CHAPTER 5

COST-BENEFIT ANALYSIS OF TICKS AND TICK-BORNE DISEASES CONTROL

5.1 Introduction

Various techniques are available to assess the impact of agricultural research and development and are well documented in Anandajayasekeram *et al.* (1996: 83) and in Marasas (1999: 61). The techniques included are, namely modified peer review, user surveys, benefit-cost method, cost effectiveness analysis, partial indicators, patent analysis, case studies, mathematical programming and econometric methods. The choice of method is primarily dictated by the problem under evaluation. Benefit-cost method is, however, much more appropriate for past research projects than for ongoing or future research, hence the adoption of the benefit-cost method in this study. In addition, the main value of benefit-cost analysis in research and development impact assessment is that it offers a systematic framework for identifying the costs, benefits and wider implications of research and development.

Using the cattle values discussed in Chapter 2 as a point of departure, this chapter examines the costs and benefits of tick control at the farm level. The "with" and "without" dipping scenario will be incorporated into the analysis to provide a basis for cost-benefit analysis. The "without" scenario analysis is based on secondary data whereas the "with" scenario uses survey data. The (potential) benefits for the "without" dipping scenario are dealt with in the first half of this chapter assuming no dipping was pursued. The costs and benefits for each strategy will be compared to determine whether it is economically justified to control ticks and tick-borne diseases.

5.2 The Socio-Economic Value for the "With" and "Without" Dipping Scenario

The socio-economic values for the aforementioned scenarios are related to the different products or benefits obtained from the control of ticks and tick-borne diseases.

Furthermore, the socio-economic value to be derived from each strategy is largely the direct opposite of the other. The "with" scenario results in increased agricultural production through decreased morbidity and mortality rates. The mortality savings (deaths prevented) directly affect total off-take per time horizon and herd population structure. If mortality savings are high and the herd expanding, higher off-take rates are possible. This contributes towards an increase in human wellbeing through increased farm income and food availability. Under these circumstances of increased production, elementary economics suggests a decrease in the price of the products thereby enhancing food affordability, *ceteris paribus*.

Other aspects of the livestock production process in which parasites may influence the income from livestock is with regard to product quality. There are two principal mechanisms through which parasite affects product quality as suggested by Morris and Meek (1980: 171). Firstly, it may influence product characteristics including composition so that the consumer obtains less value from its use. In some cases the market price of the product in monetary terms is lower leaving less income available for household expenses e.g. school fees. Secondly the occurrence of ticks and tick-borne diseases (parasitism) influences the marketability of products. Examples of the consequences of such problems include the downgrading of the hide with a lower price due to evidence of tick damage. The attainment of the full productive potential of livestock is according to Umali *et al.* (1994) influenced by the availability and quality of animal health services. However, the benefits to be derived from the "with" scenario are constrained by the following factors such as the purchasing power, access to credit, extension services, adequate market infrastructure, *etc.* Apparently the socio-economic value for the "with" scenario, in particular, significantly contributes towards food security and therefore needs further exploration.

5.3 The Financial Burden of Dipping

In several countries in southern Africa, government veterinary services have a special role in ticks and tick-borne diseases control, being responsible for funding and implementation of extensive rural dipping programmes for peasant farming communities (Norval *et al.*, 1992). Venda too is a region where public sector involvement in rural communal dipping is substantial. The government maintains a network of some 127 cattle diptanks which at present serves 104 778 head of cattle owned by communal farmers.

The control of ticks and tick-borne diseases is inexpensive only if ticks are effectively controlled. However, it becomes expensive to farmers if tick-borne diseases emerge and farmers have to buy their own medicines usually from farmer's co-operatives. The cost of acaricides alone in the control of ticks amounted to R80 million in 1994 (Onderstepoort Veterinary Institute, 1997). Government also spends considerable amounts of money annually on research, training and extension services related to the control of ticks and tick-borne diseases. Parastatals (e.g. Agricultural Research Council–Onderstepoort Veterinary Institute) and international organization (e.g. Food and Agriculture Organization) also spend large sums of money on research aimed at developing improved control methods. Ticks cost South African agriculture more than R500 million per annum in direct and indirect losses (Farmers Weekly, 1998: 47).

As in Zambia and Kenya, the dipping of cattle in Venda is provided at heavily subsidised rates to the communal cattle owners. Subsidisation of the veterinary services in many developing countries has according to Umali *et al.* (1994) resulted in trade-offs between quantity and quality. In addition, Mukhebi and Perry (1992) argue that in recent times the budget of governments in most of the African countries have shrunk and the scarcity of foreign exchange for imports has grown more acute. As a result, the competition for limited government resources from other pressing national social development needs have heightened and the quantity and quality of animal health services and infrastructure has consequently declined considerably.

The justification for public sector funding of veterinary services for peasant farmers in southern Africa according to Norval *et al.* (1992) is a thorny issue. In the present economic climate in Africa, Lawrence (1996) predicts that there is unlikely to be any improvement in the government dipping services, and tick control will fall more and more into the hands of the cattle owners themselves. Therefore, it is sensible to expect that in the situation where acaricides cost is recovered, rural farmers will welcome the end of compulsory intensive dipping where it is recognised to be unnecessary in favour of strategic tick control strategy. This is more applicable to the situation where dipping frequency is linked to the costs of dipping. The practical scope for moving away from intensive dipping of cattle seem to be of urgent interest and obviously will benefit the farmers.

As previously mentioned, it currently costs communal farmers in Venda R1 and government R12 to dip a head of cattle each year. However, there is a group of commercial farmers that bears the full cost of controlling ticks and tick-borne diseases in their own herds. Depending on the frequency of application, annual costs of acaricides to these farmers who bear the full cost of control can range from US$ 2 to US$ 20 per animal as estimated by Mukhebi (1992). The current cost of acaricides to the government escalates with the worsening dollar exchange rate and inflation (Dipping survey, 1997). In order to choose the optimal level of treatment, Norval *et al.* (1992) argue that one must be able to model the impact of different scenarios of intervention upon tick infestation, tick population dynamics, breed susceptibility to tick infestation and damage coefficients.

5.4 Farmer's Costs of Production.

Although dipping and other veterinary services for cattle are provided by the government in the communal areas, farmers also incur other production costs (see Table 5.1). The main cost to household of maintaining livestock is herding labour. At least 11% of the respondents use hired labour for herding. Labour is hired at an average salary of R2066.00 per year. For cattle owners there are a number of different options for mobilising herding labour. Co-operative arrangements between or amongst households are popular where 2 to 5 relatively small herds are combined and the households rotate the responsibility for payment as a way of reducing costs. Hired labour is only an option open to those households with sufficient cash. The first option is the use of own household labour. It is only in Dzanani where hired labour is not employed. The use of hired labour gives an indication that the day to day management of the cattle is in the hired labourer's hands leaving more chances for disease occurrence. This is especially true in those cases where the cattle owners are not resident in the communal grazing areas.

Table 5.1: Farmers' Economic Costs of Livestock Services.

Area	Purchased worm remedies	Labour for herding	Vaccination	Tickicides	Medicines
			R/year		
Vyeboom	104	2040	66	146	35
Malongana	148	2600	155	124	128
Guyuni	101	3513	105	79	175
Matshena	117	2100	19	33	39
Dzanani	47	-	55	154	70
Tshifudi	104	2040	66	146	35
Average	104	2066	79	110	85

The second largest cost item to the farmer is that of tickicides at an average cost of R110/year. With the probable exception of labour, the cost of the other cost items is indicative of the priority the farmers attach in their husbandry practices to the severity of the problem. In addition, the cost of tickicides may indicate the level of tick challenge of a particular area, *ceteris paribus*. The Open area thus has a higher tick challenge than the Yellow Line area as revealed by their respective tickicides costs, the only exception being Tshifudi in the Yellow Line area. Other costs incurred include the costs of vaccination, worm remedies and other medicines for both endo and ectoparasites.

5.5 Costs and Benefits of Alternative Control Programmes

The outbreak of East Coast fever in the early nineteenth century presented the Venda government (then the South African Government) with only two basic options, namely to control or not to control. The assessment of an animal health project takes into account the incidence of disease outbreaks before and after the project, as well as the losses which would result from failure to implement the project (Sidibe, 1981). This section examines those two options/scenarios herein referred to as:

- A 'do nothing' strategy ("without" dipping scenario)
- A control strategy ("with" dipping scenario)

Emphasis will be given to the comparison of the costs and benefits of each strategy at the household level had the strategy been adopted.

5.5.1 Estimations of Economic Costs and Benefits of Disease Control Programmes

Knowledge of factors relating to costs incurred and benefits accrued is important when dealing with the appraisal of alternative control strategies. These factors are important because they enable one to differentiate between the various alternative control programmes. Establishing standard methods to measure both costs and benefits in order to determine the cost-benefit ratio is not possible, since this differs in terms of the disease, the species affected and their levels of production (Paniagua Arellano and Diaz Yubero, 1983). Perry and Mukhebi (1995) also admit that the quantification of output losses (costs) is not a simple task. They argue that there are often problems in separating these losses from the effects of confounding factors such as other diseases and production constraints. Accurate measurement of the level of diseases and their effects on productivity requires intensive record keeping, which are often nonexistent or unavailable, or requires time consuming and expensive field surveys and monitoring studies to be conducted. The determination of the cost-benefit ratio requires the following evaluation of costs (Denes, 1983: 306; Paniagua Arellano and Diaz Yubero, 1983: 350)

- The mortality and morbidity rate[4].
- Losses in meat, milk, *etc.*
- Infertility and abortion.
- Treatment (acaricides).
- Other potential losses (expenses resulting from the closing of domestic and export markets).

[4] Mortality rate refers to death and morbidity refers to the loss in the productive performance of an animal

The following benefits will be gained from the control of these negative factors:

- A reduction in the mortality and morbidity rate.
- Increase in the production of meat, milk, hides, *etc*.
- Increase in the fertility and birth rates.
- Other potential benefits (i.e. the opening up of markets, the improved sanitary quality of the products and thus a higher sales price).
- The relief from socio-psychological embarrassment borne by the animal owner and his neighbours as a result of the disease.
- Avoidance of permanent loss of value, which include short, and long term irrecoverable losses with secondary multiplier effects.

There are costs which must be incurred in order to achieve these benefits and such costs can be grouped into:

- Direct costs, including investment and salaries.
- Indirect costs, including improved standard of hygiene in the animal husbandry facilities.

It must be stressed that it is not always possible to evaluate the above mentioned losses since some cannot be quantitatively assessed, and the system available for this purpose is sometimes nonexistence. To calculate losses or benefits the following are mostly used: statistics, estimates by experts, actual verification based on research or survey data, observations made while programmes are put into practice and findings from comparative studies.

Once these physical output losses or benefits have been quantified, they must be valued in monetary terms to reduce them to a common unit of measurement before they can be aggregated. This requires the use of appropriate prices for valuation, which are not often obvious. Quantification of economic losses and benefit of a disease is of value in demonstrating the magnitude of the economic impact caused by the disease, particularly to those who make decisions affecting financial allocations for disease control programmes (Perry and Mukhebi, 1995).

Indirect losses are even more complex and difficult to quantify meaningfully, but they should not be ignored in order to provide a more comprehensive assessment of the impact of the disease.

5.5.2 A 'Do Nothing' Strategy

The introduction of exotic breeds made Africa vulnerable to tick-borne diseases as mentioned before. Due to breed susceptibility, it would probably have been irrational at the time to adopt this strategy for economic reasons. Had this strategy been adopted, tick-borne diseases would have been an epidemic in the continent, but as time progresses cattle would have adapted and there would have been a move to enzootic stability (Spickett, 1998). The existence of enzootic stability implies that control could have been selective, strategic and focused only on susceptible target cattle populations.

