see Equation 16).

In brief, large values for C3 signify high numbers of female animals and bulls in the herd (there could be less if the value of C3 was smaller). This implies that the investment necessary to manage the herd and the cost associated with its maintenance are greater than that required when C3 is small. This excessive investment and increase in costs must be financed by an increase in the prices of the farm products. Price increases of milk and meat reduce the markets' consumption potential of these products and so generate the critical tension with regard to subsequent price increases, and reductions in levels of productivity. Equation 2 divides the age at bulling weight (C2) into the age at weaning (C5) and the subsequent delay in reaching bulling weight after having been weaned (C6).

(2) $C2 = C5 + C6$

where: C5 = age of the calf at weaning (months)
C6 = the period of time between weaning and reaching bulling weight (months)

The age at weaning (C5) depends on the calf's birth weight and its subsequent liveweight gain, which in turn depends on the genotype of the animal, its health status, nutrition and other environmental factors. This variable thus reflects the level of management of the pregnant cow and the subsequent care and management of the calf. The variable C6 reflects the level of management that the female calf receives and influences the age at which she calves down for the first time.

The variable C6, the delay in reaching bulling weight after being weaned, like C3 is a principal determinant of the replacement herd size. As the value of C6 increases the number of animals in the young heifer group will have to increase if the adult herd size is to be maintained, which again implies inefficiency and an increase in investment and the costs associated with the maintenance of the herd.

The group of variables C2, C3, C4, C5 and C6 thus form a group of variables whose management and administration is fundamental to the efficiency of the productivity of the herd.

Equations 3 , 4 and 5 define the variables C2, C5 and C6 in terms of the growth rates achieved by the animals during these specific periods (TC1, TC2 and TC3).

(3) C2 = (PA - PN)/(TC3 * 30.4) Note 365/12 = 30.4 days/month

where: PA = bulling weight (kg)
PN = birth weight (kg)
TC3= liveweight gain from birth to bulling weight (kg/d)

(4) C5 = (PD - PN)/(TC1 * 30.4)

where: PD = weaning weight (kg)
TC1 = mean liveweight gain from birth to weaning (kg/d)

(5) C6 = (PA - PD)/(TC2 * 30.4)

where: TC2 = mean liveweight gain from weaning to bulling weight (kg/d)

The value for each of these liveweight gains is obtained directly from the production records of the farm. Changes in these liveweight gains (TC1, TC2 and TC3), as a result of changes in farm management, will have a direct influence on variables C2, C4, C5 and C6 and will thus influence the herd's efficiency. In simple terms the group of variables C1 to 6 are fundamental in determining the age at first calving, the size of the replacement herd, the efficiency of the herd productivity and thus profitability.

### 3.1.2 *The frequency of calving*

It is well established that the lifetime milk production of a cow reaches a maximum when the cow calves every year. This is easy to understand. The daily production of a cow reaches a maximum a short time after calving and from then on the daily production decreases until the end of the lactation. Thus increasing the frequency of calving increases the mean daily production during the cows life, and so increases the total production during its lifetime . The equation 6 expresses the two components of the calving interval ($I_2$)

(6) $I_2 = I_3 + I_4$

where: $I_2$ = calving interval (days)
$I_3$ = lactation length (days)
$I_4$ = dry period between calvings (days)

The fundamental variable in determining the length of the calving interval is the interval between calving and conception ($I_5$), the gestation period being fixed (Equation 7).

(7) $I_2 = I_5 + 282$

where: $I_5$ = the interval between calving and conception (days)

Obviously this delay in conception in the adult cow ($I_5$) is synonimous with the corresponding delay in the heifer (C3) and the same discussion applies, the variable $I_5$ determining lactation length and calving interval which in turn determine the relative sizes of the dry cow and lactating cow groups and thus the efficiency of the herd (see Equations 9 and 10).

### 3.2 *The size and structure of the herd*

In order to be able to calculate stocking rate, the production of milk, the production of weaned calves that are not required as herd replacements and the costs associated with the maintenance and production of the herd, the herd size and its' structure must be known.

#### 3.2.1 *The adult herd*

(8) $H = CL + CD + B_1 + B_2$

where: H = mean size of the adult herd
CL = mean number of cows in production
CD = mean number of dry cows in the herd
$B_1$ = number of bulls with the cows in production
$B_2$ = number of bulls with the bulling heifers

Of course the number of dry cows in relation to the number in production will depend on the relationship between the calving interval ($I_2$), the length of lactation ($I_3$) and the length of the dry period ($I_4$) as follows :

(9) $CL = I_3 * (CL + CD)/I_2$

(10) $CD = I_4 * (CL + CD)/I_2$

#### 3.2.2 *The non-adult herd*

##### 3.2.2.1 *Suckling calves*

In the traditional system of meat and milk production of Latin America the cows are milked with the calf at foot which implies the rearing of the calves by restricted suckling and the virtual coincidence of the weaning of the calf

and the end of the lactation. This implies that the number of suckling calves in the herd is related to the number of cows in production (CL), although the number of still births (N) and the level of mortality (M1) will also influence the mean number of suckling calves that there are on the farm, this being estimated by Equation 11.

(11) $BL = (CL - (N * CL/P)) * (1 - (0.005 * M1))$

where: BL = mean number of suckling calves in the herd
M1 = % mortality between birth and weaning
N = number of still births/year

*3.2.2.2 Replacement heifers*

In order to maintain the size of the adult herd, for each adult cow that leaves the herd a heifer must calve. The number of heifers that are required to calve per year (NP) is desribed as follows:

(12) $NP = ((CL + CD) * 12/E) + ((CL + CD) * M4 /100)$

where: NP = number of heifers that must calve/year
E = the expected life of a cow in the adult herd (from first calving until leaving the herd) (months)
M4 = % mortality in the adult herd

Note. E does not include mortality in the adult herd.

In order that this number of heifers calve each year, a larger number of replacement heifers must reach bulling weight, since not all heifers reaching bulling weight will necessarily calve , due to infertility and mortality.

(13) $NR = (NP + B1)/(1 - (M3/100))$

where: NR = number of heifers that must reach bulling weight/year
B1 = number of heifers that must be sold due to infertility/year
M3 = mortality between bulling weight and first calving (%)

The loss of animals between weaning and bulling weight will be due to mortality occurring during this period of growth. Thus the number of weaned calves that must be reared as replacements can be expressed in the following form:

(14) BR = NR/(1 - (M2/100))

where: BR = number of weaned calves that must be reared as replacements
M2 = mortality between weaning and bulling weight (%)

Having established these values it is easy to estimate the mean size of the replacement animal groups (NJ and NM).

