Executive summary

Tick-borne diseases constrain cattle production in Asia, Africa and Australia. The diseases theileriosis, babesiosis, anaplasmosis and heartwater can cause mortality, along with reduced milk and meat production. To estimate the economic impact of these tick-borne diseases, average productivity of representative livestock systems need to be estimated, the incidences of these diseases in each system assessed, and production losses in disease-affected cattle require calculation.

Estimation of the economic impacts of these debilitating domestic livestock diseases is, however, confounded by the lack of accurate estimates of disease prevalence, the heterogenous nature of cattle production throughout these regions and complexity associated with the estimation of direct and indirect disease-related production losses. The objectives of this report are to:

- Characterise livestock production systems in Africa, Asia and Australia using sets of tables that describe herd structure, milk production and off-take rates.
- Describe tick and tick-borne disease incidence in the livestock systems of South Africa, Zimbabwe, Tanzania, Kenya, India, China, Thailand, Philippines, Indonesia, Australia and Nepal.
- Estimate the annual economic impact of tick and tick-borne diseases in each of the above countries.
- Provide an overview of a spreadsheet model, **TickCost**, which has been developed as part of this project, and can be used to cost tick-borne diseases.

With increasing pressure on research agencies to demonstrate positive research impacts and a paucity of data upon which to base economic studies, the estimation of tick-borne disease costs will help researchers and policy-makers set research priorities and identify potential economic benefits of animal-health related research in these regions.

Livestock systems

There are a great range of cattle breeds, agro-climatic conditions and livestock production practices in Asia, Africa and Australia. To systematically assess the impacts of tick-borne diseases, national herds are categorised into major livestock production systems-based on system definitions used by Sere and Steinfeld (1996), but modified to account for the differing impacts of tick-borne diseases. Parameters such as milk yield, utilisation of cattle for traction, manure production and the live weight of marketed cattle vary considerably, but vary less within a particular livestock system (e.g. small-holder dairy) than across systems (e.g. small-holder dairy versus pastoralist). Average values are collated for each representative system and provide a base line from which yield reductions, as a result of tick-borne disease, can be estimated.

Livestock system production assumptions for African livestock systems are provided in Table 1. These assumptions are used in each of the African country tick-borne disease cost assessments. For the purposes of this study, five systems have been chosen to characterise cattle production in Africa.

Table 1: Cattle productivity for each African system

Livestock system	Small-scale mixed (meat-milk)	Small-scale dairy commercial	Large scale pastoral	Large dairy	Large beef
Liveweight of adult cattle (kg)	250	450	250	450	450
Liveweight of immature cattle (kg)	150	250	150	250	250
Turn-off (%)	4	25	4	25	25
Adult composition of herd (% of herd)	60	60	60	60	60
Breeding cows (% of adult herd)	50	67	50	67	67
Milk production (kg/cow /year)	194	1,844	0	4,010	0

Large-scale beef production primarily occurs in South Africa and Zimbabwe, while large dairy production is also found in these countries and Kenya. There have been a large number of dairy development schemes throughout eastern and southern Africa. Many small-holders have acquired exotic crossbred dairy cattle and produce milk on a commercial basis. This type of farming enterprise is referred to as small-scale dairy production throughout the country cost assessments contained in the report. The small-scale production of indigenous cattle breeds such as the East African Zebu and Sanga type cattle, is the most widespread form of cattle production in eastern and southern Africa. Beef and milk production is typically low for this system as for the large-scale (pastoral) production of indigenous cattle breeds.

The milk and meat production and herd structure assumptions for Asia and Australian livestock systems are outlined in Table 2. Small-holder meat is the livestock production system most commonly found in China, Thailand, Indonesia and the Philippines. Traditionally milk consumption has been low in these countries and production has only recently become significant with the importation of European cattle types for dairy purposes. Cattle are often kept in association with the household where husbandry practices such as grooming to prevent the build-up of external parasites are carried out.

Table 2: Cattle productivity for Asian and Australian livestock systems

Livestock system	Small-scale (milk)	Small-scale commercial	Small-scale (meat)	Large dairy	Large beef
Liveweight of adult cattle (kg)	250	450	250	450	450
Liveweight of immature cattle (kg)	150	250	150	250	250
Turn-off (%)	0	0	4	25	25
Adult composition of herd (%)	60	60	60	60	60
Breeding cows (% adult herd)	50	67	50	67	67
Milk production (kg/cow/year) [(e)]	579	2,544	0	4,882	0

In India and Nepal, large numbers of indigenous cattle are raised primarily for milk and traction purposes. These types of cattle are included within the small-scale milk production system throughout the report. Small-scale commercial production has become more widespread in many Asian countries with the importation of European cattle types and through breeding programs. Within India, Indonesia, Thailand and China, there have been government initiatives to breed cattle with the objective of increasing milk yields. These cattle are most susceptible to tick-borne diseases and because of their high value, there is a sufficient incentive for owners to invest in some form of tick control. In India alone, there are estimated to be 10 million improved cattle types (Singh 1992) which are highly susceptible to infection by *Anaplasma*, *Babesia*, tick worry and *Theileria annulata*.

Large scale commercial dairy production is primarily confined to Australia, although there are significant state run herds in China. In Australia, dairy production is practised in all states and is commonly found close to urban centres. The dairy herds of south-east Queensland and the Atherton Tablelands are within areas where ticks and tick-borne diseases are present and cows consequently suffer the impacts of tick worry, *Anaplasma* and *Babesia*.

Within the Asia-Australia region, commercial beef production is primarily practiced in Australia, where the availability of land permits extensive grazing. Cattle production occurs throughout the country, but only 30% of the herd is estimated to be at risk from the impact of ticks and tick-borne diseases. The tick risk area is found in the states of Queensland, Western Australia and the Northern Territory.

The incidence of tick and tick-borne diseases

The distribution of tick-borne diseases is dictated by the presence of specific tick vectors for each of the diseases. Anaplasmosis and babesiosis are primarily transmitted by ticks of the genus *Boophilus,* found throughout Africa, Asia and Australia. Heartwater (*cowdriosis*) is vectored by *Amblyomma sp*p in Africa. Theileriosis, called tropical theileriosis in Asia and northern Africa is vectored by ticks of the genus *Hyalomma*. It is known as East Coast Fever (*Theileria parva*) in Central and Eastern Africa where it is transmitted by the tick *Rhipicephalus appendiculatus*. (Brown 1997).

Estimates of disease incidence (clinical disease, which in the case of tick-worry and theileriosis causes morbidity losses) and case fatalities (Mukhebi *et al* 1992) are described for immature and adult cattle within each production system in each country. Tick-borne disease incidences and cattle fatalities are generally higher in commercial production systems (du Plessis *et al* 1994, Mukhebi *et al* 1992, Meltzer *et al* 1996, Singh 1992) than small-scale production systems where indigenous cattle types are raised. Young cattle have higher innate resistance to most tick-borne diseases (Mahoney and Ross 1972) and consequently case fatalities are typically lower for this stock class.

Tick-borne diseases cause mortality as well as production losses in cattle that recover from the effects of infection. During the period of infection, milk production, cattle growth, manure production and capacity for animal draught power are usually reduced. The severity of reduced productivity is a function of stock age, breed, physiological status and level of nutrition. A set of production loss tables have been complied to estimate the production losses associated with tick-borne disease infection in cattle in each of the livestock systems of Africa and Asia. African production loss assumptions are provided in Table 3. Morbidity losses have been included for animals that suffer fatality as a result of these diseases. The data sources used to derive these estimates are found in each of the country cost assessments.

Table 3: Annual Production losses in African disease-affected cattle (by system)

	Tick Worry		*Anaplasma and Babesia*		*Theileriosis*		Heartwater	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Small meat-milk (mixed)								
Liveweight loss (kg/hd/yr)	5	3	0	0	13	15	0	0
Milk loss (kg/hd/yr)	4	0	0	0	49	0	0	0
Large-scale pastoral								
Liveweight loss (kg/hd/yr)	5	3	0	0	13	15	0	0
Milk loss (kg/hd/yr)	4	0	0	0	49	0	0	0
Commercial beef								
Liveweight loss (kg/hd/yr)	23	13	0	0	23	25	0	0
Commercial dairy								
Liveweight loss (kg/hd/yr)	23	13	0	0	23	25	0	0
Milk loss (kg/hd/yr) [(b)]	201	0	0	0	1,002	0	0	0
Small-scale commercial								
Liveweight loss (kg/hd/yr)	23	13	0	0	23	25	0	0
Milk loss (kg/hd/yr)	92	0	0	0	461	0	0	0

Production losses are typically higher in European and exotic crossbred cattle. A large number of studies have measured the impact of ticks on cattle growth (Sing *et al* 1983), theileriosis on milk and liveweight (Singh 1992, Mukhebi *et al* 1992). The results of these scientific studies are used throughout the costing analysis, and supplemented with expert opinion where data deficiencies exist. Asian production loss assumptions are outlined in table 4.

Table 4: Annual Production losses in disease-affected cattle of Asia and Australia

Disease	Tick Worry (feeding ticks)		*Anaplasma and babesia*		*Theileria annulata*	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale meat						
Liveweight loss (kg/hd/yr)	5	3	0	0	13	15
Large-scale beef						
Liveweight loss (kg/hd/yr)	23	13	0	0	23	25
Small-scale commercial dairy						
Liveweight loss (kg/hd/yr)	23	13	0	0	23	25
Milk losses (kg/hd/yr)	127	0	0	0	356	0
Large-scale commercial dairy						
Liveweight loss (kg/hd/yr)	23	13	0	0	23	25
Milk losses (kg/hd/yr)	0	0	0	0	683	0

National economic loss and control costs

The production losses estimated for each representative livestock system are aggregated to a country level using national cattle population data. National production losses are multiplied by livestock product prices to estimate the aggregate economic value of production losses. Prices have not been adjusted to account for tariffs and other forms of price distortion. Analysts may wish to adjust prices within the spreadsheet to examine the sensitivity of disease cost estimates to assumed prices. Prices have been difficult to collect in many countries where central authorities do not collect this data. Averages regional prices have been included for some countries.

The annual costs of ticks and tick-borne diseases in selected countries of Africa, Asia and also are shown in Figure 1. Of the countries assessed, the aggregate costs of tick and tick-borne diseases are greatest for India, where it was estimated that these diseases cost $US 355 million in 1998. The smallest economic impact was estimated for the Philippines, reflecting the small number of cattle that reside in this country.

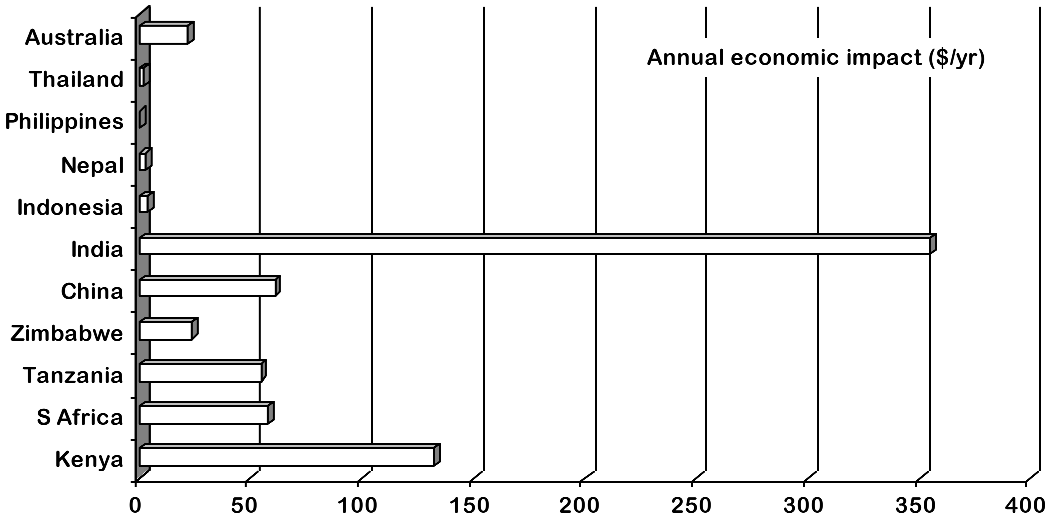

Figure 1: Annual economic impact of tick and tick-borne diseases (US$m)

The Indian cattle herd, at 209 million head (FAO 1998) is by far the largest of all countries included in the study. Most of the cattle found in India are Brahman types with high natural resistance to the feeding of ticks and tick-borne diseases. There has, however, been a steady increase in the utilisation of European and cross-bred cattle throughout the country. In 1997, it was estimated that 10 million, or 5%, of the Indian herd was comprised of these cattle types.

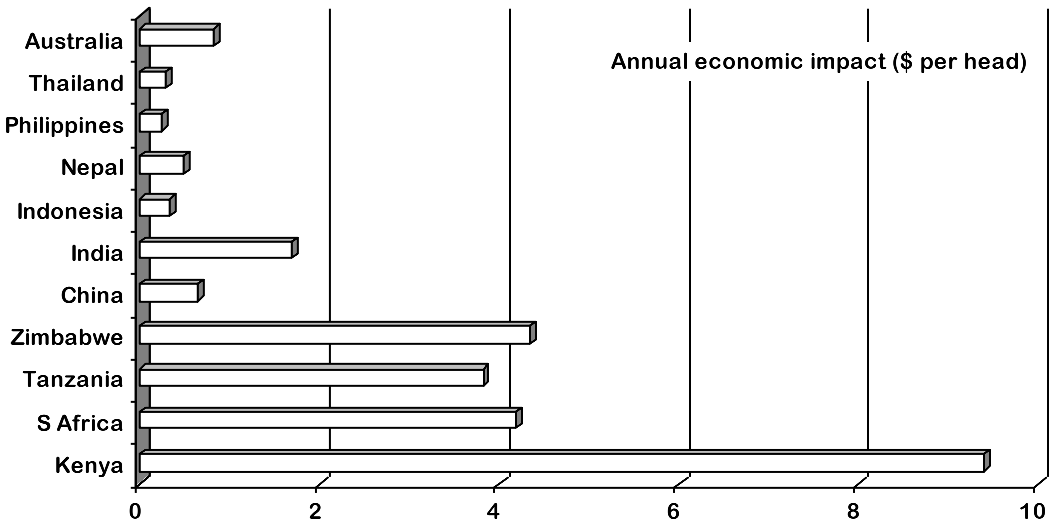

Figure 2: Annual economic impact of tick-borne diseases on a per head basis.

The annual cost per head of ticks and tick-borne diseases is lower in the Asia-Australia region compared to Africa. In African countries such as Zimbabwe, Tanzania, Kenya and the Republic of South Africa, cattle producers employ high intensity tick control methods and the highly pathogenic tick-borne disease *Theileria parva* (East coast fever) is endemic in much of this area.

Cattle producers use a variety of control methods to offset production losses associated with ticks and tick-borne diseases. Acaricides are primarily used to manage ticks and tick-borne diseases in the commercial herds of Australia, South Africa, Kenya, Zimbabwe, Tanzania and Uganda. The use of acaricides in small-scale cattle production is limited. In some countries, such as Zimbabwe, the government finances the operation and maintenance of dipping facilities for small-scale producers (Perry *et al* 1990).

Other production related issues were described by experts as being more significant constraints on cattle production in the Asia region. Specifically, issues relating to cattle nutrition, improving the genetic potential of the herd and the extension of management techniques were thought to be of much higher importance. Diseases associated with internal parasites and Foot and Mouth disease (FMD) were estimated to generate much larger production and control costs in the selected Asian countries where these disease costs were compared to tick related diseases. Without examining the economic attractiveness of differing animal research projects using ex-ante cost-benefit analysis, it is not possible to recommend priority areas of livestock research for this region. The data collected as part of this project, should however, provide baseline information upon which economic studies can be conducted.

Spreadsheet model

A spreadsheet-based model (Excel 97, Microsoft Corporation) has been developed to pull all these elements of the economic impact assessment procedure together and estimate total annual costs of ticks and associated by country or region, depending on the user's needs. Preliminary data is included for 11 countries, but the framework is appropriate for use elsewhere, and the data is intended to be used as a starting point. Ideally, country analysts will insert up-to-date and relevant system specific data to generate new information for countries not yet included. The model is supported by a help system which assists spreadsheet users with operational and data background issues. Livestock productivity, tick control, disease incidence, production losses and national economic cost data are presented in a series of tables that are linked to a graphical user interface to facilitate user-friendly operation. The spreadsheet is described in Part 2 of the report.

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Table of contents

Citation and acknowledgments

McLeod, R. and Kristjanson, P. (1999), Economic Impact of Ticks and Tick-Borne Diseases to Livestock in Africa, Asia and Australia. Report to the International Livestock Research Institute, Nairobi, Kenya. July 1999.

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User Manual

Introduction to TickCost

The **TickCost** software package has been developed to help estimate the annual costs of ticks and associated diseases throughout Africa, Asia and Australia. The package is written in Excel 97 (Microsoft Corporation) and is supported by a help system which assists users with operational and data background and sources issues. This chapter contains information on the following elements of the system:

- Operating features
- Including livestock data
- Livestock systems
- Incidence of diseases
- Annual costs

What is TickCost?

Within the **Tickcost** package, the annual disease costing procedure is broken down into a number of modules which can be accessed from the user interface. Livestock productivity, tick management, disease incidence, production losses and national economic cost tables are included in the spreadsheet. Each of the modules is illustrated in the figure on the next page and a brief description of each follows the chart.

In the livestock system modules, losses in production as a result of disease are provided for five livestock systems in Asia and Africa. A range of studies, scientific literature and the opinion of experts have been used to define the productivity of cattle in each of the systems. Milk yields and meat production are described for each system and the consequent per head loss in productivity as a result of disease is specified.

The incidence of diseases are described for each of the systems in each country. Once system incidence is included, the per head production loss and control input is calculated in the spreadsheet. These loss and control statistics are calculated for cattle residing in the herd at the end of the financial year and account for all stock carried across the growing season.

By including estimates of the percentage of total national herd found in each system (referred to as system adoption) and national herd size data, the per head system losses can be aggregated to the national level. Within the spreadsheet, the aggregate losses attributable to each of the diseases are estimated for each country. Estimates of total milk loss, number of cattle fatalities and reduced meat output are all calculated.

The prices of milk, meat and livestock replacement values are included in the spreadsheet, and when combined with physical loss estimates, the national economic cost of these diseases can be estimated. In the spreadsheet the aggregate control and production loss costs are estimated for each of the diseases across the following countries in Africa, Australia and Asia: Kenya, Zimbabwe, South Africa, Tanzania, Australia, China, Thailand, Indonesia, India, Nepal and the Philippines.

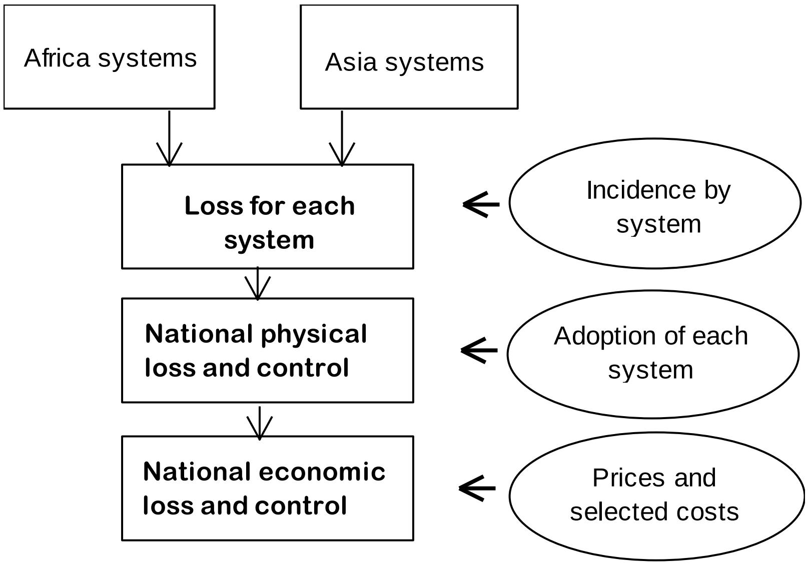


Figure: Modules in **TickCost**

Selected tables summarise these losses for each of the tick-borne diseases. It should be noted that control costs are allocated to each of the diseases in proportion to their respective production loss impacts except where control measures such as vaccines are disease specific. A selection of charts illustrate country cost impacts and the breakdown of relative importance of each disease across the countries that are included in the assessment of costs.

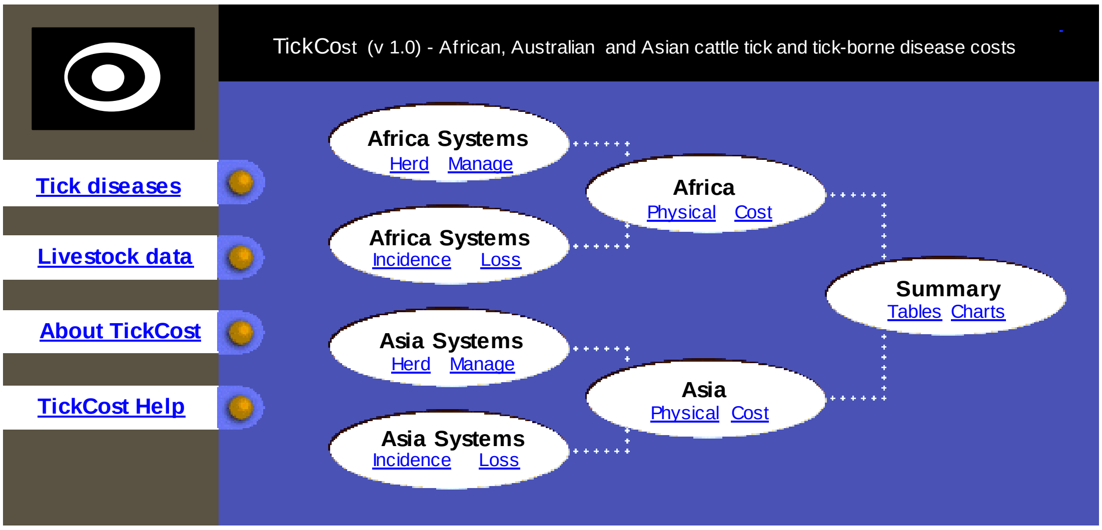
Operating Features

The spreadsheet follows standard Excel 97 operating procedures. For people who do not have significant Excel experience, they should refer to the Excel Help Manual and Help System for operational guidance. A graphical user interface has been developed to facilitate user-friendly operation of the system. A copy of the interface is provided in the figure below.

On the flow chart it is evident that the costing procedure is specified for Africa and Asia-Australia systems. Within the livestock systems part of the flow chart the following elements are evident:

- **Herd**: By clicking on this heading, the user will be directed to input areas related to herd productivity and production losses for adult and immature stock classes in the various livestock systems.

- **Manage**: By clicking on this heading, the user will be directed to input areas where the national value of acaricide purchased each year is outlined
- **Incidence**: This element will lead the user to the table where the tick and associated disease incidence estimates are included. Incidence is incorporated in the spreadsheet for each livestock system.
- **Loss**: The per head average morbidity (meat and milk) loss for cattle in each of the systems by country are found by clicking on this heading.



Note: Asia represents Asia-Australia systems.

Aggregate physical and economic losses are reported for all tick diseases as well as for tick diseases on an individual basis. The **Physical** and **Loss** categories in the Asia-Australia and Africa parts of the flow chart can be clicked on to access these results tables. The labels in this part of the flow chart include:

- **Physical**: By clicking on this label the user can move to tables which provide aggregate physical estimates of number of cattle deaths and production losses for each of the tick diseases.
- **Costs**: These tables outline the economic value of control measures used, and production losses for each of the tick and associated diseases.

In the **Summary** part of the spreadsheet the user can generate a selection of charts and summary tables outlining the impact of specific diseases and regional impact of costs.

Down the left-hand column of the interface the following elements can be viewed:

- **Tick diseases**. A dialog box describing the diseases included in the costing study and the production losses for which costs have been assessed is activated when this label is clicked.
- Click on the **Livestock Data** label when you want to edit or view herd size, price, or selected cost and system adoption assumptions for each of the countries included in the costing framework. A dialog box appears after the label is clicked and button can be pressed to go to various tables.

- **About TickCost** provides the user with some background information about the program. The date of version development is found on the dialog box along with license details.
- **TickCost Help** can be clicked when the user wishes to call up the **TickCost** help system. The system contains information about operating features of the program and also lists the various sources of information that have been used for the costing exercise. The help system can also be called from underlined **Help** in the tables and charts throughout the system. These labels are blue in colour and are linked to relevant pages of the help system.

System requirements

To run **TickCost** the user needs:

- Version of Excel 97 (Microsoft Corporation)
- Windows ’95 operating system (Microsoft Corporation)
- 8 MB Ram
- 2 MB Memory
- An IPM compatible PC

Installation

To install **TickCost**:

- Place CD-ROM in the appropriate drive
- Select run from the start menu
- Run \install.exe.

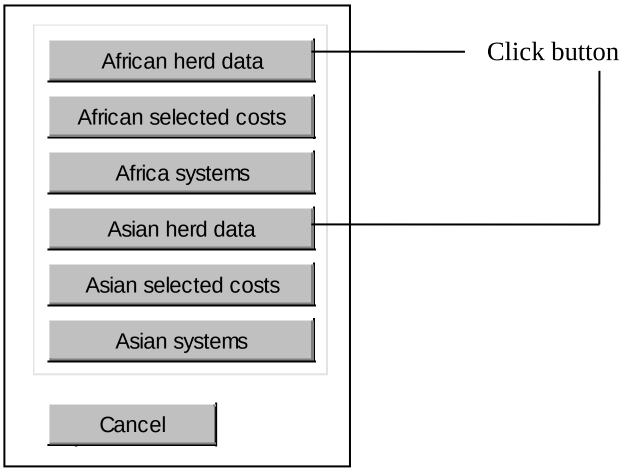
The installation routine creates a directory c:\TickCost and installs the files TickCost#99.xls, TickCost.hlp, hdk3ctnt.dll, and hdk3anim.dll to the created directory. To open the file TickCost#99.xls, use standard Windows operating procedures.

Input livestock data

While **TickCost** contains useful baseline livestock data for particular countries (i.e. from secondary sources and in many cases from ‘expert’ opinion available at the time the study was undertaken and **TickCost** developed), the intention in making it widely accessible as early as possible to potential users was that each user will include up-to-date basic livestock data outlining the size of national cattle herds, farm-gate prices for livestock products and tick control inputs. The herd size, selected costs and adoption of systems sub-sections below describe how these data can be included in the spreadsheet.

Herd size and prices

By clicking on the **Livestock data** heading, a dialog box with buttons relating to herd data, selected costs and systems buttons will appear. A copy of this dialog box is included in the figure below. To go to the head data input areas for either the African or Asia-Australia herd, click on these respective buttons.

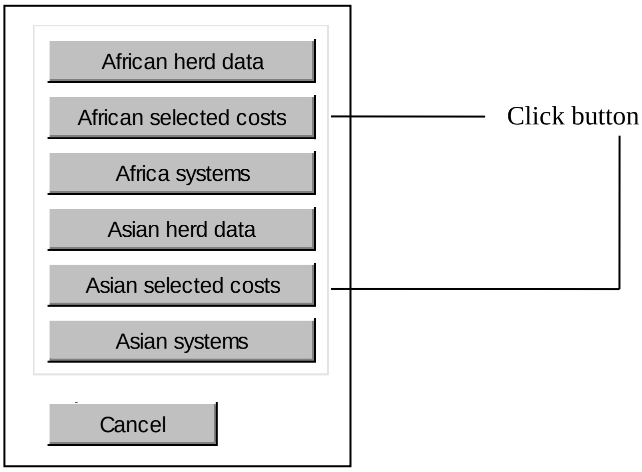


Once at the table, national cattle numbers, meat production, milk production and average farm-gate prices are included for the various countries in the study. For the most part, FAO data was used for the specific countries included during development of **TickCost**, but in some cases, country-level sources such as Ministries of Agriculture, livestock sector studies, etc. were used. References/data sources are found by clicking on help from any specific cell within the database.   Since these figures are variable and changing over time, it is important that users update them with the most reliable data available to them. Information in **Livestock data** includes:

- National cattle numbers (for all cattle types)
- The average price of meat ($US per tonne liveweight at farm-gate)
- The average price of milk ($US per tonne of milk at farm-gate)

Selected costs

To go to the selected costs area, the user must first click on the **Livestock data** heading upon which the following dialog box will appear. To access the African or Asia-Australia selected cost table, click on the respective button.