A 'do nothing' strategy would have incurred no additional government expenditure and farmers would have maintained the use of their cattle, although the cattle would not have performed as efficiently as before the introduction of the disease. In addition, the income forgone from cattle products would have been higher relative to the income forgone under the control strategy discussed below. This is because of the high morbidity and mortality rate estimated to be 4 percent. Although this strategy was not adopted, an effort should be made to estimate the losses in the absence of control and then estimate the extent to which these losses will be reduced by the strategy followed.

5.5.3 A Control Strategy

One of the most significant consequences of the East Coast fever control programmes was the introduction of compulsory dipping in acaricides throughout the infected areas. Whether eradication of East Coast fever can be attributed entirely to the dipping programme and the other control measures that were applied, or whether climatic changes brought this about, or at least facilitated the elimination of a specific population of ticks responsible for transmission of East Coast fever is open to speculation (Norval, 1992).

The benefits derived under this strategy are higher than the benefits derived under the aforementioned strategy. This is because of a relatively low morbidity and mortality rate of 3% in the sampled region. Most developing regions were left with a tradition of short interval dipping which has persisted to the present day. If properly applied dipping provides very good control of all tick-borne diseases.

5.6 Derivation of Costs and Benefits Estimates

5.6.1 The "Without" Dipping Scenario

One of the most important components in a cost-benefit analysis of the disease control programmes is the estimation of losses per animal from disease. The estimation of physical losses for individual animals is always a problem (Beal, 1981). This problem is worse in a situation without a control programme, because dipping has been in operation comprehensively since the start of the century. Moreover, it is difficult, if not impossible, to have access to data from the period before the dipping programme. This lack of data resulted in one major problem; the accurate determination of the effects to be assessed, the costs and benefits and the exact method to be used to measure these effects. It was decided to assess only direct benefits that appear at the farm level in terms of milk and meat production gains/losses, low productivity due to longer calving interval and impacts on draught power.

The derivation of benefits for the "without" scenario was performed on the basis of various estimates through making use of the Delphi technique. Experimental data comparing the effect of ticks and tick-borne diseases on livestock productivity between tick free and tick infested herds is unavailable for South Africa. Estimates of impact on productivity done by the Food and Agriculture Organization in Zambia were used with minor adjustments (Pegram *et al.*, 1993).

Table 5.2 presents various figures used for the estimation of costs and benefits for both milk and meat (beef). Based on the income from milk production as reported in Table 5.2, the impact on morbidity and mortality was calculated for the without situation as follows (i.e. income gained from milk production):

Morbidity = 326 (sampled average herd size) * 38% (cows percentage) * 405 (value per year)

Mortality = 326 (sampled average herd size) * 4% (mortality rate) * 38% (cows percentage) * 405 (value per year)

Table 5.2: Values for the Possible Calculation of Milk and Meat Benefits

Dipping scenarios	Average live-body weight (Kg)	Beef price/ kilogram* (R)	Average herd size	Cows herd composition (%)	Mortality rate (%)	Value of milk/ year (R)	Value of a cow/ year (R)
"With"	241	5	329	39	3	526	1152
"Without"	234	5	326	38	4	405	1036

*Source: Own survey data

It was estimated that on average the mortality rate would have stabilised at 4% without the control programme (Spickett, 1998). However, the initial mortality rate would have been 10% without dipping at the beginning of the century. This possible decline in mortality is based on the assumption that breeds with a strong immune system (predominantly the Nguni breed) would have survived better and on the basis of the "survival of the fittest" would have dominated the national herd.

Income gained from beef production is calculated as follows:

Morbidity = 57 (average number of cattle sold) * 234kg (weight) * R5 (price per kilogram)

Mortality = 326 (sampled average herd size) * 4% (mortality rate) * 234kg (weight) * R5 (price per kilogram).

For a small-scale traditional farmer the selling price of a live cow is not a function of weight. However, it is assumed that price is a function of weight in this analysis so that the price of beef per kilogram can be multiplied by the total weight of an animal. Moreover, the traditional farmer sometimes salvages a sick animal for meat. In this analysis all reported deaths are considered to be unsalvaged.

With regard to draught power, two significant assumptions had to be made to perform the analysis, namely:

- Only oxen are used for ploughing.
- Infected oxen are entirely incapable of ploughing.

Oxen were grouped into two breed categories, indigenous and exotic breed, so as to attach the infection probability for each group. Grouping of breeds was done using the sampled breed percentage composition. Nguni constitute 65% of the sampled herd and it was assumed that Nguni is the only indigenous breed. Again it was assumed that both breeds have an equal infection probability of 25% without dipping. The value of oxen indicated in Table 5.3 is for an average herd of 18 oxen after taking into consideration the infection probability. The average number of oxen for the sampled herd is 24.

.Ticks may be responsible for loss in udder quarters and may increase the calving interval. The latter is the most significant parameter in determining herd productivity and, hence profitability. This type of loss is better estimated on a survey basis (Pegram *et al.*, 1993). Low productivity in milk production due to a longer calving interval for the infected cow is estimated as follows (i.e. forgone income due to longer calving interval):

Productivity = 61 (number of calves in a year) *12.5% (probability of losing a calf per cow in a year) *1 036 (average value of cattle).

5.6.2 The "With" Dipping Scenario

The derivation of benefits for this scenario is similar to the "without" scenario. Unlike the "without" scenario, this scenario relies on the survey results. Survey results reveals the mortality rate as 3%. Mortality rates exhibit a strong seasonal pattern that closely parallels the rainy season when ticks are most active. No attempt was made here to differentiate the various mortality rates for the different seasons of the year. To measure the mortality rate, sampled farmers were asked about the number of cattle deaths caused by tick-borne diseases. This relies only on the farmers' diagnosis and it is acknowledged that the reliance on farmer diagnosis has a potential for error depending on, *inter alia*, familiarity with the disease, memory and the desire to attract veterinary attention. In communal areas mortalities are not always reported, or if reported, seldomly investigated. Moreover, disease reporting in general in South Africa is unsatisfactory, and results in underreporting of most diseases and causing unreliable statistics (National Department of Agriculture, 1996/7). Although these limitations render the estimations less reliable and accurate, they serve as the only basis on which the analysis can be built. Both milk and meat production incomes can be obtained using the values in Table 5.2.

For a small-scale traditional farmer the costs of tick control can be divided into two categories, namely:

- Those that the government incurs.
- And those incurred by stockowners.

Data on government expenditure for ticks and tick-borne diseases control was obtained from the government veterinary budget, reports and records in the Department of Veterinary services. Costs incurred by the government includes costs of vehicle maintenance, insurance and allowances, stationery, dip maintenance and heavy machinery for water provision. The cost of water provision is low because the location of many diptanks was determined by the available water sources. Costs of ticks and tick-borne diseases control to individual farmers are fairly straight forward and are based upon expenses for animal treatment and acaricides application. Treatment costs largely include cost of purchased drugs, *etc*. These costs were obtained from sampled farmers' interviews and are shown in Table 5.3. Treatment of the disease is regarded as an *ex post* use of resources to restore animal performance to its previous level of health before the disease occurred back towards its previous healthy level when a disease has occurred. Whether it is worth doing, as opposed to accepting the reduced productivity or even culling the animal, is an economic decision.

5.7 A Comparison of the "With" and "Without" Scenarios.

Project impact analysis attempt to value costs and benefits that arise with the project and compare them with the situation as it would have been without the project (Gittinger, 1982). Both costs and benefits are clearly shown in Table 5.3 with milk and beef calculated in terms of mortality and a decrease in the productivity of the herd (i.e. morbidity). The forgone income for the "without" scenario due to mortality is higher than the forgone income for the "with" scenario. The difference between the "with" dipping scenario net income and the net income balance for the "without" scenario gives an incremental net loss of R23 475 per sampled herd. This amount represents the loss in income occurred in spite of the existence of the dipping programme. Disease control is economically justified only if the estimated benefits outweigh the costs incurred, i.e. the benefit-cost ratio must be greater than or equal to one. Table 5.3 shows a benefit-cost ratio that is almost equals to one. (0.8). This ratio was calculated as:

B/C = Δ in total income for both scenario / Δ in total costs for both scenario

According to Morris and Meek (1980: 165)..."monetary values must be used with caution that the numerical values obtained in an economic analysis should be seen principally as a basis for ranking strategies, not as representing the actual benefit which will be achieved under all circumstances".

This ratio suggests that the control of ticks and tick-borne diseases by the government is not economically justified and probably need to be a private sector responsibility. However, in establishing the appropriate roles for the public and private sector in the livestock services industry, it is necessary to obtain a clear understanding of the nature of the tick control service. Not only will the economic nature of the service determine whether private delivery will be feasible, but also whether private provision will results in a socially optimal level of supply (Kirsten and Randela, 1998).

The control of ticks is a private good with externality. This implies that the control of ticks by an individual farmer also benefits other farmers by reducing tick population and the chances of other farmers from getting tick-borne diseases. Therefore due to this free rider problem associated with tick control service delivery, there will be a tendency towards under-provision or no provision of this service when the production decision is profit motivated. Thus, private firms will have no incentive to provide this service because it will not be in the interest of any individual to pay for it.

Table 5.3: Comparison of Costs and Benefits for the "With" and "Without" dipping Scenarios (1997).

"With" dipping scenario				
Costs (R)		Income (R)		
Government costs*		Milk: sold	67 854	
Motor transport allowance, maintenance and insurance.	11 538	Mortality	-2 025	65 829
Heavy machinery (water provision)	661	Meat: sold	69 890	
Stationery	236	Mortality	- 11 893	
Livestock maintenance (acaricides)	15 535			57 997
Diptank maintenance	21 000			
		Draught power		6216
Total	48 970			
Farmers costs				
Tickicides	1 164			
Purchased drugs	682			
Total	1 846			
Salary	6 341			
Total Cost	57 157	Total income		130 042
Net income		72 885		
"Without" dipping scenario				
Costs		Income		
		Milk: sold	50 171	
		Mortality	- 2 007	
				48 165
		Meat: sold	66 690	
		Mortality	-15 257	
				51 433
		Draught power		4662
		Total income		104 260
		Low calving productivity		- 7 900
Total income		96 360		
Benefit-Cost ratio		*0.8*		

Furthermore, although the benefit-cost ratio is slightly less than one, this ratio can be improved by reducing the costs involved. This can be done by moving from intensive dipping to a strategic acaricides application. Such a costs decrease might possibly result in two effects namely, either the same output can be produced more cheaply or the savings can be converted into increases in output. The strategic control of ticks is a strategy based on the fact that ticks exhibit seasonal cycle and that concentration of acaricides application during the peak month of tick activity will effectively interrupt tick feeding cycle, reduce tick population thereby reducing the number of engorged females which lay eggs to perpetuate the generation.

This dipping regime is possible taking into consideration that livestock owners are more particular about regular immersion of their cattle during spring/summer period (September/October – March/April) when the presence of ticks and the damage they cause are obvious, than in winter when only few or no ticks are seen. The presence of ticks on cattle in winter varies from region to region, from few to none, depending on the degree of dryness and severity of winter cold. Thus, in some areas, there may in fact be no need to dip cattle in winter instead of dipping cattle throughout the year. It appears, therefore, that if the strategic dipping regime can be adopted, there can be a significant decrease of the dipping costs and an improvement of the benefit-cost ratio. The magnitude of a decrease in dipping costs depends on the knowledge of the optimal tick control. In addition, the range and magnitude of physical losses avoided, *inter alia*, depends on the control system used, and determined by the technique of control and the success with which it is implemented.