(15) NJ = BR * C6/12

where NJ = number of young replacement heifers

(16) NM = NR * (C3 + 9)/12

where: NM = number of bulling heifers

It should be noted that in these equations the variables C3 and C6 play a decisive role in determining the size of these two groups of replacement animals.

Having determined the herd structure the stocking rate (CA) can be calculated:

(17) CA = UA/AF

where: CA = stocking rate (animal units/ha)
UA = animal units on the farm
AF = area of the farm (ha)

In order to calculate this stocking rate the number of animal units on the farm must first be estimated (UA). This estimation is calculated using Equation 18. The coefficients in this equation are estimates of the liveweights of the different classes of animals relative to the mean liveweight of an adult animal.

(18) UA = H + (0.8 * NM) + (o.5 * NJ) + (0.2 * BL)
where H = number of adult animals

## 3.3 *The productivity of the herd*

### *3.3.1 Milk*

The total milk production per year (3Q) can be expressed

in the following form:

(19) $SQ = (CL + CD) * Q$

where: Q = mean production of milk/cow/year (quarts[1]/year)
SQ = total production of milk from the herd/year (quarts)

The annual milk production of the cows can be calculated directly from the herd records, or if lactation yields are available then this value can be converted to annual production using the following equation:

(20) $Q = PL * 365/I_2$

where: PL = production/lactation (quarts/lactation)

### 3.3.2 *Weaned calves*

The number of weaned calves that must be retained as replacements has already been calculated (BR) (see Equation 14). Having estimated this number, the number of calves that are available for sale can be calculated (BP).

(21) $BP = BD - BR$

where: BP = number of weaned calves that must be retained as replacements/year
BD = number of calves weaned/year

The number of calves weaned/year is equal to the number of calves born alive (BNV) less those that die between birth and weaning.

(22) $BD = BNV * (1 - M1/100))$

where BNV = number of calves born alive/year
M1 = mortality between birth and weaning (%)

Obviously the number of calves born alive per year will be related to the number of calvings that occur during the year (P) and to be more precise, will equal the number of calvings per year less the number of still births.

(23) $BNV = P - N$

where P = number of calvings/year
N = number of still births/year

In turn, the number of calvings will depend on the number of adult cows in the herd and the frequency of calving.

[1] *See the last page for alternative use of litres.*

(24) $P = (CD + CL) * 365/I_2$

### 3.3.3 *Cull cows*

The following equation estimates the number of cows that leave the herd/year

(25) $VD = T * (CL + CD)/100$

where: VD = number of cull cows sold/year
T = rate of turnover of the adult herd (%/year)

Obviously the determinant of the rate of turnover of the adult herd is the length of life of a cow in the adult herd (E)

(26) $T = 1200/E$

where E = duration of the period between first calving and the culling of the cow (months)

Now we have defined the production of the herd, it's structure and it's size. The next step is to calculate the value of this production (the income) and the cost of the maintenance of the herd and the production (the cost). The difference between the income and the cost represents the profitability of the herd.

## 3.4 *The calculation of the economic value of the farm: income and cost.*

In the previous section all the interelationships existing between the fundamental variables encountered within the dual-purpose production system have been discussed and furthermore these interelationships have been described in a precise mathematical form.

The productivity of the farm will be affected by the relationship that exists between the productive and non-productive periods during the life of an adult cow, and by the size of the groups of replacement animals necessary to maintain the size of the adult herd.

In this section the economic value of the farm will be estimated.

### 3.4.1 *The income*

The principal sources of income are the following: the sale of milk, the sale of weaned calves, the sale of cull cows and infertile heifers.

#### 3.4.1.1 *Milk*

With the knowledge of the total milk produced / cow/year and the price received/unit pf production (VQ), the total income from the sale of milk can be easily calculated

(27) ISQ = SQ * VQ

where: ISQ = total income from the sale of milk ($/year)
VQ = mean price of a quart of milk ($/quart)

*3.4.1.2 Weaned calves*

The number of calves available for sale per year is given by the variable BP. The total income from the sale of these calves (IBP) will be the product of the number of calves sold and the mean price received per calf (VBP). As is appreciated from the group of previous equations, BP is a residual variable. It is determined by the difference between the number of weaned calves and the number of female calves that are required to replace animals in the adult herd.

(28) IBP = BP * VBP

where IBP = total income from the sale of weaned calves ($/year)
VBP = mean price of a weaned calf ($/calf)

*3.4.1.3 Cull cows and infertile heifers*

From the number of cull cows sold/year (VD) and their value, the total income generated from the sale of these cows (IVD) can be calculated. In the same way the total income from the sale of infertile heifers sold per year can be calculated.

(29) IVD = VD * PV * VPV

(30) IBI = BI * VBI

where: IVD = total income from the sale of cull cows ($/year)
PV = mean liveweight of cull cows (kg)
VPV = price/unit of liveweight of cull cows ($/kg)
IBI = total income from the sale of infertile heifers ($/year)
VBI = mean price of an infertile heifer ($)

*3.4.1.4 The total income*

The total income is easily derived by summing the income from the various sources.

(31) IT = ISQ + IBP + IVD + IBI

where: IT = total income of the farm ($/year)

### 3.4.2 *The costs*

For the purposes of this study costs include expenses that signify an assignation of irrecuperable resources in a direct form that are destroyed in the process of their transformation to production. They are thus distinguished from investments or capitalizable costs, where the resource is not destroyed. This is the difference between cost and investment. The following outline is a guide for the calculation of the costs of production. This guide specifies the characteristics that an appropriate accounting system should have.

The business has two types of cost in the short term: costs that are related to the production (variable costs) and costs that are independant of the level of production (fixed costs).

#### 3.4.2.1 *Variable costs*

The variable costs most frequently encountered on a farm have been identified and classified. It is not intended that this classification should be exhaustive nor definitive. An infinitely long discussion could be maintained with relation to which costs should be considered as variable and those which should be regarded as fixed.

The following classification is intended as a guide only.

*Salaries* (SAL)

Foreman
Milkers
Labourers

*Maintenance of pastures* (PAST)

Renovation of old pasture
Repair of fencing
Repair of water troughs

*Fertilization* (FER)

*Supplementary feeding* (SUP)

Minerals
Molasses
Concentrates

*Animal health* (SAN)

*Fuel and electricity* (ELEC)

*Maintenance of buildings and constructions* (CONST)

*Maintenance of machinery and equipment* (MAQ)

*Replacement of bulls* (TORO)

*Others* (OTRO)

### 3.4.2.4 *Fixed costs*

As previously stated the fixed costs represent an assignation of resources aimed at the maintenance of the productive installation. This should not be confused with investment.The treatment that is given to the land will be included in this context. Land as an investment is distinct from the rent which is paid or implied for its use (current cost).

