Heartwater and the economics of livestock production on large scale commercial and smallholder farms in Zimbabwe

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Key words

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Summary

In order to assess the economic impact of heartwater (*Cowdria ruminantium* infection) and model the impact of improved vaccines against the disease, a field study was conducted to provide data on livestock productivity indicators in Zimbabwe. Cross-sectional studies were performed in the two main agro-ecological regions, lowveld and highveld, where heartwater was thought to be endemically stable and epidemic, respectively. These studies were designed to provide data on livestock productivity and profitability, and other key production indicators from the smallholder (SH) and large scale commercial (LSC) production systems, and from beef, dairy, sheep and goat enterprises. The results show that the profitability of LSC beef farms, as indicated by overall positive gross margins, was similar ($p > 0.05$) irrespective of location and whether or not heartwater cases were reported. Only LSC dairies that reported heartwater cases demonstrated a negative gross margin, though this was not significantly different from dairy farms that did not report heartwater, or from the beef farms. The highveld and lowveld SH areas, which were both assumed to be endemically stable for heartwater, displayed positive gross margins, though the margin was significantly ($p < 0.001$) higher in the highveld than in the lowveld. This study indicates that losses associated with heartwater are minimal under endemic stability and in epidemic areas where tick control is effectively implemented. Furthermore, the profitability of livestock production, in both the LSC and SH production sectors, could be increased if more cost effective methods of tick and tick-borne disease control (which is one of the major costs of production) are made available.

■ INTRODUCTION

Heartwater (*Cowdria ruminantium* infection), an economically important tick-borne disease of cattle, sheep and goats and *Amblyomma hebraeum*, the most widespread vector for the disease in Zimbabwe, were previously considered to be restricted to the southern lowveld of the country (15), where less effective tick control has resulted in the development of endemic stability for heartwater on many farms (16). Heartwater and its vectors have now become established in the highveld (16, 21, 22), which has become an epidemic, or "transitional", zone where infection is spreading. This spread is believed to threaten the viability of livestock enterprises due to the mortality and the high costs of control and treatment (3). Heartwater in Zimbabwe has historically been controlled through intensive application of acaricides to livestock in order to limit transmission of infection (15, 16). However the high cost of acaricides to farmers and the government (which provides a highly subsidized dipping service to smallholder farmers) has necessitated a re-assessment of the acaricide application policy and the consideration of alternative control strategies such as vaccination and the exploitation of endemic stability (8, 14, 19). The term "endemic stability" refers to a climax relationship between vector, host and pathogen, under which pathogen transmission rates and population immunity are high, widespread immunity prevails and clinical disease is minimal (15, 17, 20).

In order to study the epidemiology of the disease, its economic impact, and to model the potential costs and impact of alternative control measures (13, 18), accurate data were required on the

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effect of the disease under different epidemiological states (endemically stable and epidemic) on livestock productivity in different farming systems and agro-ecological zones of Zimbabwe. The results of studies to acquire such data are presented here.

■ MATERIALS AND METHODS

Design of field studies

Cross-sectional field studies were carried out to collect heartwater disease and livestock production data representing: (a) the major agro-ecological regions in Zimbabwe, lowveld and highveld where heartwater was believed to be endemically stable and epidemic, respectively; (b) the major livestock production systems, smallholder (SH) and large scale commercial (LSC) farms; (c) the major livestock products in the LSC sector, i.e. beef, dairy and small ruminants (sheep and goats). A detailed description of these regions and production systems has been reported previously (3).