5.8 Sensitivity Analysis

The mortality rate for the "without" dipping scenario is, however, subject to debates and is based on optimistic assumptions. Therefore, sensitivity analysis is conducted to determine the robustness of benefit-cost ratio against possible changes in the mortality rates. The sensitivity analysis presented in this section addresses the effects of changes in the mortality rate to 10% and the results are shown in Table 5.4. With a 10% mortality rate without the control programme the benefit-cost ratio increases from 0.8 to 1.2. Thus, it is evident that the benefit-cost ratio is sensitive to changes in the mortality rate. The 10% mortality rate was chosen assuming that it would have been probably the second lowest mortality rate to prevail in the absence of the control programme.

Table 5.4: Sensitivity Analysis of a Change in the Mortality Rate.

"With" dipping scenario				
Costs (R)		Income (R)		
Government costs*		Milk: sold	67 854	
Motor transport allowance, maintenance		Mortality	- 2 025	
and insurance.	11 538			65 829
Heavy machinery (water provision)	661	Meat: sold	69 890	
Stationery	236	Mortality	- 11 893	
Livestock maintenance (acaricides)	15 535			57 997
Diptank maintenance	21 000			
		Draught power		6216.00
Total	**48 970**			
Farmers costs				
Tickicides	1 164			
Purchased drugs	682			
Total	**1 846**			
Salary	**6 341**			
Total Cost	**57 157**	**Total income**		**130 042**
Net income		72 885		
"Without" dipping scenario				
Costs		**Income**		
		Milk: sold	38 418	
		Mortality	- 3 842	
				34 576
		Meat: sold	66 690	
		Mortality	-35 802	
				30 888
		Draught power		4662
		Total income		**70 126**
		Low calving productivity		- 7 900
Total income		**62 226**		
Benefit-Cost ratio		*1.2*		

The sensitivity analysis also shows an incremental net benefit of R10 658 per sampled herd. It is important to note that the incremental net benefit derived represent the loss in income which would have resulted from failure to implement the dipping programme.

Sensitivity analysis based on various mortality rates (i.e. worst case scenario) was also performed. In addition to the 4 and 10% mortality rate already analysed, Table 5.5 further shows the probability of occurrence for various mortality rates together with their respective benefit-cost ratios. It is evident from Table 5.5 that in the "without" dipping scenario, the would be mortality rate is inversely related to the probability of occurrence. This is because higher mortality rate e.g. 21% is relatively a worst case scenario that is unlikely to occur, hence the low probability of 2%. At 15% and 21% mortality rate the benefit-cost ratio is 1.5 and 2 respectively.

Table 5.5: Estimates of Mortality Rates for the "Without" Dipping Scenario

Mortality rate (%)*	Probability of occurrence (%)*	Benefit-cost ratio
4	80	0.8
10	40	1.2
15	10	1.5
21	2	2

*Source: Spickett (1998)

Attempts to supplement this analysis with other measures of project value, internal rate of return and net present value, were made. But lack of both benefit and costs series of data as well as data on initial investment costs precluded the performance of the analysis. This lack of data surely underscores the importance of institutionalising project monitoring and evaluation within the South African agricultural research system.

However, wherever programmes involve public expenditure the authorities responsible now require, *inter alia*, clear demonstration that programmes will show a net benefit and the extent of such benefits need to be indicated. In performing analyses of ongoing programmes, there has to be a comparison of projected future progress with what would happen in the future if the programme can be discontinued (Beal, 1980). Therefore, what is of relevance today is the analysis of what will happen in future if dipping can be completely discontinued. It is estimated that in the first, second and third year farmers are likely to face an average mortality rate of 10, 6, and 4 percent respectively (Spickett, 1998). Thus, it will only take 3 years for the herd to develop an acceptable immune system to the extent that the mortality rate can stabilise at 4%.

The reason for the high mortality rate in the first year is that dipping to some extent destroyed the immune system of especially the indigenous African breeds. In addition, it resulted in an interruption in the transmission of tick-borne pathogens and led to the establishment of a susceptible cattle population which was followed by the loss of the existing situation of enzootic stability. Considering a 10% mortality rate, of the total sampled herd of cattle (1976) 198 cattle are expected to die of tick-borne diseases resulting in a R228 0986 (198 * R1 152) loss to the sampled cattle owners. Obviously, dipping should continue but the manner in which it should continue would require further investigation with all participants within the livestock industry.

5.9 The Direct Economic Impact of Tick-borne Disease Mortalities at Farm Level.

Tick-borne diseases cause great economic losses to the individual farmer. Mukhebi and Perry (1992) categorised losses caused by tick-borne diseases into direct and indirect production losses, losses through costs incurred for controlling the disease and costs for providing research training and extension services pertaining to the diseases. Economic losses caused by tick-borne diseases are at present difficult to estimate accurately. Direct production losses can be attributed to the presence of the diseases in the cattle herd largely through mortality. Cattle which become severely infected die unless treated. Often it is the mortality rate and the cost of control that appears to receive the greatest attention and concern from those interested in controlling the diseases. This is due to the fact that mortality is more discernible than any tick-borne disease effects. Moreover, losses from morbidity are negligible compared with losses from mortality and may be ignored. It is for this reason that this section solely focuses on the effect mortality caused by tick-borne diseases have for the sampled small-scale cattle farmers.

A total number of 64 cattle died from tick-borne diseases as reported by 22% of the sampled farmers. Total cattle losses range from 2 in Dzanani to 16 in Guyuni. The most commonly found tick-borne diseases in the surveyed areas are redwater, heartwater and gallsickness. The majority of the respondents (71%) are farming with the Nguni breed which represent about 65% of the total sampled herd size. However, it constitute 80% and 50% of the total sampled herd in the Open and the Yellow Line area respectively (see Figure 5.1). With the exception of Tshifudi, group discussion indicates that the respondents within the Yellow Line area have always preferred cattle breeds that grow fast for commercial purposes.

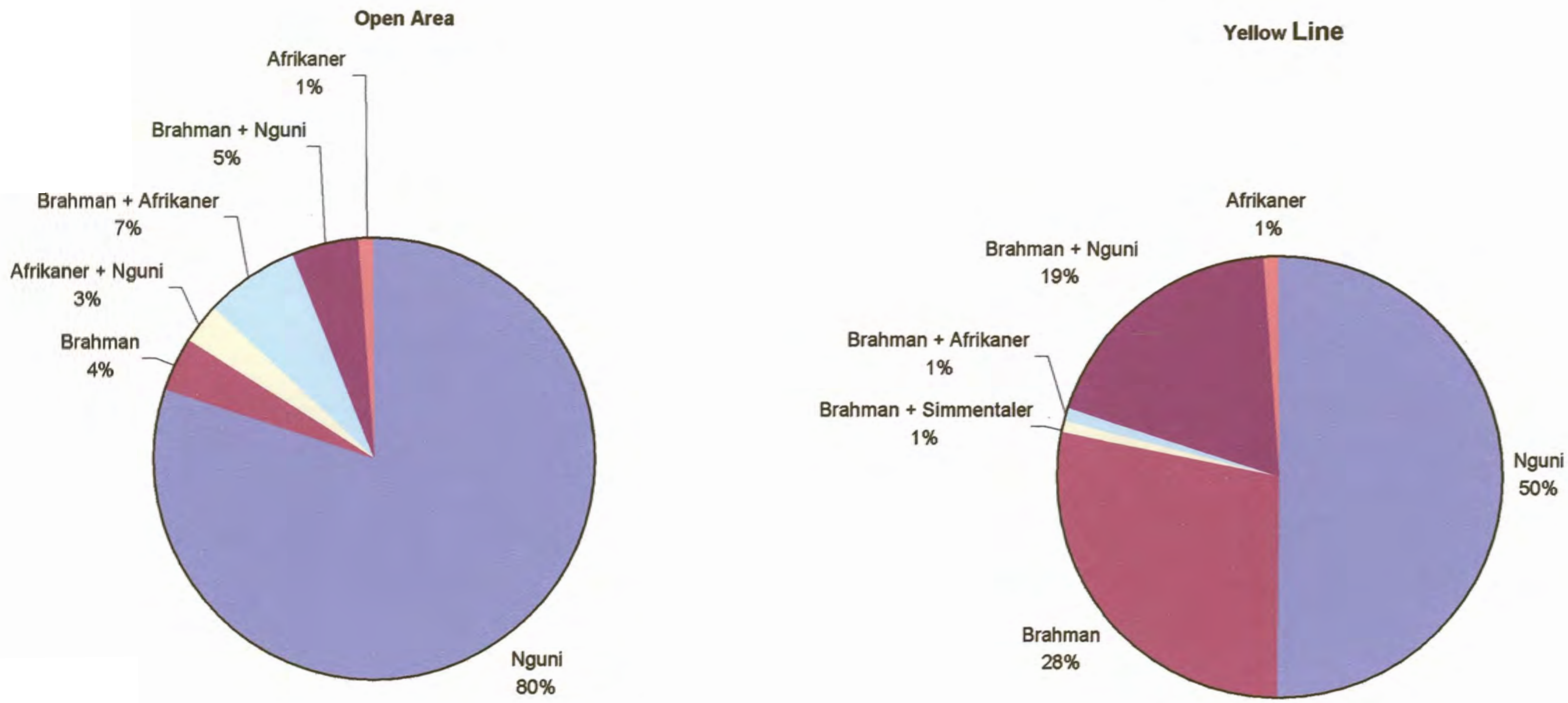

Figure 5.1: Cattle Breeds Kept by the Respondents

The Nguni breed is resistant to diseases to such an extent that little or no losses from the infection may be experienced, especially in areas where tick-borne diseases are endemically stable (Norval *et al.*, 1994). However, contrary to expectation Table 5.6 show that Nguni breed exhibited a relatively higher mortality of 2.8%, followed by the Nguni - Brahman mixed breed mortality of 0.3% in Matshena. The relatively high mortality due to tick-borne diseases in the Nguni breed can probably be ascribed to the loss of immunity caused by indiscriminatory acaricides application. More importantly, a possible explanation for this paradox could relate to poor management practices of small-scale farmers.

Evidently, tick-borne diseases hardly makes it possible for a resource poor farmer in particular to maintain the desired rate of genetic gain through selection since tick-borne diseases affect the demographic structure of the herd population. Animals which recover from tick-borne diseases may suffer from weight loss, produce low milk yields, provide less draught power and could possibly suffer from reduced fertility and delays in reaching maturity. These animals according to Lawrence (1992) remain carriers and can spread the infection, particularly heartwater.

Table 5.6: The Average Value of Cattle Lost and the Number of Cattle Deaths by Region.

Cattle breed	Vyeboom	Malongana	Guyuni	Matshena	Dzanani	Tshifudi	Mortality rate (%)
Brahman	-	0 .7 (3)	-	-	-	-	0.1
Nguni	3.4 (13)	0.7 (2)	4.9 (16)	1.9 (7)	0.69 (2)	6.5 (14)	2.8
Brahman – Nguni	-	-	-	1.7 (6)	-	-	0.2
Afrikaner – Nguni	0.3 (1)	-	-	-	-	-	0.05
Total	3.9 (14)	1.4 (5)	4.9 (16)	3.6 (13)	0.7 (2)	6.5 (14)	3.2 (64)
Total average value of cattle lost (R)	19 138	6 255	15 008	11 960	1 146	11 592	73 728

Note: Figures in parenthesis indicate the actual number of cattle mortalities whereas those outside indicate the percentage cattle mortalities.

Table 5.6 also shows the effect of mortalities in terms of the loss in income due to tick-borne diseases. The average number of cattle lost indicated in the last row/Table 5.6 represents the loss of adult cows capable of performing all the quantified values of cattle. The total average monetary value of cattle lost was estimated as follows: Taking the second column as an example:

Average value of cattle for Vyeboom	R1 367 (see Table 2.8)
Total number of cattle lost	14
Total average value of cattle lost	= R 19 138

This value reflects the cost of the loss of cattle as a result of tick-borne diseases in Vyeboom. The total average value lost ranges from R1 146 for Dzanani to R19 138 for Vyeboom. The financial loss caused by animal diseases is determined, *inter alia*, by the form of diseases. A disease can either be in an enzootic or epizootic state. The former refers to those diseases whose incidence vary from farm to farm and which the individual livestock owner can control (Dijkhuizen *et al.*, 1991: 263). Whereas epizootic diseases on the other hand are those that are usually contagious and rarely occur in certain areas and they require regional, and (inter) national control measures.