Once at the table, the following items will be listed for each country:

- Average costs of replacing adult and immature cattle the die as a result of tick-borne diseases in commercial and small-scale sectors ($US head).

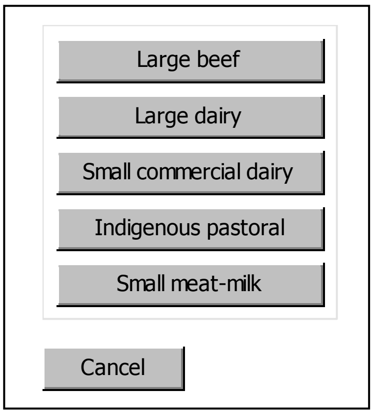
The cost of all inputs and livestock products are included for the farm-gate level. Where local prices are available, these values need to be converted to US$. Once again, these prices may vary considerably over time, thus the most up-to-date and reliable sources for this information (e.g. Ministry of Agriculture, companies selling agricultural inputs, livestock sector studies or experts) should be sought out by users. No attempt has been made to account for subsidies and other forms of price distortion.

Adoption of systems

By clicking on the **Livestock data** heading the livestock dialog box will appear. To go to the tables showing estimated livestock system adoption for each country, click on either the **Africa or Asia systems** button. This table shows the proportion of each national herd attributable to various livestock systems are included in this area.

Livestock systems

Within each livestock system, the productivity of different stock classes, disease losses and control methods are included. To access the input area for this data, click on the **Herd** heading in the Africa or Asian systems part of the flow chart and the following dialog box will appear. In the dialog box there are buttons for each of the livestock systems in each region. To go to the desired system, click on the appropriate button.



Livestock Productivity

The productivity of stock within each of the livestock systems is characterised in tables for each of the systems. The following items are found in the table and an example is included below.

- The percentage of adult and immature cattle in typical herd for this system
- The annual off-take of cattle per annum (% per year)
- The live-weight of cattle turned off
- Breeding cow (% of adult herd)
- Milk production per annum (kg/breeding cow/year)

The percentages if adult and immature at year-end are included in the table.. The turn-off liveweights for cattle sold throughout the year are also included. Similarly, milk off-take can be specified for each of the stock classes, along with the percentage of adult cattle that are breeding. cows A range of reports, journal articles and the opinion of experts in the field are used to define these productivity estimates.

Table: Livestock productivity and herd characteristics example

	Adult	Immature
Herd data		
Cattle at year end (% of herd)	60	40
Average annual turn-off (% per annum)	4	4
Average slaughter weight (kg liveweight)	250	150
Milk off-take (kg/breeding cow/yr)	194	0
Breeding cow (% of adult herd)	50	0

Impact of ticks and associated diseases

The physical losses associated with the incidence of disease are detailed for each of the stock types in each livestock system. These estimates are found in the same table as the estimated livestock productivity parameters. The production losses table includes milk and meat losses due to tick worry

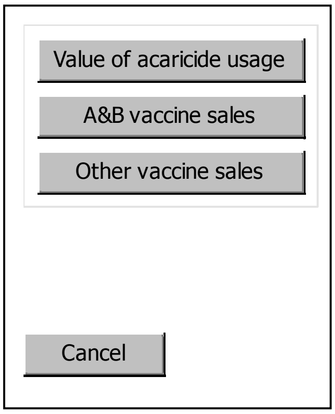
Table: Production losses in disease-affected animals example

	Adult	Immature
Tick worry morbidity losses		
Milk loss (kg/hd/yr)	0	0
Meat loss (kg/hd/yr)	21	18
Theileriosis morbidity losses		
Milk loss (kg/hd/yr)	0	0
Meat loss (kg/hd/yr)	0	0

The losses associated with *Theileriosis* are also included in the productivity loss table. In Africa, these losses are estimated for the disease *Theileria parva*, whilst in Asia losses are those associated with *Theileria annulata*. For these diseases, milk and meat are included. Previous costing studies have examined the impact of this disease on these production outputs and consequently they are included in the study.

Control methods

The use of acaricides and vaccines to control ticks and associated diseases are included in the economic costing of these diseases. To include the values of these inputs, first click **Manage** and the following dialog box will appear.



Acaricides are commonly used to manage ticks and tick borne diseases. Include the annual value of acaricide usage for each country. The value of acaricide purchases will be allocated to each disease in proportion to the current value of production losses for each respective disease.

There are vaccines currently available for *Anaplasma* and *Babesia*, *Theileria* and Heartwater disease control. In the vaccine usage column of the table, the value of vaacine sales needs to be included. In Australia, it is estimated that 0.8m doses of *Anaplasma* and *Babesia* vaccine are sold to cattle producers each year. Given that the vaccines is priced at $US 1.00 per dose, approximately $US 0.8 million are spent each year. In India and China *Theileria* vaccines have been developed and value of sales need o be included.

Production losses

Production losses are estimated for cattle in each livestock system. Initially, the incidences of disease in each system are included and system production losses estimated. Losses are then aggregated to a national level using system adoption and national herd size statistics. In this section system disease incidence, average disease production loss per head and aggregate physical losses are described.

Incidence of disease

The incidence (clinical disease) of disease and case fatality of each disease is described for tick worry, *Anaplasmosis* and *Babesiosis*, *Theileriosis* and Heartwater in specific livestock systems. To go to the system incidence table, the user should click **Incidence** in the African and Asian systems component of the flow chart. An example of the tick worry component is demonstrated in the table below.

Table: System disease incidence table example

Livestock system		Cattle in tick worry areas	Tick-worry incidence		Tick-worry case fatality	
		(% dairy herd)	(% adult herd)	(% immature herd)	(% adult incidence)	(% immature incidence)
Country		3	15	15	0	0

The above example indicates that 3% of the dairy herd are in tick worry areas. Of these cattle, 15% will suffer tick-worry, however, there will be no fatalities. For some diseases there are different incidences in adult and immature stock classes because of differing susceptibility as a result of cattle age.

Average loss per head

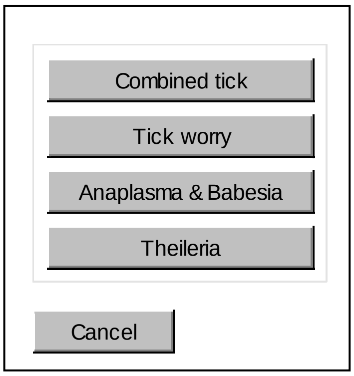
To go to the average loss per head table, the user should click **Loss** in the Asian or African systems component of the flow chart. A dialog box will appear with buttons for the different livestock systems. By clicking on the relevant button, the user will find the relevant average loss table. A sample of the productivity loss is outlined below.

Tick Worry		
	(meat kg/hd)	(milk kg/hd)
Country A	0.00	0.00
Country B	0.11	0.00

In this example, it is evident that tick worry only impacts upon meat production in this system. In Country B, tick worry is estimated to cause an 0.11kg/head meat loss for an average animal in that system.

Aggregate physical losses

The per head productivity losses for cattle in each system are aggregated to a national level using herd size and estimates of system adoption. To go to the physical loss table, the user needs to click on the **Physical** heading in the Africa or Asia-Australia section of the flow chart. Once this heading is clicked, the following dialog box with buttons for combined tick, tick worry, *Anaplasma* and *Babesia*, *Theileria*, and in the case of Africa, heartwater, will appear. Click on the relevant button to retrieve the desired tick loss table.



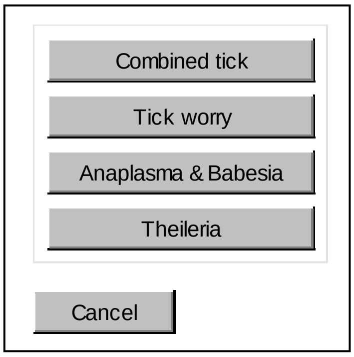
An example of the aggregate physical losses associated with tick worry is demonstrated in the table below.

Table: Physical units

		Mortality Immature Exotic	Mortality Adult Exotic	Mortality Indigenous Immature	Mortality Indigenous Adult	Meat loss (liveweight)	Milk loss
		(head/yr)	(head/yr)	(head/yr)	(head/yr)	(tonnes/yr)	(tonnes/yr)
Country A		15,624	53,332	41,190	292,907	0	398,884
Country B		0	0	98	3,263	0	3,174
Country C		4,725	16,129	69,936	74,598	5,711	34,468

Annual economic losses

The annual control and production loss costs are estimated for each disease. The physical loss estimates are combined with the prices of selected by-products and value of control measures. The user should click on the **Cost** heading in the Africa or Asia-Australia section of the flow chart to find aggregate disease costing. Once this heading is clicked the following dialog box appears.



By clicking the combined tick, tick worry, *Anaplasma* and *Babesia*, *Theileria, or heartwater* (in the case of Africa) button, annual costs relating to each of these diseases are evident. As previously mentioned, costs associated with tick acaricide usage are allocated to each of the diseases in proportion to the value of their respective production losses.

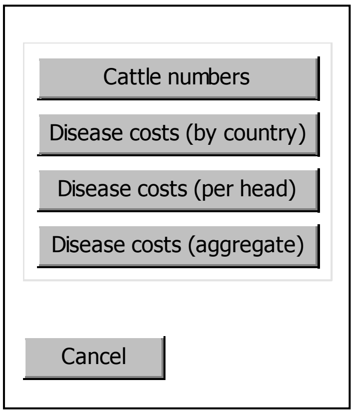
An example of the economic costs of all tick and associated diseases is shown below.

Table: Financial units

All Diseases	Acaricide	A&B vaccine	Other vaccines	Mortality	Meat loss	Milk loss	Control costs	Production loss costs
	($m/yr)	($m/yr)	($m/yr)	($m/yr)	($m/yr)	($m/yr)	($m/yr)	($m/yr)
Country A	15.8	0.4	0.2	27.6	1.7	0.3	16.4	29.5
Country B	9.2	0.0	0.0	13.9	0.6	2.3	9.2	16.8

Summary table

Under the **Summary** section of the flow chart the user can click the **Table** heading. Once this heading is clicked, the following dialog box appears.



On the dialog box there are buttons with cattle numbers, disease costs (by country), disease costs (per head) and disease costs (aggregate) headings. Click on the relevant button to view tables. Graphs can be viewed using one of two methods. Either from the interface, by clicking the Charts button, or by selecting Tables and then selecting the Charts button. To return to the interface select the Main button.

Kenya

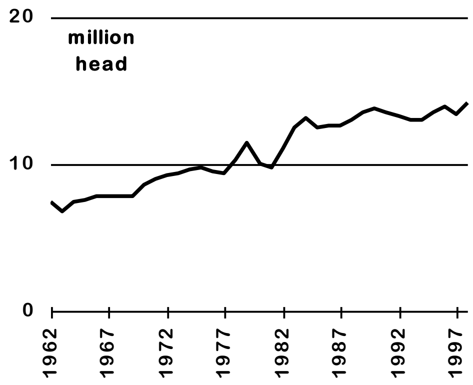


Figure 1: Size of national cattle herd

Kenya is often divided into three regions based on land productivity. First are areas of high agricultural potential with annual rainfall greater than 750 mm. These areas are mainly found in the Rift Valley, central highlands and western Kenya. Second are areas of medium agricultural productivity, including central-eastern Kenya and the coastal strip where annual rainfall is in the range of 625-750 mm. Thirdly are areas with an annual rainfall of less than 625 mm. Much of this low production region is located in the north, but also includes parts of southern Kenya along the border with Tanzania (Muriuki 1993). The bulk of the highly productive dairy sector is found in Central (highlands) and Central Rift Valley provinces of Kenya. The dairy sector is characterised by exotic genotypes and most cattle are raised on a small-holder basis. In 1990, 80% of the exotic dairy herd of around 3 million cattle was located in Rift Valley and Central provinces (Muriuki 1993).

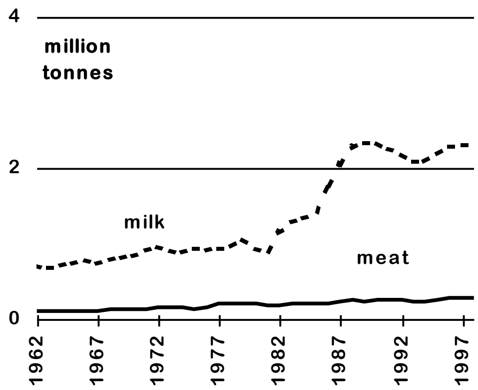


Figure 2: National production

A number of projects have been undertaken in Kenya with the goal of increasing dairy production, such as the national dairy development program (NDDP), which has been in operation in Kenya since 1980. The NDDP program has included subsidised credit during the inaugural year and extension of technical packages. In the last 10 years, Kenyan milk production has increased from around 2 to 2.4 million metric tonnes per year. This increase corresponds to an increase in the overall number of cattle, so is possibly more attributable to increased numbers of cattle than to increased productivity per head. The increase may also stem from the improved milk production estimation and recording system adopted in the recent past. Muriuki (1993) indicated that the dairy industry faces a number of constraints which include: pressure on land as a result of population growth, nutrition and water limitations, poor market infrastructure, especially roads, high prices for inputs and inadequate credit for dairy farmers. Thorpe *et al* (1993) noted that East Coast Fever was a major constraint on production, while van Schaik *et al* (1996) indicated that the use of feed concentrates and the consequent impact on milk production and calving interval significantly influenced farm profitability. Kenyan herd demographics are provided in Table 1.

Table 1: Cattle productivity and production of milk and meat in Kenya

Livestock system	Small-scale (meat-milk)	Large-scale (pastoral)	Large-scale dairy	Small-scale dairy	Total
Cattle at year end (m head) [a]	6.6	4.1	0.6	2.8	14.1
Adult cattle at year end (m head) [b]	4.0	2.5	0.4	1.7	8.6
Immatures at year end (m head) [c]	2.6	1.6	0.2	1.1	5.5
Liveweight of adult cattle (kg) [d]	250	250	450	450	-
Liveweight of immature cattle (kg) [d]	150	150	250	250	-
Milk production (kg/cow/year) [e]	194	194	4,010	1,844	-

(a): It is assumed that 4% of the national herd is comprised of large-scale dairy, pastoralism accounts for 29%, while small-mixed accounts for 47% and small-scale commercial dairy 20% (Derived from Peeler and Omore 1997). FAO (1998) statistics are used to estimate herd size.
(b): It is assumed that adult cattle comprise 60% of cattle in each production systems. Background information outlining herd structure in each systems can be derived from for Onchoke (1993) for large commercial dairy, Gitau *et al* (1994), Gitau (1997), Omore (1996) for small-scale commercial, pastoral (King *et al* 1984, Bekure *et al* 1991) and small-scale dairy-meat (mixed) (King *et al* 1984, Onchoke 1993).
(c): The number of immature cattle is derived by subtracting the number of adult cattle from total cattle numbers in each system.
(d): Liveweight assumptions are the authors. For background information on commercial cattle liveweight refer to (Commercial Farmer's Union 1994) and indigenous cattle weight (Banda and Kamwanja 1993, Berahino 1993, Mwenya 1993, Thorpe *et al* 1993). To estimate production losses in Table 4 it is further assumed that 4% and 25% of cattle are annually turned-off from indigenous and commercial production systems.
(e): Average milk production are regional averages for cattle production in east and southern Africa. Production estimates to Kenya can be found in Gitau *et al* (1994), Omore *et al* (1996) and Peeler and Omore (1997). To estimate production losses in Table 4 it is further assumed that 50% and 67% of indigenous adult and commercial adult herds are compromised of breeding cows.

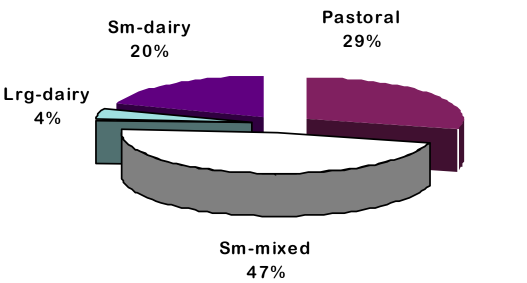


Figure 3: Composition of the herd

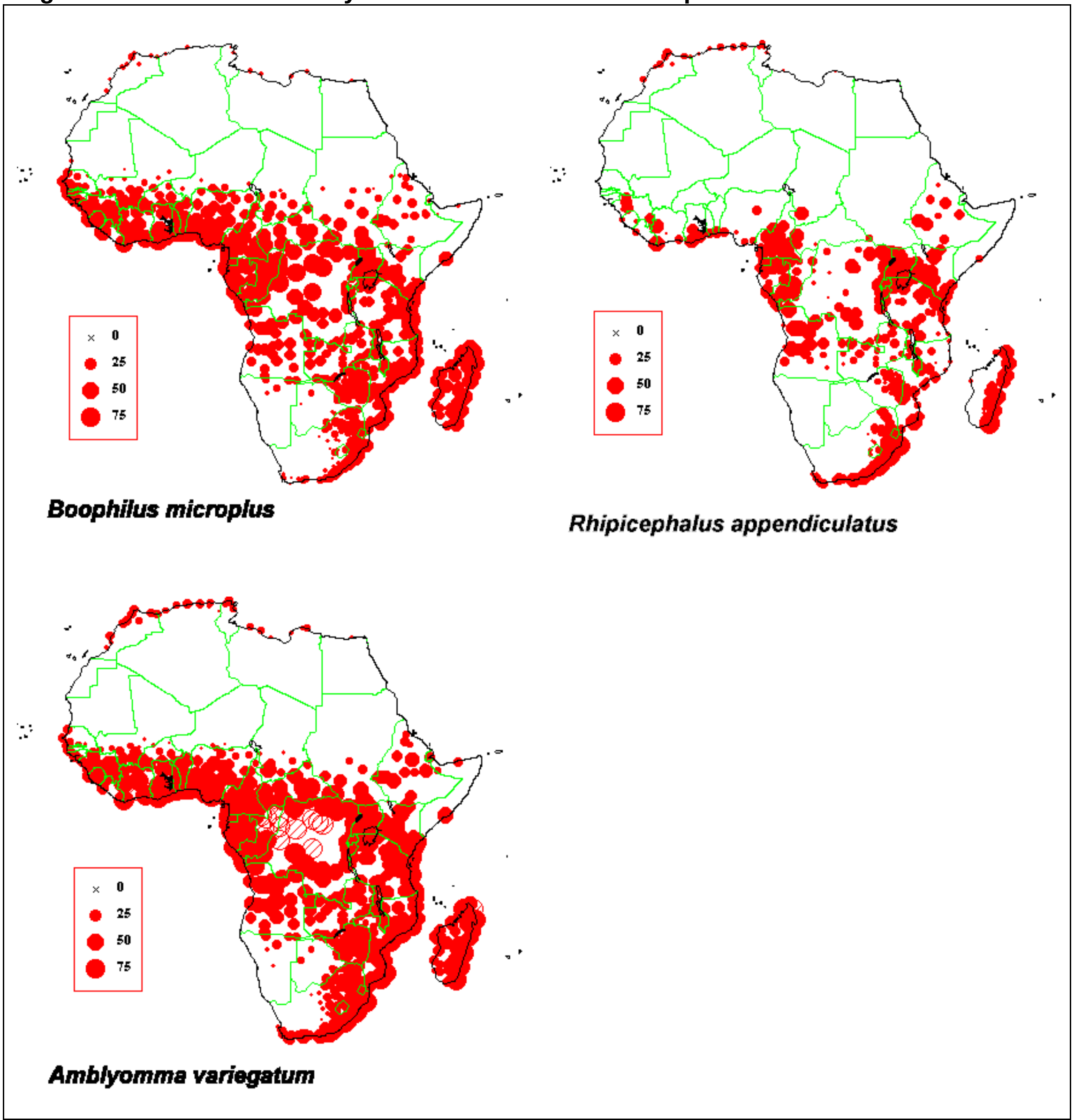
Figure 3 demonstrates the proportion of the Kenyan herd comprising large-scale dairy, small-scale dairy, pastoral and backyard cattle. Most of the milk produced in Kenya is derived from the small-holder commercial sector. Thorpe *et al* (1993) indicated that 60% of Kenyan milk production was derived from small-holder herd in high potential agricultural areas in 1986, while 30% was derived from large-scale herds and 10% from pastoral herds. Beef is sourced from culled dairy cattle and the slaughter of indigenous Zebu cattle breeds .

Ticks and associated diseases

The diseases Anaplasmosis, Babesiosis, Heartwater and East Coast Fever constrain livestock production in Kenya, along with the impact of tick worry or feeding ticks. Anaplasma and Babesia are primarily transmitted by *Boophilus spp.* ticks, Heartwater by *Amblyomma spp* and East Coast Fever by the tick *Rhipicephalus appendiculatus*. The climatic suitability of Kenya for the development of these tick species is demonstrated in Figure 4. The actual presence of tick species in climatically suitable areas needs to be confirmed by scientific survey.

The majority of indigenous and exotic cattle raised in Kenya reside in areas where tick worry is present. The impact of tick worry varies with seasonal conditions and the nutritional status of cattle. For the purposes of this impact assessment it is assumed that 15% of commercial cattle and traditional cattle, such as the East African Zebu, are subject to tick worry in a typical season. A number of studies have been conducted to determine the impact of feeding ticks on cattle. The reduction in production as a result of tick worry is outlined in Table 3.

Figure 4: Climatic suitability of Africa for selected tick species [(a)]



(a): Source - Maywald and Sutherst (1985)

The economic impact of East Coast Fever has been estimated for east and southern Africa by Mukhebi *et al* (1992). In this study, the disease was assumed to cause mortality, along with morbidity losses associated with reduced meat, milk, manure and animal draft power. The incidence and case fatalities for adult and immature cattle in each livestock system are described in Table 2.

Anaplasmosis and *Babesiosis* cause mortality and reduce cattle productivity. A survey of commercial cattle producers in South Africa, conducted by du Plessis *et al* (1994), found that approximately 0.5% of cattle within Anaplasma and Babesia endemic areas died as a result of infection by these diseases. A similar mortality rate is assumed for commercial cattle in the Anaplasma and Babesia endemic areas of Kenya.

Mortality is assumed to be greater in adult cattle as younger cattle have higher innate resistance to these diseases (Mahoney and Ross 1972). *Boophilus spp*. ticks that vector these diseases are found throughout Kenya. Following the widespread distribution of the vector ticks, it is assumed that 70% of Kenyan cattle are at risk from these diseases. The case fatalities of these diseases, is however, assumed to be lower in indigenous cattle types as these cattle are thought to have higher natural immunity to the affects of disease. Disease incidence and case fatality assumptions used in the costing are provided in Table 2.

Table 2: Incidence of tick-borne diseases in Kenya

	Tick Worry		***Anaplasma and Babesia***		***Theileria parva***		**Heartwater**	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale (meat-milk)								
Herd in endemic areas (%) [(a)]	90	90	70	70	100	100	70	70
Disease incidence (%) [(b)]	15	15	2.5	5	11	22	1	4
Case fatality (%) [(c)]	0	0	5	2.5	42	21	15	13
Mortality (%)	0	0	0.1	0.1	4.6	4.6	0.15	0.5
Large-scale (pastoral)								
Herd in endemic areas (%) [(a)]	90	90	70	70	50	50	70	70
Disease incidence (%) [(b)]	15	15	2.5	5	4	10	1	4
Case fatality (%) [(c)]	0	0	5	2.5	15	15	15	13
Mortality (%)	0	0	0.1	0.1	0.6	1.5	0.15	0.5
Small-scale dairy								
Herd in endemic areas (%) [(a)]	90	90	70	70	100	100	70	70
Disease incidence (%) [(d)]	15	15	5	10	2	10	2	8
Case fatality (%)	0	0	10	5	20	20	30	25
Mortality (%)	0	0	0.5	0.5	0.4	2.0	0.6	2.0
Large-scale dairy								
Herd in endemic areas (%) [(a)]	90	90	70	70	100	100	70	70
Disease incidence (%) [(d)]	15	15	5	10	2	25	2	8
Case fatality (%)	0	0	10	5	20	40	30	25
Mortality (%)	0	0	0.5	0.5	0.4	10.0	0.6	2.0

(a): It is assumed that 90% of all cattle are in tick worry areas, 70% of the herd is at risk from Anaplasma and Babesia. ECF areas are taken from Peeler and Omore (1997) Gitau *et al* (1999), O'Callaghan (1998), Latif *et al* (1995), Moll *et al* (1986) and Maloo (1993). Approximately 70% of the herd are assumed to be in areas where heartwater is endemic.
(b): Disease incidences for ECF are derived from Peeler and Omore (1997) Gitau *et al* (1999), O'Callaghan (1998), Latif *et al* (1995), Moll *et al* (1986), Maloo (1993). Heartwater, Anaplasmosis and Babesiosis incidences are author assumptions.
(c): Anaplasmosis and babesiosis case fatality estimates are the authors. Background information on Babesiosis may be derived from Ramsay (1997) *B. bovis* case fatality description, but should be modified to account for B.bigemina being a major cause of babesiosis in this country. Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases (Mahoney and Ross 1972). Anaplasmosis and Babesiosis case fatality in indigenous stock is assumed to be half that of exotic stock. Heartwater disease incidence estimates are made by the authors. Background data on disease incidence in Zimbabwe can be found in Meltzer *et al* (1993) and Chamboko *et al* (1996a,b).
(d): Mortality estimates are for cattle in disease risk areas. For example, in the case of heartwater in small-scale commercial dairy cattle, 2.0% of immature cattle in disease risk areas are estimated to suffer mortality as a result of this disease.

Heartwater (*Cowdria ruminatium*) is present is selected regions within Kenya. The disease can cause reduced milk and meat production, along with mortality in severe cases. The disease has higher incidence in exotic breeds. In the heartwater endemic areas of South Africa, du Plessis *et al* (1994) found an annual heartwater mortality of 1.3%.

Annual livestock and milk losses per animal attributable to the different diseases are shown in Table 3. Heartwater, anaplasmosis and babesiosis are assumed to cause negligible losses in productivity in terms of meat and milk. As could be expected, the greatest losses associated with East Coast Fever are due to milk losses in the dairy systems.

Table 3: Production losses in disease-affected cattle

	Tick Worry		*Anaplasma and Babesia*		*Theileriosis*		Heartwater	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale (milk-meat)								
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0	13	15	0	0
Milk loss (kg/hd/yr) [(b)]	4	0	0	0	49	0	0	0
Large-scale (pastoral)								
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0	13	15	0	0
Milk loss (kg/hd/yr) [(b)]	4	0	0	0	49	0	0	0
Large commercial dairy								
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0	23	25	0	0
Milk loss (kg/hd/yr) [(b)]	201	0	0	0	1,002	0	0	0
Small-scale commercial								
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0	23	25	0	0
Milk loss (kg/hd/yr) [(b)]	92	0	0	0	461	0	0	0

(a): Liveweight losses for tick worry in indigenous cattle (2% loss) are author estimates. Background information on tick worry losses can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval *et al* 1997a, b, c). Tick worry liveweight losses in exotic cattle types (5% loss in affected cattle) are author estimates. Background information on tick worry losses in commercial cattle can be derived from studies by Little (1963), Sing *et al* (1983), Seebeck *et al* (1971) and Sutherst *et al* (1983) Anaplasmosis, Babesiosis and Heartwater live weight losses are assumed to be negligible and are not included in the costing framework. Theileriosis live weight losses are derived from Mukhebi *et al* (1992) production loss estimates in African indigenous and exotic cattle.
(b): Milk losses as a result of tick worry in commercial cattle (5% loss) and indigenous cattle (2% loss) are author estimates. Background information on tick worry losses in commercial dairy cattle can be derived from studies by Jonsson *et al* (1998) and (Norval *et al* 1997a, b, c) for indigenous cattle. The effect of Anaplasmosis and Babesiosis infection on milk production is assumed to be non-significant. The impact of Theileriosis infection on milk production was derived from Mukhebi *et al* (1992).