Data collection

Field cross-sectional studies within the lowveld were carried out in selected representative areas of Insiza and West Nicholson districts of Matabeleland South Province, and Zvishavane district of Midlands Province. These areas were considered to be representative of farming systems in the endemically stable lowveld. Studies in the highveld were performed in Harare and Chikomba districts of Mashonaland East Province and in Chegutu district of Mashonaland West Province (figure 1), which were considered to be representative of production systems in the heartwater epidemic highveld zone. The selected SH and LSC areas are listed in table I. In the SH areas, farmers were selected for participation in the study from lists maintained by government district veterinary offices (DVOs). The farm lists were stratified on the basis of the dip tank they attended and a two-stage random sample of dip tanks and farms was made. In the lowveld LSC areas, 60 questionnaires were randomly distributed at farmers' union meetings. In the highveld, 40 LSC farms were purposively selected from lists of farms kept by the DVOs and the Commercial Farmers' Union. The selection criteria for LSC farms in the highveld included reported heartwater status, i.e. properties where heartwater had been reported and those which were reported to be free.

In the SH areas, farm interviews were conducted with the assistance of trained enumerators, using a pre-tested questionnaire. For the LSC farms, pre-study sensitization meetings were held with the local farmers' union on the objectives of the study. In the lowveld, LSC farmers filled-in the questionnaires independently, while in the highveld, interviews were conducted by the study investigators. In both the LSC highveld and the SH areas, the number of farms selected was dependent on logistical considerations, i.e. the practical maximum combination of study sites and farms that could be visited during the course of the study. The potential power of this sample design could not be estimated *a priori*, since little information concerning prevalence estimates and no information on distribution of management practices existed.

Data were collected at all sites on a set of key livestock production indicators. In the LSC farms, production indicators included livestock herd/flock size, livestock production levels such as milk yield, off-take rates, on-farm slaughters and calving rates, livestock inputs and costs, and other livestock output and prices. On SH farms, livestock production indicators included herd/flock

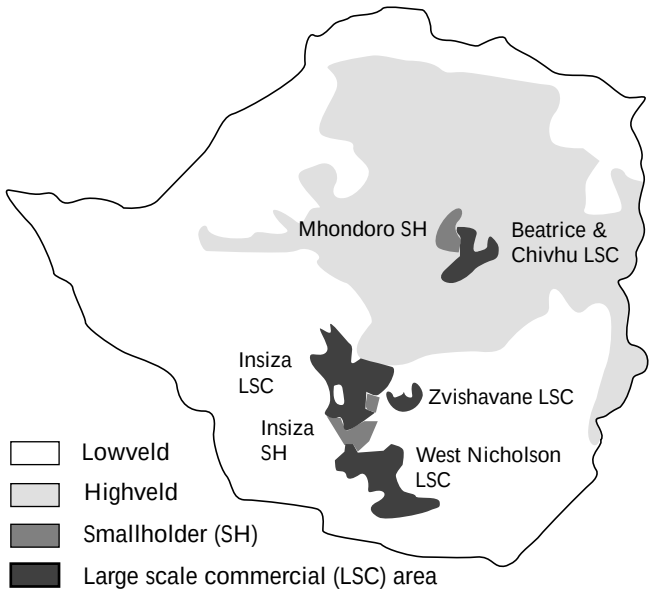

Figure 1: *Map of Zimbabwe showing the lowveld and highveld agro-ecological zones and the location of study sites for the survey on the economics of livestock production.*

size, livestock output which included milk yield, manure production, draft power, livestock sales and livestock inputs and costs and other output, such as hides. Data were also collected on heartwater control strategies and costs, total mortality (including heartwater) and suspected heartwater-specific mortality and morbidity. These have been reported elsewhere (3).

The data collected in all study sites was for the 1994-1995 agricultural season, which ran from September or October 1994 to the same months of 1995. The study in the lowveld was conducted between April and June 1995 in the SH system, and between August and December 1995 in the LSC system. The study in the highveld was carried out between November 1995 and June 1996 in the LSC system and during May and June 1996 in the SH system.

Data Analyses

The data were analyzed using the SPSS PC Release 5.0 (SPSS Inc., 1992). Owing to the frequent violation of the assumption of normality essential to most parametric statistics, distribution free non-parametric methods were employed in the analysis of continuous measures. The Kruskal-Wallis one-way analysis of variance was used to test for differences where more than two production systems were involved, while differences between two groups were analyzed using the Mann-Whitney U-test.