*Land (TA)*

There must be some way of assessing the annual cost of the land occupied by the production unit. It is suggested that the best way of quantifying this value is to use the market value for the rent of land. Although this cost is included,it is a cost that does not involve expenditure.

*Interest (INT)*

The interest paid on loans represents a fixed cost in the short term.

*Annual depreciation (DEP)*

Buildings and constructions
Tractors and vehicles
Equipment and machinery

There are various forms of calculating the depreciation of buildings and equipment, but the most simple is the one used in this work and is calculated using the linear depreciation method:

$$\text{Depreciation/year} = \frac{\text{value new (\$) - salvage value (\$)}}{\text{expected life (years)}}$$

One could start from this point to specify each one of the equations necessary to calculate each cost; however all the equations would have the same form. That is:

$$\text{Total cost of Factor A /year} = \text{Cost/unit of Factor A} * \text{Quantity of Factor A used/year}$$

In this simple model, the first approximation, the fixed and variable costs are assumed to increase in a linear fashion with the amount of the commodity used. Obviously, in the real world and in the dynamic situation, this is not the case for various reasons, such as the discounts for buying in quantity, the existance and the necessity to maintain inventories, the covering of risks against increases or decreases in price etc..

Applying the general equation to all the materials consumed by the production unit, the total costs can be calculated and thence the profitability of the farm.

The total costs (CT) are calculated in the following form:

(32) CT = SAL + PAST + FER + SUP + SAN + ELEC + CONST + MAQ + TORO + OTRO + TA + INT + DEP

where: CT = total costs of the farm ($/year)

### 3.4.3. *The profitability of the farm and the rate of return on capital invested*

Given the total income to be IT and the total cost to be CT it is easy to calculate the gross profitability (R).

(33) R = IT - CT

where R = gross profitability of the farm ($/year)

The rate of return on capital invested (TR) is calculted using the following equation:

(34) TR = (R + DEP) * 100/VI

where: TR = the annual rate of return on capital invested (%)
VI = the total value of the investment in the farm ($)

In the static model that we are considering this calculation of the rate of return on capital, provides a good enough estimate, although it is realised that it has its limitations, for the mere fact that in the real world the investment tends to be a dynamic process.

Having considered the total income and costs of the project it is necessary to make one or two important clarifications. Obviously the profitability of a project can be favourably affected by increasing the total income or decreasing the costs or by a combination of these two actions. There does, however, exist another avenue for increasing profitability and that is in the improvement in the efficiency with which inputs are converted to outputs. This model has been developed specifically with the latter in mind. Its use in practice enables one to quantify the positive effects that improvements in the levels of control and administration of the herd and its productivity will have on the profitability of the farm. It is too easy to say that the profitability of the farm will increase if the price of milk increases and the price of feed decreases. In the real world things are not this simple. A single farmer such as the one considered in this work is not able to dominate the market and influence its prices. Obviously if he had this control of the market his life would be a lot easier although that of his neighbour would not necessarily be so.

### 3.5 *The application of the model*

#### 3.5.1 *The use of the model in practise for the identification of limiting factors to profitability.*

Up until now the model has been developed considering the parameters that might affect the agricultural business and the interreactions that exist between these parameters. The basic solution of the model permits the calculation of profitability taking into account the productive periods and non-productive periods of the herd, the level of fertility and the rate of growth of young animals; it would be very useful to know which is the first limiting factor to an increase in the profitability. Obviously if the model would permit the identification of the first limiting factor, it could also predict the second limiting factor, and so on, permitting the ranking of the limiting factors in function of their economic importance.

Obviously the use of available resources in the solution or aleviation of this first limiting factor or any subsequent limiting factor, will imply the more efficient use of the resources or additional investments. The model can be used to identify these limiting factors, one by one and also provides the information to be able to calculate the benefits that are generated as a result of the elimination of a limiting factor and the costs that are involved in the execution of the improvement required. With this information the marginal benefit resulting from the elimination of a limiting factor can be estimated.

Having applied the model to a dual-purpose farm, the principal objective is the identification,for this particular case, of the weaknesses in the system. It might be, for example,that the calves are growing very slowly after weaning, or the calving interval is long, or the production of milk is low etc. The great advantage of this model amongst others, is that it can be applied to any farm as long as the present productive and reproductive parameters are known, which emphasises the essentiality of an adequate, easily analizable recording system.

The use of the model in question will also help to identify improvements that imply additional costs and those that only require improved management.

In summary, the use of the model implies the identification of management problems of the farm, and the quantitative evaluation of the costs, where applicable, and the benefits resulting from their solution.

## 4. *The computer programme*

Having developed the model described, the next obvious step was its adaptation for use in a computer.

The programme listed in the next section was written in Basic on a

SINCLAIR ZX 81 computer with 16 kilobytes of random access memory and so can be used with the majority of micro computers on the market.

In order to keep the programme short and simple and keep assumptions to a minimum, the computer programme does not include calculations of costs. The actual costs and any additional maintenance and production costs must be estimated from the information given by the computer (relating to herd structure) and the operator's knowledge of animal production and the probable costs involved in the alternative methods of improving a particular variable of the system.

The authors publish the details of the programme at this stage so that it might be tested on a wider scale. It is aimed at technicians, students, extensionists and advisers working in livestock production in the tropics and the authors encourage all kinds of feedback relating to experiences in the use of the programme and any modifications made to it.*

### *4.1 Inputs*

The programme will prompt for information relating to:

1. The adult herd size and area of the farm
2. The growth rate of young animals
3. The level of milk production
4. The calving interval and lactation length
5. The weight at which young heifers are put with the bull
6. Mortality
7. The prices obtained for the products of the farm, namely: milk, weaned calves, cull cows and infertile heifers.

The data entered by the operator should be means relating to the last year. The following information is calculated and displayed.

### *4.2 Outputs: Information calculated and displayed by the programme:*

The programme gives the calculated information in a series of tables. When one table is displayed, the programme stops and in order to continue the operator must depress the command "CONT" to see the next table.

#### *4.2.1 The herd structure and stocking rate*

The first table displayed describes the structure of the herd; that is the number of adult cows (the average number of lactating and dry animals), the number of bulls and the average number of suckling calves.

The size of the young heifer group and bulling heifer group (the herd replacements) required to maintain the size of the adult herd is also displayed along with the stocking rate. When there exist in the herd more than 25 cows or bulling heifers per bull this fact will be displayed at this stage.

* Editors note : Please refer to the editorial of this journal for notes on copyright

### 4.2.2 *The gross income.*

The total gross income is displayed and divided into that generated from the sale of milk, weaned calves, cull cows and infertile heifers.