The aggregate physical losses attributable to each of the tick diseases are outlined for various sectors within the Kenyan cattle industry. The substantial loss of milk in the small-scale mixed sector as a result of ECF infection is apparent in the table. This large loss is a function of extensive disease incidence and 25% milk reduction associated with morbidity.

Table 4: Annual physical tick and tick-borne disease production losses in Kenya

Disease	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria parva*	*Heartwater*
Small-scale mixed (meat-milk)				
Adult mortality (head) [(a)]	0	3,479	183,700	4,175
Immature mortality (head) [(a)]	0	2,319	122,467	9,649
Reduced liveweight (tonnes) [(b)]	150	0	569	0
Reduced milk production (tonnes)	1,083	0	11,031	0
Large-scale (pastoral)				
Adult mortality (head) [(a)]	0	2,147	7,360	2,576
Immature mortality (head) [(a)]	0	1,431	12,267	5,954
Reduced liveweight (tonnes) [(b)]	93	0	166	0
Reduced milk production (tonnes)	668	0	1,237	0

Table 4: Physical tick production losses in Kenya (cont)

Disease	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria parva*	*Heartwater*
Large-scale dairy				
Adult mortality (head) [(a)]	0	1,184	1,354	1,421
Immature mortality (head) [(a)]	0	790	22,560	3,158
Reduced liveweight (tonnes) [(b)]	352	0	391	0
Reduced milk production (tonnes)	7,633	0	5,654	0
Small-scale commercial dairy				
Adult mortality (head) [(a)]	0	5,922	6,768	7,106
Immature mortality (head) [(a)]	0	3,948	22,560	15,792
Reduced liveweight (tonnes) [(b)]	1,761	0	895	0
Reduced milk production (tonnes)	17,550	0	13,000	0

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.
(b): Liveweight losses are only realised for cattle that are slaughtered.

Physical control input and production loss estimates are combined with product prices to calculate annual economic costs of tick-borne diseases (Table 5). To estimate acaricide usage, it is assumed that cattle consume $US 0.1 per head of acaricide at each dipping. Following this assumption, it is estimated that annual acaricide usage in the commercial dairy system costs $US 5 head/year (Gitau *et al* 1998 - 52 dips per year), small-scale commercial cattle cost $US 1 head/year (Staal *et al* 1997 - 40% of the herd, dipped 26 times per annum), no large-scale pastoral cattle are dipped and cattle in the small-scale mixed system cost $US 0.5 head/year to treat with acaricides each year (20% of the herd dipped 26 times per year). Based on these assumptions, the aggregate cost of acaricide use in Kenya is estimated to be $US 11 million per annum. This cost is allocated to each disease in proportion to the value of residual production losses.

Given the assumptions in Tables 2 and 3, the four tick-borne diseases are estimated to cost $133 million annually. The greatest costs are associated with East Coast Fever (*T.parva*), with losses of $95 million per year.

Table 5: Annual costs of ticks and associated ideas ($US m) [(a)]

Livestock System	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria parva*	*Heartwater*
Control				
Acaricides ($m)	1.4	0.6	7.9	1.1
Vaccine ($m)	0	0	0	0
Production Losses				
Mortality ($m)	0	6.3	69.7	12.2
Milk production ($m)	13.5	0	15.5	0
Liveweight ($m)	2.4	0	2.0	0
Combined costs ($m)	**17.3**	**6.9**	**95.1**	**13.3**

(a): It is assumed that commercial adult and immature cattle have values of $US 500 and 250 per head, indigenous adult and immature cattle values of $200 and $120 per head, milk $0.5 per litre and meat $1.00 kg liveweight at farm-gate.

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Tanzania

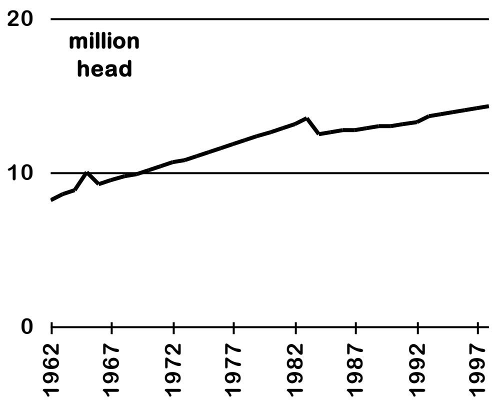


Figure 1: Size of national cattle herd

Tanzania has the second highest livestock population in sub-Saharan Africa (Rushalaza and Kasonta 1993), estimated at 14.3 million cattle (FAO, 1998). Indigenous cattle accounted for more than 90% of the national cattle herd, and breeds such as the Tanzania Shorthorn Zebu are commonly raised. Whereas the numbers of indigenous cattle and small ruminants are thought to have changed little during the last 13 years (since the livestock census in 1984), dairy cattle have nearly doubled from approximately 142,000 in 1984 to over 250,000 in 1995, an annual growth rate of at least 6% (MOAC/SUA/ILRI, 1998).

The relative growth rate of dairy cattle in urban and peri-urban areas during the same period is estimated to have been much higher. In particular, the number of dairy cattle within Dar-es-Salaam have increased ten-fold, from below 2,000 in 1984 to approximately 20,000 in 1995 (Mlozi, 1995, in MOAC/SUA/ILRI, 1998). Despite the off-take from commercial dairy herd only comprising approximately 20% of total production, it is estimated to account for at least 95% of marketed milk (Ngigwana, 1990), most of which (66%) is produced in the Arusha and Kilimanjaro regions (MOAC/SUA/ILRI, 1998).

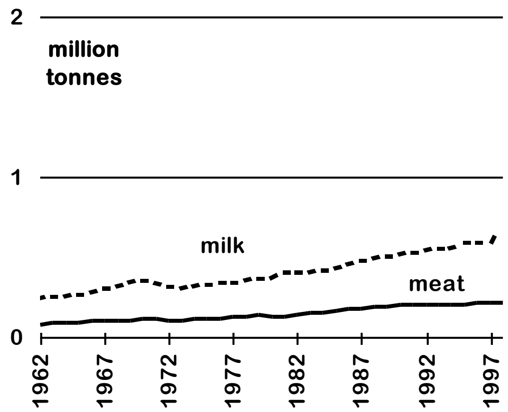


Figure 2: National production

LPRI (1983) noted that the major constraints on cattle production include poor animal nutrition, animal diseases, water shortages and the low genetic potential of indigenous cattle. The production of meat and milk over the 1962 to 1998 period is provided in the adjoining figure. Both milk and meat production have increased over this time-frame. Of the indigenous herd of 12 million cattle in 1987, 315,723 cattle were slaughtered (Swai *et al* 1993). Exotic dairy cattle generally have much higher milk yields when compared to indigenous cattle, Swai *et al* (1993) estimated that improved dairy cattle have a lactation yield of 1,500-3,000 kg per lactation.

Cattle production in Tanzania has been characterised into a number of production systems including pastoral, agro-pastoral, mixed farming, intensive dairy farming and peri-urban milk production systems. Within the peri-urban and intensive production system farmers have adopted exotic dairy breeds, milk is sold on a commercial basis and milk production occurs throughout the entire year.

Farmers raise indigenous cattle on a small-holder basis in the mixed farming and agro-pastoralism systems. Often cattle are used for draft purposes. In 1982, the Ministry of Agriculture estimated that more than 25% of the energy for cultivation was derived from animal draft power. The impact of tick-borne diseases on pastoral cattle is outlined in the Table 1.

Table 1: Cattle numbers and productivity in Tanzania (1998).

Livestock system	Small-scale (meat-milk)	Indigenous (pastoral)	Small-scale dairy	Total
Cattle at year end (million head) [(a)]	11.0	3.0	0.3	14.3
Adult cattle at year end (m head) [(b)]	6.6	1.8	0.2	8.6
Immatures at year end (m head) [(c)]	4.4	1.2	0.1	5.7
Liveweight of adult cattle (kg) [(d)]	250	250	450	-
Liveweight of immature cattle (kg) [(d)]	150	150	250	-
Milk production (kg/cow/year) [(e)]	194	194	1,844	-

(a): It is assumed that 2% of the national herd is comprised of exotic cattle. Of the indigenous production systems, pastoralism accounts for 21%, while small-scale milk meat accounted for 77% (Derived from Ministry of Agriculture 1996). FAO (1998) statistics used to estimate herd size.
(b): The percentage adult cattle is assumed to be 60% for all cattle production systems.
(c): The number of immature cattle is is derived by subtracting adult cattle from total cattle in each system.
(d): Average regional liveweights for commercial and indigenous cattle are included in the table. To estimate production losses in Table 4, it is further assumed that 4% of indigenous cattle and 25% of commercial cattle are turned-off per annum.
(e): Average regional milk production estimates are included for indigenous and commercial systems. Background information on milk production can be found in Mukhebi *et al* (1992). To estimate milk production losses in Table 4, it is assumed that 50% of indigenous adult cattle are breeding cows, while 67% of commercial adults are breeding cows.

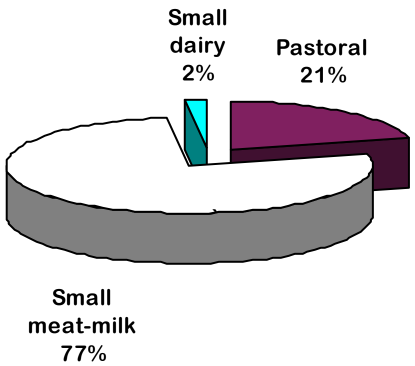


Figure 3: Composition of national herd

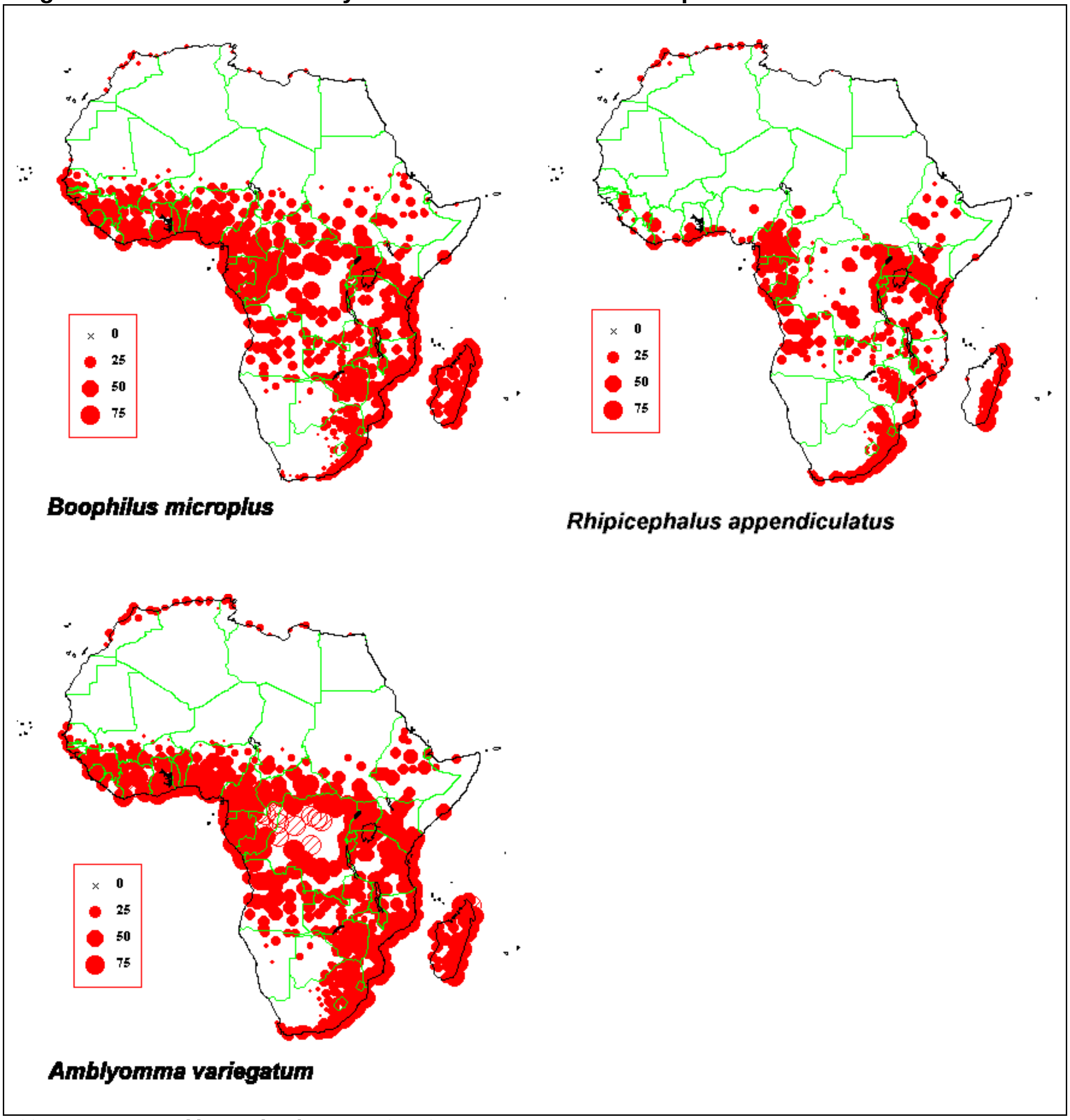
Figure 3 demonstrates the proportion of commercial small dairy, pastoral and small meat-milk cattle in the national herd. It is evident that the production of indigenous cattle within small meat-milk and pastoral systems is the major type of cattle production enterprise in Tanzania. The incidence of tick-borne diseases and resulting economic losses differ by production systems. Exotic cattle are generally considered to be more susceptible to the impact of these diseases and consequently per head production losses are greater for this sector. There are a small number of commercial beef cattle in Tanzania. These cattle are included in the small-commercial dairy system for costing purposes.

Ticks and associated diseases

The diseases Anaplasmosis, Babesiosis, Heartwater and East Coast Fever constrain livestock production in Tanzania, along with the impact of tick worry or feeding ticks.

Anaplasma Babesia are primarily transmitted by *Boophilus spp.* ticks, Heartwater by *Amblyomma spp* and East Coast Fever by the tick *Rhipicephalus appendiculatus*. The climatic suitability of Tanzania for the development of these tick species is demonstrated in the following figure. Simulation results provide an indication as to where various tick species may reside, but results need to be confirmed by scientific studies.

Figure 4: Climatic suitability of Africa for selected tick species [(a)]



(a): Source - Maywald GF and Sutherst RW. (1985)

The majority of indigenous and exotic cattle are assumed to be raised in tick worry areas. It is assumed that 15% of commercial cattle and also traditional cattle, such as the Tanzanian Shorthorn Zebu and East African Zebu, are subject to tick worry production losses in a typical season.

Anaplasmosis and *Babesiosis* cause mortality and reduce cattle productivity. A survey of commercial cattle producers in South Africa, conducted by du Plessis *et al* (1994), found that approximately 0.5% of cattle within Anaplasma and Babesia endemic areas suffered mortality as a result of infection by these parasites. In this disease impact study, it is assumed that 0.8% of commercial dairy cattle suffer mortality as a result of infection by *B.bovis*, *B.bigemina* and *A.marginale,* while 0.1% of indigenous cattle suffer fatality as a result of these parasites. Higher redwater and gallsickness mortalities in commercial cattle are included for this country, when compared to South Africa, following discussions with veterinary experts.

Mortality is assumed to be greater in adult cattle as younger cattle have higher innate resistance to these diseases (Mahoney and Ross 1972). *Boophilus spp*. ticks that vector these diseases are found throughout Tanzania. Following the widespread distribution of the vector ticks, it is assumed that 70% of Tanzanian cattle are at risk from these diseases.

Table 2: Incidence of tick-borne diseases in Tanzania

	Tick Worry (Feeding ticks)		***Anaplasma and Babesia***		***Theileria parva (East Coast Fever)***		**Heartwater**	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale (milk-meat)								
Herd in endemic areas (%) [(a)]	80	80	70	70	70	70	70	70
Disease incidence (%) [(b)]	15	15	2.5	5	5	15	1	4
Case fatality (%) [(c)]	0	0	5	2.5	15	35	15	13
Mortality (%) [(d)]	0	0	0.1	0.1	0.75	5.25	0.2	0.5
Indigenous large-scale (pastoral)								
Herd in endemic areas (%) [(a)]	80	80	70	70	70	70	70	70
Disease incidence (%) [(b)]	15	15	2.5	5	5	15	1	4
Case fatality (%) [(c)]	0	0	5	2.5	15	35	15	13
Mortality (%) [(d)]	0	0	0.1	0.1	0.75	5.25	0.2	0.5
Small-scale commercial								
Herd in endemic areas (%) [(a)]	80	80	70	70	70	70	70	70
Disease incidence (%) [(d)]	15	15	8	10	5	15	2	8
Case fatality (%)	0	0	10	8	15	35	30	25
Mortality (%) [(d)]	0	0	0.8	0.8	0.75	5.25	0.6	2.0

(a): It is assumed that 80% of all cattle are in tick worry areas, 70% of the herd is at risk from Anaplasma and Babesia, 70% of traditional and exotic cattle are in ECF areas, while 70% of the herd are in areas where heatwater is endemic
(b): Disease incidence for ECF is derived from Lessard (1990) and Lynen (personal. communication). Heartwater, anaplasmosis and babesiosis incidence are author estimates.
(c): Anaplasmosis and babesiosis case fatality estimates are author estimates. Background information on these diseases can be derived from Ramsay (1997) *B. bovis* case fatality estimates, but need to be adjusted to reflect that B.bigemina is a major cause of babesiosis in Africa. Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases (Mahoney and Ross 1972). East Coast Fever case fatality estimates are derived from Kruska (1997). Heartwater case fatality estimates are author estimates.
(d): Mortality is outlined for cattle in disease risk areas. For example, in the case of East Coast Fever in commercial cattle, 5.25% of immatures in disease risk areas are estimated to suffer mortality as a result of this disease.

Heartwater (*Cowdria ruminatium*) is present in most cattle regions within Tanzania. The disease can cause reduced milk and meat production, along with mortality in severe cases. In the heartwater endemic areas of South Africa, du Plesiss *et al* (1994) found an annual heartwater mortality of 1.3%. Heartwater mortalities of 0.6 and 2.0% are included for adult and immature cattle in the small-scale commercial system Immature mortalities have been observed to be higher in the commercial systems of Zimbabwe for this disease (Meltzer *et al* 1996). For the purposes of the cost assessment the incidence and case fatality estimates for commercial cattle are halved and assumed for indigenous cattle. Author estimates of disease estimates are included in Table 2.

The economic impact of East Coast Fever was estimated by Mukhebi *et al* (1992) and production loss estimates from the study are used in this economic assessment. The incidence and case fatalities for adult and immature cattle in each livestock system are described in Table 2 using data from the Mukhebi *et al* (1992) and also from discussions with scientists in Tanzania.

Table 3: Production losses in disease-affected cattle

	Tick Worry		***Anaplasma and Babesia***		***Theileriosis***		**Heartwater**	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale (milk-meat)								
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0	13	15	0	0
Milk loss (kg/hd/yr) [(b)]	4	0	0	0	49	0	0	0
Large-scale (pastoral)								
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0	13	15	0	0
Milk loss (kg/hd/yr) [(b)]	4	0	0	0	49	0	0	0
Small-scale commercial								
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0	23	25	0	0
Milk loss (kg/hd/yr) [(b)]	92	0	0	0	461	0	0	0

(a): Liveweight losses for tick worry in indigenous cattle (2% loss) are author estimates. Background information on indigenous cattle tick worry losses can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval *et al* 1997a, b, c). Tick worry liveweight losses in exotic cattle types (5% loss in affected cattle) are author estimates. Background information on tick worry losses in commercial cattle can be derived from studies by Little (1963), Sing *et al* (1983), Seebeck *et al* (1971) and Sutherst *et al* (1983) Anaplasmosis, Babesiosis and Heartwater live weight losses are assumed to be negligible and are not included in the costing framework. Theileriosis live weight losses are derived from Mukhebi *et al* (1992) estimates of production losses in African indigenous and exotic cattle.
(b): Milk losses as a result of tick worry in commercial cattle (5% loss) and indigenous cattle (2%) are author estimates. Background information on tick worry losses in commercial cattle can be derived from Jonsson *et al* (1998) and (Norval *et al* 1997a, b, c) for indigenous cattle. The effect of Anaplasma and Babesia infection on milk production is assumed to be non-significant. The impact of Theileriosis on milk production was derived from Mukhebi *et al* (1992).

The aggregate physical losses attributable to each of the tick diseases are outlined for each livestock system in the Tanzanian cattle industry. Total production losses are greatest for indigenous cattle production systems as there are larger numbers of cattle in these systems. East Coast Fever is the disease that causes the highest number of deaths. Meat, manure and traction production losses are not substantial.

Table 4: Annual physical tick and tick-borne disease production losses in Tanzania

Disease	**Tick Worry (feeding ticks)**	***Anaplasma and Babesia***	***Theileria parva***	***Heartwater***
Small-scale mixed (milk-meat)				
Adult mortality (head) [(a)]	0	5,781	34,685	6,937
Immature mortality (head) [(a)]	0	3,854	161,862	16,032
Liveweight losses (tonnes) [(b)]	222	0	393	0
Reduced milk production (tonnes)	1,600	0	5,832	0
Indigenous (pastoral)				
Adult mortality (head) [(a)]	0	1,577	9,459	1,892
Immature mortality (head) [(a)]	0	1,051	44,144	4,372
Liveweight losses (tonnes) [(b)]	61	0	271	0
Reduced milk production (tonnes)	436	0	1,590	0
Small-scale commercial dairy				
Adult mortality (head) [(a)]	0	961	901	721
Immature mortality (head) [(a)]	0	641	4,204	1,602
Liveweight losses (tonnes) [(b)]	159	0	109	0
Reduced milk production (tonnes)	1,582	0	2,307	0

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.
(b): Liveweight losses are only realised for cattle that are slaughtered.

Physical control input and production loss estimates are combined with product prices to calculate economic costs. MOAC (1998) estimated that small-scale commercial dairy cattle (intensive rural dairy with crosses) consume $US 15 per cow each year in acaricide treatments. Given cows only comprise a proportion of the dairy herd, it is assumed that commercial dairy cattle (all stock classes), on average, consume $5 per head/year in acaricide. Given this assumptions, the total cost of acaricide treatment for cattle in this system is estimated to be $2.0 million in 1998, given that approximately 0.31 cattle were estimated to be carried in this livestock system. Indigenous cattle are also dipped within small-scale mixed and pastoral production systems (Technical Committee 1992). The exact nature of dipping practice in these systems is not readily apparent and acaricide use is not included in the assessment for these production systems. Acaricide use costs for the small-commercial dairy system are allocated to each disease in proportion to calculated production losses of each disease.

Table 5: Annual costs associated with ticks and associated ideas ($US m) [(a)]

Livestock System	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria parva*	*Heartwater*
Control				
Acaricides	0.1	0.1	1.6	0.2
Vaccines [(b)]	0	0	na	0
Production Losses				
Mortality	0	2.7	35.1	5.0
Milk production	2.4	0	6.3	0
Liveweight	0.4	0	0.8	0
Combined costs ($)	**2.9**	**2.8**	**43.8**	**5.2**

(a): It is assumed that commercial adult and immature cattle have values of $US 500 and 250 per head, indigenous adult and immature cattle values of $200 and $120 per head, milk $0.65 per litre and meat $1.00 kg liveweight at farm-gate. (b): Cattle are vaccinated for ECF in Tanzania, but the exact nature of these costs are not available.

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South Africa

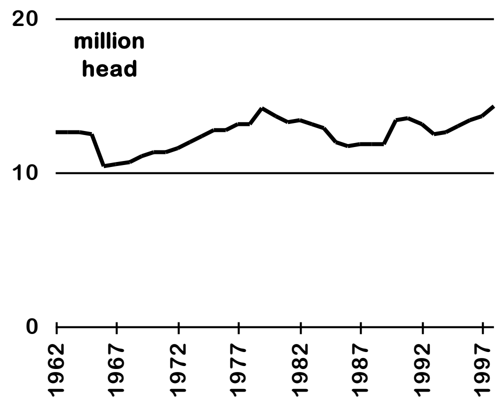


Figure 1: Size of national cattle herd

Cattle are raised in South Africa on a commercial and small-holder basis. USDA (1998) estimated that the small-holder sector accounted for 40% of the entire cattle herd in 1997. The national herd has increased in size by 10% over the 1962-1998 period. Last season there was good rainfall for livestock production and the herd size increased in conjunction with reduced livestock slaughter. In 1997, the livestock industry in South Africa experienced significant changes in agricultural policy that resulted in the dismantling of the Meat Board. The South African Meat Industry Company has acquired some of the Meat Board's activities, including market information collection and dissemination. Abattoirs indirectly controlled by the Meat Board are currently operating below capacity, as farmers can now slaughter cattle at the abattoir of their choice. During 1997, South Africa was declared partially Foot and Mouth Disease Free and animal health authorities in South Africa are working to totally eradicate this disease (USDA 1998).

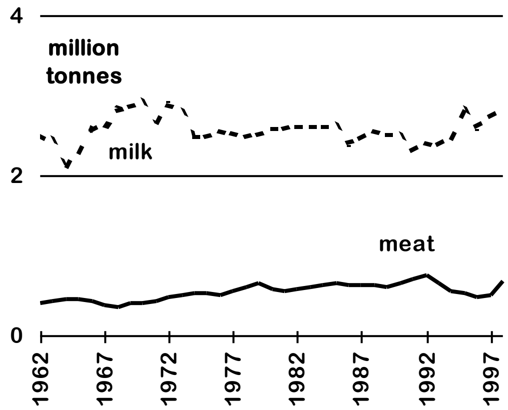


Figure 2: National production

The production of meat and milk over the 1962 to 1998 period is illustrated in the adjoining figure. It is evident that the increase in meat production follows the increase in national herd size. The national herd is dominated by the large-scale production of beef cattle on a commercial basis. In 1997, the commercial beef sector represented approximately 52% of the national herd. Most cattle are raised in the eastern and northern provinces of South Africa. Cattle production is not extensively practiced in the dry western provinces where sheep production is the dominant livestock activity. Apart from KwaZulu-Natal, South Africa has no national tick control program and private farmers decide on the appropriate form of tick control. To better understand farmer tick control attitudes, two surveys have been recently undertaken by du Plessis *et al* (1994) and Spickett and Fivaz (1993). Major issues raised in the du Plessis *et al* (1994) survey outlined by Potgieter (1996) include:

- The present heartwater vaccine does not control this disease adequately
- Anaplasmosis and babesiosis vaccinations have no beneficial effect on the mortality rates of these diseases in heartwater regions
- The authors believe the frequency of acaricide application is too high in heartwater endemic areas
- Farmers do not regard heartwater in cattle as a serious problem

Major issues raised in the Spickett and Fivaz (1993) survey outlined by Potgieter (1996) include:

- Producers use intensive tick control
- Beef and dairy farmers primarily used synthetic pyrethroid acaricides
- Most farmers switch between acaricides in relation to price
- Small numbers of cattle producers use tick-borne disease vaccines

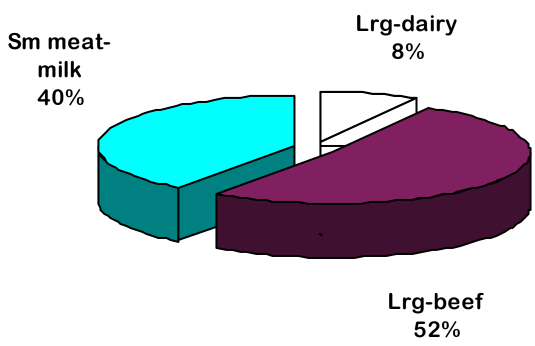


Figure 3: Composition of national herd

Prior to outlining tick-borne disease costs for South Africa, an overview of cattle numbers, average milk production and cattle slaughter weights are provided in Table 1. Figure 3 outlines the numbers of cattle in small-scale and large-scale commercial systems as percentages of the national herd.