In both LSC and SH farms, gross margin analysis was performed. A gross margin is an indicator of the gross profitability and productivity of farm enterprises competing for farm or household resources. The gross margin was obtained by subtracting the total variable costs for each farm or household from gross output. The gross output or income was calculated from the total value of outputs sold and consumed by the farm or household (7). Livestock inputs, which included dips, veterinary drugs and medicines, feed, labour, and machinery operating costs, were aggregated to give the total variable costs of production of the livestock enterprise. The cost of inputs used in the analyses was the expenditure by farmers on various input items purchased or hired. In SH areas, labour hired to herd livestock was included in

the calculations, while in LSC farms, all labour is hired and was included. The output prices used were obtained from the value of output sold. In both SH and LSC farms, the resultant gross margin was divided by the number of animals owned or on the farm to give the gross margin in Z$[1] per head.

In both the LSC and SH areas, the farms were divided into various categories for this analysis. Firstly, farms were categorized on the basis of agro-ecological region (lowveld or highveld). Secondly, within the heartwater endemic lowveld, LSC farms were designated as reporting heartwater deaths (H farms) or not reporting heartwater deaths (NH farms) during the study period. In the heartwater transitional highveld region, LSC farms were grouped into properties where heartwater had been confirmed (H farms) and farms where heartwater had not been reported or confirmed (NH farms). Finally, LSC farms were also grouped on the basis of the major livestock products, i.e. beef, dairy, sheep and goats. Within the SH areas, households were grouped only on the basis of agro-ecological zone and livestock products, cattle, sheep and goats. Categorization on the basis of heartwater state was not done because of (a) inadequate disease knowledge and diagnostic facilities for identification of heartwater cases, and (b) a high degree of homogeneity between households in the intensity of tick-borne disease control, and thus probable disease state (3).

■ RESULTS

Study participation

In SH areas, a total of 250 lowveld and 60 highveld households were successfully interviewed by enumerators (table I). In lowveld SH study areas, a total of 288 households were selected initially from stock registers, which are updated twice annually. Data collection began 3-4 months after selection and some selected households (13%) could not be found, possibly because they had moved from the respective areas since the last register update. Such households were not replaced due to the high initial sample size selected. In the highveld SH study area, the target sample size was maintained at 60 households by selecting replacements from the sampling frame, if household were not found at the start of data collection. Forty seven percent of the initial sample in the SH highveld had to be replaced.

In the LSC sector, 13 fully completed questionnaires were received from farmers in the lowveld (22% response rate) and 35 (88% response rate) highveld LSC farmers were successfully interviewed by the study investigators.

Cattle herd composition

Cattle were the main livestock enterprise on all lowveld and highveld LSC and SH study farms. In the LSC sector, the proportion of mature cows in herds differed between production systems ($p = 0.02$), 37% on lowveld beef farms, 45% on highveld beef farms and 52% on highveld dairies (table II). In SH areas, cows comprised 38% of lowveld herds, compared to 27% in highveld herds ($p < 0.001$), while oxen comprised 13% in the lowveld compared to 30% in the highveld ($p < 0.001$). The results of the proportion of other cattle types are given in table II.

Economic performance of enterprises

Large scale commercial cattle

Tables III and IV provide the values of livestock production indicators estimated on the lowveld and highveld LSC beef farms. Cattle sales and slaughters were the main outputs from the farms. The off-take rate, defined as the percentage of the herd sold, was similar ($p = 0.32$) on lowveld H (13.8%) and NH farms (13.5%). The off-take rates on highveld H (23%) and NH beef farms (25%) were similar, and significantly ($p = 0.02$) higher than in the lowveld. On-farm slaughter (0.4%) and cattle purchases (approximately 1%, $p = 0.58$) were similar in the lowveld and in the highveld, irrespective of reported heartwater status. The gross