### 4.2.3 *Technical coefficients.*

Next follow a series of tables that detail the technical coefficients exhibited during the last year by the farm under analysis. Some of the technical coefficients were prompted initially by the programme, the others have been derived from the primary data.

These coefficients are classified as follows:

(i) LIVEWEIGHT GAINS of the non-adult animal.
(ii) MORTALITY within the distinct animal groups.
(iii) LENGTH OF THE GROWTH PERIODS; that is age at weaning, age at bulling weight and first calving. The time spent by a replacement heifer in the young heifer group and bulling heifer group is also displayed, these being the principal determinants of the size of these two groups of animals.
(iv) CALVING INTERVAL AND ITS COMPONENTS; namely lactation length, the length of dry period and the calving to conception interval.
(v) THE PRODUCTIVITY of the herd in terms of milk production per cow per year and per lactation, production of weaned calves not required as replacements and the number of cull cows and infertile heifers sold/year.
(vi) THE RATE OF TURNOVER OF THE ADULT HERD.

## 4.3 *The changing of a single variable*

Having displayed all the information relating to the herd performance and productivity during the last year, the operator will have noticed areas in which deficiencies exist.

In order to assess the eventual effect of the correction of this deficiency the programme at this stage permits the operator to change the value of one variable.

To permit this change, the variables have been classified in the following seven sections:

1. Mortality and still births
2. Liveweights and liveweight gains in the non-adult animals
3. The calving interval
4. The level of milk production
5. The rate of turnover of the adult herd
6. The stocking rate
7. The prices obtained for the farm products

When the new value for the variable chosen is typed into the computer the programme is run and the new gross income, herd structure and technical coefficients are displayed.

Changing a variable in Sections 1 or 2 will also result in a change in stocking rate. If the operator wishes to keep the stocking rate at its original level then, having changed a variable in Section 1 or 2, he must then change the stocking rate back to its original value.

When the rate of turnover of the adult herd is changed then the stocking rate is maintained at its original level. In simple terms, when the rate of turnover is increased this will increase the number of animal units represented by the replacement animals in the herd. The programme thus adjusts the size of the adult herd (reduces it in this case) to maintain the stocking rate at its original level.

### 4.3.1. *Changing the stocking rate*

The stocking rate (animal units/hectare) is calculated on the basis of whole numbers of animals; it is thus possible that the new stocking rate chosen ( eg 2.21 animal units/ha ) is impossible to obtain on the basis of whole animal numbers, in this case the nearest possible stocking rate to that chosen is acceptable by the programme and displayed along with the appropriate herd structure. In the new herd structure there will be at least one bull per 25 cows and bulling heifers.

### 4.3.2. *The identification of limiting factors to the profitability of the farm.*

It is important to stress that the programme calculates total income and herd structure for each situation.

Before variables are changed it is advisable to calculate the fixed and variable costs, the capital invested and the rate of return of that capital for the present situation.

The process of changing the value of a given variable in practice, will invariably involve costs. Often there will be various methods of carrying out the change, each with its own pattern of costs, and some alternatives might involve additional capital investments.

From information calculated by the programme the operator can deduce the amount of additional income a given improvement will *eventually* generate when the improvement has been achieved. Against this must be offset the costs of carrying out the improvement and its subsequent maintenance.

In short, for each situation a cost-benefit analysis must be carried out to identify the most financially rewarding variable to change and the most efficient way of changing it.The model is used to: (1) calculate the progressive benefits specific to the changing of one variable, and (2) calculate changes in the herd structure during the period in which the variable is being changed, to facilitate the calculation of the costs associated with the improvement of a particular variable and its eventual maintenance.