Table 1: Cattle productivity and production of milk and meat

Livestock system	Small-scale (meat-milk)	Large beef	Large dairy	Total
Cattle at year end (m head) [(a)]	5.5	7.2	1.1	13.8
Adult cattle at year end (m head) [(b)]	3.3	4.3	0.7	8.3
Immatures at year end (m head) [(c)]	2.2	2.9	0.4	5.5
Liveweight of adult cattle (kg) [(d)]	250	450	450	-
Liveweight of immature cattle (kg) [(d)]	150	250	250	-
Milk production (kg/cow/year) [(e)]	194	0	4,010	-

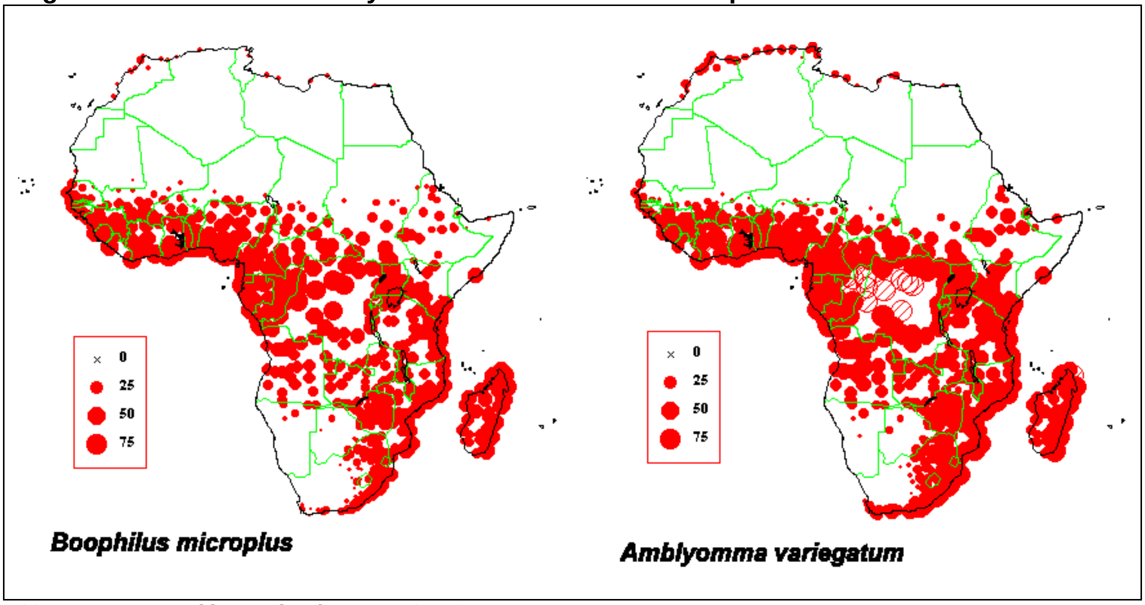
(a) Cattle numbers are derived from FAO 1998 herd numbers and USDA (1998)
(b): Adult cattle are assumed to represent 60% of each production system.
(c): The number of immature cattle is derived by subtracting the number of adult cattle from total herd size estimates.
(d): Liveweight assumptions are the authors. Background information on cattle production in this region can be derived from Commercial Farmers Union (1991, 1994). To estimate production losses in Table 4, it is assumed that 4% and 25% of cattle are annually turned-off from indigenous and commercial production systems.
(e): An average milk production of 194 kg for small-scale meat-milk cows is an author estimate. A large-scale dairy yield of 4,010 kg per cow per year is derived from Commercial Farmers Union (1994). To calculate annual milk production losses in Table 4 it is assumed that breeding cows account for 50% of adult small-scale cattle and 67% of adult commercial cattle.

Ticks and associated diseases

The diseases Anaplasmosis, Babesiosis, and Heartwater cause production losses in South Africa, along with the impact of tick worry or feeding ticks. Figure 4 illustrates the climatic suitability of South Africa for the development of the tick species

Boophilus microplus and *Amblyomma variegatum.* Climatic suitability was mapped using the CLIMEX simulation model developed by Maywald and Sutherst (1985). Simulation analysis provides an indication where vector ticks may be found, but scientific survey is required to confirm the actual presence of these species. Heartwater is vectored by *Amblyomma hebraeum* in South Africa and the disease is mainly found in the northern and eastern provinces.

Figure 4: Climatic suitability of Africa for selected tick species [(a)]



(a): Source - Maywald GF and Sutherst RW. (1985)

Tick worry is assumed to affect the majority of cattle raised in South Africa. For the purposes of this impact assessment, it is assumed that 15% of commercial cattle and small-holder cattle are subject to tick worry in a typical season. Commercial cattle are treated with acaricides as part of routine animal husbandry practice. These cattle types are more susceptible to the impact of tick worry when compared to indigenous types. Correspondingly, tick worry incidence is assumed to be similar. A number of studies have been conducted to determine the impact of feeding ticks on cattle. The reduction in production as a result of tick worry is outlined in Table 3.

Anaplasmosis and *Babesiosis* cause mortality and reduce cattle productivity. A survey of commercial cattle producers in South Africa, conducted by du Plessis *et al* (1994), found that approximately 0.5% of cattle within heartwater endemic areas suffered *Anaplasmosis* and *Babesiosis* related mortality each year as a result of infection by these diseases. This rate of mortality is assumed for commercial cattle in this study. Mortality is assumed to be greater in adult cattle as younger cattle have higher innate resistance to these diseases (Mahoney and Ross 1972, Ramsay 1997).

Anaplasma is vectored by the *ticks R. Simus*, *R. evertsi*, *B. decoloratus*, *B. microplus, H.m rufipes* and *S. calcitrans*, while Babesia is transmitted by *B. decoloratus and B. microplus*. Potgieter (1996) estimated that 99% of the national herd resided in Anaplasma endemic areas, while 92% of cattle were in Babesia endemic areas. Disease incidence and case fatality assumptions used in the costing are provided in Table 2.

Heartwater (*Cowdria ruminatium*) is endemic in the northern and eastern regions of South Africa. du Plesiss *et al* (1994) found an annual heartwater mortality of 1.3% in endemic areas. These production losses are not substantial and are not included in the costing framework.

Table 2: Annual incidence of tick-borne diseases in South Africa

	Tick Worry		***Anaplasma and Babesia***		**Heartwater**	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale mixed (meat-milk)						
Herd in endemic areas (%) [(a)]	90	90	90	90	38	38
Disease incidence (%) [(b)]	15	15	2.5	5	1	4
Case fatality (%) [(c)]	0	0	5	2.5	15	13
Mortality (%) [(d)]	0	0	0.1	0.1	0.2	0.5
Large-scale beef						
Herd in endemic areas (%) [(a)]	90	90	90	90	38	38
Disease incidence (%) [(b)]	15	15	5	10	2	8
Case fatality (%) [(c)]	0	0	10	5	30	25
Mortality (%)	0	0	0.5	0.5	0.6	2.0
Large-scale dairy						
Herd in endemic areas (%) [(a)]	90	90	90	90	38	38
Disease incidence (%) [(d)]	15	15	5	10	2	8
Case fatality (%)	0	0	10	5	30	25
Mortality (%)	0	0	0.5	0.5	0.6	2.0

(a): It is assumed that 90% of all cattle are in tick worry areas, 90% of the herd is at risk from Anaplasma and Babesia infection and 38% of cattle are in Heartwater areas (Potgieter 1996).
(b): The incidence of tick worry, Heartwater, Anaplasmosis and Babesiosis are author assumptions
(c): Tick worry is not assumed to cause death in affected cattle. Anaplasmosis and Babesiosis case fatality estimates are author estimates. Background information on these diseases may be derived from Ramsay (1997) *B. bovis* case fatality estimates. Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases (Mahoney and Ross 1972). Anaplasmosis and Babesiosis case fatality in indigenous stock is assumed to be half that of exotic stock. Heartwater case fatality assumptions are the authors. Background information on this disease is outlined in du Plessis *et al* (1994) and Meltzer *et al* (1996).
(d): Mortality is outlined for cattle in disease-risk areas.

The losses in milk and meat production as a result of ticks and tick-borne disease infection are outlined in Table 3 for commercial and small-holder cattle types. Production loss estimates are derived from scientific studies, surveys and expert opinion. Data sources are provided in the table footnotes.

Table 3: Annual production losses in disease-affected cattle

	Tick Worry		***Anaplasma and Babesia***		**Heartwater**	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale mixed (meat-milk)						
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0	0	0
Milk loss (kg/hd/yr) [(b)]	4	0	0	0	0	0
Large-scale beef)						
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0	0	0
Large-scale dairy						
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0	0	0
Milk loss (kg/hd/yr) [(b)]	201	0	0	0	0	0

(a): Liveweight losses for tick worry in indigenous cattle are author estimates. Background information on the impact of these diseases can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval et al 1997a, b, c). Tick worry liveweight losses in exotic cattle types are derived from Little (1963,), Sing *et al* (1983), Seebeck *et al* (1971) and Sutherst *et al* (1983). Anaplasmosis, Babesiosis and Heartwater live weight losses are assumed to be negligible and are not included in the costing framework.

(b): Milk losses as a result of tick worry are author estimates. Background information on the impact of tick worry on dairy cattle can be derived from Jonsson *et al* (1998) for exotic cattle and (Norval et al 1997a, b, c) for indigenous cattle.

The aggregate physical losses attributable to each of the tick-borne diseases are outlined for the various livestock systems of the South African cattle industry. Liveweight loss is the only morbidity production loss cost associated with the beef sector.

Table 4: Annual physical tick and tick-borne disease production losses in South Africa

Disease	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Heartwater*
Small-scale mixed (meat-milk)			
Adult mortality (head) [(a)]	0	3,726	1,888
Immature mortality (head) [(a)]	0	2,484	4,363
Liveweight (tonnes) [(b)]	125	0	0
Milk loss (tonnes)	902	0	0
Large scale beef			
Adult mortality (head)	0	19,375	9,817
Immature mortality (head)	0	12,917	21,815
Liveweight (tonnes)	4,481	0	0
Large scale dairy			
Adult mortality (head)	0	2,981	1,510
Immature mortality (head)	0	1,987	3,356
Liveweight (tonnes)	689	0	0
Milk (tonnes)	14,941	0	0

(a): Mortality losses are calculated using percentage mortality, herd affected and year-end cattle statistics.
(b): Liveweight losses are only realised for cattle that are slaughtered.

Economic costs of ticks and associated diseases are detailed in the table below. Physical control input and production loss estimates were combined with product prices to calculate economic costs. Of the production losses, mortality is estimated to be the most significant.

Table 5: Annual costs associated with ticks and associated diseases ($US m) [(a)]

Livestock System	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Heartwater*
Control			
Acaricides	5.5	6.7	5.5
Vaccine	0	0.5	0.2
Production Losses			
Mortality	0	14.8	12.3
Milk production	7.9	0	0
Liveweight	4.2	0	0
Combined	**17.6**	**22.0**	**18.0**

(a): It is assumed that commercial adult and immature cattle have values of $US 450 and 250 per head, indigenous adult and immature cattle values of $200 and $120 per head, milk $0.5 per litre and meat $0.80 kg liveweight at farm-gate. Acaricide and vaccine usage derived from OVI data.

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Zimbabwe

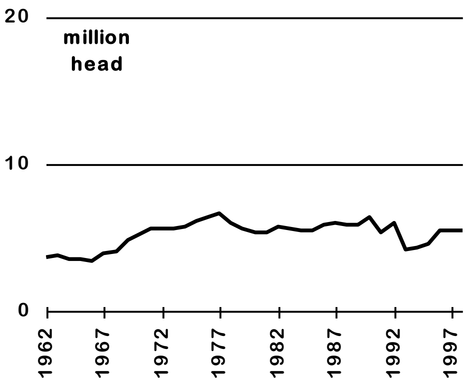


Figure 1: Size of national cattle herd

Since 1970, a number of factors have shaped the cattle industry which include a reduction in cattle numbers during the war years; the recent severe drought (1992 and 1995) and an increasing proportion of communal cattle. The communal proportion of the national herd increased over the last ten years. In the medium term, it is anticipated that stock numbers will build up in the commercial sector as producers aim to reinstate herd sizes and increase sales into the lucrative EU market, where livestock products fetch premium prices. The future of this market largely depends on the prevalence and control of Foot and Mouth disease and whether preferential marketing arrangements associated with the LOME convention are extended.

The majority of cattle raised in the communal sector is used for draught power, milk production, social functions (e.g. funerals and weddings) and beef consumption. Milk is consumed by the family or sold to neighbours, while excess older animals are sold to local village butcheries and marketed domestically.

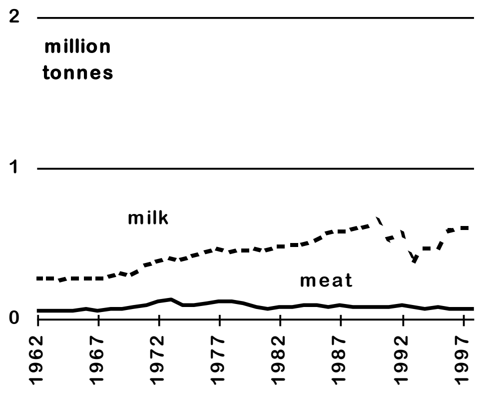


Figure 2: National production

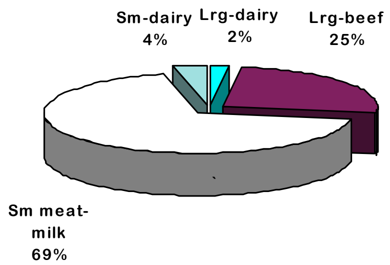
Commercial beef production occurs throughout Zimbabwe. European, Brahman and exotic crossbred cattle are commonly grazed in this sector and production losses associated with tick-borne diseases are thought to be greatest for this segment. Perry *et al* (1990) reported that the use of exotic cross-breed cattle and a habitat on commercial farms conducive to the development of important tick species results in the high incidence of tick-related diseases in this sector.

The dairy segment was made up of approximately 105,365 cattle in 1995 and is concentrated in the high rainfall areas of Zimbabwe where agro-climatic conditions support this highly intensive activity. A range of exotic cross-bred cattle are used to produce milk.

Table 1: Cattle numbers, productivity and production of milk and meat in Zimbabwe

Livestock system	Small-scale (meat-milk)	Small-scale commercial	Large beef	Large dairy	Total
Cattle at year end (m head) [(a)]	3.8	0.2	1.4	0.1	5.5
Adult cattle at year end (m head) [(b)]	2.3	0.12	0.8	0.06	3.3
Immatures at year end (m head) [(c)]	1.5	0.08	0.6	0.04	2.2
Liveweight of adult cattle (kg) [(d)]	250	450	450	450	-
Liveweight of immature cattle (kg) [(d)]	150	250	250	250	-
Milk production (kg cow year) [(e)]	194	1,844	0	4,010	-

(a): Herd structure is derived from Republic of Zimbabwe (1997) and FAO 1998 herd numbers.
(b): It is assumed that adult cattle comprise 60% of cattle in each production system. Analysts may wish to use country-specific herd statistics.
(c): The number of immature cattle is derived by subtracting the number of adult cattle from total herd size estimates.
(d): Liveweights for adult and immature cattle are author estimates. Background information on cattle production in this region can be derived from Commercial Farmers Union (1991, 1994) and Berahino, (1993), Mwenya, (1993) for indigenous cattle. Meat production losses outlined in Table 4 assume that 4% of indigenous and 25% of commercial cattle are turned-off per annum.
(e): Milk production estimates are author assumptions. Background information about cattle productivity can be derived from Commercial Farmers Union (1994). Small-scale commercial and meat-milk production estimates are the authors. The estimation of milk production losses in Table 4 assumes that 50% of meat-milk adult cattle and 67% of commercial adult cattle are breeding cows.



The majority of communal farmers have small herds of four to sixteen head of cattle and rely on government managed dipping to control ticks, although an annual dipping levy of $Z 3 per head was introduced in 1995. Because of the long history of intensive dipping and the overgrazing of some areas, some tick-borne diseases are no longer a major problem for parts of this sector (Perry *et al* 1990).

The incidence of tick-borne diseases is reported by government veterinary officers on an annual basis. In 1995, the provinces of Manicaland, Mashonaland East, Mashonaland West and Mashonaland Central experienced the greatest number of anaplasmosis and babesiosis outbreaks (P. Gamble 1995, in Lubulwa and Hargreaves 1996). A number of small-scale farmers raise cattle for commercial beef and dairy purposes. This sector is commonly referred to as the small-scale commercial sector. Many of the cattle in this segment are exotics or cross-breeds highly susceptible to tick-borne diseases.

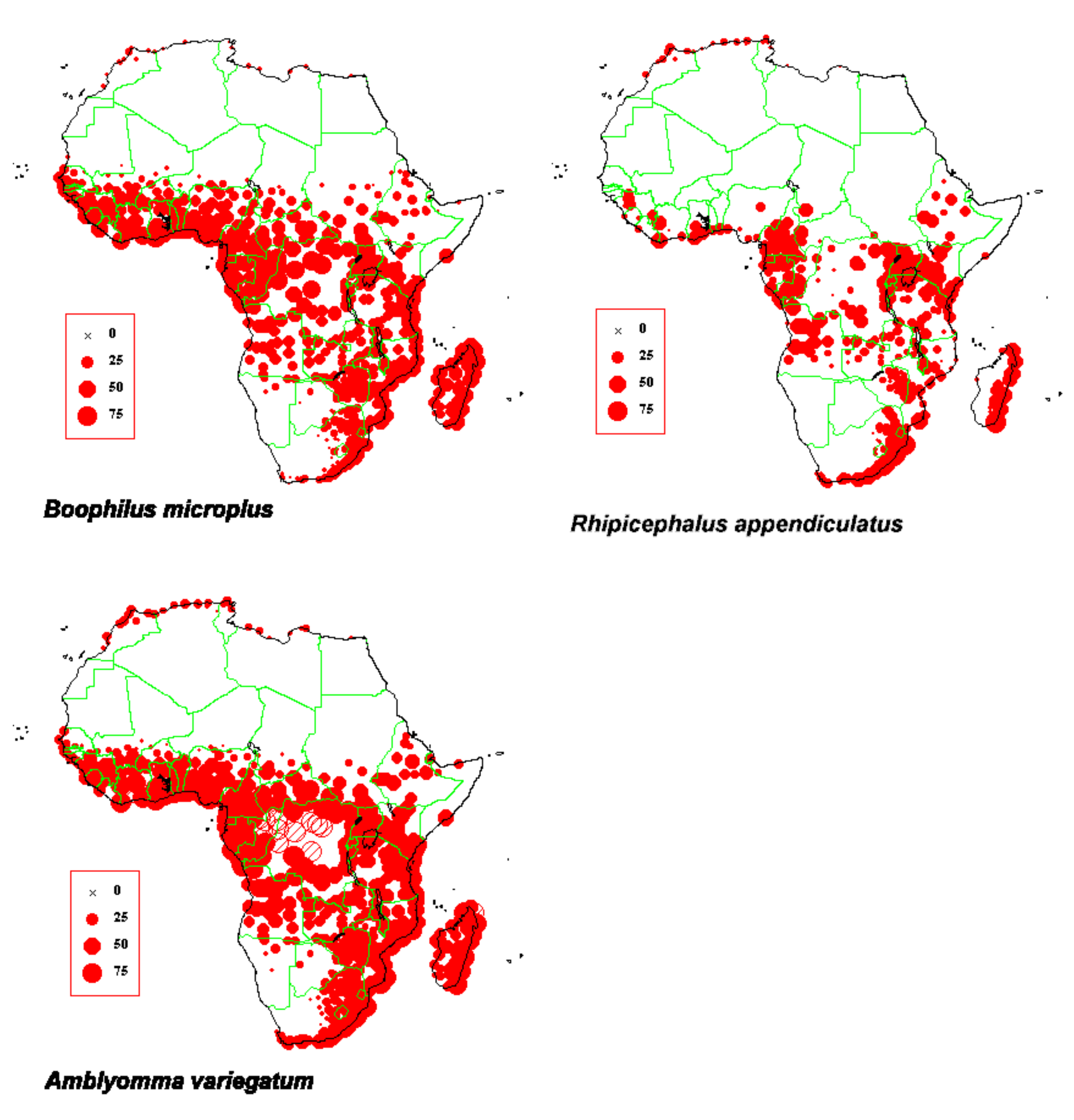
Ticks and associated diseases

herd

The diseases Anaplasmosis, Babesiosis, Heartwater and Theileriosis constrain livestock production in Zimbabwe, along with the impact of tick worry or feeding ticks. Anaplasma and Babesia are primarily transmitted by *Boophilus spp.* Heartwater by *Amblyomma spp* and Theileriosis by *Rhipicephalus spp.* ticks The climatic suitability of Zimbabwe for the development of these tick species is demonstrated in Figure 4. These simulation results provide an indication as to where vector tick species may be found, however, the actual presence of particular tick species need to be confirmed by surveys.

Tick worry is assumed to affect the majority of indigenous and exotic cattle raised in Zimbabwe. For the purposes of this impact assessment, it is assumed that 15% of commercial cattle and traditional Sanga type cattle are subject to tick worry in a typical season. Commercial and communal cattle are treated with acaricides (Perry et al 1990, Commercial Farmers Union 1991, 1994) as part of routine animal husbandry practice and ticks are unlikely to build-up on cattle within these livestock systems. A number of studies have been conducted to determine the impact of feeding ticks on cattle. The reduction in production as a result of tick worry is outlined in Table 3.

Figure 4: Climatic suitability of Africa for selected tick species [(a)]



(a): Source - Maywald and Sutherst (1985)

Anaplasmosis and *Babesiosis* cause mortality and also reduce cattle productivity. A survey of commercial cattle producers in South Africa, conducted by du Plessis *et al* (1994), found that approximately 0.5% of cattle within Anaplasma and Babesia endemic areas of this country suffered mortality as a result of infection by these diseases. A similar mortality rate is assumed for commercial cattle in the Anaplasma and Babesia-endemic areas of Zimbabwe. Mortality is assumed to be greater in adult cattle as younger cattle have higher innate resistance to these diseases (Mahoney and Ross 1972). *Boophilus spp*. ticks that vector these diseases are found throughout Zimbabwe (Perry *et al* 1990). Following the widespread distribution of relevant vector ticks, it is assumed that 90% of Zimbabwean cattle are at risk from these diseases. *Anaplasmosis* and *Babesiosis* mortality is assumed to be lower in indigenous cattle types, when compared to commercial cattle. Following discussions with experts, *Anaplasmosis* and *Babesiosis* case fatality estimates are assumed to be similar for commercial and indigenous cattle types. Disease incidence and case fatality assumptions used in the costing are provided in Table 2.

Table 2: Incidence of tick-borne diseases in Zimbabwe

	Tick Worry (Feeding ticks)		***Anaplasma and Babesia***		***Theileriosis***		**Heartwater**	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale (milk-meat)								
Herd in endemic areas (%) [(a)]	90	90	90	90	17	17	52	52
Disease incidence (%) [(b)]	15	15	2.5	5	5	10	1	4
Case fatality (%) [(c)]	0	0	10	5	15	20	15	13
Mortality (%) [(d)]	0	0	0.3	0.3	0.75	2.0	0.2	0.5
Commercial dairy								
Herd in endemic areas (%) [(a)]	90	90	90	90	67	67	25	25
Disease incidence (%) [(b)]	15	15	5	10	5	10	2	8
Case fatality (%) [(c)]	0	0	10	5	15	20	30	25
Mortality (%) [(d)]	0	0	0.5	0.5	0.75	2.0	0.6	2.0
Commercial beef								
Herd in endemic areas (%) [(a)]	90	90	90	90	67	67	25	25
Disease incidence (%) [(b)]	15	15	5	10	5	10	2	8
Case fatality (%) [(c)]	0	0	10	5	15	20	30	25
Mortality (%) [(d)]	0	0	0.5	0.5	0.75	2.0	0.6	2.0
Small-scale commercial								
Herd in endemic areas (%) [(a)]	90	90	90	90	17	17	25	25
Disease incidence (%) [(b)]	15	15	5	10	5	10	2	8
Case fatality (%) [(c)]	0	0	10	5	15	20	30	25
Mortality (%) [(d)]	0	0	0.5	0.5	0.75	2.0	0.6	2.0

(a): It is assumed that 90% of all cattle are in tick worry areas, 90% of the herd is at risk from Anaplasma and Babesia infection, 17% of small-holder indigenous cattle and 67% of commercial farms are in Theileriosis risk areas (Lessard 1995). It is further assumed that 25% of commercial cattle are in heartwater endemic areas (derived from Mukhebi *et al* 1997) and 52% of communal cattle reside in heartwater endemic areas (derived from Mukhebi *et al* 1997).
(b): Theileriosis incidence is derived from Republic of Zimbabwe (1995b). Heartwater, Anaplasmosis and Babesiosis incidence assumptions are the authors.
(c): Tick worry is not assumed to cause death in affected cattle. Anaplasmosis and Babesiosis case fatality estimates are author assumptions. Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases (Mahoney and Ross 1972). Theileriosis case fatality estimates are derived from Republic of Zimbabwe (1995b). Heartwater case fatality estimates are the authors.
(d): Mortality is outlined for cattle in disease risk areas.

Heartwater (*Cowdria ruminatium*) is primarily found in the lowveld region of Zimbabwe, although the disease is spreading into the highveld. A range of studies have been undertaken to estimate the economic cost of heartwater in Zimbabwe. Meltzer *et al* (1996) found that 2.3% of commercial calves and 0.6% of commercial cattle over 13 months suffered heartwater mortality in the lowveld. Chamboko *et al* (1997a) found that 0.9% of the commercial herd in Matabeleland province of Zimbabwe was suspected to suffer mortality as a result of heartwater. In the heartwater endemic areas of South Africa, du Plesiss *et al* (1994) found an annual heartwater mortality of 1.3%. The disease can cause reduced milk and meat production. These production losses are not substantial in animals that recover from the disease.

The economic impact of Theileriosis has been estimated for Eastern and Southern Africa by Mukhebi *et al* (1992). In this study, the disease was assumed to cause mortality, along with morbidity losses associated with reduced meat and milk production. Theileriosis incidences and case fatalities for adult and immature cattle in each livestock system are described in Table 2 using data from a survey undertaken by the Department of Veterinary Services (Republic of Zimbabwe 1995b).

Table 3: Production losses in disease-affected cattle

	Tick Worry		***Anaplasma and Babesia***		***Theileriosis***		**Heartwater**	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale (meat-milk)								
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0	13	15	0	0
Milk loss (kg/hd/yr) [(b)]	4	0	4	0	49	0	0	0
Commercial beef								
Liveweight loss (kg/hd/yr) [(a)]	23	10	0	0	23	20	0	0
Commercial dairy								
Liveweight loss (kg/hd/yr) [(a)]	23	10	0	0	23	20	0	0
Milk loss (kg/hd/yr) [(b)]	201	0	0	0	1,002	0	0	0
Small-scale commercial								
Liveweight loss (kg/hd/yr) [(a)]	23	10	0	0	23	20	0	0
Milk loss (kg/hd/yr) [(b)]	92	0	0	0	461	0	0	0

(a): Liveweight losses for tick worry in indigenous cattle (2% loss) are author estimates. Background information on tick worry is provided in studies where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval *et al* 1997a, b, c). Tick worry liveweight losses in exotic cattle types (5% loss in affected cattle) are author estimates. Background information on tick worry in commercial cattle is provided in studies described by Little (1963), Sing *et al* (1983), Seebeck *et al* (1971) and Sutherst *et al* (1983) Anaplasmosis, Babesiosis and Heartwater live weight losses are assumed to be negligible and are not included in the costing framework. Theileriosis live weight losses are derived from Mukhebi *et al* (1992) estimates of production losses in African indigenous and exotic cattle.
(b): Milk losses as a result of tick worry in commercial cattle (5% loss) are author estimates. Background information on tick worry is outlined in studies by Jonsson *et al* (1998) and (Norval *et al* 1997a, b, c) for indigenous cattle (2% loss).