1. Exchange in 1995 was approximately Z$ 10 = US$ 1

Table I

The design of cross-sectional field economics studies

Agro-ecological region	Production system	Sample size	Total farms completed
Highveld			
	Smallholder		
	Mhondoro Communal Land	60	60
	Large Scale Commercial (LSC)		
	Beatrice-Chivhu LSC area		
	- Beef	28	25
	- Dairy	12	10
	Total LSC	40	35
Lowveld			
	Smallholder		
	Insiza Communal Land	104	85
	Godhwayo Communal Land	104	86
	Nkankezi Resettlement farms	40	40
	Godhwayo Small Scale Commercial farms	40	39
	Total smallholder	288	250
	Large Scale Commercial		
	Insiza-Zvishavane-West Nicholson LSC areas		
	- Beef	60	13

Table II

Cattle herd composition (%) on large-scale commercial and smallholder farms in the lowveld and highveld, Zimbabwe, 1995

	Large scale commercial farms			Smallholder farms	
Agro-ecological region	**Lowveld**	**Highveld**		**Lowveld**	**Highveld**
Production system	**Beef**	**Beef**	**Dairy**	**Mixed**	**Mixed**
Age group	**herd (%)**				
Bulls	2	2	2	2	8
Cows	37	45	52	38	27
Heifers	19	17	25	16	16
Steers	22	17	0.2	10	10
Male Calves	12	13	10	10	4
Female Calves	12	12	14	10	6
Oxen	0	0	0	13	30

Table III

Production parameters of lowveld LSC cattle producing farms Zimbabwe, 1995

Heartwater state	**Reporting heartwater deaths**	**Not reporting heartwater deaths**
Number of responding farms	n = 7	n = 6
Mean farm size (ha)	29708 (50441)*	2514 (1476)
Mean number of cattle	4402 (7768)	693 (764)
Calving rate (%)	66	55
Sales		
No. of farms selling	n = 7	n = 6
Mean number sold	608 (934)	93 (101)
Mean sale price (Z$**/head)	2579 (904)	2764 (473)
Herd sold (%)	13.81	13.46
On-farm slaughters		
No. of farms slaughtering	n = 3	n = 0
Mean number slaughtered	28 (26)	0
Mean slaughter value (Z$/head)	2340 (550)	0
Herd slaughtered (%)	0.28	0
Purchases		
No. of farms purchasing	n = 5	n = 1
Mean number purchased	11 (6)	6
Mean purchase price (Z$/head)	5465 (2088)	n.r.***
Herd purchased (%)	0.18	0.14
Total input and output		
Total variable costs (Z$/head)	326 (283)	203 (170)
Total dipping as % of total variable costs	9.29	15.35
Gross output (Z$/head)	423 (235)	260 (276)
Gross margin (Z$/head)	97 (268)	57 (259)

* Numbers in brackets are the standard deviations

** Exchange in 1995 was approximately Z$ 10 = US$ 1

*** Not reported in the questionnaire

margins on lowveld H and NH beef farms were Z$ 97 and Z$ 57/head (range: -Z$ 236 to +Z$ 460), respectively (p = 1.0). The gross output on lowveld H farms was Z$ 423/head compared to Z$ 260/head on NH farms (p = 0.25), and the total variable costs were Z$ 326/head and Z$ 203/head, respectively (p = 0.25). The large difference in the output and costs reported could probably be due to under or over-reporting by some farmers. The cost of dipping cattle constituted approximately 15% and 9% of these costs on lowveld H and NH farms, respectively (p = 0.12). In the highveld the gross margin of H beef farms (Z$ 367/head) was not significantly different (p = 0.50, range: -Z$ 614 to +Z$ 1,682) from that of NH beef farms (Z$ 561/head), and this profitability was not higher than in the lowveld (p = 0.05). The cost of dipping on highveld H and NH farms constituted approximately 12% and 10% of these costs, respectively (p = 0.20), which was similar to the costs in the lowveld (p = 0.06).

There were no lowveld LSC dairy farms in this study. On the highveld LSC dairy farms, cows in milk constituted 40% of the herd (table IV). The bulk of the milk produced was sold off-farm. With the exception of total dipping costs, all production indicators reported were similar on H and NH dairy farms (p > 0.05). As a proportion of total variable costs, dipping costs were higher (p = 0.02) on H (2.9%) than on NH (1.6%) dairy farms.