The total loss of cattle value to the surveyed areas is estimated at:

Number of cattle died * average value per cattle

64 * R 1 152 = R 73 728

The estimate indicates that the total direct loss in milk, traction, manure and sales caused by tick-borne diseases in the surveyed areas is R73 728. It is important to note that as the number of cattle death increases, the total cattle value lost also increases. From Table 2.8, it is apparent that milk production due to cattle death represent the greatest financial loss followed by meat sales, work of cattle and manure. This is slightly in contrast with a study done by Mukhebi and Perry (1992) in 11 African countries on the annual economic losses due to East Coast fever (appendix 2 Table 1) where the reduction in milk production represented the greatest financial loss followed by traction, beef and manure.

occurrence of a catastrophe in less developed regions. To avoid further cattle deaths it is important to examine the real causes influencing the occurrence of those deaths. Although cursory discussed below, all factors influencing the occurrence of diseases need further investigation.

5.10 Factors Influencing the Occurrence of Tick-borne Diseases

Socio-economic factors have a strong influence on the distribution, dynamics and significance of animal diseases, particularly in developing areas where there are wide differences in the socio-economic status of the inhabitants (Perry and Mukhebi, 1995). Socio-economic factors are generally taken to mean the non-physical properties or characteristics of human environments, which can greatly influence the natural environment.

In broader terms, the essence of these factors mean the economic status of a human population, and all the other characteristics which can be influenced by that, such as level of education, income (occupation), access to resources, including capital, land and services. Throughout the world, public health research demonstrates that people in the lowest socio-economic group experience the highest rate of livestock mortality and morbidity (Coetzer, 1995). Considering two of the most important socio economic characteristics namely, educational qualifications and residential status, the majority (52%) followed by 19% of the sampled farmers are pensioners and the unemployed respectively[5]. It is therefore not surprising that the majority of cattle owners (43%) do not have a single year of formal education.

In addition to socio economic status, disease occurrence and the resulting economic losses vary widely within and among countries due to differences in livestock production systems, cattle breeds, level of disease risk, disease control policies and programmes (Coetzer, 1995). The occurrence and prevalence of parasitic infections in a given locality

[5] See appendix 2 (Table 2) for a detailed information on socio-economic characteristics of the respondents

is a reflection of a complex interaction between the environment and the host species that are present.

The existence of dual socio-economic divisions of land use, namely the commercial farming areas and the communal land has an influence in the occurrence of certain tick-borne diseases. In commercial farming areas, for example, the relatively low cattle stocking density, high standard of pasture management and adequate tree cover ensure a near perfect environment for the tick vector *Rhipicephalus appendiculatus* that causes theileriosis. In contrast, the high population density, poor pasture management and scarcity of tree cover in the communal lands means the tick cannot survive and is absent from most of the communal lands even though they occur within a climatically suitable environment in terms of rainfall and temperature,

According to Norval *et al.* (1992) there is evidence of variation in susceptibility of different cattle types and breeds to different tick species. Improved breeds of livestock are much more susceptible to the effects of tick-borne diseases infections, and considerable investment in disease control technologies such as acaricides is required (Perry and Mukhebi, 1995). Furthermore, as farmers move up the socio-economic ladder, they wish to exploit opportunities to enhance their productivity by investing in more productive livestock. The existence of Afrikaner crosses is, *inter alia*, attributed to the Venda government breeding policy that was aimed at improving animal production. This policy resulted in the introduction of state owned Afrikaner bulls in the late 1970s. However, this venture was met with little success.

Future expectations are that the introduction of improved but susceptible breeds is likely to occur probably with an increase in the standard of living accompanied with improvements in socio-economic status. Closely related to this is a change of farmers' motive towards cattle farming from a cultural motive to a commercial one. To achieve this, respondents were asked about the preferred breed of their choice for future use. The research results (see appendix 2 Table 3) reveals that the Nguni breed is favoured by 58% of the farmers, followed by the Brahman (16%) and the Afrikaner (12%). Given that the

Nguni constitute 65% of the sampled breed, results shows a decrease of 11% in the Nguni breed in favour of more improved breeds.

5.11 Conclusion

The cost-benefit analysis of ticks and tick-borne diseases control programme was done in two scenarios, namely the "with" and "without" control scenario. Emphasis was given to the comparison of the costs and benefits of each strategy at the household level, had both strategies been adopted. The income forgone in terms of milk, meat, draught power and low productivity under the "without" scenario is larger than the income forgone under the "with" scenario.

The results of this chapter reveal a benefit-cost ratio which is less than one (0.8) using a 4% mortality rate. This ratio can possibly be improved by reducing the current dipping costs through the adoption of a strategic tick control. However, this ratio seem to be sensitive to changes in the mortality rate yielding a benefit-cost ratio of 1.2 when the mortality rate is changed from 4% to 10%. Although the benefit-cost ratio is less than one, the dipping programme still deserves government support because of the economic (public) nature of the service it provides. More importantly, in less developed areas dipping forms part of the whole veterinary surveillance programmes which in essence is a purely public good. The information from a surveillance programme benefits the whole sector and cannot be appropriated by any livestock farmer.

CHAPTER 6

DEMAND FOR LIVESTOCK TICK CONTROL SERVICE

6.1 Introduction

Animal health control services remain an important input support function for any livestock farmer, as diseases and high mortality are major constraints on livestock production in Southern Africa (Nell *et al.*, 1998). In South Africa's developing areas animal health services are provided at highly subsidised charges or "free of charge" as explained previously. It costs the government R12.00 and communal farmers R1.00 to dip a head of cattle per year. Under government service, it is compulsory for farmers to take their animals for dipping at stated intervals to achieve more effective and widespread control.

This chapter attempts to identify factors that influence farmers' willingness-to-pay, as well as the revealed preference for dipping frequency from the point of view of the respondents if dipping legislation were to be relaxed. To achieve this, a multivariate regression analysis and a logistic regression model are applied. A fundamental purpose of multivariate regression analysis is the prediction of the dependent variable with a set of independent variables. In addition, logistic regression analysis presents a unique complement to a multiple regression in its ability to utilise a binary dependent variable but also predicts the probability of an event.

Identification of factors that determine the demand for livestock services can possibly have promising and cost-saving impacts on the planning and extension of future livestock disease control programmes. In addition, the rationale for identifying those factors is important, more particularly to extension educators, technical assistants and policy makers involved in livestock development in order to target and deliver effective tick control programmes. However, due to communal farming complexities, this analysis is based on the assumption that dipping price per head of cattle per year remains fixed irrespective of dipping frequency. It is important to note that data limitations precluded the significance and inclusion of all the factors likely to influence the demand for dipping service and the willingness-to-pay for such a service.

6.2 The Respondents' Revealed Dipping Demand frequency

To determine whether farmers are in favour of the present dipping arrangements respondents were asked about dipping intervals that they prefer for future tick control should the legislation be relaxed. The majority of the respondents (51%) prefer to dip their cattle twenty six times per year (i.e. equivalent to once per week in summer). This ranges from 2% in Vyeboom to 33% both in Malongana and Matshena as indicated in Table 6.1. Secondly, 41% of the respondents prefers to dip their cattle once per week with the majority in Tshifudi (29%). Farmers' tendency towards high acaricides treatment frequency is probably indicative of high tick challenge in the region and also reflects the attitude of the majority of farmers towards intensive tick control.

The overall dipping frequency ranges from three times a week to a strategic tick control based on tick counting. Few farmers (2%) are undoubtedly in favour of an opportunistic (strategic) tick control measure based on tick counting. This means that acaricidal treatment will be applied only when there is relatively high tick numbers. Strategic tick control would make for less intensive use of expensive acaricides and would reduce (save) the cost of ticks and tick-borne diseases control. However, the costs of the method and the economics of its application will obviously vary in time and space in each region depending on the cattle type, tick ecology and epidemiology, and the prevailing level of disease risk.

Table 6.1: **Revealed Dipping Demand Frequency**

Frequency (times per year)	Vyeboom	Malongana	Guyuni	Matshena	Dzanani	Tshifudi	Total
	%						Number
Two	100	-	-	-	-	-	1
Twelve	-	-	-	100	-	-	1
Twenty six	2	33	23	33	9	-	64
Thirty six	-	100	-	-	-	-	1
Fifty two	26	-	16	2	28	29	51
Hundred and four	50	-	-	-	-	50	2
Hundred and fifty six	-	-	-	-	50	50	2
Tick counting matters	33	33	-	-	33	-	3

Note: Most of the farmers' responses were on weekly basis but converted to an annual basis such that:
Fifty two = once/week Hundred and four = twice/week
Twenty six = once/two weeks Hundred and fifty six = thrice/week
Twelve = once/month Thirty six = thrice/month

6.3 Farmers' Willingness-To-Pay for Dipping Services

The concept of willingness-to-pay is borrowed from demand theory. It is derived from an interpretation of a point on a demand curve representing the maximum price that a customer would be willing to pay for the corresponding quantity of a particular good (Mansfield, 1975). It is used to impute the real value of a service to a customer or group of customers. The willingness-to-pay criterion is advantageous because it is a measure of farmer's response to a particular technology. Baker *et al*. (1988) argue that farmers are probably better qualified to give a broad, inclusive evaluation of the technology's value to themselves than any other group. However, the farmers' assessment of a particular technology is influenced by many factors, such as economic and social factors. In their evaluation attitude towards risk is one of the most important factors that influence the willingness-to-pay for a particular project.

Ultimately it is farmers who have to decide whether to adopt a certain technology. These decisions are based on their own perception and ability to pay for the service/technology. Therefore, this study used the willingness-to-pay approach to estimate the demand for dipping services. Each farmer was thus asked as to how much (s)he thinks it costs government to dip a head of cattle per year. The results are shown in Table 6.2.

Table 6.2: Farmers Willingness-To-Pay and Government Estimated Contribution to Dipping Services by Area

Areas	Farmers willingness-to-pay (R/head/year)		Farmers estimated government contribution (R/head/year)		Average farmers' willingness-to- pay (R/head/year)	Farmers' estimates of government contribution (R/head/year)
	Min	Max	min	max		
Vyeboom	1	30	14	500	3	257
Malongana	0.50	15	5	333	2	35
Guyuni	0.50	2	10	50	1	24
Matshena	0.50	5	10	500	2	51
Dzanani	0.50	20	0.50	1000	2	500
Tshifudi	0.50	14	1	1500	2	234
Average	0.50	30	0.50	1500	2	184

Source: Own survey data

All the sampled farmers (125) are willing to contribute to any services aimed at controlling ticks and tick-borne diseases, but the amount that they are willing to pay varies. As could be expected the majority of the sampled farmers (67%) feel that cost recovery should continue at the current cost to the farmer of R1/head/year. The minority (10%) is prepared to pay a lower price relative to the currently charged price.

At least 23% of farmers are willing to pay relatively high prices if dipping services can be guaranteed to be effective and improved. The maximum willingness-to-pay ranges from as low as R2.00 in Guyuni to a maximum of R30.00/head /year in the Vyeboom area (see Table 6.2). The findings of some recent studies (Umali *et al.*, 1994) indicate that farmers are generally willing to pay for reliable and effective services. On average sampled farmers are willing to contribute R2/head/year for dipping as shown by Table 6.2. The willingness-to-pay gives some indication of the farmer's assessment of a technology's value. Subsistence farmers in particular may find it difficult to estimate the benefits of dipping or omit important benefits thereof, especially when such benefits are not readily apparent or quickly converted into cash.