The aggregate physical losses attributable to each of the tick diseases are outlined for each livestock system in the Zimbabwe cattle industry. Production losses are greatest for the indigenous backyard cattle production system as there are more cattle in this system. Theileriosis and heartwater cause the greatest number of cattle deaths, despite being endemic to selected parts of the country. These diseases are the most pathogenic and are assumed to result in the high number of fatalities.

Table 4: Annual physical tick and tick-borne disease production losses in Zimbabwe

Disease	**Tick Worry (feeding ticks)**	***Anaplasma and Babesia***	***Theileriosis***	***Heartwater***
Small-scale mixed (meat-milk)				
Adult mortality (head) [(a)]	0	5,123	2,903	1,776
Immature mortality (head) [(a)]	0	3,416	5,161	4,105
Reduced liveweight (tonnes) [(b)]	86	0	25	0
Reduced milk production (tonnes)	620	0	488	0

Table 4 (cont): Annual physical tick and tick-borne disease production losses in Zimbabwe

Disease	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileriosis*	*Heartwater*
Small-scale commercial dairy				
Adult mortality (head) [(a)]	0	594	168	198
Immature mortality (head) [(a)]	0	396	299	440
Reduced liveweight (tonnes) [(b)]	137	0	16	0
Reduced milk production (tonnes)	1,369	0	431	0
Large-scale commercial beef				
Adult mortality (head)	0	3,713	4,146	1,238
Immature mortality (head)	0	2,475	7,370	2,750
Reduced liveweight (tonnes) [(b)]	859	0	328	0
Large-scale commercial dairy				
Adult mortality (head)	0	297	332	99
Immature mortality (head)	0	198	590	220
Reduced liveweight (tonnes)	69	0	31	0
Reduced milk production (tonnes)	1,489	0	1,847	0

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.
(b): Liveweight losses are only realised for cattle that are slaughtered.
(c): Manure losses are estimated for all cattle carried across the year.

Physical control input and production loss estimates are combined with product prices to calculate economic costs. Heartwater vaccine is imported from South Africa, but because the amount purchased is very small, the cost of these vaccine is not included in the assessment. Similarly, only small volumes of Anaplasma, Babesia and Theileria vaccines are sold by veterinary services, and consequently these costs are not included. Acaricides are commonly used in Zimbabwe to manage ticks and tick-borne diseases.

Table 5: Annual costs of ticks and selected tick-borne diseases ($US m) [(a)]

Livestock System	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileriosis*	*Heartwater*
Control				
Acaricides ($m)	1.2	1.9	3.2	1.1
Vaccine ($m)	0	0	0	0
Production Losses				
Mortality ($m)	0	4.3	5.4	2.4
Milk production ($m)	1.7	0	1.4	0
Liveweight ($m)	1.0	0	0.4	0
Combined costs ($m)	**3.9**	**6.2**	**10.4**	**3.5**

(a): It is assumed that commercial adult and immature cattle have values of $US 450 and 250 per head, indigenous adult and immature cattle values of $200 and $120 per head, milk $0.5 per litre and meat $0.90 kg liveweight at farm-gate.

In 1996, the Zimbabwe government purchased $US 1.8 million ($Z 27.2 million) worth of acaricides for use in communal areas (Chamboko *et al* 1996b). Commercial cattle producers privately control ticks. In the lowveld, Chamboko *et al* (1996a) found average annual acaricide usage varied from $Z 54 per head on farms where wildlife was present to $Z19 per head where no wildlife resided. Lawrence (1997) estimated the annual acaricide use on large-scale farms to be in the order of $Z 60 per head each year.

In this analysis, it is assumed that cattle cost $Z 40 per head each year to treat with acaricides. Given that there were approximately 2.1 million commercial cattle carried in Zimbabwe during 1998 (1.7 million cattle, 25% cattle turn-off), it is estimated that

$Z 84 million was spent by commercial farmers on acaricides in this year. This estimate is presented in US dollar terms in Table 5 in conjunction with communal acaricide use costs. Acaricide costs are allocated to each disease in proportion to the value of estimated production losses.

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Australia

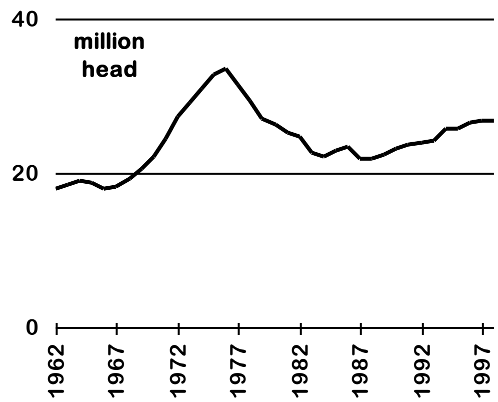

Figure 1: Size of national cattle herd

The size of the Australian cattle herd fluctuates with movements in livestock prices and seasonal conditions. In the adjoining figure it is evident that there has been a gradual upward trend in the size of the herd over the 1961 to 1996 period (Figure 1). In these years the herd has increased 51%. During the mid-seventies there was a boom in the cattle industry and the national herd reached a peak of 33 million head. Following a fall in prices the herd size shrunk during until the mid-1980's when it began growing steadily again.

Beef cattle are grown in all states of Australia. Queensland, New South Wales and Victoria have the highest beef cattle populations and in some instances cattle are raised in association with cropping enterprises. European breeds such as Hereford, Angus and Shorthorns are commonly found throughout the temperate areas of the cattle industry. Cattle tick (*Boophilus microplus*) is found in Queensland, the Northern Territory and northern Western Australia. Since the mid 1970's, Brahman cattle have been imported to reduce the impact of ticks on cattle productivity. Homan *et al* (1993) estimated that there are approximately 10,000 properties within the tick endemic areas of Queensland or approximately 7 million cattle. Given that there were 24m cattle in the country at the time of the Homan *et al* (1994) report, approximately 30% were subject to tick infestation and associated diseases.

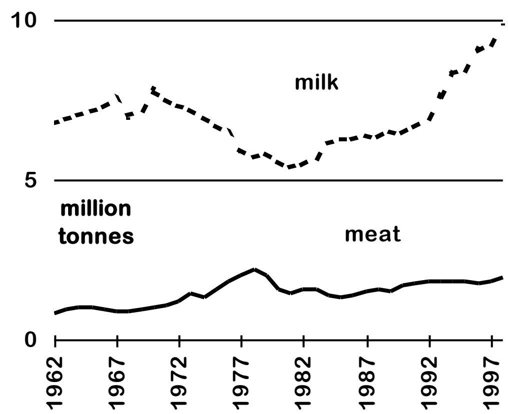

Figure 2: National production

The production of meat and milk over the 1961 to 1996 period is provided in Figure 2. It is evident that the production of meat follows the trend in cattle numbers over this period. Of the total cattle herd in 1997, there were approximately 2.0 million cows dedicated to dairy production (ABARE 1997). These cattle are raised close to urban centres where fresh milk can be more readily sent to market. Milk production has increased by 48% over the 1961 to 1996 period. Homan *et al* (1993) estimated that approximately 180,000 dairy cattle in Queensland were at risk from tick infestation. Given that there were 2.53m dairy cows and calves in Australia at the end of 1993 (ABARE 1997), approximately 7% of Australian dairy cattle reside in tick affected areas.

The number of cattle marketed during 1998 was estimated to be 9.3 million (ABARE 1998). Herd demographics are provided in the following table.

Table 1: Cattle productivity and production of milk and meat in Australia

Livestock system	Large-scale dairy	Large-scale beef	Total
Cattle at year end (million head) [(a)]	2.7	24.0	26.7
Adult cattle at year end (million head) [(b)]	1.7	14.4	16.1
Immature at year end (million head) [(c)]	1.0	9.6	10.6
Liveweight of adult cattle (kg) [(d)]	450	450	-
Liveweight of immature cattle (kg) [(d)]	250	250	-
Milk production (kg/cow/year) [(e)]	4,882	-	-

(a): It is assumed that 90% of the national herd is comprised of beef cattle. (Derived from ABARE 1997)
(b): Adult cattle are assumed to comprise 60% of the national herd.
(c): The number of immature cattle is derived by subtracted adult cattle from total cattle.
(d): Liveweight assumptions are the authors. Background information on cattle liveweight cane be found in MRC (1993). It is assumed that 25% cattle are turned-off per year.
(e): An average annual milk production of 4,882 kg for commercial dairy cows is derived from ABARE (1998). It is assumed that breeding cows comprise 67% of the adult herd.

The outlook for beef and milk production is, in part, governed by the economic climate in Asia. Prices in markets such as the live SE Asian cattle trade have declined and export volumes sharply decreased (ABARE 1998). With financial turmoil in the region, the national herd could reduce in size over the immediate term.

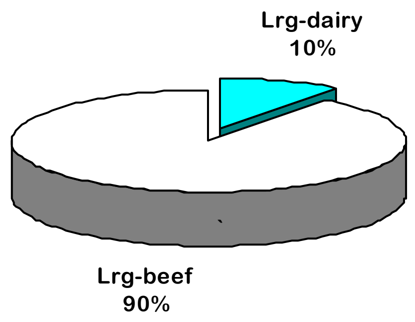

Figure 3: Composition of national herd

Figure 3 demonstrates the proportion of dairy and beef cattle in the Australian herd. The production of cattle on a large-scale basis in Asia is assumed to occur exclusively in Australia. There are large-scale enterprises in China and selected other Asian countries, however, these systems are estimated to only represent a minor part of production in these countries.

Ticks and associated diseases

The tick *Boophilus microplus* is the species of major importance in Australia and transmits the diseases *Anaplasmosis* and *Babesiosis*. The potential distribution of this tick species in Australia is outlined in Figure 4. The actual presence of the species and associated diseases needs to be confirmed through scientific studies. *Theileria annulata* is not found in Australia and the incidence of this disease is estimated to be non-significant.

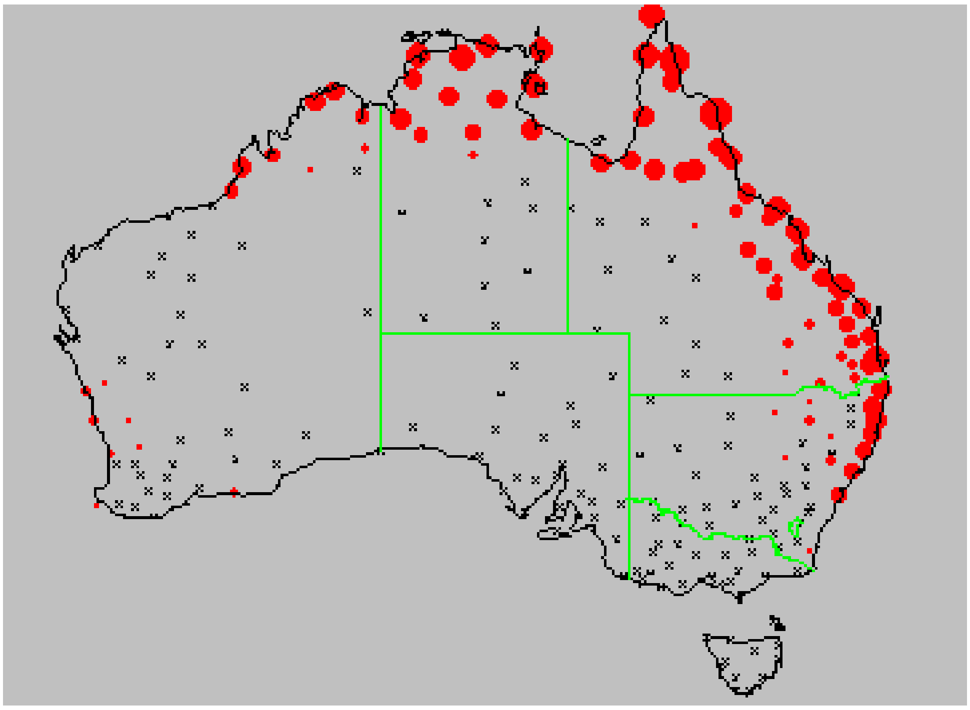

Figure 4: Potential distribution of *B.microplus* in Australia. Source: Maywald and Sutherst (1985).

In 1998, seven million beef cattle were assumed to reside in the tick-affected areas of Australia. Beef producers are the major buyers of the live *Anaplasma* and *Babesia* vaccine produced and distributed by the Tick Fever Research Centre in Brisbane. Of the 0.8m doses sold in 1997, 0.8 million doses were assumed to be purchased by beef producers. The vaccine is generally administered to younger stock classes to maximise the protective life of the vaccine and minimise the chances of any severe vaccine reactions.

Table 2: Incidence of tick-borne diseases in Australia

	Tick Worry		***Anaplasma and Babesia***	
	Adult	Immature	Adult	Immature
Large-scale beef				
Herd in endemic areas (%) [(a)]	30	30	30	30
Disease incidence (%) [(b)]	15	15	5	10
Case fatality (%) [(c)]	0	0	10	5
Mortality (%)	0	0	0.5	0.5
Large-scale dairy				
Herd in endemic areas (%) [(a)]	7	7	7	7
Disease incidence (%) [(d)]	15	15	5	10
Case fatality (%)	0	0	10	5
Mortality (%)	0	0	0.5	0.5

(a): The author assumed that 30% of beef cattle and 7% of dairy cattle are in tick worry areas. These estimates are derived from Homan *et al* (1994). Similar percentages of dairy and beef cattle were assumed to be at-risk from Anaplasma and Babesia infection. (b): Anaplasmosis , tick worry and Babesiosis incidence are author estimates. (c): Tick worry is not assumed to cause death in affected cattle. Anaplasmosis and Babesiosis case fatalities estimates are author assumptions. Background information on these diseases can be derived from Ramsay (1997), *B. bovis* case fatality estimates. Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases (Mahoney and Ross 1972). (d): Mortality is outlined for cattle in disease risk areas.

Anaplasma and *Babesia* infection is assumed to cause an annual mortality of 0.5% of cattle within tick affected areas. A survey of commercial cattle producers in South Africa, conducted by du Plessis *et al* (1994), found that approximately 0.5% of cattle within tick endemic areas suffered mortality as a result of infection by these diseases. Incidence levels based on this survey are applied to beef cattle in Australian tick risk areas.

Tick worry incidence is assumed to be greater than that of anaplasmosis and babeiosis mortality, and is estimated to affect 15% of cattle in endemic areas. The incidence of tick worry is not likely to be more widespread than the above estimate, as most cattle producers have a low tolerance for ticks. Fifty-five percent of the cattle producers who responded to a survey outlined by Elder *et al* (1979) would only allow cattle to accumulate the 'odd tick' prior to dipping, and 14.75% of respondents would tolerate up to 50 adult female ticks prior to dipping.

An average weight loss of 23 kg in adult affected stock and 13 kg in immature stock was included (Table 3) and is derived from the liveweight loss studies outlined in the livestock systems description section. Tick worry was estimated to reduced milk production by 240 kg per annum in tick affected dairy cows.

Table 3: Production losses in tick-borne disease-affected cattle

	Tick Worry		***Anaplasma and Babesia***	
	Adult	Immature	Adult	Immature
Large-scale beef				
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0
Large-scale dairy				
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0
Milk loss (kg/hd/yr) [(b)]	244	0	0	0

(a): Tick worry liveweight losses in exotic cattle types are author estimates. Background information on tick worry losses in commercial cattle can be derived from Little (1963), Sing *et al* (1983), Seebeck *et al* (1971) and Sutherst *et al* (1983) Anaplasma and Babesia live weight losses are assumed to be negligible and are not included in the costing framework.

(b): Milk losses as a result of tick worry are author assumptions (5%). Background information on tick worry losses in commercial cattle can be derived from Jonsson et al (1998).) Anaplasma and Babesia milk losses are assumed to be negligible and are not included in the costing framework.

The aggregate physical losses attributable to each of the tick diseases are outlined for the entire Australian cattle industry by system in Table 4. Because the beef sector is larger than dairy, there are a great deal more deaths associated with *Anaplasma* and *Babesia* infection in this sector. Liveweight loss is the only production loss cost associated with the beef sector. Milk, manure and traction losses are not a feature of beef production in Australia.

Table 4: Physical tick production losses in Australia

Disease	**Tick Worry**	***Anaplasma and Babesia***
Large-scale beef)		
Adult mortality (head) [(a)]	0	21,627
Immature mortality (head) [(a)]	0	14,418
Liveweight (tonnes) [(b)]	5,001	-
Large-scale dairy		
Adult mortality (head) [(a)]	0	561
Immature mortality (head) [(a)]	0	374
Liveweight (tonnes) [(b)]	130	0
Milk loss (tonnes)	3,422	0

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.

(b): Liveweight losses are only realised for cattle that are slaughtered.

Economic costs of ticks and associated diseases are detailed in Table 5. Physical control input and production loss estimates were combined with product prices outlined in the footnotes to Table 5 in order to calculate economic costs. The cost of acaricide is allocated between diseases in proportion to production loss costs.

Table 5: Tick and associated disease losses in Australia

Disease	Tick Worry	*Anaplasma* and *Babesia*
Control ($m) [(a)]		
Acaricide	1.4	3.6
Vaccines	0	0.8
Production Losses ($m)		
Mortality [(b)]	0	11.5
Milk production [(b)]	1.0	0
Liveweight [(b)]	3.4	0
Combined cost and loss ($m)	**5.9**	**15.9**

(a): Acaricide use is assumed to be widespread in tick-risk areas.
(b): It is assumed that commercial adult cattle have a value of $350, immature cattle a value of $250 per head, milk $0.3 per litre and meat $0.67 kg liveweight at farm-gate. Mortality, milk and meat production losses are valued using animal health economics techniques described in Dijkhuizen and Morris (1997).

In 1995/96, AVCARE estimated that approximately $US 5 million dollars of these chemicals were purchased by Australian farmers. Labour costs are note estimated as these costs are likely to be sunk, and many cattle producers do not factor labour costs into their tick management decision making (Elder *et al* 1979). Vaccine sales were estimated to be 0.8m doses per year.

Of the production losses, mortality is estimated to be the most significant. In 1998 it is estimated that mortality associated with *Anaplasma* and *Babesia* resulted in the majority of losses for Australian cattle producers. It is difficult to define the incidence of tick fever in the field, particularly in the northern areas of Australia where disease surveillance is limited and few specimens are submitted for diagnosis (Bock *et al* 1995).

Reduced live weight is estimated to be the loss of second most importance and accounted for $US 3.4 million in 1998. This estimate is much less than previous cost estimates by authors such as McLeod (1995) and Sing *et al* (1993) and reflects a much lower estimate of liveweight loss in affected animals.

Disease comparison

Meat Research Corporation (MRC) (1993) published the results of a survey conducted by the Endemic Diseases Working Party of the Animal Health Committee which asked veterinarian to rank diseases in terms of prevalence and loss. A table of results is taken from MRC (1993) and included below for readers to gain an appreciation for the importance of various diseases.

Table 6: Ranking of beef cattle diseases by impact, MRC (1993, p 13). [(a)]

Disease	NSW	QLD-NT	SA	TAS	VIC	WA	AUS
Helminthiasis							69
Ticks-Tick fever							64
Leptospirosis							54
Poor reproduction							49
Ephemeral fever							46
Botulism							40
Plant poisoning							30
Bloat							25
Feedlot diseases							23
Metabolic diseases							20
Mineral deficiencies							19
Buffalo fly							18
Pestivirus							16
Vibriosis							16
Cancer eye - carcinoma							8
Akabane							8
Clostridial diseases							8
Calf scours							7
Footrot							6
Lice							5
Actinobacilliosis							3
Pink eye							2
Johne's disease							1
Photosensitisation							0.4
Brassica poisoning							0.2

(a): The rankings indicate the national impact of each disease on beef production

From Table 6 it is apparent that helminthiasis is considered to be the major disease constraint in Australian cattle. Ticks and associated disease were then considered to be the problem of second-most importance. Leptospirosis, poor reproductive performance and ephemeral fever were the next three disease constraints considered to affect cattle productivity across the entire country.

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China

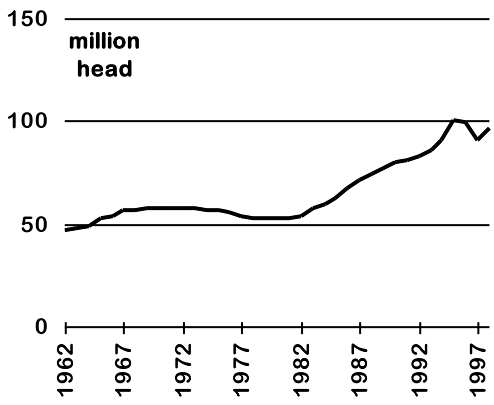

Figure 1: Size of national cattle herd

Cattle are raised in Chinese farmland and grazing areas. Within farmland areas, cattle are commonly raised in association with cropping enterprises and are used for draught or traction purposes. Extensive grazing areas exist in western areas of China and some of the cattle in this region are raised on a nomadic basis. Of the 29 provinces in China, approximately six contain areas where cattle are exclusively grazed (Tuan 1987). The existence of cattle in many of China's farm land areas has traditionally been driven by a requirement for draught power and only recently has beef become a significant by-product.

The Chinese cattle herd has experienced substantial growth since 1980. Over the last 17 years, the size of the herd has grown by 83%. Most cattle are found in farmland regions, but cattle are spread throughout the country. Beef production has increased following the rapid increase in national herd size. Since 1961 beef production has increased at a rate considerably higher than the annual percent increase in national herd size.

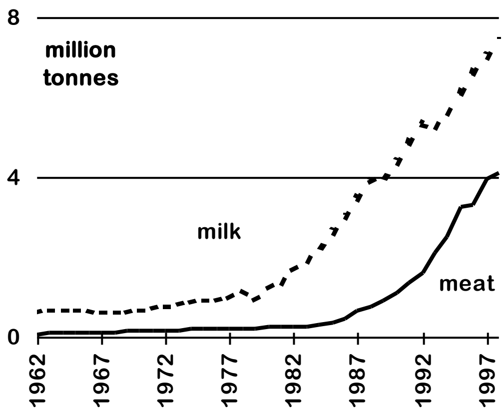

Figure 2: National production

The Chinese government has promoted dairy development. The increase in milk production, over the 1961-1996 period, is illustrated in the adjoining figure. In Heilongjiang province, Tuan (1987) reports that authorities provide 0.1 hectare of fodder land and some concentrates with each additional cow raised. ADB (1994) report that in provinces such as Hunan, private dairy herds commonly usually have around five cows with milk yields of approximately 3,000 kgs per lactation. Poor nutrition was cited as the major constraint on milk yield. In the past, most dairies have been state operated and many of the buildings were run by collectives near urban centres. Often these farms were run as dry lot operations and included exercise yards, milking sheds, silos and barns.

Table 1: Cattle productivity and production of milk and meat in China

Livestock system	Small-scale (Indigenous meat)	Small-scale (Commercial dairy)	Total
Cattle at year end (million head) [(a)]	94.2	1.9	96.1
Adult cattle at year end (million head) [(b)]	56.5	1.1	57.6
Immatures at year end (million head) [(c)]	37.7	0.8	38.5
Liveweight of adult cattle (kg) [(d)]	250	450	-
Liveweight of immature cattle (kg) [(d)]	150	250	-
Milk production (kg cow year) [(e)]	-	2,544	-

(a): Approximately 2% of the national herd is assumed to be dairy cattle. Based on herd structure outlined in Tuan (1987).
(b): Adult cattle are assumed to account for 60% of the herd
(c): Immature are assumed to account for 40% of the herd
(d): Catttle liveweights are author estimates. Background information on cattle liveweights in China can be derived from ADB (1994). To estimate liveweight production losses in Table 4, it is assumed that 4% of .indigenous cattle are turned-off per annum.
(e): An average annual milk production of 2,544 kg per cow is included (Asian commercial dairy herd average production). To estimate milk production losses it is assumed that breeding cows comprise 67% of the adult commercial herd.

The dominant cattle production system in China is small-scale production of cattle for beef and draught purposes. Breeds such as yellow cattle are found within this system. Approximately 66% of beef cattle are reared in farmland regions, whilst the remainder is found the grazing area. In provinces such as Xinjiang and Hubei, herds typically number one to two cows (ADB 1994).

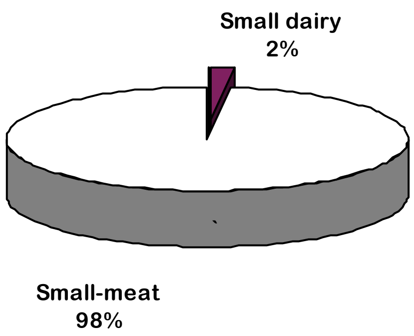

Figure 3: Composition of national herd

The composition of the Chinese cattle herd is outlined in the adjoining figure. Dairy cattle are assumed to constitute 2% of the national herd. Large numbers of dairy cattle are found in the provinces of Nei Monggol, Xinjiang and Heilongjiang. In 1979, these three regions accommodated 49% of all milking cows in China (Tuan 1987). Nei Monggol alone accounted for 25% of dairy cattle. Improved dairy cattle are thought to be more susceptible to ticks and associated diseases when compared to indigenous breeds.

Ticks and associated diseases

The tick-borne diseases *Anaplasma*, *Babesia*, *Theileria annulata* and tick worry are found in selected parts of China. Tick-borne disease distribution is largely determined by the climatic suitability of regions within China for vector tick species. Anaplasma is primarily vectored by the tick *Boophilus microplus*, Babesia by *Boophilus microplus*, *Ixodes ricinus* and *Rhipicepialus haemaphysoloides*, and Theileria annulata by *Hyalomma detritum* and *Hyalomma albopictum.*

Figure 4 illustrates the climatic suitability of China for the development of the tick species *Boophilus microplus*. Climatic suitability was mapped using a simulation model developed by Maywald and Sutherst (1985). The simulation model results provide an indication as to where this tick species may be present. It is evident that the southern regions of China are the most favourable habitats for this tick species. Given that the southern provinces appear to be most suitable for the presence of this tick species, it is assumed that 70% of the Chinese herd is within *Anaplasma* and *Babesia* endemic areas.

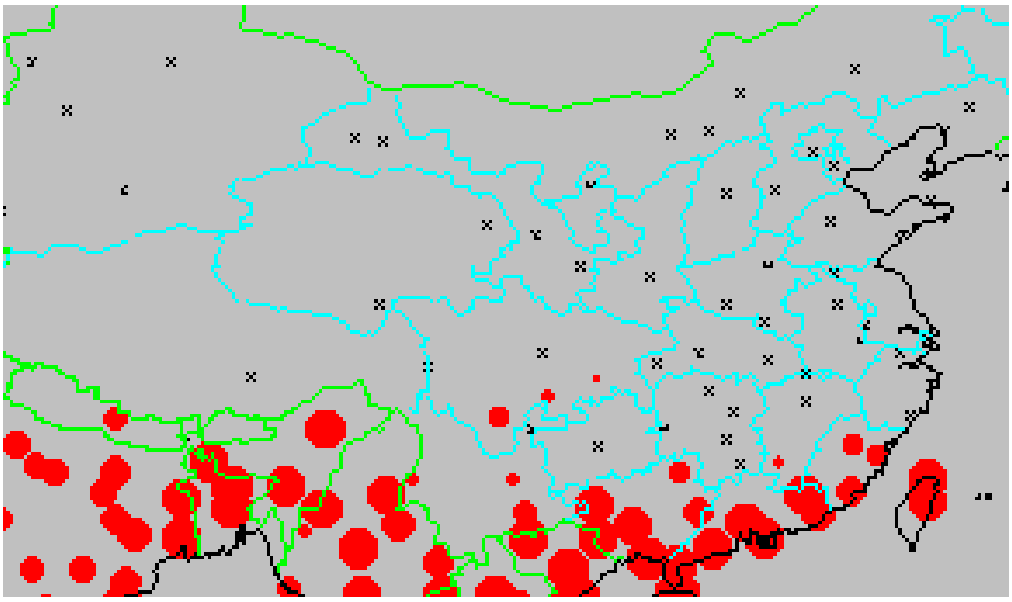

Figure 4: Potential distribution of *B.microplus* in China. (Source: Maywald and Sutherst 1985)

Of the 96 million cattle in China, approximately 70% are estimated to be in areas where tick worry is assumed to cause production losses. Tick worry was estimated to reduced milk production by 127 kg per annum in tick-affected dairy cows. These loss estimates are derived from the liveweight loss studies outlined in Table 3 footnotes.