The gross profitability, as shown by the gross margin, was Z$ 1,505/head on NH dairy farms, but was negative on H dairies, an indication that costs were higher than the income realized. The proportion of variable costs spent on dipping on H dairies were significantly (p < 0.001) greater than on lowveld and highveld beef farms.

Table IV

Production parameters of highveld LSC cattle producing farms
Zimbabwe, 1995

Production system	**Beef**		**Dairy**	
Heartwater state	**Heartwater farms**	**Non-heartwater**	**Heartwater farms**	**Non-heartwater**
Number of responding farms	n = 20	n = 5	n = 4	n = 6
Mean farm size (ha)	1729 (940)	1129 (229)	1737 (811)	933 (431)
Mean number of cattle	517 (298)	431 (77)	647 (353)	429 (204)
Milk Production				
Mean number of cows in milk	-	-	253 (135)	179 (79)
Mean lactation period (days)	-	-	287 (40)	271 (34)
Mean milk produced/cow/year (litres)	-	-	4306 (528)	4474 (821)
Mean milk sold/cow/year (litres)	-	-	3782 (982)	3388 (796)
Price of milk sold (Z$/litres)	-	-	1.71 (0.21)	1.88 (0.12)
Calving rate (%)	72	77	91	79
Sales				
No. of farms selling	n = 20	n = 5	n = 2	n = 5
Mean number sold	124 (79)	106 (48)	19 (16)	87 (52)
Herd sold (%)	22.8	24.5	1.43	16.87
Mean sale price (Z$/head)	2909 (701)	3609 (435)	2800 (283)	2067 (609)
On-farm slaughters				
No. of farms slaughtering	n = 14	n = 3	n = 3	n = 5
Mean number slaughtered	7 (10)	3 (1)	35 (58)	5 (3)
Herd slaughtered (%): mean	0.96	0.37	4.02	1.05
Mean slaughter value (Z$/head)	2857 (580)	2452 (1091)	2460 (598)	2570 (328)
Purchases				
No. of farms purchasing	n = 10	n = 4	n =0	n = 0
Mean number purchased	30 (66)	18 (22)	0	0
Herd purchased (%): mean	2.9	3.3	0	0
Mean purchase price (Z$/head)	5726 (2701)	7357 (3555)	0	0
Total input and output				
Total variable costs (Z$/head)	393 (314)	316 (180)	4198 (3126)	2461 (982)
Total dipping as % of total variable costs	9.8	11.9	2.9	1.6
Gross output (Z$/head)	760 (514)	877 (445)	3770 (1955)	3966 (906)
Gross margin (Z$/head)	367 (577)	561 (540)	-428 (4548)	1505 (652)

Large scale commercial sheep and goats

Sheep and goats were kept by few LSC farms in both the lowveld (n = 4) and highveld (n = 12) (table V). The average number of sheep on LSC farms was significantly (p = 0.04) higher in the lowveld (245) than in the highveld (95). One farmer in the lowveld sold 5% of the flock while four farmers in the highveld sold an average of 32% of the flock. Three farmers in the lowveld slaughtered an average of 26% of the flock compared to five farmers in the highveld who slaughtered an average of 9% of the flock. Prices realized from sheep sales in the highveld (Z$ 513/head) were more than three times the prices realized from sheep sales in the lowveld (Z$ 166/head). However, despite this, the estimated gross margin was similar (p = 0.31) in the lowveld (Z$ 10) and the highveld (Z$ 9).

None of the lowveld study farms kept goats. The average number of goats reported by the four highveld farms with goats was 129 (table V). Three farms reported goat sales of an average of 28.4% of the flock per year, while two farms reported on-farm slaughters of 5.8% per year. Only one farm reported selling goat skins, and one farm reported goat purchases. The overall performance of LSC goats was estimated to be Z$ 41/head.