THE COMPUTER PROGRAMME : SINCLAIR ZX 81 - BASIC

```
   1 REM "FARM"
   2 PRINT "MODEL DUAL PURPOSE F
ARM
            (MILK/MEAT)
            -FIRST APPROXIMATION
"
   3 PRINT
   4 PRINT "COPYRIGHT S.BERRY AN
D
            J.A.HERRERO,
            DOMINICAN REPUBLIC,
            MAY,1982."
   5 PRINT
   6 SLOW
   7 PAUSE 300
   8 PRINT "PLEASE ANSWER THE FO
LLOWING     QUESTIONS: -"
   9 PRINT
  10 PRINT "HOW BIG IS THE FARM
IN HECTARES?"
  11 PRINT
  12 INPUT AF
  13 CLS
  16 PRINT "HOW MANY COWS ARE TH
ERE?"
  22 PRINT
  25 PRINT "HOW MANY BULLS ARE T
HERE WITH   THE BULLING HEIFERS?
"
  30 INPUT B2
  32 PRINT
  35 PRINT "HOW MANY BULLS ARE T
HERE WITH   THE MILKING COWS?"
  40 INPUT B1
  45 LET B=B1+B2
  50 CLS
  60 PRINT "AT WHAT AGE ARE THE
CALVES      WEANED?"
  85 INPUT C5
  87 PRINT
  90 PRINT "WHAT IS THE MEAN CAL
VING        INTERVAL, IN DAYS?"
 110 INPUT I2
 111 LET P=INT (V*365/I2+.5)
 115 PRINT
 125 PRINT "WHAT IS THE MEAN LAC
TATION      LENGTH, IN DAYS?"
 130 INPUT I3
 132 CLS
 165 PRINT "WHAT IS THE PERCENTA
GE ANNUAL   MORTALITY"
 186 PRINT
 187 PRINT "1. BETWEEN BIRTH AND
 WEANING?"
 190 INPUT M1
 192 PRINT
 193 PRINT "2. BETWEEN WEANING A
ND BREEDING WEIGHT?"
 194 INPUT M2
 195 PRINT
 197 PRINT "3. BETWEEN BREEDING
WEIGHT AND  FIRST CALVING?"
 200 INPUT M3
 202 PRINT
 205 PRINT "4. IN THE ADULT HERD
"
 210 INPUT M4
 212 CLS
 215 PRINT "HOW MANY STILLBIRTHS
 OCCUR       DURING THE YEAR?"
 220 INPUT N
 222 PRINT
 225 PRINT "HOW MANY INFERTILE H
EIFERS HAVE TO BE SOLD EACH YEAR
?"
 230 INPUT BI
 232 CLS
 235 PRINT "AT WHAT WEIGHT(KG) A
RE THE      HEIFERS PUT TO THE B
ULL?"
 240 INPUT PA
 242 PRINT
 245 PRINT "WHAT IS THE MEAN BIR
TH WEIGHT?"
 250 INPUT PN
 252 PRINT
 255 PRINT "DO YOU KNOW THE MEAN
 WEANING     WEIGHT, YES OR NO?"
 260 INPUT A$
 262 PRINT
 265 IF A$="YES" THEN GOTO 285
 270 PRINT "WHAT IS THE LIVEWEIG
HT GAIN OF  THE CALVES TO WEANIN
G?"
 275 INPUT TC1
 276 CLS
 277 LET PD=INT (.5+PN+(C5*30.4*
TC1))
 280 GOTO 295
 285 PRINT "PLEASE WRITE IT IN K
ILOS?"
 290 INPUT PD
 291 PRINT
 292 LET PD=INT (PD+.5)
 293 LET TC1=(PD-PN)/(C5*30.4)
 295 PRINT "DO YOU KNOW THE RATE
 OF TURNOVEROF THE ADULT HERD, Y
ES OR NO?"
 300 INPUT A$
 302 PRINT
 310 IF A$="YES" THEN GOTO 330
 315 PRINT "WHAT IS THE EXPECTED
 LIFE        (MONTHS) OF A  COW I
N THE ADULT HERD?"
 320 INPUT E
 321 CLS
 325 LET T=INT (1200/E+.5)
 327 GOTO 340
 330 PRINT "PLEASE WRITE IT IN P
ERCENTAGES"
 332 INPUT T
 333 CLS
 335 LET E=1200/T
 340 PRINT "DO YOU KNOW THE COWS
 MEAN        LACTATION YIELD, YES
 OR NO?"
 345 INPUT A$
 346 PRINT
 350 IF A$="YES" THEN GOTO 385
 355 PRINT "DO YOU KNOW THE COWS
 MEAN ANUAL YIELD, YES OR NO?"
 360 INPUT C$
 361 PRINT
 365 IF C$="YES" THEN GOTO 410
 370 PRINT "WHAT WAS THE TOTAL M
ILK         PRODUCTION (QUARTS)
DURING THE  YEAR?"
 375 INPUT S0
 376 CLS
 377 LET Q=INT (S0/V+.5)
 380 LET PL=INT (Q*I2/365+.5)
 382 GOTO 445
 385 PRINT "PLEASE WRITE IT IN Q
UARTS?"
 390 INPUT PL
 391 CLS
 395 LET Q=INT (PL*365/I2+.5)
 400 LET S0=V*Q
 405 GOTO 445
 410 PRINT "PLEASE WRITE IT IN Q
UARTS?"
 415 INPUT Q
 417 PRINT
 420 LET PL=INT (Q*I2/365+.5)
 425 LET S0=INT (V*Q+.5)
 445 PRINT "AT WHAT AGE(MONTHS)
DO THE      HEIFERS REACH BULLIN
G WEIGHT?"
 450 INPUT C2
 452 PRINT
 455 LET TC3=(PA-PN)/(C2*30.4)
 460 LET C6=C2-C5
 465 PRINT "WHAT IS THE MEAN AGE
(MONTHS) AT FIRST   CALVING?"
 470 INPUT C4
 472 CLS
 475 LET C3=C4-C2-9
 485 PRINT
 500 PRINT "WHAT WAS THE MEAN PR
ICE($) PAID TO YOU FOR CULL COWS
?"
 501 INPUT VPU
 502 PRINT
 505 PRINT "WHAT WAS THE MEAN PR
ICE($) PAID TO YOU FOR INFERTILE
 HEIFERS?"
 506 INPUT VBI
 507 PRINT
 510 PRINT "WHAT WAS THE MEAN PR
ICE($) PAID TO YOU FOR WEANED CA
LVES?"
 515 INPUT VBP
 517 PRINT
 520 PRINT "WHAT WAS THE MEAN PR
ICE($) PAID TO YOU FOR A QUART O
F MILK?"
```