Zhang (1991) reported that the *Hyalomma* species of ticks, which spread *Theileria annulata*, are found primarily in the northern provinces of the country. In the absence of specific incidence information it is assumed that 50% of cattle in China are raised in *Theileria annulata* endemic areas. Indigenous cattle are estimated to be less susceptible to the disease. The incidence of ticks and tick-borne diseases for dairy and indigenous-beef cattle are provided in Table 2.

Table 2: Annual incidence of ticks and associated diseases in China

Disease	Tick Worry (feeding ticks)		*Anaplasma and Babesia*		*Theileria annulata*	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale meat (Indigenous)						
Herd in endemic areas (%) [(a)]	70	70	70	70	50	50
Disease incidence (%) [(b)]	15	15	2.5	5	5	5
Case fatality (%) [(c)]	0	0	5	2.5	5	5
Mortality (%)	0	0	0.1	0.1	0.3	0.3
Small-scale commercial dairy						
Herd in endemic areas (%) [(a)]	70	70	70	70	50	50
Disease incidence (%) [(d)]	15	15	5	10	10	10
Case fatality (%)	0	0	10	5	10	10
Mortality (%)	0	0	0.5	0.5	1.0	1.0

(a): Assumed from distribution maps
(b): Assumed disease incidence in indigenous stock is half that of exotic cattle due to higher natural resistance

(c): Case fatality in indigenous stock is assumed to be half that of exotic stock
(d): Anaplasma and babesia incidence is an author estimate. Background information on these diseases can be derived from disease incidence reported in South African and Australian exotic cattle grazing in disease endemic areas (du Plessis *et al* 1994, Mahoney and Ross 1972, Ramsay 1997). Theileria annulata incidence is derived from reported incidence in exotic dairy cattle in Gujarat, India (Singh 1992). In this study it was noted that there were 3,800 acute cases of tropical theileriosis from a herd of 40,000 exotic dairy cattle in the Kaira district, Gujarat.

Table 3 outlines the average production loss per head for cattle that have been infected with tick-borne disease or have suffered the impact of feeding ticks (tick-worry). It is assumed that indigenous Chinese cattle have higher natural resistance to ticks and tick-borne diseases when compared to exotic cattle such as Holstein-Friesians.

Table 3: Production losses in disease-affected cattle

Disease	**Tick Worry (feeding ticks)**		***Anaplasma and babesia***		***Theileria annulata***	
	Immature	Adult	Immature	Adult	Immature	Adult
Small-scale meat [a]						
Liveweight loss (kg/hd/yr)	3	5	0	0	25	23
Small-scale commercial dairy						
Liveweight loss (kg/hd/yr) [b]	0	0	0	0	0	0
Milk losses (kg/hd/yr) [c]	0	127	0	0	0	356

(a): Liveweight losses for tick worry in indigenous cattle (2%) is an author estimate. Background information can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval et al 1997a, b, c). No studies outlining Anaplasma and babesia live weight losses have been found to date. Theileria annulata live weight losses (10% immatures and 5% adults) were derived from Mukhebi *et al* (1992) estimates of Theileria parva losses in African indigenous cattle.
(b): Tick worry liveweight losses in exotic cattle types are not included as dairy cattle are primarily raised for milking purposes. Anaplasma and babesia live weight losses are not included in the analysis
(c): Milk losses as a result of tick worry is estimated to be 5% in dairy cattle is an author estimate.

The physical losses attributable to each of the diseases are outlined in Table 4. Physical losses are greatest for the indigenous cattle sector despite the higher susceptibility of exotic cattle to tick-borne diseases. The higher physical losses are a result of the much larger size of the indigenous cattle sector, where it is estimated that 92 million cattle are raised, compared to 4 million improved dairy cattle.

Table 4: Annual physical tick and tick-borne disease production losses in China

Disease	**Tick Worry (feeding ticks)**	***Anaplasma and Babesia***	***Theileria annulata***
Small-scale meat			
Adult mortality (head) [a]	0	49,443	70,634
Immature mortality (head) [a]	0	32,962	47,089
Liveweight losses (tonnes) [b]	1,661	0	989
Small-scale commercial dairy			
Adult mortality (head)	0	4,036	5,766
Immature mortality (head)	0	2,691	3,844
Liveweight losses (tonnes)	0	0	0
Milk losses (tonnes) [c]	10,268	0	13,691

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics
(b): Liveweight losses are only realised for cattle that are slaughtered.
(c): Milk losses are calculated for lactating cows in the small-scale commercial dairy herd.

The economic losses associated with each of the diseases are outlined in Table 5 for all cattle in China. A tropical theileriosis vaccine has been developed in China and approximately 1.8 million doses had been sold by 1990 (Zhang 1991). Current production levels are not readily obtainable and the cost of vaccine usage is not included in the economic assessment.

Table 5: Annual costs associated with ticks and associated ideas ($US million) [(a)]

Livestock System	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria annulata*
Control			
Acaricide	0	0	0
Production Losses			
Mortality	0	19.4	27.2
Milk production	5.1	0	6.8
Liveweight	1.2	0	0.7
Combined Costs	**6.3**	**19.4**	**35.2**

(a): It is assumed that commercial adult and immature cattle have values of $US 350 and $250 per head, indigenous adult and immature cattle values of $250 and $150 per head, meat $0.7 per kg live and milk $0.5 per litre.

Of the production losses, the cost of animal mortality represents the most significant cost. The production losses associated with *Theileria annulata* infection ($35 million/year) are estimated to be the most substantial of the diseases assessed in this study.

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India

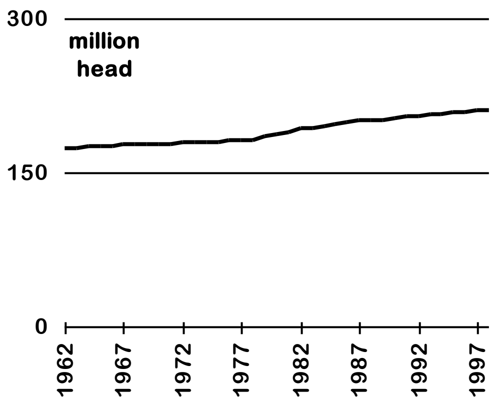

Figure 1: Size of national cattle herd

India accounted for 15% of the total world cattle population in 1993 (World Bank 1996). The number of cattle in India (around 200 million) has increased over the last 15 years despite more widespread use of farm machinery, a shift toward buffalo and greater utilisation of small ruminants in degraded areas. As the cattle population has expanded, the output of livestock products has also increased. Cattle milk production has increased over the 1960 to 1997 period. Increases in milk production have outpaced the increase in cattle numbers, largely due to a reduction in oxen composition of the herd, and the adoption of higher producing dairy animals.

Cattle are raised across India, but the largest numbers of cattle are found in the higher rainfall areas throughout the Ganges plain, west coast and eastern region. World Bank (1996) noted that these areas are characterised by high population densities and widespread production of rain-fed rice.

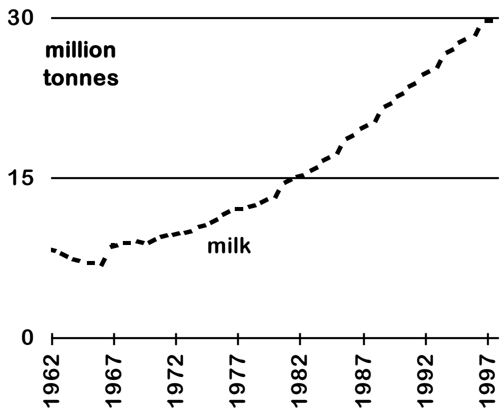

Figure 2: National production

There have been a number of livestock development programs undertaken to increase the productivity of cattle. Currently much of the breeding effort is coordinated by the National Dairy Development Board. The Indian Veterinary Research Institute also conducts a substantial breed improvement program. Large numbers of European and cross-bred cattle have been introduced to increase the supply of milk. Singh (1992) estimated that there are approximately 10 million improved cattle in the Indian herd. These cattle are referred to as the small-scale commercial herd in this study. Swiss Development Cooperation (1995) estimated that approximately four million of these cattle were breeding females. Given that the total herd was estimated to be 197 million in 1997 (FAO 1998), improved cattle represented 5% of the herd.

Table 1: Cattle numbers and productivity in India

Livestock system	Small-scale (Indigenous milk)	Small-scale (Commercial dairy)	Total
Cattle at year end (million head) [(a)]	198.6	10.5	209.1
Adult cattle at year end (million head) [(b)]	119.2	6.3	125.5
Immatures at year end (million head) [(c)]	79.4	4.2	83.6
Milk production (kg/cow/year) [(d)]	579	2,544	-

(a): It is assumed that small-scale commercial cattle comprise 5% of the national herd (Derived from Swiss Development Cooperation 1995)
(b): Adult cattle are assumed to comprise 60% of the herd
(c): The number of immature cattle is calculated by subtracting adult cattle from total cattle numbers.
(d): The small-scale commercial dairy yield of 2,544 kg per year is derived from D.K Singh (pers comm), World Bank (1996), Saxena (1994) and Atmaran (1993). Small-scale indigenous production is derived from from D.K Singh (pers comm), World Bank (1996), Saxena (1994) and Atmaran (1993). Breeding cows are assumed to represent 67 and 50% of adult cattle in commercial and indigenous systems.

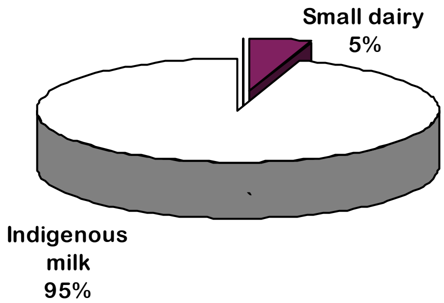

Figure 3: Composition of national herd

Most cattle raised in India are part of small-holder systems. A Department of Agriculture and Cooperation (1987) census found that the average Indian herd size was 3.7 heads of cattle and buffalo, and 56% of bovines are raised on less than one hectare of land. The increased use of motorised traction has reduced the use of animals for draught purposes. World Bank (1996) noted that the number of tractors has increased from 30,000 to 1.14 million, and the oxen population has decreased from 80-65 million since 1961.

Ticks and associated diseases

Tick-worry, *Anaplasma*, *Babesia* and *Theileria annulata* are found in India. There has been a number of surveys in India to estimate the incidence of these diseases, with the All Indian Coordinated Research Project being the most recent. Laboratory analysis of 395 specimens from diseased dairy cattle in the Kaira district of Gujarat (1995-96) indicated that *Theileria annulata* is the most prevalent tick-borne disease in this district.

Figure 4 illustrates the climatic suitability of India for the development of the tick species *Boophilus microplus*. Climatic suitability was mapped using a simulation model developed by Maywald and Sutherst (1985). The simulation model results provide an indication as to where this tick species may be present. It is evident that most regions of India are the most favourable habitats for this tick species. Consequently, it is assumed that 80% of the Indian herd is within *Anaplasma* and *Babesia* endemic areas.

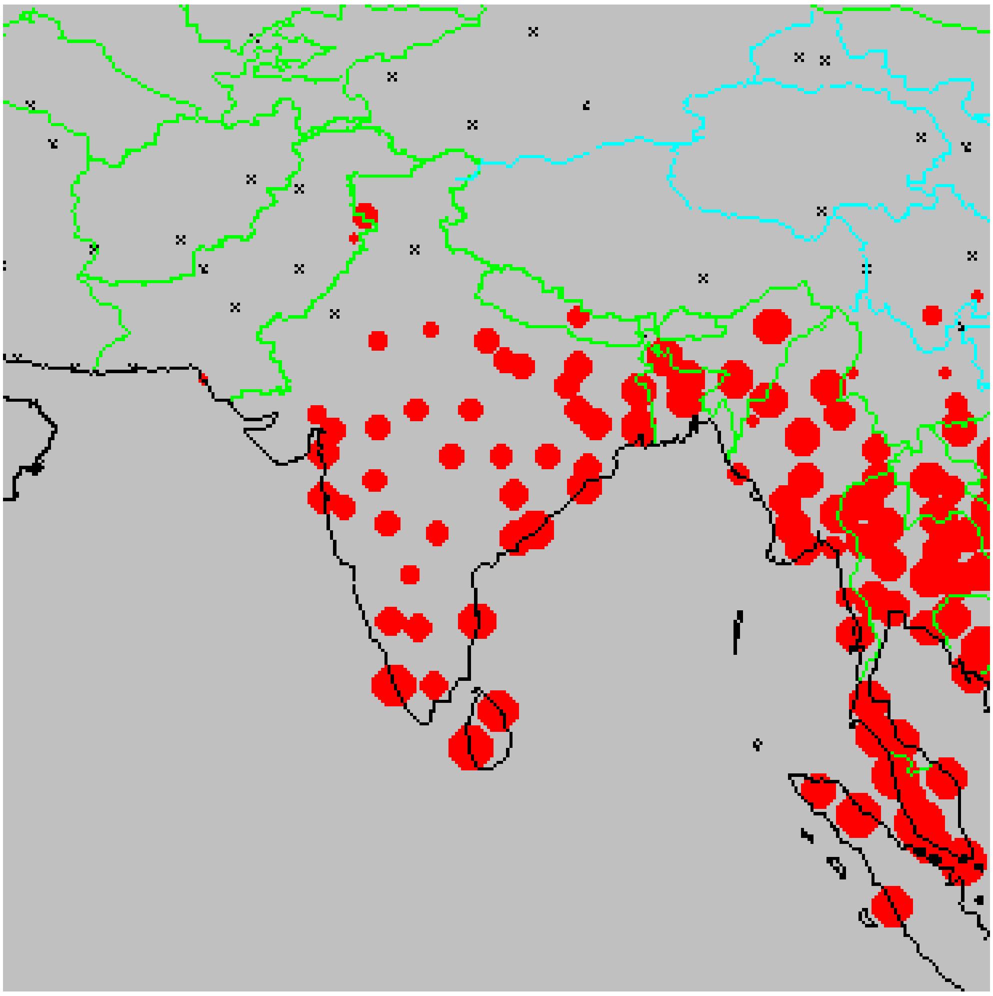

Figure 4: Distribution of *B. microplus* in southern Asia. (Maywald and Sutherst 1985)

The incidences of tick diseases are illustrated in Table 2. Major assumptions relevant to the economic impact assessment include:

Table 2: Incidence of ticks and associated diseases in India

Disease	**Tick Worry (feeding ticks)**		***Anaplasma and Babesia***		***Theileria annulata***	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale indigenous (milk)						
Herd in endemic areas (%) [a]	80	80	80	80	80	80
Disease incidence (%) [b]	15	15	2.5	5	5	5
Case fatality (%) [c]	0	0	5	2.5	5	5
Mortality (%)	0	0	0.1	0.1	0.3	0.3
Small-scale commercial dairy						
Herd in endemic areas (%) [a]	80	80	80	80	80	80
Disease incidence (%) [d]	15	15	5	10	10	10
Case fatality (%)	0	0	10	5	10	10
Mortality (%)	0	0	0.5	0.5	1.0	1.0

(a): Herd affected estimates are the authors.
(b): It is assumed that disease incidence in indigenous stock is half that of exotic cattle due to higher natural resistance
(c): Case fatality in indigenous stock is assumed to be half that of exotic stock
(d): Anaplasmosis and babesiosis incidence are author estimates. Background information on these diseases can be derived from disease incidence reported in South African and Australian exotic cattle grazing in disease endemic areas (Spikett and Fivaz 1992, Mahoney and Ross 1972, Ramsay 1997). *Theileria annulata* incidence is derived from reported incidence in exotic dairy cattle in Gujarat, India (Singh 1992). In this study it was noted that there were 3,800 acute cases of tropical theileriosis from a herd of 40,000 exotic dairy cattle in the Kaira district, Gujarat.

Tick worry is assumed to decrease milk production in both crossbred and indigenous cattle. It is assumed that 80% of the Indian herd is raised in areas where tick worry is endemic. Indigenous cattle are generally considered to have greater natural resistance to the impact of feeding ticks and therefore the incidence and accompanying production losses are assumed to be lower than that of exotic crossbred and purebred dairy cattle.

Anaplasma and *Babesia* are found throughout India and it is assumed that 80% of the herd is at risk from the impact of these diseases. These diseases have been found to cause substantial loses in Australia and South Africa (du Plessis *et al* 1994), and diagnosis at the NDDB laboratories indicates that these parasites are present in India. In this analysis, it is assumed that 10% of immature exotic cattle and 5% of adult exotic cattle suffer severe infection each year. Immature cattle have higher natural resistance to these diseases (Mahoney and Ross 1972).

It is further assumed that 10% of adult exotic cattle and 5% of immature cattle that become infected with these diseases suffer fatality. Using these assumptions, the average annual mortality in commercial cattle for these diseases is estimated to be 0.5%. These estimates can be compared with *Anaplasmosis* and *Babesiosis* impacts in South Africa. du Plessis *et al* (1994) found that 0.5% of South Africa exotic cattle suffered fatality as a result of these diseases. Indigenous cattle are assumed to suffer lower case fatalities and infection rates when compared to exotic cattle.

Theileria annulata is endemic throughout India. For the purposes of this study it is assumed that 80% of the Indian herd is in tropical theileriosis risk areas. Singh (1992) indicated that 3,800 exotic cattle suffered *Theileria annulata* mortality in the Kheda district of Gujarat during 1989. A total of 40,000 exotic cattle were present in the district at this time. (ie. 9.5% disease incidence). In the analysis it is assumed that 10% of exotic cattle suffer *Theileria annulata* each year throughout India. Indigenous cattle are less susceptible to tick-borne diseases when compared to imported European types. It is assumed that indigenous cattle mortality is half that experienced by exotics. Case fatalities of 5% and 10% are included for indigenous and exotic cattle.

Table 3: Production losses in disease-affected cattle

Disease	**Tick Worry (feeding ticks)**		***Anaplasma and babesia***		***Theileria annulata***	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale indigenous (milk) [(a)]						
Milk loss (kg/hd/yr)	12	0	0	0	81	0
Small-scale commercial dairy [(b)]						
Milk losses (kg/hd/yr) [(c)]	127	0	0	0	356	0

(a): Milk losses for tick worry in indigenous cattle (2%) is an author estimate. Background information on tick worry losses can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval et al 1997a, b, c).
(b): Tick worry liveweight losses in exotic cattle types are not included as dairy cattle are primarily raised for milking purposes.
(c): Milk losses in exotic cattle (5%) as a result of tick worry is an author estimate. Background information on tick worry losses in commercial cattle can be derived from Jonsson et al (1998). The impact of Theileria annulata infection on milk production (14% loss) is an author estimate derived from Singh (1992).

Production losses in disease affected cattle are provided in Table 4. The availability of production loss data is a major factor determining whether disease impact data has been included for the various tick-borne diseases. By combining per head losses outlined in Table 3 with assumed rates of incidence (Table 2), the physical losses associated with each disease are estimated.

These physical losses associated with each disease are shown in Table 4. *Theileria annulata* infection is estimated to cause more than 0.4 million cattle deaths per annum. The majority of fatalities are estimated to occur in the small-scale indigenous sector, primarily because this sector is much greater in size than the commercial sector.

Table 4: Annual physical tick and tick-borne disease production losses in India

Disease	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria annulata*
Small-scale indigenous			
Adult mortality (head) [(a)]	0	119,187	238,374
Immature mortality (head) [(a)]	0	79,458	158,916
Reduced milk production (tonnes)	82,811	0	193,226
Small-scale commercial dairy			
Adult mortality (head) [(a)]	0	25,892	50,184
Immature mortality (head) [(a)]	0	16,728	33,456
Reduced milk production (tonnes)	63,834	0	119,157

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.

Economic losses associated with each of the diseases are provided in the following table. Acaricide use has not been included in the economic impact assessment since the use of these chemicals is confined to state-run breeding farms and this cost is non-significant in the context of the entire cattle industry. The cost associated with the use of *Theileria annulata* vaccine is also very small. Currently 70,000 doses of the vaccine are sold each year at a cost of $US 0.9 per dose.

Table 5: Annual economic costs of ticks and associated diseases in India ($US)

Diseases	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria annulata*
Control			
Acaricides [(a)]	0	0	0
Vaccine [(b)]	0	0	0.1
Production Losses [(c)]			
Mortality	0	57.2	114.4
Milk production	58.7	0	125.0
Combined Costs	**58.7**	**57.2**	**239.5**

(a): Due to the limited use of acaricides, no cost has been included
(b): The vaccine cost accounts for 70,000 doses of tropical theileriosis vaccine, at $0.9 per dose
(c): It is assumed that commercial adult and immature cattle have values of $US 450 and $250 per head, indigenous adult and immature cattle values of $250 and $150 per head, and milk $0.4 per litre.

Costs associated with cattle mortality, estimated to be $114 million per year for *Theileriosis* and $57 million annually for *Anaplasmosis* and *Babesiosis* constitute the most significant production loss cost for these diseases. Milk production is the next most important production loss, since most cattle within India are used for milking purposes.

Theileria annulata is estimated to be the most significant tick-borne disease of cattle in India. Because *Anaplasmosis* and *Babesiosis* prevalence is assumed to be relatively low in indigenous stock, these diseases do not generate substantial economic costs.

With further increases in the size of the Indian improved cattle herd, there is likely to be greater costs associated with these diseases.

Production constraints

During project consultations, Indian scientists were asked what they considered to be the most substantial constraints to cattle production in India. A summary of the responses from IVRI and NDDB scientists is outlined below:

- Proper selection of native stock for upgrading. Lack of progeny testing, artificial insemination problems
- Malnutrition, environmental stress and less productive old animals
- Inadequate health coverage

Opportunities for cattle research

During project consultations, Indian scientists were asked what they considered to be the most fruitful opportunities for cattle research in India. A summary of the responses from IVRI and NDDB scientists is outlined below:

- Improved feed and fodder supply
- Introduction and breeding of high milk yielding cattle
- Improved disease monitoring and surveillance
- Improved extension of cattle management practice

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Indonesia

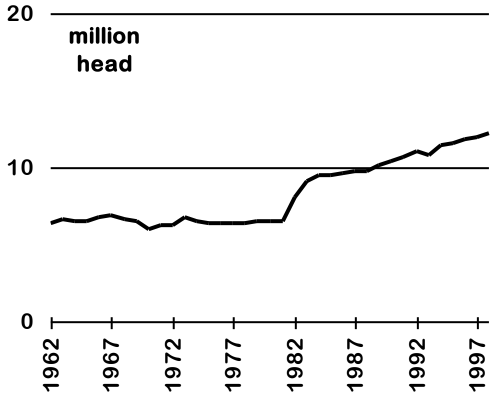


Figure 1: Size of national cattle herd

Indonesia has the largest cattle herd of all south-east Asian countries, with approximately 12 million cattle. The nation has 1.6 million more cattle than the second-most cattle populous country of Myanmar. The number of cattle has been steadily increasing over the last 30 years, with a corresponding boost in meat production. In recent years, the largest percent increases in herd sizes have occurred in the areas of Kalimantan Timur, Jambi, and Lampung.

Most cattle are found in the provinces of Jawa Tengah and Jawa Timur, and this distribution reflects areas of high population density. The average number of cattle per household has also been increasing. In 1983, the average number of cattle was 2.2 per household and by 1993 this had increased to 3.6 head (Direktorat Jenderal Peternakan 1996). The largest herds are found in the province of Nusa Tengarra Timur where lower population densities have provided capacity for large herd sizes. Draught animal power is often in short supply in this province and humans conduct a significant proportion of land preparation activities (Chaniago *et al* 1993).

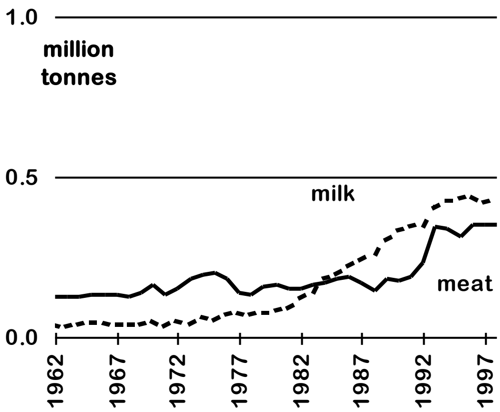


Figure 2: National production

Most cattle production in Indonesia is undertaken by small holder cattle producers. Traditionally, cattle have been raised for draught and beef purposes (Komarudin *et al* 1993, Santoso *et al* 1993, Krisanto 1982). There has been an increase in the number of dairy cattle within Indonesia, although these cattle only make up 3% of the total herd. Most of this herd is found in Java where milk processing capacity has been established. From 1985 to 1994 the dairy herd increased from 175 to 330 thousand head (Direktorat Jenderal Peternakan 1996). Dairy farms are small in size and an average dairy producer holds approximately three to four head of cattle. The small size of dairy herds has been attributed to agricultural credit schemes that target small holder producers and subsistence farmers that tend to predominate in the region. Mastika (1997) noted that most farming occurs on holdings of approximately 0.25-0.3 ha per household. Animal numbers and livestock productivity in the dairy and small-scale cattle production sectors of Indonesia are outlined in Table 1. Meat and milk production estimates are, in part, based on average regional livestock productivity benchmarks and differ slightly from national livestock production statistics.

Table 1: Cattle productivity and production of milk and meat in Indonesia (1998)

Livestock system	Small-scale meat (Indigenous)	Small-scale commercial dairy	Total
Cattle at year end (million head) [(a)]	11.8	0.4	12.2
Adult cattle at year end (million head) [(b)]	7.1	0.3	7.4
Immatures at year end (million head) [(c)]	4.7	0.1	4.8
Liveweight of adult cattle (kg) [(d)]	250	450	-
Liveweight of immature cattle (kg) [(d)]	150	250	-
Milk production (kg cow year) [(e)]	-	2,544	-

(a): It is assumed that 3% of the national herd is comprised of small-scale dairy and backyard production 97% (Direktorat Jenderal Peternakan 1996)

(b): It is assumed that adult cattle comprise 60% of the commercial and small-meat systems.

(c): The number of immature cattle is calculated by subtracting adult cattle from total cattle numbers.

(d): Liveweight assumptions are the authors. Background information on cattle weights can be derived from USDA (1998) and Commercial Farmer's Union (1994). To estimate meat production losses, it is assumed 4% of indigenous cattle and 25% of commercial cattle are turned-off each year.

(e): A small-scale commercial dairy yield of 2,544 kg per year is an author estimate. Background information on milk production can be derived from national milk production statistics (Direktorat Jenderal Peternakan 1996). It is assumed that 40% of the adult commercial herd is comprised of breeding cows.