Smallholder cattle

Owing to the lack of knowledge of livestock diseases among the respondents in SH areas, the results are not reported by heartwater state. Rather, the results are reported in terms of different agro-ecological zones, lowveld and highveld. Table VI gives a summary of some of the production indicators of lowveld and highveld SH farms. Smallholder farms produce many products from the cattle enterprise, which include milk, manure, hides, draft power and sales of live animals. Milk production was lower (p < 0.001) in the lowveld (112 litres/year) than in the highveld (217 litres/year). Milk production refers to the amount of milk available to the household. The amount of milk sucked by the calf was not estimated in this study. A greater proportion of the milk produced was sold in the lowveld (7.9%) than in the highveld (3.3%) (p = 0.04). The average price was, however, higher in the highveld than in the lowveld (p < 0.001). For manure production, an average ox-drawn cart (size, 180 cm x 110 cm x 40 cm) was estimated to carry 320 kg of dry manure, and this was used to estimate quantity of manure produced by all livestock. The average dry manure per head produced by cattle per year was 691 kg in the lowveld compared to 371 kg in the highveld (p = 0.03). Traction output (draft power) was estimated as the amount of land cultivated per animal per year. This was estimated to be 1.47 ha in the highveld and 2.95 ha in the lowveld (p < 0.001). Hides or skins from livestock found dead or slaughtered were either used by the household or sold. Sale of skins were reported in both the lowveld and highveld and average prices were Z$ 32 and Z$ 26, respectively.

The off-take rate (defined as the percentage of the herd sold) for cattle was slightly, though significantly (p = 0.02), higher (3.9%) in highveld SH areas than in the lowveld (3.2%). Overall, the economic performance was positive in SH areas, and the gross margin was significantly (p < 0.001) higher in the highveld (Z$ 348/head) than in the lowveld (Z$ 102/head).

Smallholder sheep and goats

Goats were kept by 87% of SH households in the lowveld and by 52% of households in the highveld (table VII). The average number of goats was significantly (p < 0.001) higher in the lowveld (13/household) than in the highveld (5/household). The contribution of goats to the SH households include meat, cash income from sales, milk, manure and skins. The average proportion of the flock consumed was approximately 14% in the lowveld and 16% in the highveld (p = 0.89). Goat milk production and utilization was reported only in the lowveld (89 litres/head/year) and this was all utilized by the households. Approximately 5% and 12% of the flock were sold in the lowveld and highveld, respectively (p = 0.01). Most skins were used by the household and few were sold. Goat manure was produced in both the lowveld and highveld, 156 kg/head and 28 kg/head, respectively (p < 0.001), and most of this (100% in the highveld and 80% in the lowveld) was used by the households. Overall, the gross margin in SH goats was positive, Z$ 40/head in the lowveld and Z$ 44/head in the highveld, respectively (p = 0.63).

Table V

Production parameters of LSC sheep and goat producing farms, Zimbabwe, 1995

Agro-ecological region	Lowveld	Highveld		Lowveld	Highveld
Sheep			**Goats**		
No. of farms with sheep	n = 4	n = 8	No. of farms with goats	n = 0	n = 4
Mean farm size (ha)	13703 (18020)	1964 (1080)	Mean farm size (ha)	-	1180 (686)
Mean number of sheep	245 (122)	95 (81)	Mean number of goats on farm	-	129 (90)
Sheep sales			Goat sales		
No. of farms selling	n = 1	n = 4	No. of farms selling	-	n = 3
Mean sale price (Z$/head)	166	513 (202)	Mean sale price (Z$/head)	-	293 (179)
Flock sold (%)	5.42	32.24	Flock sold (%)	-	28.4
Sheep slaughters and purchases			Goat slaughters and purchases		
No. of farms slaughtering	n = 3	n = 5	No. of farms slaughtering	-	n = 2
Flock slaughtered (%)	25.77	8.52	Flock slaughtered (%)	-	5.8
Flock purchased (%)	0	0.13	Flock purchased (%)	-	0.13
Sheep total input and output			Goat input and output		
Total variable costs (Z$/head)	45 (16)	144 (119)	Total variable costs (Z$/head)	-	69 (50)
Gross output (Z$/head)	55 (39)	152 (159)	Gross output (Z$/head)	-	110 (73)
Gross margin (Z$/head)	10 (30)	8 (77)	Gross margin (Z$/head)	-	41 (50)