THE COMPUTER PROGRAMME : SINCLAIR ZX 81 - BASIC

```
 525 INPUT VO
 527 PRINT
 530 LET H=V+B
 535 LET I5=I2-282
 540 LET I4=I2-I3
 545 LET NP=((12*V)/E)+(M4*V/100
)
 550 LET VD=INT (T*V/100+.5)
 555 LET TC2=(PA-PD)/(C6*30.4)
 560 LET CL=INT (I3*V/I2+.5)
 565 LET CD=V-CL
 575 LET BNV=P-N
 580 LET NP=(NP+BI)/(1-(M3/100))
 585 LET I5O=5O*VO
 587 LET IBI=BI*VBI
 590 LET IVD=VD*VPV
 600 LET BL=INT ((CL-(N*CL/P))*(
1-(.005*M1))+.5)
 610 LET BD=INT (BNV*(1-(M1/100)
)+.5)
 615 LET NM=INT ((C3+9)*NR/12+.5
)
 620 LET BR=INT (NR/(1-(M2/100))
+.5)
 625 LET NJ=INT (BR*C6/12+.5)
 630 LET BP=BD-BR
 635 LET UA=H+(.8*NM)+(.5*NJ)+(5
L*.2)
 640 LET IBP=BP*VBP
 645 LET CR=(INT (100*UA/AF+.5))
/100
 647 CLS
 650 PRINT "STRUCTURE OF THE HER
D"
 652 PRINT
 655 PRINT "ADULT COWS",V
 656 PRINT " COWS IN PROD.",CL
 657 PRINT " DRY COWS",CD
 658 PRINT
 659 PRINT "BULLS",B
 660 PRINT
 670 PRINT "BULLING HEIF.",NM
 671 PRINT
 675 PRINT "YOUNG HEIF.",NJ
 676 PRINT
 680 PRINT "SUCKLING CALV.",BL
 681 PRINT
 682 PRINT "STOCKING RATE",CR;"
AU/HA"
 685 IF B/(NM+CL)>.04 THEN GOTO
688
 686 PRINT
 687 PRINT "**NB**THERE ARE MORE
 THAN 25   COWS AND BULLING HEIF
ERS PER    BULL"
 688 STOP
 689 CLS
 690 PRINT "          GROSS INCOME
 ($)"
 692 PRINT
 695 PRINT "FROM THE SALE OF: -"
 697 PRINT
 700 PRINT " 1.MILK",I5O
 701 PRINT
 710 PRINT " 2.CALVES",IBP
 711 PRINT
 715 PRINT " 3.CULL COWS",IVD
 717 PRINT
 718 PRINT " 4.INFERTILE
           HEIFERS",IBI
 719 PRINT
 720 PRINT " TOTAL",I5O+IBP+IVD+
IBI
 721 STOP
 722 CLS
 725 PRINT "    TECHNICAL COEFFI
CIENTS"
 726 PRINT
 727 PRINT "1.LIVEWEIGHTS AND LI
VEWEIGHT    GAINS"
 728 PRINT
 729 PRINT "BIRTH WEIGHT        =
";PN;" KG"
 730 PRINT
 731 PRINT " WEIGHT AT WEANING =
";PD;" KG"
 732 PRINT
 733 PRINT " LIVEWEIGHT GAIN"
 734 PRINT
 735 PRINT " -TO WEANING = ";(IN
T (TC1*100+.5))/100;" KG/DIA"
 736 PRINT
 737 PRINT " -FROM WEANING TO ";
PA;"KG      = ";
(INT (TC2*100+.5))/100;" KG/DAY"
 738 STOP
 739 CLS
 740 PRINT "2.ANNUAL MORTALITY(P
ERCENTAGE)"
 741 PRINT
 742 PRINT " TO WEANING
          ";M1
 743 PRINT
 745 PRINT " BETWEEN WEANING AND
";PA;"KG   ";M2
 746 PRINT
 747 PRINT " BETWEEN ";PA;"KG AN
D FIRST
   CALVING ";M3
 750 PRINT " IN THE ADULT HERD
          ";M4
 751 PRINT
 752 PRINT " ";N;" STILLBIRTHS/Y
EAR"
 753 STOP
 754 CLS
 755 PRINT "3.LENGTH OF PERIODS
OF GROWTH"
 757 PRINT
 758 PRINT "AGE AT FIRST CALVING
= ";C4;" MTHS"
 759 PRINT
 760 PRINT " AGE AT WEANING
= ";C5;" MTHS"
 761 PRINT
 762 PRINT " LENGTH OF THE PERIO
D BETWEEN    WEANING AND ";PA;"K
G    = ";C6;" MTHS"
 763 PRINT
 764 PRINT " AGE AT ";PA;"KG
     = ";C2;" MTHS"
 765 PRINT
 766 PRINT " LENGTH OF THE PERIO
D BETWEEN     ";PA;"KG AND FIRST
 CALVING
     = ";C3+9;" MTHS"
 767 STOP
 768 CLS
 769 PRINT "4.THE CALVING INTERV
AL AND ITS  COMPONENTS"
 770 PRINT
 771 PRINT "THE CALVING INTERVAL
= ";I2;" DAYS"
 772 PRINT
 773 PRINT " LACTATION LENGTH
= ";I3;" DAYS"
 774 PRINT
 775 PRINT " DRY PERIOD
= ";I4;" DAYS"
 776 PRINT
 777 PRINT " CALVING TO CONCEPTI
ON INTERVAL
= ";I5;" DAYS"
 778 STOP
 779 CLS
 780 PRINT "5.THE PRODUCTIVITY"
 781 PRINT
 782 PRINT "LACTATION YIELD     =
";INT (PL+.5);" QUARTS"
 783 PRINT
 785 PRINT "PRODUCTION/COW/YEAR
= ";INT (Q+.5);" QUARTS"
 786 PRINT
 787 PRINT "PRODUCTION OF SALEAB
LE WEANED   CALVES                =
";BP;"/YEAR"
 788 PRINT
 790 PRINT "NUMBER OF CULL COWS=
";VD;"/YEAR"
 791 PRINT
 792 PRINT "NUMBER OF INFERTILE
HEIFERS                           =
";BI;"/YEAR"
 793 PRINT
```