It should be noted here that the question regarding farmers' willingness-to-pay was experienced as a sensitive one. Farmers perceived it to be indicative of a new basis for future policy making with regard to ticks and tick-borne disease control. Therefore, farmers seemed to be reluctant to provide this information and the estimates are likely to be biased downwards.

With regard to the farmers' view on the estimated costs that they think the government spend per dip per cattle per year, at least 34% of the sampled farmers were able to estimate an average cost to the government of R184/head/year. However, the general feeling for those farmers that were unable to estimate the cost to the government felt that it was higher than what they are currently contributing. Since many of the cattle owners are poor and have to rely on meagre pensions for their existence, they are not in favour of an increase in dipping costs and feel that some form of subsidy on dipping costs is called for. Using both the 1996 and 1999 prices, it approximately costs the government an average amount of R12.00 and R22.00 to dip a head of cattle per year for forty dippings, respectively[6].

6.4 Factors Influencing Farmers' Demand for Veterinary Services.

Livestock owners take many things into account when deciding whether or not to make use of animal health services. Umali *et al.* (1994) identified the most important factors influencing the demand for veterinary services as:

- *The size of the herd.* The size of the herd has many ramifications for veterinary care. A general (although not infallible) rule of thumb is that, as the herd size increases the veterinary cost per animal decreases. The cost differential can become a screening device as to who can afford veterinary services, because larger farmers may be able to afford the service. Similarly, owners of small herds can still take advantage of economies of scale by becoming members of a producer association. However, producers associations are rarely being established by small or subsistence farmers. Under certain circumstances, if established, they are of a short-term nature to overcome a certain pressing problem or need.

[6] These costs include only dipping (acaricides) costs and exclude salaries, transport costs etc

- *The relation of benefit to cost.* Normally farmers demand animal health care only if the benefits of the veterinary care exceed its cost i.e. a benefit-cost ratio greater than one.
- *The nature of the disease and the economic losses associated with it.* Different diseases have different effects on livestock and the economic impact on the livestock enterprise thereof may also be different. The risk of economic losses is greater for some diseases than for others: thus if the disease is not economically threatening, a farmer may forgo veterinary care. For instance, a dairy herd owner may be more inclined to take steps to combat brucellosis than to deal with heartwater. Closely related to this, another factor that comes into play in the owners decision on how to deal with disease may be the breed of cattle involved because of differences in genetic potential or disease resistance.
- *The nature of the livestock production system.* The type of livestock production system affects the potential for disease transmission. Livestock in the extensive breeding areas have a higher risk of diseases than livestock kept under intensive farming. This can probably be ascribed to overstocking which is typical of communal grazing areas. It is expected that these farmers may have a higher demand for preventative services than farmers under intensive farming systems because the risk of disease outbreaks is higher.

6.5 Methodologies for Measuring Demand Functions

Regression analysis is the common approach taken to estimate demand or preference functions. Indeed the literature on these analyses has expanded rapidly in various direction of sophistication. Most of these studies have used time series data with continuous variables in a multivariate regression framework. A similar approach has been used with cross-section data explaining the continuous dependent 'demand' variable with independent continuous variables.

However, in analyses that use farm data from cross-sectional surveys, binary responses are often encountered because of the categorical nature of the decision. When a service is introduced a farmer is confronted with a decision to which (s)he reacts positively or negatively. Differences in such reaction result from the fact that producers do not have the same resource endowments, they have different objectives and utility preferences, and are often of different socio-economic backgrounds.

In order to account for these binary responses the regression literature has expanded to facilitate a binary dependent variable in the form of logit, tobit and probit models. This analysis will use both a multivariate as well as a logistic regression approach. These different methodologies will complement each other and enrich the analysis of the survey data.

6.5.1 Multivariate Regression Model

The multivariate regression model can be expressed as:

$$y_i = \delta_0 + \sum_{i=1}^{n} \delta_i x_i \qquad (1)$$

Y_i is the dependent variable, X_i are the explanatory variables. These can include both the dichotomous and continuous variables.

6.5.2 Logistic Regression Model

The logistic regression model can be expressed as:

$$Log\left(\frac{P_{(y=1)}}{1-P_{(y=1)}}\right) = \beta_0 + \sum_{i=1}^{n} \beta_i \chi_i \text{ or as } \left(\frac{P_{(y=1)}}{1-P_{(y=1)}}\right) = e^{(\beta_0 + \sum_{i=1}^{n} \beta_i \chi_i)} \qquad (2)$$

Where P is the probability that y=1 and χ_i are the set of explanatory variables. In this analysis χ will contain both dichotomous and continuous variables as in the multivariate regression analysis in the previous section. In the second expression in equation (2) the left-hand side is an odds ratio and the right hand side gives the marginal effects of χ_i on the odds.

6.5.3 Dependant and Explanatory Variables

The multivariate regression analysis will use the price farmers are willing to pay and the frequency with which farmers would like to dip their animals as dependent variables. These are both continuous. The first variable will be transformed into binary form for the logistic regression. The price farmers are willing to pay will be 1 when the price is higher than what they are currently paying for the dipping service (i.e.>R1.00) and 0 if it is lower (i.e. ≤R1.00). This cut-off in prices was chosen primarily to determine the factors that determine whether a farmer is willing to pay more for the dipping service than (s)he is currently paying.

Several independent variables were selected to estimate the predicted values of the dependent variables. The choice of variables used is largely based on Tambi *et al.* (1999) who extensively reviewed factors influencing farmers' demand for private veterinary services. Factors that influence both the willingness-to-pay and the revealed preference for dipping services are arguably similar. Some of the variables chosen were either dichotomous or continuous and are listed in Table 6.3.

Table 6.3: Definition of Variables Influencing both Farmers' Willingness-To-Pay and the Revealed Demand for Dipping Services

Explanatory Variables	Variable description
Dichotomous variables	
Residential status	1 – if the farmer is employed 0 – if farmer is not employed
Breed composition	1 – if farming with exotic breed 0 – if farming with Nguni only
Outreach Programmes (e.g. farmers' days)	1 – if farmers have outreach programmes 0 – if farmers do not have outreach programmes
Investment	1 – if farmers have alternative investment opportunity beside cattle farming 0 – if farmers do not have alternative investment opportunities.
Crop farming	1 – if farmers also practice crop farming 0 – if farmers do not practice crop farming.
Satisfaction with the dipping programme	1 - if satisfied with the dipping programme. 0 – if not satisfied with the dipping programme.
Perception about the disease*	1 - if farmers associate ticks with diseases. 0 – if farmers do not associate ticks with diseases
Continuous Variables	
Age	Age of farmer in years
Educational qualification	The level of education in years
Farming experience	Number of years of experience with livestock farming acquired by the farmer
Value of the cattle	The value of cattle measured in monetary terms (see chapter 2)

* This variable is assumed to have no influence on the farmers' willingness-to-pay for dipping services.

These factors are hypothesized to have different impacts on the dependent variables and the rationale for including these variables in the model is as follows. Demand for the dipping service and the willingness-to-pay are hypothesised as a positive function of employment. This is attributed largely to the income (salary) received which is likely to increase farmers ability and willingness to pay a higher price and possibly demand more animal health services. As far as farmers' age is concerned the relationship may be positive or negative depending on the stages of development. Younger farmers are assumed to have relatively high socio-economic status. These farmers may recognise the importance of maintaining a healthy herd through intensive dipping and as such may be prepared to pay higher prices for dipping services probably because of their understanding of the 'paying for the service' principle. Whereas very old farmers tend to be less energetic and more relaxed about disease and pest control, obviously these farmers might not be prepared to pay higher prices for a service that they might seldom use.

Closely related with age is experience. It is hypothesized that long term farming experience is negatively related to the willingness-to-pay and positively related to the dipping frequency. Farmers with long term farming experience are generally pensioners and are traditionally not used to the payment of rising prices and are characterised by the dependency syndrome. They have traditionally also been exposed to an intensive dipping frequency at a fixed cost. Thus, the number of years in livestock farming could positively or negatively influence the willingness–to-pay depending on the farmers position in the life cycle.

The variable breed composition was included to account for the differences in responses between farmers with exotic breeds and the Nguni breed. Breed of cattle is expected to influence farmers' willingness-to-pay for dipping services, as well as the revealed preference for dipping either negatively or positively depending on the genetic potential of the breed kept. Exotic breeds are more susceptible and less tolerant to diseases than the Nguni breed. It is therefore hypothesised that farmers with exotic breeds are expected to prefer an intensive dipping programme and will be willing to pay a higher price for the service. This is because farmers with exotic breeds are likely to be those with relatively higher socio-economic status, and *vice versa* for the Nguni breed farmers.

Education and training have been shown to influence farmers' adoption and farm management behaviour (Jones *et al.*, 1989). Educated farmers tend to be more conversant with improved husbandry methods and generally recognise the importance of having a healthy herd through disease and pests control. For such farmers, demand for animal health services is high. Thus, farmers with a high level of formal education are expected to prefer an intensive dipping programme and would be willing to pay more for dipping services probably because high education level is mostly associated with higher paying jobs.

Outreach programmes (e.g. farmers' days) are expected to positively influence the willingness-to-pay and negatively influence the dipping frequency. This might probably be the result of the current emphasis on the 'paying for the service' principle and the tick control strategy advocated under the tick control programmes is one of less acaricides application (strategic dipping). In addition, outreach programmes are assumed to be more relevant and informative than formal education, *ceteris paribus*. The attendance of farmers' days by rural livestock households in less developed areas to an extent reflect the degree of farmers' involvement and commitment in livestock production. Such attendance helps them to be up-to-date and remain informed.

There seems to be a limitation of investment opportunities in rural areas with cattle being the main and better investment opportunity as expressed by 88% of the sampled farmers. Under these circumstances one would expect that farmers without better alternative investment opportunity would be willing-to-pay a higher price and would prefer an intensive dipping service. This is probably because farmers will want to ensure that their investment (livestock) is highly protected from any natural shocks e.g. diseases. Intensive dipping would therefore be preferred to maintain a good health of the animal thereby ensuring the highest possible return from the investments. Crop farming is expected to positively influence the willingness-to-pay and negatively influence the revealed demand for dipping. The positive relationship might be attributed to the income derived from both enterprises that likely increases the buying ability assuming that farmers do sell their surplus produce. The negative relationship, however, can be attributed to labour flexibility between the livestock and crop farming enterprises such that the farmer might not prefer dipping his cattle intensively, as (s)he would like to devote more time towards crop production.

Satisfaction with the programme was also included in the model to reveal farmers' attitude towards the dipping programme. Unsatisfactory services usually yield negative attitudes towards that particular service. Therefore, farmers' willingness-to-pay and the demand for dipping are hypothesized as a positive function of farmers' satisfaction with the dipping service. In addition, satisfaction with the dipping programme implies that farmers might be getting value from their contribution.

The value of the cattle expressed in monetary terms is expected to positively influence both dipping frequency and the willingness-to-pay. Similarly, farmers who highly value their livestock are expected to prefer an intensive dipping frequency. This is due to the fact that healthy animals are usually valued higher than the unhealthy ones, hence the preference of an intensive dipping frequency in order to maintain the value of an animal. If this value can actually be realised, the more farmers will be willing to pay a higher price due to higher income likely to be received. Demand for tick control services is also hypothesized as a positive function of farmers' knowledge about tick-borne diseases herein referred to as perception about the disease. Thus, if farmers associate ticks with diseases, more farmers would like to intensively control ticks so as to avoid the cause of the disease (i.e. ticks).