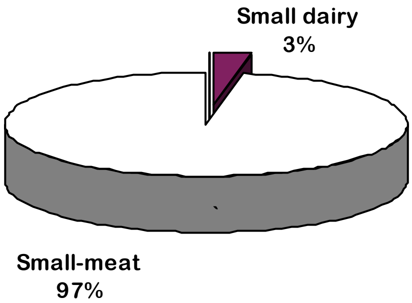


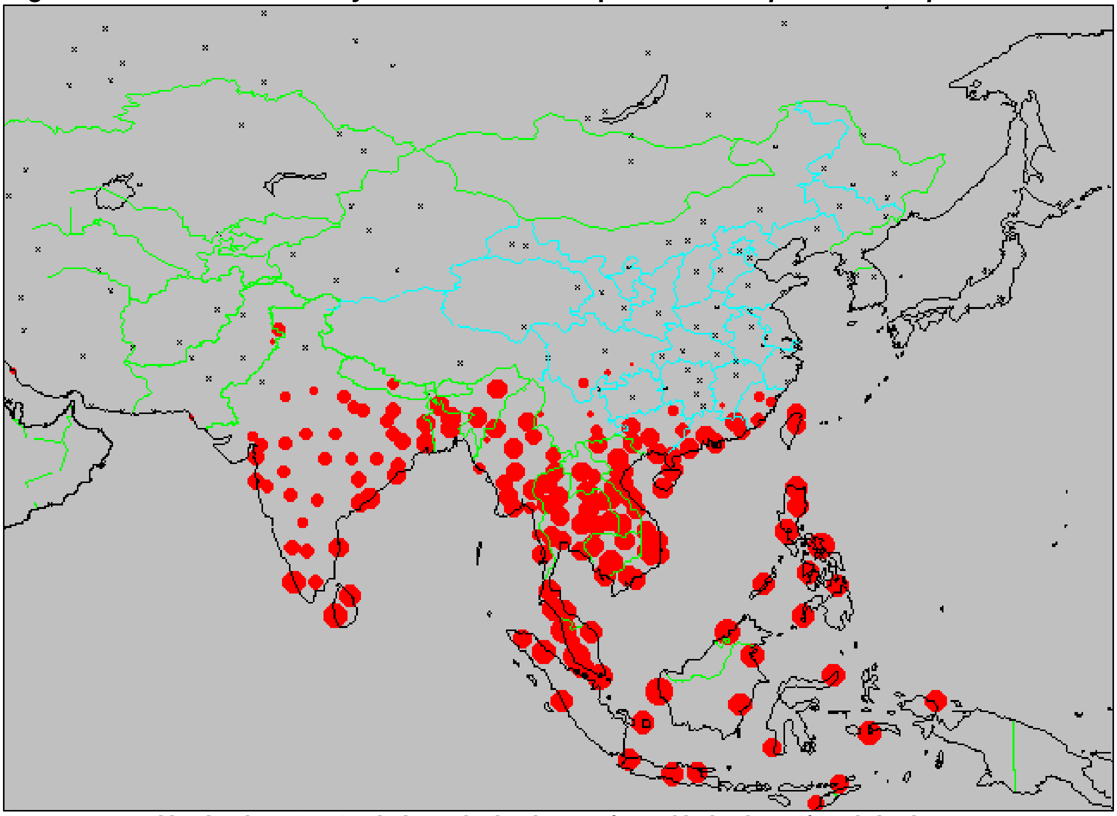
Figure 3: Composition of the national herd

The adjoining figure illustrates the breakdown of the Indonesian herd into small-scale backyard (beef) and small scale commercial (dairy) production. It is evident that small-holder beef production dominates the Indonesian cattle industry. Currently, the small-scale commercial sector is estimated to account for 3% of all cattle in the country. An import-based feeder cattle industry was also developing in Indonesia, but has declined in importance since depreciation of the rupiah. Gde (1997) noted that tick-borne diseases do not cause substantial mortality of imported cattle and tick-impacts in this sector are not explicitly calculated.

Tick and associated diseases

Dharma (1997) indicated that *Boophilus microplus* is the most important tick species in the Nusa Tengarra region. In the same report, it was noted that both *Boophilus microplus* and *Amblyomma testudinarium* have been found on Bali cattle, within Bali, but tick species such as *Rhipicephalus* and *Haemaphysalis* have not been observed. The Disease Investigation Centre in Bali has not recorded an outbreak of tick diseases in the Nusa Tengarra region for the last twenty years (Dharma 1997). The climatic suitability of Asia for the development of the tick species *Boophilus microplus* is outlined in Figure 4 using the CLIMEX simulation model (Maywald and Sutherst (1985). The pattern of *Boophilus microplus* climatic suitability mapped in Figure 4 is similar to the distribution of anaplasmosis and babesiosis in SE Asia described by Jorgensen (1991).

Figure 4: Climatic suitability of Asia for development of *Boophilus microplus* [(a)]



(a): From Maywald and Sutherst (1985). The larger the dot, the more favourable the climate for tick development.

The incidence of tick worry and *Anaplasma* and *Babesia* are outlined in the following table. Partoutomo (1997) noted that *Theileria orientalis* has been found in dairy cattle of Java, but no clinical signs of the disease have been observed.

Table 2: Incidence of tick-borne diseases in Indonesia

	Tick Worry		*Anaplasma and Babesia*	
	Adult	Immature	Adult	Immature
Small-scale meat (indigenous)				
Herd in endemic areas (%) [(a)]	80	80	80	80
Disease incidence (%) [(b)]	15	15	2.5	5
Case fatality (%) [(c)]	0	0	5	2.5
Mortality (%)	0	0	0.1	0.1
Small-scale commercial dairy				
Herd in endemic areas (%) [(a)]	80	80	80	80
Disease incidence (%) [(d)]	15	15	5	10
Case fatality (%)	0	0	10	5
Mortality (%)	0	0	0.5	0.5

(a): It is assumed that 80% of all cattle are in tick worry areas, and 80% of the herd is at risk from Anaplasmosis and Babesiosis
(b): Anaplasma and Babesia incidence are author estimates.
(c): Tick worry is not assumed to cause death in affected cattle. Anaplasma and Babesia case fatality estimates are author assumptions. Background information on these diseases can be derived from Ramsay (1997) *B. bovis* case fatality estimates. Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases. Anaplasmosis and Babesiosis case fatality in indigenous stock is assumed to be half that of exotic stock.
(d): Mortality is outlined for cattle in disease risk areas.

Anaplasmosis and *Babesiosis* cause higher production losses in adult cattle as younger cattle have greater natural immunity (Mahoney and Ross 1972). These diseases are assumed to be prevalent across most of the country, but cause low levels of production losses due to endemic stability. The incidence of disease is greater in the small-scale commercial herd. Given this sector only accounts for a small proportion of the total Indonesian herd (3%), losses are estimated to be minor.

Production losses in disease affected cattle are described in Table 3. By combining productivity loss in affected cattle with incidence data, physical losses associated with each disease are estimated. It should be noted that meat loss is only estimated for cattle that are slaughtered and milk losses are only assessed for cows within the small-scale commercial dairy sector.

Table 3: Production losses in tick-borne disease-affected cattle

	Tick Worry		***Anaplasma and Babesia***	
	Adult	Immature	Adult	Immature
Small-scale meat (indigenous)				
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0
Small-scale commercial dairy				
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0
Milk loss (kg/hd/yr) [(b)]	127	0	0	0

(a): Liveweight losses for tick worry in indigenous cattle are derived author estimates. Background information about tick-worry losses can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval et al 1997a, b, c). Tick worry liveweight losses in exotic cattle types are author estimates. Background information about tick-worry losses in commercial cattle can be derived from Little (1963), Sing *et al* (1983), Seebeck *et al* (1971) and Sutherst *et al* (1983) Anaplasma and Babesia live weight losses are assumed to be negligible and are not included in the costing framework.
(b): Milk losses as a result of tick worry are author estimates. Background information about tick-worry losses can be derived from Jonsson *et al* (1998) in exotic cattle and (Norval et al 1997a, b, c) for indigenous cattle. Anaplasmosis and Babesiosis milk losses are assumed to be negligible and are not included in the costing framework

Table 4: Physical tick production losses in Indonesia

Disease	**Tick Worry**	***Anaplasma and Babesia***
Small-scale meat (indigenous)		
Adult mortality (head) [(a)]	0	7,100
Immature mortality (head) [(a)]	0	4,734
Liveweight (tonnes) [(b)]	239	0
Small-scale commercial dairy		
Adult mortality (head) [(a)]	0	878
Immature mortality (head) [(a)]	0	586
Liveweight (tonnes) [(b)]	0	0
Milk loss (tonnes)	2,235	0

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.
(b): Liveweight losses are only realised for cattle that are slaughtered.

Milk production losses are not substantial because most cattle in Indonesia are not primarily used for milking purposes. The economic losses and control costs associated with each of the diseases are included in Table 5. It is assumed that cattle are not treated using acaricides in either production system. Vaccines are not used within Indonesia for any of these diseases. It must be noted that many of the cattle shipped from Australia to Indonesia as part of the live cattle trade are treated with an *Anaplasma* and *Babesia* vaccine.

Table 5: Annual tick and associated disease economic losses in Indonesia ($US million)

Disease	Tick Worry	*Anaplasma* and *Babesia*
Control ($m) [(a)]		
Acaricide	0	0
Production Losses ($m)		
Mortality [(b)]	0	3.1
Milk production [(b)]	0.7	0
Liveweight [(b)]	0.2	0
Combined cost and loss ($m)	**0.9**	**3.1**

(a): Acaricide use is limited in Indonesia and is assumed to be negligible.
(b): It is assumed that commercial adult and immature cattle have values of $US 500 and $250 per head, indigenous adult and immature cattle values of $250 and $150 per head, meat 0.7 kg liveweight and milk $0.33 per litre.

The costs associated with mortality are the most significant production loss costs in Indonesia. The next most important production loss is that associated with reduced live weight. This loss is also relatively minor because young cattle are often marketed. Younger cattle have lower susceptibility to *Anaplasma* and *Babesia* when compared to adults.

Disease comparison

Diseases and conditions such as *brucellosis, haemorrhagic septicaemia* and nutritional deficiency are likely to represent greater constraints on livestock production in Indonesia when compared to tick-borne diseases. These diseases cause reproduction and production failure in livestock. Their economic impacts, however, are not well recorded. It was noted that the role of ticks or other vectors still require further investigation. Indonesia has been currently recommended as a free country of Foot and Mouth Disease by the OIE. The opportunity for out breaks of this disease should be taken into consideration since clinical signs of FMD may occur in Indonesia at any time due to the present changes in global trade.

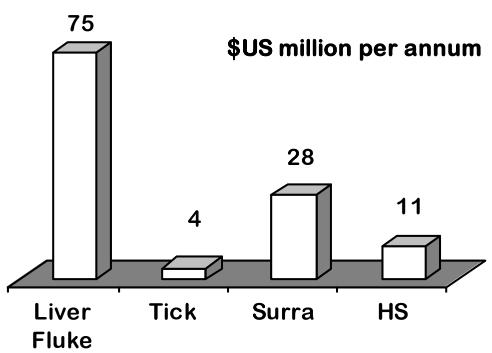


Fig 5: Economic impact of selected diseases

To gain an appreciation for the relative importance of tick-borne disease costs, relative to other diseases in Indonesia, a disease cost comparison is included (Figure 5). The costs of the other diseases are drawn from a series of studies undertaken by the Indonesian government and a review of the Indonesian livestock industry by Winrock International (1986).

In Figure 5, it is evident that liver fluke is the most important constraint facing the Indonesian cattle industry. Winrock International (1986) reported that liver fluke is both common and widespread in most parts of Indonesia despite the aquatic snail host being restricted to the coastal areas of drier eastern islands. Acute cases of the disease are rare in cattle and the parasite is only found in the animal at slaughter when meat inspection takes place. In the same report, it is noted that despite control methods being available, they are rarely used because of cost and poor knowledge of the parasite.

The next most important disease is Ascariasis and is caused by the parasite *Neoascaris vitulorum*. The disease causes considerable mortality and retards the growth of calves. The disease is particularly severe in buffaloes but can be controlled by piperazine, a chemical which is relatively cheap and available throughout central Indonesia (Winrock International 1986). The annual cost of this disease has been estimated to be $38 million per annum. This disease requires further field investigations, particularly the prevalence rate, distribution, mortality rate and economic impact.

Typanosomiasis or ‘surra’ is found throughout Indonesia except the province of Irian Jaya. The disease results in reduced work output from draft animals and has been estimated to cause economic losses of approximately $28 million per year. Winrock International (1986) indicate that treatment is expensive and only lasts for a short period of time.

Table: Annual costs of selected diseases in Indonesia ($US million) [a]

Disease	Control Cost ($m)	Production Loss ($m)	Combined Loss ($m)	Source
Liver fluke	na	75	75	Winrock International (1986)
Ascarisis	na	38	38	DGLS (1984) [b]
surra	na	28	28	DGP (1984) [b]
Anthrax	na	20	20	Winrock International (1986)
HS	na	11	11	DGP (1984) [b]
Tick related	0	4.0	4.0	This report

(a): Costs are provided on a nominal basis.
(b): Taken from Winrock International (1986)

It is evident that tick associated diseases only comprise a minor cost or constraint to the Indonesian cattle industry. Even in the feedlot industry, where substantial numbers of cattle are shipped from Australia to Indonesia, there are limited losses associated with tick-borne diseases. Gde (1997) indicates that cattle mortality of approximately 0.1-0.5% occurs in these cattle. Most losses are associated with acidosis.

Production constraints

As part of this project, researchers in Indonesia were asked what they considered to be the three most important constraints on cattle production in their country. Approximately 26 people in Indonesia provided a response to this question and their answers are illustrated in the chart below. It is evident that inappropriate management of cattle and poor nutrition are the major constraints to productivity. The highest priority, or largest number of first constraint preferences, was attributed to nutrition. In recent years there has been widespread drought throughout eastern Indonesia and areas in this country suffers from seasonal shortages in feed supply.

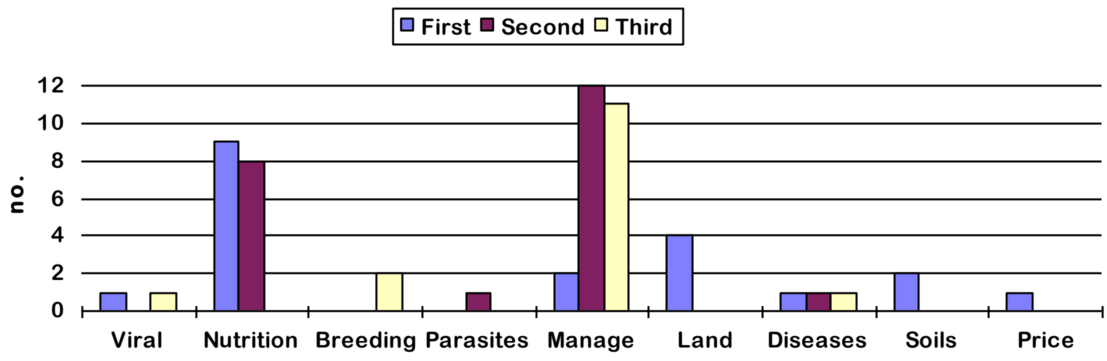


Figure: Cattle production constraints in Indonesia (First, is the most important constraint), N=26.

Opportunities for cattle research

Researchers were also asked to nominate what they considered to be the most fruitful areas for cattle research. A collation of their first, second and third preferences are outlined in the figure below.

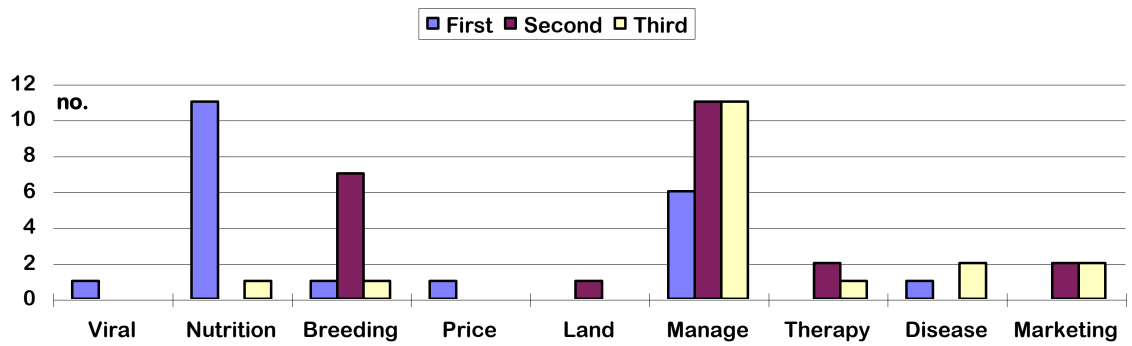


Figure: Cattle research opportunities in Indonesia (First, is the most fruitful opportunity), N=26.

- It is evident that most of the experts feel that nutrition offers the greatest research opportunity. Currently, some cattle nutrition issues are being investigated, including forage utilisation and the scope for using concentrates in lot fed cattle (Mastika *et al* 1996, Arka 1996)
- Improved management of cattle is the second opportunity of highest potential. Research relating to shrub and tree management, along with improved 'cut and carry' and three strata production systems (Nitis *et al* 1991) is being undertaken.
- An improvement in the genetic potential of the herd through cattle breeding is also perceived to be a major avenue for improving the production of cattle.

Outside of the workshops, it was suggested that the following research areas should be targeted.

- Nutrition for quality, cheaper formulation, alternative animal feed, local feed development, availability and deficiency.
- Breeding for quality, improvement, resistance and technology.
- Monitoring and surveillance for exotic diseases.

- Marketing/Agribusiness for distribution, pricing, management and information network system.
- Therapy for drug availability, accessibility and quality, and local drug development.

Additionally, the Strategic Plan by the Research Institute for Veterinary Science and Livestock Development Programme (Directorate General of Livestock Services) has identified the following disease priorities :

- *Brucellosis*
- *Jembrana*
- *Anthrax*
- *Haemorrhagic Septicaemia*
- *Fasciolosis*
- *Surra*
- *Malignant Catarrhal Fever*
- *Anaplasmosis*
- *Infectious Bovine Rhinotracheitis*
- *Babesiosis*

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Nepal

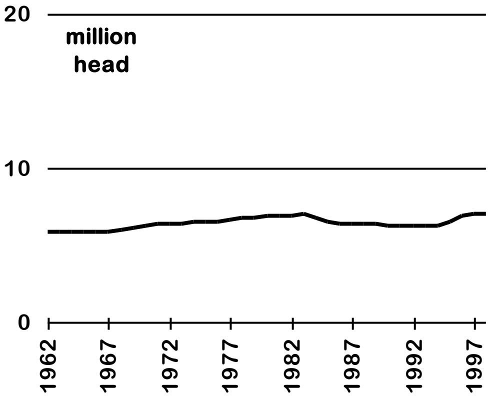

Figure 1: Size of national cattle herd

There were seven million cattle in Nepal at the end of 1998 (FAO 1998) and the herd size has increased by 21% since 1961 (Figure 1). Milk production has also increased by 94% over this period. (Figure 2, FAO 1998). Cattle are raised in three (lowlands, mid-hills and Himalayan) broad physiographic regions of Nepal. The lowlands, or Tarai, are in the south of the country. Approximately 36% of the cattle population are found in this region, where cattle are kept as part of sedentary production systems and used for draft, cart pulling and rice polishing. Agriculture is intensive in the Tarai and cattle are often fed with crop residues and crop by-products.

The mid-hills lie to the north of the Tarai, in altitudes of 800-2400 m above sea level. This region contains the valleys of Katmandu and Pokhara and accounts for 42% of the Nepalese land area. Shresthra and Pradham (1995) indicated that 51% of the cattle population reside in the mid-hills. Feed shortages often occur in this region and cattle are moved to the lower hills in search of forage.

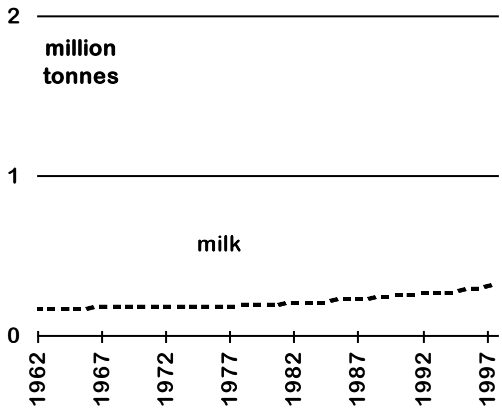

Figure 2: National production

The Himalayan region makes 35% of the Nepalese land area and in 1993 had 13% of the cattle. This region has eight of the world's ten highest mountains, and livestock are raised on a transhumance basis. During winter, cattle are moved to the mid-hill region for grazing. There have been a number of livestock development programs undertaken in recent years to increase the productivity of cattle (ADB 1996). In 1952, 20 Sindhi cows and two breeding bulls were imported. Since this initial importation, European and cross-bred cattle have been introduced to increase the supply of milk. In this analysis, it is estimated that there are approximately 0.1 million crossbred milking cattle in the Nepalese herd.

Most livestock in Nepal are native breeds with low levels of productivity. Ruminant production is governed by the availability of fodder from forests along with crop residues. With rapid depletion of forests and poor quality of crop residues in many areas, feed and fodder shortages are increasingly becoming a major constraint on cattle production in Nepal (Shresthra and Pradham 1995).

Table 1: Cattle numbers and productivity in Nepal, 1998

Livestock system	Small-scale milk (Indigenous)	Small-scale commercial (Dairy)	Total
Cattle at year end (million head) [(a)]	7.0	0.1	7.1
Adult cattle at year end (million head) [(b)]	4.2	0.06	4.3
Immatures at year end (million head) [(c)]	2.8	0.04	2.8
Milk production (kg/cow/year) [(d)]	579	2,544	-

(a): It is assumed that small-scale crossbred commercial cattle comprises 1.4% of the national herd.
(b): Adult cattle are assumed to comprise 60% of the herd
(c): The number of immature cattle is calculated by subtracting adult cattle from total cattle numbers.
(d): The small-scale commercial dairy yield of 2,544 kg per year is derived from D.K Singh (personal communication), World Bank (1996), Saxena (1994). Small-scale indigenous production is derived from D.K Singh (pers comm), World Bank (1996), Saxena (1994). Milk yield estimates are average annual values for lactating cattle. To estimate production losses in Table 4 it is assumed that 67% of the adult commercial herd and 50% of the adult indigenous herd are breeding females.

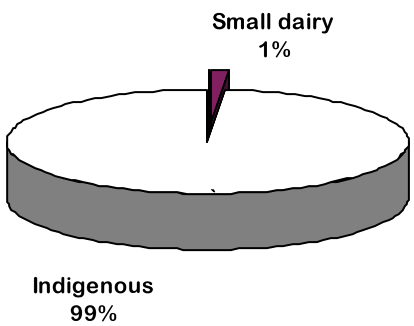

Figure 3: Composition of Nepalese herd

Most of the cattle raised in Nepal are part of small-holder systems, using native cattle breeds (Sir cattle). The breakdown of the Nepalese cattle herd into small-scale indigenous cattle production (Indigenous) and improved exotic crossbreds (Small dairy) is outlined in Figure 3.

Ticks and associated diseases

Tick-worry, *Anaplasma, Babesia* and *Theileria annulata* are found in Nepal (OIE 1998). There is limited data outlining the incidence of these diseases in this country. Jorgensen (1991) indicated that *Babesia* and *Anaplasma* are regarded as serious diseases of cattle in China and India, countries that share borders with Nepal. The climatic suitability of southern Asia for *B. microplus* is outlined in Figure 4. Climatic mapping only provides an idea as to where this vector tick species may be found and scientists need to confirm disease and tick presence through the use of surveys.

Singh (1991) indicated that *Theileria annulata* was present in all areas of India except in the Himalayan ranges, where the climate is not favourable for tick development. Given that the various species of tick vectors which include *Hyalomma anatolicum anatolicum*, *Hyalomma dromedarii*, *Hyalomma marginatum isaaci* and *Hyalomma detrium* are not found in mountainous areas of southern Asia, cattle raised in the lowlands of Nepal are primarily affected by *Theileria annulata*. Shresthra and Pradham (1995) indicated that 36% of the Nepalese herd resided in the lowlands or Tarai region of Nepal.

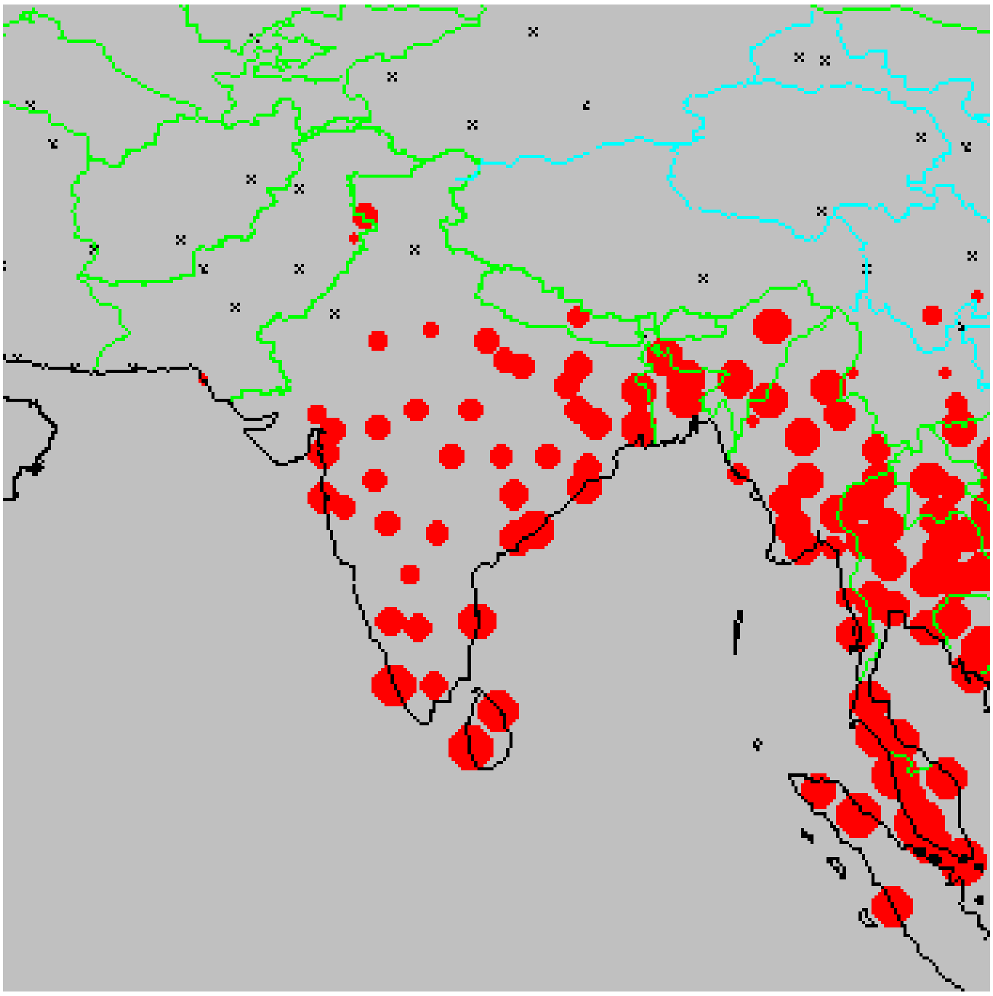

Figure 4: Potential distribution of *B. microplus* in southern Asia. (Source Maywald and Sutherst 1985)

The incidences of tick disease are illustrated in the following table. Major assumptions relevant to the economic impact assessment include:

Table 2: Incidence of ticks and associated diseases in Nepal

Disease	Tick Worry (feeding ticks)		*Anaplasma and Babesia*		*Theileria annulata*	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale indigenous (milk)						
Herd in endemic areas (%) [(a)]	30	30	30	30	30	30
Disease incidence (%) [(b)]	15	15	2.5	5	5	5
Case fatality (%) [(c)]	0	0	5	2.5	5	5
Mortality (%)	0	0	0.1	0.1	0.3	0.3
Small-scale commercial dairy						
Herd in endemic areas (%) [(a)]	30	30	30	30	30	30
Disease incidence (%) [(d)]	15	15	5	10	10	10
Case fatality (%) [(e)]	0	0	10	5	10	10
Mortality (%)	0	0	0.5	0.5	1.0	1.0

(a): Herd affected estimates are the authors. Many cattle in Nepal are grazed in mountainous areas where ticks and tick-borne diseases are not widespread.
(b): It is assumed that Anaplasma, Babesia and tropical theileriosis incidence in indigenous stock is half that of exotic cattle due to higher natural resistance. Tick worry incidence estimates are author estimates.
(c): Case fatality in indigenous stock is assumed to be half that of exotic stock
(d): Anaplasma and babesia incidence are author estimates. Background information on these diseases can be derived from disease incidence reported in South African and Australian exotic cattle grazing in disease endemic areas (du Plessis et al 1994, Mahoney and Ross 1972, Ramsay 1997). Theileria annulata incidence is derived from reported incidence in exotic dairy cattle in

Gujarat, India (Singh 1992). In this study it was noted that there were 3,800 acute cases of tropical theileriosis from a herd of 40,000 exotic dairy cattle in the Kaira district, Gujarat.
(d): Anaplasma and babesia case fatalities are author assumptions,. The assumed Theileria annulata case fatality estimate of 10% in commercial dairy cattle is derived from Singh (1991).