THE COMPUTER PROGRAMME : SINCLAIR ZX 81 - BASIC

```
 795 PRINT "RATE OF TURNOVER OF
THE HERD     = ";T;" PERCENT"
 796 STOP
 797 CLS
 799 PRINT "WOULD YOU LIKE TO CH
ANGE THE     VALUE OF ONE OF THE
VARIABLES,   YES OR NO?"
 800 INPUT A$
 801 CLS
 802 IF A$="NO" THEN GOTO 1515
 803 PRINT "THE VARIBLES HAVE BE
EN           CLASSIFIED AS FOLLOW
S:-
                1.MORTALITY AND STI
LLBIRTHS        2.LIVEWEIGHTS AND L
IVEWEIGHT         GAINS OF THE NON-
ADULT             ANIMALS
                3.THE CALVING INTER
VAL             4.THE LEVEL OF MILK
 PRODUCTION     5.THE RATE OF TURNO
VER OF THE        ADULT HERD
                6.THE STOCKING RATE
                7.THE PRICES OBTAIN
ED FOR THE        FARM PRODUCTS

               IN WHICH CATEGORY(1,
2,3,4,5,6      OR 7) DOES THE VARIA
BLE YOU WISHTO CHANGE LIE?"


 804 INPUT A
 805 CLS
 806 IF A=1 THEN GOTO 813
 807 IF A=2 THEN GOTO 917
 808 IF A=3 THEN GOTO 1170
 809 IF A=4 THEN GOTO 1190
 810 IF A=5 THEN GOTO 1223
 811 IF A=6 THEN GOTO 1243
 812 IF A=7 THEN GOTO 1260
 813 PRINT "PLEASE INDICATE WITH
 A NUMBER    BETWEEN 1 AND 5 WHIC
H OF THE     FOLLOWING VARIABLES
YOU WISH TO CHANGE:-"
 815 PRINT
 816 PRINT " 1.MORTALITY TO WEAN
ING"
 818 PRINT
 820 PRINT " 2.MORTALITY BETWEEN
 WEANING       AND ";PA;"KG"
 822 PRINT
 825 PRINT " 3.MORTALITY BETWEEN
 ";PA;"KG AND      FIRST CALVING"
 827 PRINT
 830 PRINT " 4.MORTALITY IN THE
ADULT HERD"
 835 PRINT
 840 PRINT " 5.THE NUMBER OF STI
LLBIRTHS          PER YEAR"
 845 INPUT A
 847 CLS
 850 IF A=1 THEN GOTO 865
 852 IF A=2 THEN GOTO 875
 854 IF A=3 THEN GOTO 887
 855 IF A=4 THEN GOTO 900
 858 IF A=5 THEN GOTO 910
 865 PRINT "WHAT IS THE NEW LEVE
L OF         ANNUAL MORTALITY(PER
CENTAGE)     TO WEANING?"

 867 INPUT M1
 870 GOTO 800
 875 PRINT "WHAT IS THE NEW LEVE
L OF         ANNUAL MORTALITY(PER
CENTAGE)     BETWEEN WEANING AND
 ";PA;"KG"
 880 INPUT M2
 885 GOTO 820
 887 PRINT "WHAT IS THE NEW LEVE
L OF         ANNUAL MORTALITY(PER
CENTAGE)     BETWEEN ";PA;"KG AND
 FIRST        CALVING?"
 890 INPUT M3
 895 GOTO 580
 900 PRINT "WHAT IS THE NEW LEVE
L OF         ANNUAL MORTALITY(PER
CENTAGE)     IN THE ADULT HERD?"
 902 INPUT M4
 905 GOTO 545

 910 PRINT "WHAT IS THE NEW VALU
E FOR THE    NUMBER OF STILLBIRTH
S/YEAR?"
 915 INPUT N
 916 GOTO 575
 917 PRINT "WHICH OF THE FOLLOWI
NG VARIABLES(1,2,3 OR 4) DO YOU
WISH TO      CHANGE?"
 920 PRINT
 925 PRINT " 1.WEANING WEIGHT"
 930 PRINT
 940 PRINT " 2.LIVEWEIGHT GAIN T
O WEANING"
1045 PRINT
1050 PRINT " 3.LIVEWEIGHT GAIN F
ROM WEANING     TO ";PA;"KG"

1055 PRINT
1060 PRINT " 4.BULLING WEIGHT"

1065 INPUT A
1067 CLS
1070 IF A=1 THEN GOTO 1090
1075 IF A=2 THEN GOTO 1100
1080 IF A=3 THEN GOTO 1140
1085 IF A=4 THEN GOTO 1165
1090 PRINT "WHAT IS THE NEW WEAN
ING WEIGHT?"
1095 INPUT PD
1100 LET TC1=(INT (100*((PD-PN)
(C5*30.4)+.5)))/100
1102 LET C6=(INT (100*((PA-PD).
30.4*TC2)+.5)))/100
1105 LET C2=C5+C6
1110 LET C4=C2+C3+9
1111 CLS
1112 PRINT "WHAT WOULD BE THE VA
LUE($) OF A CALF WITH THIS LIVEW
EIGHT AT     WEANING?"

1113 INPUT VBP
1115 GOTO 527
1120 PRINT "WHAT IS THE NEW LIVE
WEIGHT GAIN  (KG/DAY) TO WEANING?
"

1125 INPUT TC1
1126 CLS
1130 LET PD=INT (.5+PN+(C5*30.4*
TC1))
1132 PRINT "WITH THIS RATE OF LI
VEWEIGHT     GAIN THE CALVES WILL
 HAVE A      LIVEWEIGHT AT WEANIN
G OF ";PD;"KG"
1133 PRINT
1134 PRINT "WHAT WOULD BE THE VA
LUE($) OF A CALF WITH THIS LIVEW
EIGHT AT     WEANING?"
1135 INPUT VBP
1136 LET C6=(INT (100*((PA-PD)/(
30.4*TC2)+.5)))/100
1137 LET C2=C5+C6
1138 LET C4=C2+C3+9
1139 GOTO 527
1140 PRINT "WHAT IS THE NEW LIVE
WEIGHT GAIN  (KG/DAY) FROM WEANIN
G TO ";PA;"KG?"
1145 INPUT TC2
1146 LET C6=(INT (100*((PA-PD)/(
30.4*TC2)+.5)))/100
1147 LET C2=C5+C6
1148 LET C4=C2+C3+9
1150 GOTO 527
1155 PRINT "WHAT IS THE NEW BULL
ING            WEIGHT(KG)?"
1160 INPUT PA
1161 LET C6=(INT (100*((PA-PD)/(
30.4*TC2)+.5)))/100
1162 LET C2=C5+C6
1163 LET C4=C2+C3+9
1165 GOTO 527
1170 PRINT "WHAT IS THE NEW CALV
ING            INTERVAL(DAYS)"
1175 INPUT I2
1180 LET P=INT (V*365/I2+.5)
1182 LET 9=INT (PL*365/I2+.5)
1184 LET 50=V*9
1185 GOTO 535
1190 PRINT "WHAT IS THE NEW LACT
ATION        YIELD(QUARTS)?"
```

THE COMPUTER PROGRAMME : SINCLAIR ZX 81 - BASIC

```
1195 INPUT PL
1200 LET Q=INT (PL*365/I2+.5)
1205 LET S0=Q*V
1210 LET I50=S0*VQ
1215 GOTO 647
1220 PRINT "WHAT IS THE NEW RATE
 OF TURNOVEROF THE ADULT HERD(PE
RCENTAGE)?"
1225 INPUT T
1230 LET E=1200/T
1231 LET CN=CA
1232 LET NP=((12*V)/E)+(M4*V/100
)
1233 LET VD=T*V/100
1234 LET NR=(NP+BI)/(1-(M3/100))
1235 LET NH=(C3+9)*NR/12
1236 LET BR=NR/(1-(N2/100))
1237 LET NJ=BR*C6/12
1238 LET BP=BD-BR
1239 LET UA=H+(.8*NM)+(.5*NJ)+(.
2*BL)
1240 LET CA=UA/AF
1241 GOTO 1246
1242 PRINT "WHAT IS THE NEW STOC
KING  RATE   (AU/HA)?"
1243 INPUT CN
1245 LET CN=(INT (CN*100+.5))/10
0
1246 LET CA=(INT (CA*100+.5))/10
0
1247 IF CN=CA THEN GOTO 1376
1248 FAST
1249 LET X=0
1250 LET Y=0
1255 IF CN>CA THEN GOTO 1261
1257 IF CN<CA THEN GOTO 1265
1260 IF CP>CN THEN GOTO 1265
1261 IF Y=1 THEN GOTO 1335
1262 LET X=1
1263 LET V=V+1
1264 GOTO 1275
1265 IF X=1 THEN GOTO 1335
1266 LET Y=1
1267 LET V=V-1
1275 LET CL=INT (I3*V/I2+.5)
1276 LET B1=.04*CL
1280 LET CD=V-CL
1285 LET BL=INT ((CL-(N*CL/P))*(
1-(.005*M1))+.5)
1290 LET NP=(V*12/E)+(V*M4/100)
1295 LET NR=(NP+BI)/(1-(M3/100))
1300 LET BR=INT (NR/(1-(N2/100))
+.5)
1305 LET NJ=INT (BR*C6/12+.5)
1310 LET NH=INT ((C3+9)*NR/12+.5
)
1311 LET B2=.04*NM
1312 LET B=INT (B1+B2+1)
1314 LET H=V+B
1315 LET UA=H+(.8*NM)+(.5*NJ)+(.
2*BL)
1320 LET CP=UA/AF
1325 LET CP=(INT (CP*100+.5))/10
0
1327 IF CP=CN THEN GOTO 1335
1330 GOTO 1260
1335 CLS
1340 LET I50=V*Q*VQ
1345 LET P=INT (V*365/I2+.5)
1350 LET BD=INT ((P-N)*(1-(M1/10
0))+.5)
1355 LET BP=BD-BR
1360 LET IBP=BP*VBP
1365 LET VD=INT (V*T/100+.5)
1370 LET IVD=VD*VPU
1372 LET CA=(INT (CP*100))/100
1373 CLS
1374 PRINT "SLOW"
1375 GOTO 647
1376 CLS
1377 PRINT "THE NEW VALUE GIVEN
FOR THE     STOCKING RATE IS THE
 SAME AS THEACTUAL VALUE"
1378 PRINT
1379 GOTO 1242
1380 PRINT "PLEASE INDICATE WITH
 A NUMBER    BETWEEN 1 AND 4 WHIC
H OF THE     FOLLOWING PRICES YOU
 WISH TO     CHANGE"
1385 PRINT
1390 PRINT " 1.THE PRICE RECEIVE
D FOR A          QUART OF MILK"
1395 PRINT
1400 PRINT " 2.THE PRICE RECEIVE
D FOR            WEANED CALVES"
1405 PRINT
1410 PRINT " 3.THE PRICE RECEIVE
D FOR A          CULL COW"
1411 PRINT
1412 PRINT " 4.THE PRICE RECEIVE
D FOR            INFERTILE HEIFERS
"
1415 INPUT A
1420 CLS
1421 REM
1425 IF A=1 THEN GOTO 1440
1430 IF A=2 THEN GOTO 1450
1435 IF A=3 THEN GOTO 1460
1436 IF A=4 THEN GOTO 1495
1440 PRINT "WHAT IS THE NEW PRIC
E RECEIVED  FOR A QUART OF MILK?
"
1445 INPUT VQ
1450 LET I50=S0*VQ
1455 GOTO 647
1460 PRINT "WHAT IS THE NEW PRIC
E RECEIVED  FOR A WEANED CALF?"
1465 INPUT VBP
1470 LET IBP=BP*VBP
1475 GOTO 647
1480 PRINT "WHAT IS THE NEW PRIC
E RECEIVED  FOR A CULL COW?"
1485 INPUT VPU
1490 LET IVD=VD*VPU
1492 GOTO 647
1495 PRINT "WHAT IS THE NEW PRIC
E RECEIVED  FOR INFERTILE HEIFER
S?"
1500 INPUT VBI
1505 LET IBI=VBI*BI
1510 GOTO 647
1515 STOP


PLEASE NOTE-THIS PROGRAMME HAS
BEEN TRANSLATED FROM THE
ORIGINAL, WRITTEN IN SPANISH"
```