6.6 Empirical Results

6.6.1 Factors Influencing Farmers' Willingness-to-Pay

Empirical estimates derived from the multivariate regression analysis are presented in Table 6.4. The level of significance chosen was 15%, and it was chosen because of the limited number of usable observations from the farmers' survey in estimation. In addition, the level of statistical significance was chosen to be able to determine those variables most affecting the independent variables. The results of the multivariate regression analysis on the willingness-to-pay indicate that at least three variables are statistical significant, namely residential status (P=0.14), herd composition (P=0.11) and satisfaction with the programme (P=0.14). As expected residential status and satisfaction with the programme variables are of the hypothesized positive sign. Contrary to expectation, however, farmers with exotic breeds are not willing to pay a higher price.

This can be ascribed to the communal grazing complexities where a farmer might unintentionally end-up farming with exotic breeds as a result of his/her cattle (possibly Nguni) mating with the exotic bulls of other farmers usually of a relatively high socio-economic status. This to a certain extent indicate a need to strengthen the delivery of extension services to the study area. The extension messages should, *inter alia*, cover topics on the advantages of keeping indigenous African breeds. As such this is an added advantage for ease of implementation of strategic tick control.

Table 6.4: Multivariate and Logistic Regression for Factors Influencing the Willingness-to-Pay

Independent variable	Multivariate Regression Results		Logistic Regression Results		
	δ_i	t-value (t-Prob)	β_i	t-value (t-Prob)	Exp (β_i)
Constant	2.46	1.24 (0.21)	-0.13	-0.08 (0.93)	0.87
Human resource					
Educational qualification	0.30	0.64 (0.52)	0.31	0.88 (0.38)	1.36
Farming experience	-0.02	-0.77 (0.44)	-0.03	-1.67 (0.09)	0.97
Liquidity					
Residential status (Employment)	1.34	1.48 (0.14)	0.53	0.89 (0.37)	1.69
Structure of production					
Herd composition (Exotic/Nguni)	-1.25	-1.61 (0.11)	-1.07	-1.84 (0.07)	0.34
Value of cattle	0.01	0.49 (0.62)	0.01	0.74 (0.46)	1.01
Crop farming	1.00	1.15 (0.32)	0.37	0.47 (0.64)	1.45
Extension					
Outreach programmes	-1.07	-1.19 (0.24)	0.63	0.87 (0.38)	1.88
Attitude					
Satisfaction with dipping service	1.92	1.47 (0.14)	0.03	0.03 (0.98)	1.03
Regional differences					
Dzanani	-1.77	-1.23(0.22)	-1.55	-1.39 (0.17)	0.21
Guyuni	-3.22	-2.54 (0.01)	-2.76	-2.24 (0.27)	0.06
Matshena	-0.99	-1.05 (0.30)	-0.49	-0.75 (0.45)	0.47
Goodness of fit	0.11		0.81		

There also appears to be strong regional differences with regard to farmers willingness-to-pay. For unknown reasons, the results indicate that farmers in Guyuni are not willing to pay a higher price for dipping services. The goodness of fit is measured by R^2 and judging from the results the explanatory variables explain at least 11% of the variation in the farmers willingness to pay. In models with qualitative dependent variables, the conventionally computed R^2 is likely to be much lower than one because corresponding to a given dependent and independent variables is 0 or 1. As a result the "use of the coefficient of determination as a summary statistic should be avoided in models with qualitative dependent variables" (Gujarati, 1988: 472).

Applying the logistic regression model, at least two variables, namely farming experience (P=0.09) and herd composition (P=0.07) were significant at the 10% level of significance as indicated in Table 6.4. Farmers with a relatively long term farming experience are not willing to pay a higher price for dipping services as expected. Again, as in the multivariate regression analysis farmers with exotic breeds are not willing to pay a higher price for dipping services. There is a slight indication of regional differences in farmers' willingness-to-pay amongst Dzanani, Guyuni and Matshena. The negative sign of all the coefficient in all the aforementioned diptanks indicate that farmers in those diptanks are not willing to pay a higher price. These results are consistent with the results of the multivariate regression analysis. A possible explanation that can be advanced is that the three diptanks probably experience a low tick challenge such that farmers might not see the need for a higher price. If this explanation holds true, it therefore indicates that there are some dynamics in tick occurrence or changes in tick distribution taking place within and amongst the veterinary zones because one would expect a higher tick challenge in Matshena (Yellow Line area). The specified model provided encouraging results with a goodness of fit of 0.82.

The existence of regional differences in farmers' willingness to pay is probably an indication that financial contribution by farmers towards dipping needs to vary from a region to a region. This is sensible taking into consideration the variation in tick challenge amongst the regions. It appears irrational for farmers in different regions facing different tick challenge and different dipping frequency to contribute an equal amount of dipping costs. It seems therefore that farmers' contribution need to be closely linked with dipping frequency so as to avoid cross subsidisation.

The exponential of β_i column (Exp (β_i)) in Table 6.4 shows the odds of having an event occurring versus not occurring, per unit change in an explanatory variable. Using this interpretation, the odds for farming experience and herd composition (exotic breeds) to be willing to pay a higher price are 0.97 and 0.34 times less that of their counterparts, respectively. This means that for an additional year of farming experience gained farmers have 0.5 probability to be willing to pay a higher price for dipping, and those owning exotic breeds have a low probability (0.25) to be willing to pay a higher price i.e. exotic breed farmers have a higher probability (0.75) to be willing to pay a lower price. There also appears an indication that farmers in Dzanani, Guyuni and Matshena have a low probability (0.18 on average) to be willing to pay a higher price.

6.6.2 Factors Influencing Dipping Frequency

Unlike the analysis on the willingness-to-pay, factors influencing dipping frequency were determined using the multivariate regression analysis only. This is because of a lack of clear quantitative identification between intensive and strategic tick control dipping frequency for the survey area. The results are indicated in Table 6.5.

Table 6.5: Multivariate Regression for Factors Influencing the Dipping Frequency

Independent variable	Dipping frequency	
	Percentage of median	
	δ_1	t-value (t-Prob)
Constant	2.45	0.63 (0.53)
Human resource		
Farming experience	-0.06	-0.97 (0.33)
Liquidity		
Residential status (Employment)	37.66	13.64 (<0.001)
Structure of production		
Herd composition (Exotic/Nguni)	-1.26	-0.52 (0.61)
Value of cattle	0.01	0.88 (0.38)
Crop farming	3.70	1.15 (0.25)
Extension		
Outreach programmes	-1.80	-0.67 (0.50)
Regional differences		
Dzanani	-5.29	-1.60 (0.11)
Tshifudi	4.51	1.38 (0.17)
Goodness of fit	0.67	

At least one variable, namely employment ($P<0.001$) was the only significant variable. As expected the demand for the dipping service is of a hypothesized positive function of employment. Thus, employed farmers are prepared to adopt an intensive dipping frequency than the unemployed ones. There is also a slight indication of regional differences in dipping frequency preferences in Dzanani and Tshifudi. Sampled farmers in Dzanani do not prefer an intensive dipping whereas those in Tshifudi seem to prefer an intensive dipping frequency. This probably confirms the existence of differences in tick prevalence between the two areas, Yellow Line and the Open area, with the former considered as a high tick prevalent area. The goodness of fit as measured by R^2 is impressive since the explanatory variable explain 67% of the variation in the dipping frequency.

The results obtained from both Table 6.4 and 6.5 suggest a more significant role of human resource, liquidity, attitude and structure of production (herd composition) over other factors in affecting both the willingness-to-pay, as well as the dipping frequency.

Given that the average willingness to pay for dipping is less than the subsidised price by government, it probably indicates that in the foreseeable future subsidising the price of dipping is likely to be the norm. However, most governments according to Umali *et al* (1994) no longer have enough funds, are unable to meet the increasing needs of farmers and the availability and quality of veterinary service is rapidly declining. Therefore, information provided by the results of the study illustrate that a good understanding of those factors is necessary for those who want to get into private veterinary practice and for government wanting to privatise the delivery of veterinary services. This is because from a provider standpoint, demand must be large enough to make private practice a profitable endeavour. In addition, the results obtained have certain implications for the extension services especially towards the adoption of new practices. Prospects indicate a move from intensive acaricides application in favour of less intensive dipping based on strategic tick control. An awareness of those factors influencing the adoption of new practices is, *inter alia*, helpful to the extension agents in selecting the teaching tools to be used to yield the desired resultant end products.

An important question that one may ask is how extension agents can use the results to influence the diffusion process in adopting strategic dipping given factors influencing the willingness-to-pay and dipping frequency? The effectiveness of the extension services or method depends upon the knowledge of the target group. Thus, before strategic dipping can be implemented it is important to know the target group so that the extension method employed can be effective towards its adoption. This is crucial considering that in most cases adoption behaviour differs across socio-economic groups and overtime. From the study results, one can realise that there are various groups of farmers that can be categorised into potential adopters and non-potential adopters. In this regard, extension agents might increase their impact by co-operating with potential adopters since they tend to be people who are capable, willing and sometimes in a position to influence other farmers.

6.7 Conclusion

This chapter attempted to identify factors influencing both the demand for dipping services and farmers' willingness-to-pay using the multivariate regression and the logistic regression model. Significant factors influencing the willingness-to-pay were human resource, structure of production, and liquidity. Liquidity also influences the dipping frequency. The influence of liquidity (employment) on both the willingness to pay and the dipping frequency underscores the importance of job creation. More importantly job creation strategies in rural areas should, *inter alia*, aim at increasing the utility farmers gain from cattle by providing marketing opportunities for cattle and their products. These results are an indication that the significant possible predictor variables of adoption must be attended to when adoption policies are set for veterinary services in general.

The structure of production, herd composition in particular, provides an interesting results with both models indicating the unwillingness-to-pay a higher price for dipping services by farmers owning exotic breeds. This to an extent implies that private veterinarians intending to provide veterinary services in less developed regions need to seriously consider the structure of production in order to stimulate the demand for animal health services. On the basis of the preceding discussion, the results of the study seem to indicate that research needs to be done focussing on the effects of various breed types on the demand for animal health services.

CHAPTER 7

FUTURE STRATEGIES TO CONTROL TICKS AND TICK-BORNE DISEASES IN LESS DEVELOPED AREAS.

7.1 Introduction

The preceding chapters demonstrated that the current method of ticks and tick-borne diseases control is clearly beset with numerous limitations and is evidently inadequate and unsustainable. In tropical developing countries where problems of ticks and tick-borne diseases of livestock are the most acute, there is no longer a universal acceptance of the notion that intensive dipping in acaricides is the appropriate and desirable way to manage the problem (George, 1992). Again, experience (de Castro and Newson, 1993) has shown that the intensive use of acaricides, though beneficial in the short term if applied efficiently, soon leads to the loss of protective immunity against ticks and tick-borne diseases. Any prolonged interruption in the tick control programme leave the cattle population vulnerable to major outbreaks of tick-borne diseases or the build up of debilitatingly high tick population. Moreover, economic studies have shown that there is no justification for continuing or attempting to re-establish short interval dipping in indigenous, low producing cattle (Lawrence, 1996). As a result, the role that acaricides should play in the control or management of ticks and tick-borne diseases complex in Africa has been the subject of intensive debate in recent years, particularly in southern Africa where East Coast fever is considered to have been eradicated (Norval *et al.*, 1992).

With the above concerns in mind, there is a need to revise ticks and tick-borne diseases control practices especially in the light of current understanding of the economics of tick control. However, differences in livestock production systems and animal disease control strategy mean that individual countries will need to assess their own policy option to determine approaches compatible with optimal and sustainable application of new control strategies.

In Venda, the following strategies will be necessary to prevent future occurrence and the probable resultant of cattle mortalities caused by tick-borne diseases. In pursuing these strategies it is essential to remember that the disease does not exist in vacuum.

7.1.1 Host Resistance

Strict tick control is difficult to maintain in many less developed countries and more rigorous methods for controlling ticks and tick-borne diseases are imperative. The most important element in the control package is the use of breeds of cattle that are genetically resistant to tick infestation. In Africa, it is evident from a number of studies that indigenous breed of cattle (e.g. Nguni) are more resistance than Taurine breeds and their crosses for a variety of tick species and that there is considerable variation in individual resistance within breeds (Norval, 1992; Fasanmi and Onyima, 1992). Resistant animals have a tendency towards light tick burden and requires less dipping thereby making control relatively easy and cheaper.