It is assumed that 30% of the indigenous and commercial herds are raised in areas where tick worry is endemic. Indigenous cattle are generally considered to have greater natural resistance to the impact of feeding ticks and production losses assumptions are assumed to be lower than that of exotic crossbred dairy cattle.

Table 3: Production losses in disease-affected cattle

Disease	Tick Worry (feeding ticks)		*Anaplasma and babesia*		*Theileria annulata*	
	Adult	Immature	Adult	Immature	Adult	Immature
Small-scale indigenous (milk) [(a)]						
Milk loss (kg/hd/year)	12	0	0	0	81	0
Small-scale commercial dairy						
Milk losses (kg/hd/year) [(b)]	127	0	0	0	356	0

(a): Milk losses of 2% for tick worry in indigenous cattle is an author estimate derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval et al 1997a, b, c).
(b): Milk losses of 5% in exotic cattle as a result of tick worry is an author estimate derived from Jonsson *et al* (1998). The effect of Anaplasma and babesia infection on milk losses is assumed to be non-significant. The impact of Theileria annulata infection on milk production (14% loss) was derived from Singh (1992).

Anaplasmosis and *Babesiosis* are found in selected parts of Nepal and it is assumed that 30% of the indigenous and exotic herd are at risk from the impact of these diseases. These diseases have been found to cause substantial loses in Australia and South Africa (du Plessis *et al* 1994). In this analysis, it is assumed that 10% of immature exotic cattle and 5% of adult exotic cattle suffer acute infection each year. Immature cattle have higher natural resistance to these diseases (Mahoney and Ross 1972). It is further assumed that 10% of adult exotic cattle and 5% of immature cattle that become infected with these diseases suffer fatality. Indigenous cattle are assumed to suffer lower case fatalities and infection rates when compared to exotic cattle.

Theileriosis caused by *Theileria annulata* is endemic throughout India and also southern Nepal. For the purposes of this study, it is assumed that 30% of the Nepalese herd is in tropical theileriosis risk areas. Singh (1992) indicated that 3,800 exotic cattle suffered *Theileria annulata* caused mortality in the Kheda district of Gujarat during 1989. A total of 40,000 exotic cattle were present in the district at this time and correspondingly a disease incidence of 10% has been included in this cost assessment for commercial dairy cattle. Indigenous cattle are less susceptible to tick-borne diseases when compared to imported European types. In this analysis, it is assumed that indigenous cattle mortality is 50% of that experienced by exotics. Case fatalities of 10 and 5% are included for exotic and indigenous cattle.

The physical losses associated with each of the diseases are evident in the following table. *Theileria annulata* infection is estimated to have caused more than 5,422 cattle fatalities in 1998. The majority of fatalities is estimated to occur in the small-scale indigenous sector, primarily because this sector is much greater in size than the commercial sector.

Table 4: Annual physical tick and tick-borne disease production losses in Nepal

Disease	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria annulata*
Small-scale indigenous			
Adult mortality (head) [d]	0	1,564	3,127
Immature mortality (head) [a]	0	1,042	2,085
Reduced milk production (tonnes) [b]	1,086	0	2,535
Small-scale commercial dairy			
Adult mortality (head) [d]	0	63	126
Immature mortality (head) [d]	0	42	84
Reduced milk production (tonnes) [e]	161	0	300

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.
(b): Milk losses are only realised for adult cows
(c): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics
(d): Milk losses are calculated for lactating cows in the dairy herd.

The economic losses associated with each of the diseases are provided in the following table. Acaricide use has not been included in the economic impact assessment.

Table 5: Annual economic costs of ticks and associated diseases in Nepal ($US million)

Diseases	Tick Worry (feeding ticks)	*Anaplasma and Babesia*	*Theileria annulata*
Control			
Acaricides [a]	0	0	0
Production Losses [b]			
Mortality	0	0.6	1.2
Milk production	0.5	0	1.1
Combined costs	**0.5**	**0.6**	**2.3**

(a): Due to the limited use of acaricides, no cost has been included
(b): It is assumed that commercial adult and immature cattle have values of $US 450 and 250 per head, indigenous adult and immature cattle values of $250 and $150 per head, and milk $0.4 per litre.

Costs associated with cattle mortality are estimated to be the most significant production loss cost for all diseases except tick worry. Based on the assumptions outlined in Tables 2 and 3, *Theileria annulata* is associated with an annual loss of $2.3 million, Anaplasmosis and babesiosis $0.6 million, and tick worry $0.5 million.

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Philippines

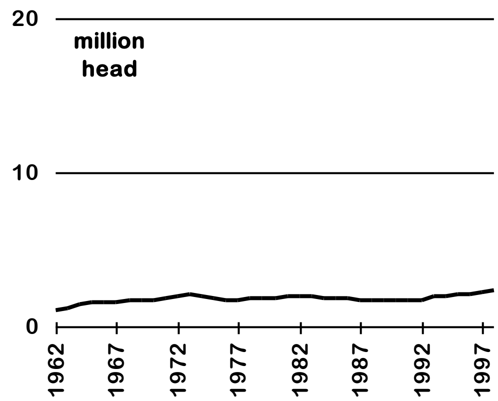

Figure 1: Size of national cattle herd

Currently there are approximately 2.4 m cattle in the Philippines livestock industry (FAO 1998). Over the last 30 years there has been a steady increase in the size of the herd (Figure 1). Most cattle are found in Northern Luzon, Mindano, Cebu and around metro Manila. From Figure 2, it is evident that beef output has increased following growth in the national herd. In recent years there has been an increased in the feed-lotting of cattle. Frequently cattle are purchased from countries including Australia, and are shipped to the Philippines for finishing. The future prospects for this industry are governed by currency exchange rates and the availability of feed-stuffs.

In the past there has been extensive ranching of cattle on the island of Mindano. Beef production has been drastically reduced due to problems of law and order in the region. The commercial sector is now dominated by the importation of live cattle for lot feeding. There have been reports of *Anaplasmosis* and *Babesiosis* outbreaks in shipments of imported cattle.

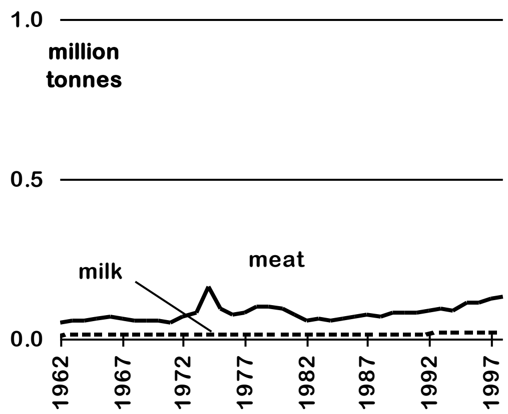

Figure 2: National production

There have been efforts to establish a Philippine dairy industry. Because the national dairy industry only supplies a small proportion of national dairy product demand, a large amount of dairy produce needs to be imported. The productivity of dairy cattle in the Philippines is thought to be constrained by lack of development funds, lack of high yielding dairy animals and low returns on production as a result of product dumping (de Guzman 1993). The majority of cattle raised in the country belong to the small-scale indigenous beef production system. These cattle are commonly used for draught purposes and cattle are slaughtered for beef. For the purposes of the study it is assumed that all cattle in the Philippines belong to this system.

Livestock system	Small-scale (backyard)	Total
Cattle at year end (million head) [(a)]	2.4	2.4
Adult cattle at year end (million head) [(b)]	1.4	1.4
Immatures at year end (million head) [(c)]	1.0	1.0
Liveweight of adult cattle (kg) [(d)]	250	-
Liveweight of immature cattle (kg) [(d)]	150	-

Table 1: Cattle productivity and production of meat in the Philippines

(a): It is assumed that all of the national herd is comprised of small-scale backyard production. Commercial cattle only comprise a small proportion of national herd.
(b): Adult cattle are assume to comprise 60% of this system.
(c): The number of immature cattle is calculated by subtracting adult cattle from total cattle numbers.
(d): Cattle liveweights are author assumptions..

Tick and associated diseases

Anaplasma and *Babesia*, and tick worry have been reported in the Philippines. The potential distribution of *B.microplus*, a vector of these diseases is provided in the Figure 1. The actual presence of the vector tick in various parts of the Philippines needs to be confirmed by scientific survey.

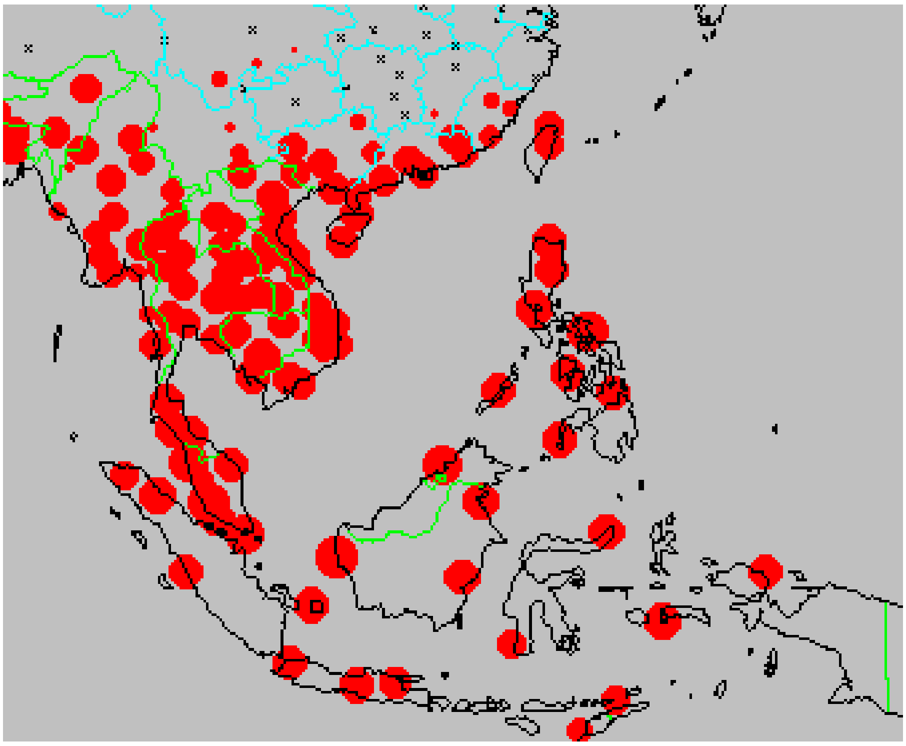

Figure: Potential distribution of *B.microplus* (Source Maywald and Sutherst 1985)

Infection by *Theileria annulata* is not widespread and disease losses are not included for this disease. A high incidence of *Anaplasma* and *Babesia* have been occasionally reported in shipments of cattle for lot feeding. Assumed levels of incidence for tick-worry, babesiosis and anaplasmosis are included in Table 2.

Table 2: Annual incidence of tick-borne diseases in Philippines

	Tick Worry		*Anaplasma and Babesia*	
	Adult	Immature	Adult	Immature
Small-scale meat (indigenous)				
Herd in endemic areas (%) [(a)]	90	90	90	90
Disease incidence (%) [(b)]	15	15	2.5	5
Case fatality (%) [(c)]	0	0	5	2.5
Mortality (%) [(d)]	0	0	0.1	0.1

(a): It is assumed that 90% of all cattle are in tick worry areas, and 90% of the herd is at risk from Anaplasma and Babesia
(b): Anaplasma and Babesia incidence are author estimates
(c): Tick worry is not assumed to cause death in affected cattle. Anaplasma and Babesia case fatality estimates are author estiames. Background information about the incidence of B.bovis in Australia can be derived from Ramsay (1997). Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases (Mahoney and Ross 1972). Anaplasma and Babesia case fatality in indigenous stock is assumed to be half that of exotic stock
(d): Mortality is outlined for cattle in disease risk areas.

The morbidity losses in disease affected cattle are provided in Table 3. Meat losses for the small-meat system are described in the table. By multiplying the per head losses by assumed rates of incidence, the physical losses associated with each disease are estimated. It should be noted, however, that meat loss is only estimated for cattle that are slaughtered.

Table 3: Production losses in tick-borne disease-affected cattle

	Tick Worry		*Anaplasma and Babesia*	
	Adult	Immature	Adult	Immature
Small-scale meat (indigenous)				
Liveweight loss (kg) [(a)]	5	3	0	0

(a): Liveweight losses for tick worry in indigenous cattle are author estimates (2%). Background information on tick worry can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval et al 1997a, b, c). Anaplasmosis and Babesiosis live weight losses are assumed to be negligible and are not included in the costing framework.

The physical losses associated with each of the tick diseases are provided in Table 4. It is evident that the only production losses assumed to occur are associated with reduced cattle live weight and mortality. This is because the dairy sector has been excluded from the study and milk is not derived from cows in the small beef sector.

Table 4: Physical tick production losses in Philippines

Disease	**Tick Worry**	***Anaplasma and Babesia***
Small-scale meat (indigenous)		
Adult mortality (head) [(a)]	0	1,620
Immature mortality (head) [(a)]	0	1,080
Liveweight (tonnes) [(b)]	54	0

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.
(b): Liveweight losses are only realised for cattle that are slaughtered.

The economic losses associated with each of the diseases are illustrated in Table 5. No acaricide or vaccine costs are included in the analysis, as use of these products to suppress the production losses associated with these diseases is limited. The use of vaccines to treat cattle shipped to the Philippines occurs primarily in Australia. Of the production losses, mortality is the most significant. Live weight losses are estimated to be minor.

Table 5: Annual cost of tick and associated disease losses in the Philippines

Disease	Tick Worry	*Anaplasma* and *Babesia*
Control ($m) [(a)]		
Acaricide	0	0
Production Losses ($m)		
Mortality [(b)]		0.6
Immature mortality [(b)]	0.0	
Combined cost and loss ($m)	**0.0**	**0.6**

(a): Acaricide use is limited in the Philippines and is assumed to be negligible.
(b): It is assumed that indigenous adult and immature cattle values of $250 and $150 per head, and meat $0.7 kg liveweight.

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Thailand

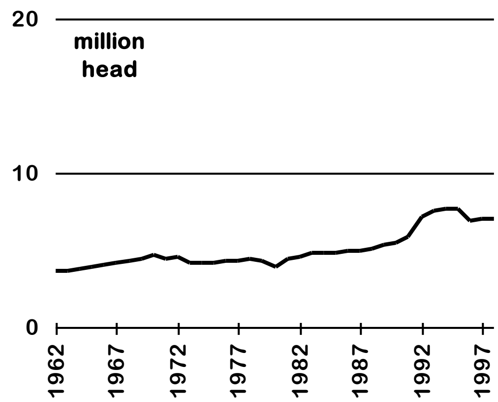

Figure 1: Size of national cattle herd

Cattle have been traditionally raised in Thailand for draught and crop producing activities. Draught animals are frequently used for land preparation and manure output is incorporated as organic fertiliser. In the past, beef was commonly derived from cast for age farm animals. Khajarern and Khajarern (1989) estimated that a Thai family receives one-fifth of their income from livestock products and the remaining four-fifths from crop-related activities. It has been estimated that families frequently hold one head of cattle which is used for 130 days of draught animal power per annum. (Panayotou 1985, referenced in Murphy and Tisdell 1995).

With the rise in economic prosperity of Thailand there has been increased demand for beef. Increases in the size of the tourism industry have also resulted in a greater demand for milk and meat products. The increase in real prices for cattle products has underpinned the increased size of the Thai cattle herd (Murphy and Tisdell 1995). In conjunction with the increase in herd size, there is less dependence on cattle as a source of draught power. The introduction of irrigation and double cropping has facilitated an increase in the use of farm mechanisation. The buffalo herd has decreased as a result of this trend toward increased farm mechanisation and also from greater demand for cattle products. In 1983 it was estimated that there were 6.5m buffalo in Thailand which decreased to 4.8m in 1992 (Office of Agricultural Economics 1993).

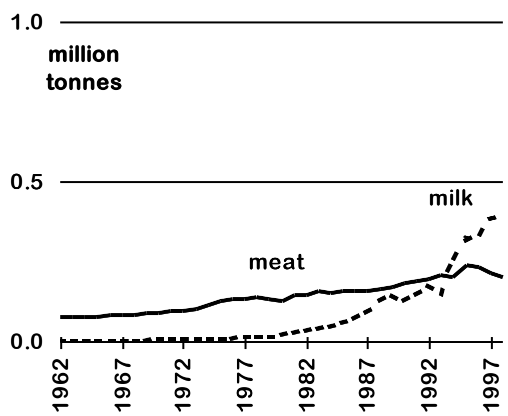

Figure 2: National production

Growth in meat and milk production is evident in the adjoining figure. The dairy herd has increased in response to increased milk consumption. Dairy cattle numbers have risen from 13,700 head in 1982 to approximately 70,000 cattle in 1990. Much of the dairy herd is concentrated in the provinces of Chiang Mai, Nakhon Pathom, Ratchaburi and Saraburi (Kehren and Tisdell 1997). Given that the total number of cattle in Thailand during 1997 was estimated to be seven million (FAO 1998), the dairy or small-commercial herd is estimated to represent approximately 1% of all cattle in Thailand. Exotic cattle breeds have been introduced to increase the productivity of dairy animals. These cattle are more susceptible to tick borne disease problems than the local cattle, which are native and Brahman cross-breeds. With continued income growth in Thailand and larger numbers of tourists visiting the country there is likely to be greater demand for milk products and increased dairy productivity in the future.

Table 1: Cattle productivity and production of milk and meat in Thailand

Livestock system	Small-scale meat (indigenous)	Small-scale dairy (commercial)	Total
Cattle at year end (million head) [(a)]	6.9	0.07	7.0
Adult cattle at year end (m head) [(b)]	4.2	0.04	4.2
Immatures at year end (m head) [(c)]	2.7	0.03	2.7
Liveweight of adult cattle (kg) [(d)]	250	450	-
Liveweight of immature cattle (kg) [(d)]	150	250	-
Milk production (kg/cow/year) [(e)]	-	2,544	-

(a): It is assumed that 1% of the national herd is comprised of exotic cattle.
(b): It is assumed that 60% of the herd is comprised of adult cattle.
(c): The number of immature cattle is derived by subtracting adult cattle estimates from total cattle populations in each system.
(d): Liveweights are author assumptions.
(e): A commercial dairy yield of 2,544 kg per year is assumed.

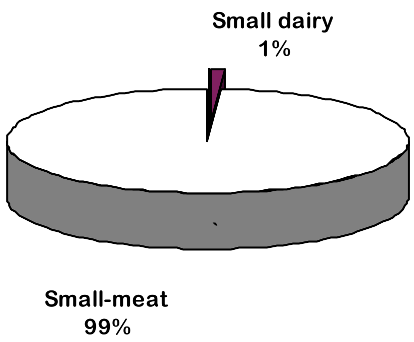

Figure 3: Contribution of systems to herd

Productivity levels are lower than that in many temperate countries. Kehren and Tisdell (1997) indicated that Thai dairy cattle produce 9-10L per day as opposed to Swedish cattle that produce 17-18 L/day. The effects of hot weather, disease and inadequate nutrition constrain dairy production in this country. The contribution of small-scale meat and the dairy based small-scale commercial livestock sector are illustrated in the adjoining figure. It is evident that small-scale commercial enterprises comprise only a small proportion of total cattle production in Thailand, but is likely to grow in significance over the medium to long term.

Tick and associated diseases

The diseases *Anaplasmosis* and *Babesiosis* are found in Thailand. The tick species *Boophilus microplus* is found throughout the country and the potential distribution of this tick species is provided in the figure below. The actual presence of this species in all of the areas containing red markers needs to be confirmed by scientific survey and studies.

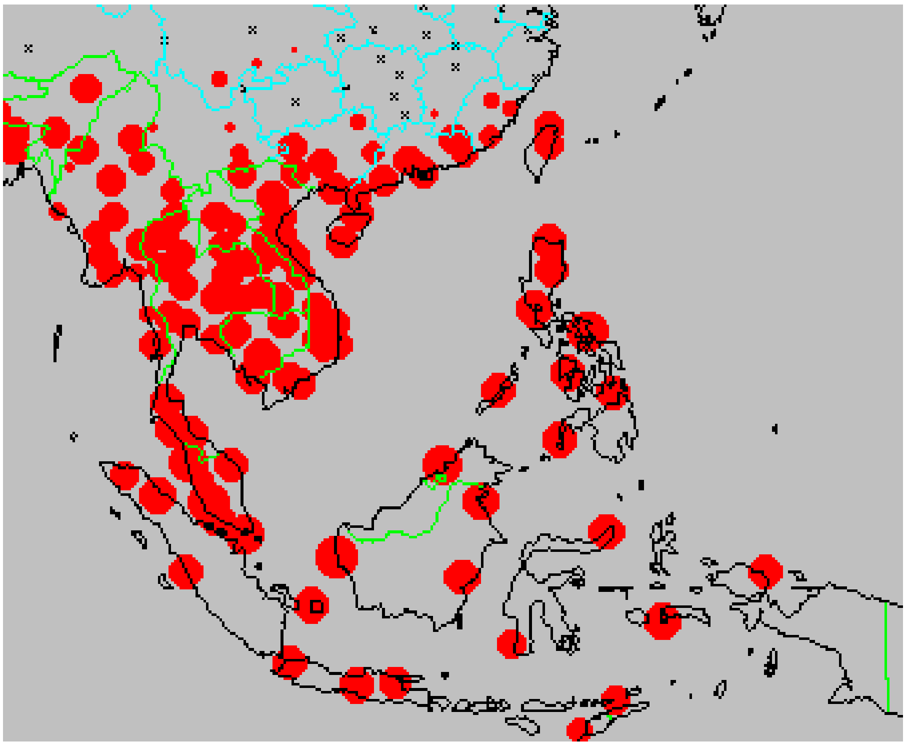

Figure 4: Potential distribution of *B.microplus* in SE Asia (Source Maywald and Sutherst 1985)

Tick worry, anaplasma and babesia incidence assumptions are outlined for both the small-scale beef and small-scale commercial livestock systems in Table 2.

Table 2: Incidence of tick-borne diseases in Thailand

	Tick Worry		*Anaplasma and Babesia*	
	Adult	Immature	Adult	Immature
Small-scale meat (indigenous)				
Herd in endemic areas (%) [(a)]	90	90	90	90
Disease incidence (%) [(b)]	15	15	2.5	5
Case fatality (%) [(c)]	0	0	5	2.5
Mortality (%)	0	0	0.1	0.1
Small-scale dairy				
Herd in endemic areas (%) [(a)]	90	90	90	90
Disease incidence (%) [(d)]	15	15	5	10
Case fatality (%)	0	0	10	5
Mortality (%)	0	0	0.5	0.5

(a): It is assumed that 90% of all cattle are in tick worry areas, and 90% of the herd is at risk from Anaplasmosis and Babesiosis.
(b): Anaplasmosis and Babesiosis incidence are author estimates, along with tick worry incidence.
(c): Anaplasmosis and Babesiosis case fatality estimates are author assumptions. Background information on these diseases can be derived from Ramsay (1997) *B. bovis* case fatality estimates. Case fatality is lower for immature animals as cattle within this stock class are less susceptible to the affects of these diseases (Mahoney and Ross 1972). Anaplasmosis and Babesiosis case fatality in indigenous stock is assumed to be half that of exotic stock
(d): Mortality is outlined for cattle in disease risk areas. The level of Anaplasma and Babesia related mortality outlined for the commercial herd in Thailand is similar to that described for commercial cattle in the Anaplasma and Babesia endemic areas of South Africa (du Plessis *et al* 1994, Spickett and Fivaz 1992).

The morbidity losses in disease affected cattle are included Table 3. Meat and milk losses for the small meat and commercial sectors are described in the table. Meat loss is only estimated for cattle that are slaughtered and milk losses for dairy cows in the small-scale dairy production sector.

Table 3: Production losses in tick-borne disease-affected cattle

	Tick Worry		*Anaplasma and Babesia*	
	Adult	Immature	Adult	Immature
Small-scale meat (indigenous)				
Liveweight loss (kg/hd/yr) [(a)]	5	3	0	0
Small-scale commercial				
Liveweight loss (kg/hd/yr) [(a)]	23	13	0	0
Milk loss (kg/hd/yr) [(b)]	127	0	0	0

(a): Liveweight losses for tick worry in indigenous cattle are author estimates. Background information about tick-worry losses can be derived from studies in Africa where indigenous (Sanga type) cattle were challenged with *Amblyomma spp*. and *Rhipicephalus spp*. ticks (Norval et al 1997a, b, c). Tick worry liveweight losses in exotic cattle types are author estimates. Background information about tick-worry losses in commercial cattle can be derived from Little (1963), Sing *et al* (1983), Seebeck *et al* (1971) and Sutherst *et al* (1983) Anaplasma and Babesia live weight losses are assumed to be negligible and are not included in the costing framework.
(b): Milk losses as a result of tick worry are author estimates. Background information about tick-worry losses can be derived from Jonsson *et al* (1998) in exotic cattle and (Norval et al 1997a, b, c) for indigenous cattle. Anaplasmosis and Babesiosis milk losses are assumed to be negligible and are not included in the costing framework

The physical losses attributable to each of the diseases are outlined in Table 4. It is evident that losses associated with live weight are relatively small.

Table 4: Annual physical tick and tick-borne disease production losses in Thailand

Disease	**Tick Worry**	***Anaplasma and Babesia***
Small-scale meat (indigenous)		
Adult mortality (head) [(a)]	0	4,678
Immature mortality (head) [(a)]	0	3,119
Liveweight (tonnes) [(b)]	157	0
Small-scale commercial dairy		
Adult mortality (head) [(a)]	0	189
Immature mortality (head) [(a)]	0	126
Liveweight (tonnes) [(b)]	0	0
Milk loss (tonnes)	481	0

(a): Mortality losses are calculated using percentage mortality, herd affected and cattle at year end statistics.
(b): Liveweight losses are only realised for cattle that are slaughtered.

The economic losses and control costs associated with tick-borne diseases are outlined in Table 5. From the table, it is evident that chemical and vaccine use is non-significant. Some cattle entering the Thai dairy sector are treated with *Anaplasma* and *Babesia* vaccine. This cost is estimated to be very small and is not included in the study. The cost associated with grooming cattle to remove ticks is not included in the study as farmer labour is assumed to be a sunk cost.

Table 5: Annual tick and associated disease economic losses in Thailand ($US million)

Disease	**Tick Worry**	***Anaplasma* and *Babesia***
Control ($m) [(a)]		
Acaricide	0	0
Production Losses ($m)		
Mortality [(b)]	0	1.8
Milk production [(b)]	0.2	0
Liveweight [(b)]	0.1	0
Combined cost and loss ($m)	**0.3**	**1.8**

(a): Acaricide use is limited in Thailand and is assumed to be negligible.
(b): It is assumed that commercial adult and immature cattle have values of $US 600 and $250 per head, indigenous adult and immature cattle values of $250 and $150 per head, meat 0.7 kg liveweight and milk $0.33 per litre.

Costs associated with *Anaplasmosis* and *Babesiosis* mortality represent the most significant tick disease cost in Thailand. As previously mentioned, the physical losses of milk and meat are relatively minor due to the small size of the dairy herd and natural resistance of indigenous cattle to tick-borne diseases. *Anaplasmosis* and *Babesiosis* are estimated to cause significantly more losses than tick worry. A range of studies outlined in the livestock description section have found that live weight losses in indigenous cattle are relatively minor.

Disease Comparison

Only one economic study (Bartholomew and Culpitt 1992) relating to improved foot and mouth disease control in the provinces of Lampang, Lamphun and Changmai has been uncovered as part of research associated with this project. In the study, it is estimated that improved foot and mouth control would return 11.75 Bt for every Bt spent on project development (10% discount rate assumed).

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