## THE SYMBOLS USED IN THE MODEL

| SYMBOL | MEANING | UNITS OF MEASUREMENT |
|---|---|---|
| AF | Area of the farm | Ha |
| B1 | Number of bulls with the milking cows | Bulls |
| B2 | Number of bulls with the bulling heifers | Bulls |
| BD | Number of calves weaned/year | Calves/year |
| BI | Number of infertile heifers sold/year | Heifers/year |
| BL | Average number of suckling calves in the herd | Calves |
| BNV | Number of calves born alive/year | Calves/year |
| BP | Number of calves weaned/year that are not required as replacements | Calves/year |
| BR | Calves weaned/year that must be reared as replacements | Weaned calves/year |
| CONST | Cost of the maintenance of buildings | $/year |
| C2 | Age at which the heifers reach bulling weight | Months |
| C3 | Delay between bulling weight and conception | Months |
| C4 | Age at first calving | Months |
| C5 | Age at weaning | Months |
| C6 | Delay in reaching bulling weight after being weaned | Months |
| CA | Stocking rate | Animal Units/ha |
| CD | Mean number of dry cows in the herd | Cows |
| CL | Mean number of cows in production | Cows |
| DEP | Annual depreciation | $/year |
| E | The expected life of a cow in the adult herd | Months |
| ELEC | Cost of fuels and electricity | $/year |
| FER | Cost of fertilizer | $/year |
| H | Mean size of the adult herd | Adult animals |
| IBI | The total income from the sale of infertile heifers | $/year |
| IBP | Total income from the sale of weaned calves | $/year |
| INT | Interest paid on loans | $/year |
| IT | Total income | $/year |

## THE SYMBOLS USED IN THE MODEL

| | | |
|---|---|---|
| IVD | Total income from the sale of cull cows | $/year |
| ISQ | Total income from the sale of milk | $/year |
| $I_2$ | Calving interval | Days |
| $I_3$ | Lactation length | Days |
| $I_4$ | Length of the dry period | Days |
| $I_5$ | Interval between calving and conception | Days |
| MAQ | Cost of maintenance of machinery and equipment | $/year |
| M1 | Annual mortality between birth and weaning | % |
| M2 | Annual mortality between weaning and bulling weight | % |
| M3 | Annual mortality between bulling weight and first calving | % |
| M4 | Mortality in the adult herd | % |
| N | Number of stillbirths/year | Stillbirths/year |
| NJ | Average number of young heifers in the herd | Young heifers |
| NM | Average number of bulling heifers in the herd | Bulling heifers |
| NP | Number of heifers that must calve down/year | Heifers/year |
| NR | Number of heifers that must reach bulling weight/year | Heifers/year |
| OTRO | Other costs | $/year |
| P | Number of calvings in the herd/year | Calvings/year |
| PA | Bulling weight employed on the farm | Kg |
| PAST | Cost of pasture maintenance | $/year |
| PD | Weaning weight | Kg |
| PL | Production/lactation | Quarts |
| PN | Birth weight | Kg |
| PD | Mean weaning weight of calves | Kg |
| PV | Mean liveweight of cull cows | Kg |
| R | Net profit of farm | $/year |
| SAL | Total cost of salaries | $/year |
| AN | Total cost of veterinary assistance | $/year |

## THE SYMBOLS USED IN THE MODEL

| | | |
|---|---|---|
| SUP | Total cost of supplementary feeds | $/year |
| T | Rate of turnover of the adult herd | % |
| TA | Rentable value of the land occupied by the farm | $/year |
| TC1 | Liveweight gain to weaning | Kg/day |
| TC2 | Liveweight gain from weaning to bulling weight | Kg/day |
| TC3 | Liveweight gain from birth to bulling weight | Kg/day |
| TORO | Cost of replacement of bulls | $/year |
| TR | Rate of return on capital invested | % |
| Q | Milk production/cow/year | Quart/cow/year |
| SQ | Total annual milk production | Quarts/year |
| UA | Number of animals units on the farm | Animal units |
| VEP | Average value of a weaned calf | $/calf |
| VD | Number of cull cows sold/year | Cull cows/year |
| VI | Total value of the investment in the farm | $ |
| VPV | Price obtained for cull cows/kg liveweight | $/kg |
| VQ | Mean price obtained for a quart of milk | $/quart |

**Note:**

One quart = 0.946 litres

When it is more convenient, litres may be used directly without transformation. In this case, both yields and prices should be typed into the computer on the basis of litres.

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