Despite the increasing recognition of Nguni resistance to ticks and tick-borne diseases it is still inadequately exploited in control strategies and large number of animals in Venda are subjected to unnecessary intensive acaricides application. There is no any economic justification to intensively control ticks and tick-borne diseases for the low producing indigenous breed. However, for non-indigenous cattle with a higher production potential, short interval dipping is economically justified and it will continue to be so (Lawrence, 1996).

Failure to exploit tick resistance directly in Africa has been the result of a number of factors, foremost being the general acceptance of acaricides application as a necessity of acaricides procedure in cattle husbandry by most farmers. Linked to this is a widespread belief that even small numbers of ticks have large effects on the health and productivity of cattle. Moreover, tick control procedures were set by the requirements of the Taurine animals and the potential resistance of the indigenous breeds was ignored such that Nguni breed was intensively dipped at the expense of their immune system. Therefore wherever and whenever the control of ticks on livestock is considered worthwhile, the use of tick resistant livestock should be considered a viable option among the many factors that are weighed when devising and evaluating management strategy.

The exploitation of host resistance requires a concerted extension effort for active tick control and optimal results. Through extension services farmers should be advised and convinced to cull very susceptible animals in their herd early to upgrade the tick resistant potential of their herds by using only tick resistant cattle for breeding. However, this change is likely to be slow since some farmer's decisions on cattle breeds are deeply rooted and often driven by aesthetic, cultural, social as well as economic consideration. For a poor resource farmer like in Venda this seem to be a viable option taking into consideration that the majority of the sampled cattle owners (71%) are farming with the Nguni breed. However, host resistance to tick infestation in our local breed of cattle and the assessment of its effective role in tick control should be further investigated. And this will provide further information on the ranking of animals for tick resistance and subsequent application in livestock improvement programmes.

7.1.2 Strategic Tick Control

Strategic tick control is an attempt to control ticks and reduce losses in animal production due to tick infestation while decreasing the cost for the control. Under this strategy acaricides are applied only when it is necessary especially during period of high tick challenge. Due to low productivity of the local breed of cattle, it is difficult and virtually irrational to suggest a longer period of tick control. In addition, the increasing costs of acaricides, maintenance of the infrastructure, salaries for personnel, *etc* possibly creates a tick control programmes where the benefits may not be adequate to justify the expense. According to Norval *et al.* (1992) the other main disadvantage of acaricides have been the rate at which their costs have increased relative to the value of cattle products. Therefore, with adequate cattle owners participation and organisational support from government personnel this strategy can help to solve this economic problem. Its overall aim according Bezuidenhout and Bigalke (1987) is to:

- Reduce costs
- Decrease the tick population of an area
- Assist in increasing animal production
- Ensures that enzootic stability is maintained

However, strategic tick control is not a panacea. Practically it is a very difficult strategy to apply because (Bachmann, 1992):

- Tick numbers peak at different times for different tick species, and different stages in the life cycle of ticks.
- The times when numbers peak differ from area to area, and also possibly from year to year depending on climatic variations.
- Peaking of tick numbers might take place on other cattle breed which cannot be dipped simultaneously.
- Farmers who attempt to apply strategic dipping must be dedicated, observant and able to interprete information.

It appears possible that overtime the current benefits obtained more especially from the Nguni breed can be obtained with less cost. More importantly, it is not the total costs of the disease that is useful, but rather the avoidable costs. The economically optimal disease control policy is that which gives the lowest attainable total costs, i.e. the least-cost combination of control expenditure and losses (McInerney *et al*., 1992).

Unfortunately, very little relevant information on exactly how to strategically control ticks is presently available (Bezuidenhout and Bigalke, 1987). The main reasons for this are a lack of knowledge on the infection rate of ticks, the factors that influence such a rate and the absence of a practical method to determine the percentage of infected ticks. It would be of great value if one could attempt to turn these limitations into opportunities for future research.

7.1.3 Integrated Tick Control Strategy

Most farmers in less developed regions are resource poor and it is therefore important that ticks and tick-borne diseases control strategies should be aimed at making control affordable and readily available to these farmers. This cannot be achieved by adopting a control strategy that is totally dependant on acaricides, but based on cheaper, safer and sustainable methods of tick control such as the use of natural pesticides in integrated tick programmes.

Current policies is to combine two or more of the available techniques for controlling ticks and tick-borne diseases to produce an integrated system of tick management. According to Mukhebi and Perry (1992) disease control in any country or area is possible only if the different measures complement each other. As the name indicates, integrated control strategies are based on the use of several different methods for the control of ticks and tick-borne diseases, as opposed to the use of a single method such as intensive acaricides application for the control of the entire ticks and tick-borne diseases complex. The philosophy is that different methods for ticks and tick-borne diseases control are complementary, economically viable and sustainable such that if one control measure breaks down a robust integrated control system still remains effective. This strategy is necessary as it is now clear that tick eradication by means of acaricides is unachievable and that the control of ticks and tick-borne diseases by intensive acaricides treatment of livestock is expensive.

The aims of integrated control strategies should be to manage tick population and tick-borne diseases within acceptable limits in which the risks of disease outbreaks are minimal (Norval *et al.*, 1992). Moreover,…"the objective of tick control should be to reduce tick population below the economic threshold so that control costs are less than the anticipated benefits, not all of which can be priced in subsistence economies" (de Castro and Newson, 1993: 13). Tick population can possibly be managed by utilising host resistance with strategic tick control measures previously discussed. Whereas tick-borne diseases can be managed by ensuring that all domestic livestock are immune to the diseases that occur there. Immunity may possibly be maintained by simply ensuring that tick numbers are high enough to perpetuate endemic stability. The essence of the integrated control programmes is to provide sufficient tick control to increase cattle productivity, while not reducing tick numbers to the extent that endemic stability is adversely affected.

Pegram *et al.* (1993: 4) mentioned some of the main essential elements of an integrated ticks and tick-borne diseases programme, namely:

- Appropriate legislation
- Correct extensive message for both disease and vector control
- Enzootic stability to tick-borne diseases
- Host resistance to ticks using the correct breed
- Appropriate strategies, such as minimal control in periods of low challenge and strategic control for seasonal challenges
- Economics and marketing, considering the costs of acaricides production and delivery and type of farming.

For resource poor farmers a policy of minimal intervention can be the best strategy. Evidently, integrated tick control strategy seems to be the best strategy to be pursued by those farmers. It costs little and does not start the dangerous course of replacing a stable system with an unstable one henceforth maintained only by expensive inputs.

In adopting this strategy, Mukhebi (1992) suggests three important factors to be taken into consideration namely: political, social and economic factors. Informed professional staff will need to convince politicians of the necessity of accelerating the revision of legislation (that makes intensive tick control obligatory) to facilitate the changes and the benefits to be gained thereof. Secondly, extension services extended to participating farmers through auxiliary fields staff will need to be given high priority. Farmers and advisers need to be educated to accept the benefits gained from boasting immunity to tick-borne diseases and achieving host resistance to ticks that would results from relaxed tick control regime. Thus, there need to be improved communication with the end users of the policies i.e. field animal health personnel and farmers. As farmers are expected to contribute the control costs of this strategy, efforts to improve available markets for livestock products will be required. For a small-scale farmer, it appears appropriate that such efforts need to be accompanied by the incentives to sell.

Given integrated control option, a sound management decision requires input based upon knowledge of the biology and ecology of the target tick species, the cost of ticks and tick-borne diseases on the productivity of the breed of livestock (George, 1992). Moreover, in animal production system one of the variable input is the cost of diseases. An integrated tick control strategy, *inter alia*, aims at decreasing the cost of diseases. If this costs can be reduced the same output can be produced more cheaply (thus efficiency) and the savings can be converted into other developmental needs such as education.

7.2 Investment in Disease Research and Development

There seem to be no animal production system without health control in its various forms. Diseases occurrence are dynamic and frequently change, new and more effective drugs, *etc* need to be developed. With this in mind, research and disease control are to be treated as productive factors that are complementary with other factors in the production sectors. It is in the long-term interest of South Africa to invest in disease research and technology. Research starts with problems, priorities, knowledge and resource base. It is therefore crucial to employ a participatory approach in all the phases of agricultural research and development. As primary beneficiaries, farmers in particular should actively be involved since they validate technology adoption.

Moreover, research and development is an important avenue of growth in the livestock sector. Recent emphasis placed on the role of the small farmer requires public sector investment to provide services that are essential if he/she is to compete with large-scale enterprises in animal production. Thus, government should play an active role in agricultural research and development with more emphasis on disease surveillance and diagnostics. A fundamental requirement for the national and international control of animal diseases is the provision of a comprehensive system of disease surveillance and disease reporting (Griffiths, 1976). There is a great need for improved disease surveillance in most of the developing countries as evidenced by the tick-borne diseases induced mortality that is unreliably high. Such a disease surveillance system should be able to answer questions such as when, where, how and why did the disease occur or spread.

7.3 The Delivery of Veterinary Services: Public versus Private Good Debate

In establishing the appropriate roles for the public and private sector in the livestock services industry, it necessary to obtain a clear understanding of the economic nature of each service. This involves the identification of various areas that constitute the veterinary services. In most production system the veterinary service cover three broad areas; animal health care, production and public health. According to Gros (1994) animal health services consists of preventative (e.g. tick control) and curative care, as well as the delivery of veterinary pharmaceuticals. Production services on the other hand, are more specifically geared to increase the product of individual animals and herds; they include such extension services as artificial insemination to achieve genetic improvements.

Animal health care delivery alone involves a wide range of activities, some of which have private good attributes, while others may best be defined as having public good ones. In the veterinary service area some aspects (i.e. curative services and drug sales) exhibit private good characteristics; thus, other things being equal, if delivered by the private sector an economically optimal quantity is likely to be provided. Curative care is, however, only an imperfect private good. It can be argued, especially where contagious diseases are involved, that all producers benefit when one of their neighbours' animal is cured of a disease. If left untreated such disease could spread to other animals. Hence there is a spill-over effects of externality in such cases.

On the other hand, other aspects such as preventative and promotive services are at best public goods which will likely be underprovided unless undertaken by an entity other than the private sector. Thus, the privatisation of public goods especially those involving preventative and public health services is likely to results in significant market failures.

The only way such goods can be optimally provided is if some kind of collectivity (e.g. the state) assumes responsibility for service delivery.

With the above in mind, it is evident that both the public and the private sector can play a complementary rather than a mutually exclusive role in certain areas. The question is not so much state or market, or private versus the public sector, but rather to what extent and in what form these institutions should participate in a given domain (Leonard, 1993; Gros, 1994). There are certain areas in which optimality is more likely to be achieved if both sectors are involved. The veterinary service delivery is thus one area in which state and private sector participation is not incompatible but complementary in the African setting.

7.4 Provision of Dipping Services

For a long time tick control has been regarded as a national concern, hence the provision of communal diptanks by government. In poor-rural areas the provision of dipping services by government is justified and as such will continue to be its responsibility to ensure food security, alleviate poverty and other social benefits. However, the provision of tick control at a highly subsidised charge places a heavy burden on government budget and usually leads to deterioration in the quality of the services. The principle of "pay for services" is a good principle, but not necessarily of first priority in the complicated field of dipping, especially in controlled areas. Fortunately, all the sampled farmers feel that cost recovery should continue with the majority (67% as previously stated) being in favour of the same price presently charged by the government. However, at least 23% of the sampled farmers are conditionally prepared to contribute a relatively high price only if dipping services can be improved. It is therefore sensible to suggest that farmers should get the best services in return to their contribution. To this end, ways of increasing the farmers' choice must be considered. Similarly, this suggests that there should be a marriage between the public and the private sector in the provision of tick control.

7.5 Formation of Farmer's Organisations

There is a window for opportunity available to all cattle owners' in the communal areas in terms of improving cattle production in general. To explore such an opportunity farmers should organise their own organisations and cooperatives to be able to address their own problems and to seek for solutions themselves. If not, farmers reliance on governmental institution will persist, as it is one of the main factors that characterises cattle owners in Venda. Effective farmers groups are the most likely channels through which to resolve deficiencies in animal production because they are able to provide benefits that are difficult to secure from individual efforts. The formation of farmers' unions could answer questions such as what will the government do for them instead of asking what will they do for their government. In addition, the formation of such unions must be viewed in the context of the whole farming system. If proved successful and effective, such a formation should coincide with the gradual handing over of some recurrent expenditures such as the provision of consumables (e.g. acaricides, vaccines, drugs, *etc*) to the communal farmers.

7.6 Improvement of Livestock Production Extension

For a successful disease control, it appears fundamental to strengthen extension activities and be given high priority. Among other things, the construction of diptanks (as previously stated) was seen as an opportunity by the government for effective extension, education, and training, practical demonstration, inspection, uptake of accurate census data and calculation of stock density. It was observed, for example, that the inspection expected to be done by the animal health extension officers is limited because their duties at the diptank is predominantly counting and recording. It is rarely possible, if not impossible, to count, record and inspect simultaneously. The expertise of any animal health extension officer is to control diseases through for example vaccination, health care (referrals to the state veterinarian) and advisory services.

At the root of many of problems of small-scale farmers lie ignorance and lack of communication. It is not, however, ignorance in a pejorative sense, but rather a lack of knowledge (Dreyer, 1997). It is therefore recommended that the major objectives of extension should be to transfer relevant knowledge and information to enhance the productive capacity of farmers. Failure in education of livestock owners and the general public have probably accounted for more problems in successful pursuit of animal disease management than any other single factor. According to Unklesbay (1992) recent research projects have shown that improvements in animal health are feasible once the stockowners receive appropriate educational information. More importantly, livestock record keeping as an integral part of disease control should be emphasized within the extension services. This will enhance farmers' data and information reliability necessary for livestock development strategy.

It is therefore important that educational ventures such as farmer's days need serious attention and be promoted 'by doing'. The implementation of such ventures should be the responsibility of everyone including high schools, universities, non-governmental organisations, various government departments, research institutions e.g. Onderstepoort Veterinary Institute, *etc*. For their success, such ventures should be planned in such a way that they are accessible to the resource poor farmers.

CHAPTER 8

SUMMARY AND CONCLUSION

8.1 Introduction

This chapter provides the summary of the study and conclusions on future action needed to maintain cattle productivity, especially with regard to the optimal control strategies for ticks and tick-borne diseases in developing areas based on the Venda region as an example.

8.2 Summary

Two veterinary zones, namely the Yellow Line and the Open area, of the Venda region in the Northern Province were surveyed in order to evaluate the justification of the ticks and tick-borne diseases control programme (i.e. dipping), as well as assessing the socio-economic impact of the programme at the farm level. In South Africa, dipping of cattle was implemented at the start of the 20^{th} century after the introduction of tick-borne diseases such as heartwater, redwater and gallsickness. However, heartwater occurs most frequently and was probably the first to be established tick-borne disease of cattle in Africa. It spread into South Africa through the coastal areas of the then Eastern Cape Province and it was eradicated in 1954. This breakthrough can be attributed to a blood vaccine which was developed at Onderstepoort Veterinary Institute.

The livestock sector plays an important social, economic and cultural role in the economies of developing areas hence the control of ticks and tick-borne diseases and the resultant eradication of East Coast fever. These roles have been analysed both in quantitative and qualitative terms. Survey results revealed that Venda cattle herds produce a wide diverse array of useful goods and services including meat, milk, traction power and some donations to the community. The majority of the sampled farmers (97%) keep cattle for both subsistence and commercial purposes. At least 3% of the respondents keep cattle solely for commercial purposes.

A quantitative assessment of the value of livestock revealed an average economic value of R1 152 using the sales criteria. Several aspects were considered to measure the economic value and those values are mainly based on the assumption that price reflect value. The aspects considered for valuation are, namely:

- Biological productivity
- Off-take
- Value of milk
- Value of draught power (ploughing)
- Value of manure use

These method are not optimising models but do provide a useful method for estimating the value of livestock for small household herds. Of the total economic value, milk contributes a relatively larger proportion of R526 followed by off-take (R353), work of cattle (R259) and lastly manure use (R14.00). However, the quantified economic value derived does not take into account the benefits derived from an integrated crop-livestock system. Under this system the areas of interaction are both complementary and competitive.

An important observation is that some values are largely performed by animals of a certain age group or sex. For instance, animal off-take and draught power is often concentrated on oxen. Butcheries and friends (i.e. private sales) are the most commonly used market outlets used by 47% and 26% of the respondents who sold their cattle, respectively. With the exception of Tshifudi, auctions venues were only used by 22% of the sampled farmers located within the Yellow Line area.

However, ticks are still the most important parasitic vector of cattle that inhibit farmers in the attainment of their farming objectives. The control of ticks and tick-borne diseases is of importance in maintaining the productivity of cattle. The classical and the most widely used ticks and tick-borne diseases control measure is the plunge dip. After the eradication of East Coast fever, short interval dipping of livestock became a standard compulsory method of tick control enforced by law. Cattle are either dipped weekly or fortnightly. The collection of cattle at diptanks presents a useful vehicle for disease surveillance and extension. Moreover, due to a lack of a reliable formal market it offers some unintended services as a place where private buyers and cattle owners can negotiate terms of trade thereby reducing the transaction costs.

The widespread application of acaricides as a tick control measure has certain flaws and limitations as expressed by 11% of the respondents. The development of tick resistance and lack of dipping water supply are the major problems advanced by 79% and 14% of the dissatisfied farmers, respectively. In addition, the use of plunge dip is not applicable during drought times due to the weak condition of the animals. Due to some of these limitations, 61% of the respondents supplement dipping with both modern and traditional tick control measures. A large number of the respondents (45%) control ticks to avoid wounds, diseases and possible deaths. The most common tick problems experienced by the respondents (70%) amongst their livestock are tick wounds and tick damage.

Intensive acaricides application cannot be justified on economic grounds in indigenous breeds when taking into consideration their inherent immune system against diseases. The frequency of acaricides application depends on the area, tick challenge, breed of cattle and the level of control required. However, in the surveyed areas dipping frequency seem to be influenced solely by the level of tick challenge. The majority of the farmers (90%) are still in favour of the intensive dipping of cattle. Intensive acaricides application results in highly susceptible cattle population because cattle are not exposed to the parasites resulting overtime in a loss of immunity.

It costs the government R12.00 and farmers only R1.00 to dip a head of cattle per year irrespective of the dipping frequency. However, governments spend a considerable sum of money annually on research, training and extension services related to the control of ticks and tick-borne diseases. Surveyed farmers spend an average annual amount of R110 on tickicides only. Surveyed farmers are willing to spend an average amount of only R2.00 to dip a head of cattle per year in spite of the higher costs borne by the government.

The "with" and "without" dipping scenarios comparison shows a benefit-cost ratio of 0.8 indicating that the provision of the dipping programme by the government is not economically justified. However, this ratio can be improved by reducing the dipping costs through strategic tick control. In addition, the government should continue providing the dipping service largely because of the economic nature of the service (public good) it provides. The benefit cost ratio is, however, sensitive to changes in the mortality rate. When the mortality rate for the "without" scenario is assumed to be 10%, the ratio increases from 0.8 to 1.2 indicating that it is worthwhile to control ticks and tick-borne diseases through dipping.

Several aspects were considered for the possible calculation of benefits, namely milk, meat and draught power. Costs of control included both government and farmers costs. The "with" and "without" dipping scenarios mortality is 3% and 4% respectively, assuming if dipping was not pursued. The difference between the "with" scenario net income and the net income balance for the without scenario gives an incremental net loss of R23 475 per sampled herd.

A 3% mortality rate for the "with" scenario results in a total average loss of R73 728 in income. A relatively higher mortality rate of 3.9% in Vyeboom makes it possible for this area to contribute a larger proportion of R19 138 to the total loss. Of the 3% mortality rate the Nguni breed contributes 2.8% in spite of its resistance to diseases. Two possible reasons can be advanced for this. Firstly, this is probably due to a loss of immunity caused by intensive acaricides application; secondly, this could be related to poor cattle management practices by the sample farmers. With a mortality rate of 4%, the "without" scenario results in a total average potential loss of R211 344 to all the farmers in the surveyed areas, *ceteris paribus*.

Using the dipping programme as an example, it is important to know various significant factors influencing the demand, as well as farmers' willingness-to-pay for veterinary services before any alternative options aiming at improving animal health can be introduced. This was done by applying both the logistic regression model, as well as a multivariate regression analysis. The results of the multivariate regression analysis revealed that satisfaction with the dipping programme and employment positively influence the willingness to pay whereas farmers owning exotic breeds are willing to pay less for dipping services. This can be ascribed to the communal grazing complexities where a farmer might unintentionally end up farming with exotic breeds as a result of his/her cattle (possibly Nguni) mating with exotic bulls of other farmers.

Applying the logit model, the results further indicate that farmers with long term farming experience are not willing to pay a higher price. This is probably because farmers with long term farming experience are generally pensioners and have been 'spoiled' by state provision of (almost) free veterinary services. Thus, such farmers are not used to the payment of rising prices. As far as dipping frequency is concerned, the results of the multivariate regression analysis shows that employed farmers prefer an intensive dipping frequency. This can be attributed largely to the income (salary) received which likely increase farmers' ability to pay and possibly demand more animal health service.

Finally, the results of the study show a need to revise ticks and tick-borne diseases control practices. Experience shows that there is no justification for continuing or attempting to re-establish intensive acaricide application in indigenous low producing cattle. Current policies is to combine two or more of the available techniques to produce an integrated system of tick management rather than the use of a single method such as intensive acaricides application. The main elements of an integrated tick control strategy are namely:

- Host resistance to ticks using the correct breed
- Enzootic stability to tick-borne diseases
- Appropriate legislation
- Economics and marketing, considering the costs of acaricides production, delivery and type of farming
- Appropriate strategies, such as minimal control in periods of low challenge and strategic control for seasonal challenges.

The main advantage associated with this strategy is that it reduces costs and decreases the tick population of an area thereby assisting in increasing animal production. However, tick-borne diseases do not exist in vacuum. It needs to be complemented with other aspects necessary for livestock development in less developing areas. Such aspects involve the formation of farmers' organisation and improvement of livestock production extension services. The latter aspect further calls for a continual government investment in disease research.

8.3 Areas for Future Research

This study primarily provides an overview of the justification of the existence of the dipping programme in less developed areas particularly focusing on the socio-economic impact of the programme. In this regard a question still remain unanswered. What is an optimal tick control dipping frequency in the area? In an attempt to answer this question, *inter alia*, a multi-criteria strategy need to be applied that takes into account the social, economic, environmental and technical consequences of such a strategy, unlike cost-benefit analysis that is based on costs and benefit of the programme. To achieve this, the expertise of epidemiologists, animal scientists and social scientists need to be integrated to produce an optimal tick control frequency. It is evident that to have a reasonable chance of success, such research should be multi-disciplinary in nature.

Socio-economic capacity in veterinary components of the South African national agricultural research system is often non-existence or ill-equipped to conduct research. It is therefore crucial to integrate the social discipline within the national agricultural research system. This will, *inter alia*, ensure that the new technologies developed by research are appropriate to the needs of target clients and can be sustainable, without causing any detrimental effects on household, community and national economies.