Table VI

Production parameters of cattle owning smallholder households, Zimbabwe, 1995

Agro-ecological region	Lowveld	Highveld
Number of cattle owners	n = 217	n = 60
Mean number of cattle owned	9 (10)	10 (8)
Milk production		
No. of hhs* milking	n = 186	n = 49
Mean number of cows milked	2 (1)	3 (2)
Milk production/cow/year (litre)	112 (176)	217 (170)
Total milk sold/cow/year	2 (11)	5 (20)
Price of milk/litre (Z$)	1.75 (0.7)	4.22 (1.02)
Manure production		
No. of hhs reporting manure production	n = 114	n = 53
Manure produced/year (kg/head)	691 (1215)	371 (443)
No. of hhs selling manure	n = 29	n = 3
Total manure sold/year (kg/head)	174 (203)	41 (11)
Price of manure/kg (Z$)	0.06 (0.03)	0.13 (0.11)
Traction output/animal/year (ha)	2.95 (3.2)	1.47 (0.59)
Hides		
No. of hhs reporting hides	n = 24	n = 19
No. of hides home used	1 (0.4)	2 (0.8)
No. of hhs selling hides	n = 23	n = 14
No. of hides sold	2 (1.4)	2 (1.1)
Price/hide (Z$)	32 (22)	26 (18)
Sales		
No. of hhs selling	n = 37	n = 17
Mean number sold	2 (2)	1 (1)
Mean sale price (Z$/head)	2004 (1087)	1316 (443)
Herd sold (%)	3.23	3.87
Purchases		
No. of hhs purchasing	n = 20	n = 6
Mean number purchased	2 (1)	2 (2)
Mean purchase price (Z$/head)	1810 (1070)	1367 (273)
Herd purchased (%)	2.15	1.61
Consumed		
No. of hhs consuming	n = 16	n = 23
Mean number consumed	1 (0.3)	1 (0.8)
Herd consumed (%)	0.89	5.16
Total input and output		
Total variable costs (Z$/head)	113 (507)	61 (131)
Gross output (Z$/head)	215 (350)	409 (292)
Gross margin (Z$/head)	102 (600)	348 (312)

* Households

Sheep were reared by 19% of households in the lowveld and by 3% of households in the highveld. The average number of sheep in both the lowveld and highveld was similar, 9 per household (table VIII). Like goats, the contribution of sheep to output included meat, cash income from sales, manure and skins. An average of 3% of each sheep flock was sold by nine of the 47 sheep-rearing households in the lowveld, while neither of the two sheep-rearing households in the highveld reported any sales. Approximately 10% and 18% of each flock was consumed by the household in the lowveld and highveld, respectively ($p = 0.17$). Production of sheep manure was reported by very few farmers in both the highveld (2) and lowveld (18) and production amounted to 48 kg/head/year and 209 kg/head/year, respectively. Lowveld SH households sold approximately 9% of their sheep manure at an average price of 2 cts/kg. The overall performance of sheep in SH areas, as estimated by the calculated gross margin, was Z$ 2/head in the lowveld and Z$ 37/head in the highveld ($p = 0.06$).

Table VII

Production parameters of goat owning smallholder households, Zimbabwe, 1995

Agro-ecological region	Lowveld	Highveld
No. of goat owners	n = 218	n = 31
Mean number of goats owned	13 (11)	5 (3)
Milk production		
No. of hhs rep. milk production	n = 28	n = 0
Mean number of goats milked	7 (5)	0
Total milk produced/head/year (all home used) (litres)	89 (101)	0
Manure production		
No. of hhs producing manure	n = 100	n = 23
Total manure produced (k/head)	156 (211)	28 (25)
No. of hhs selling manure	n = 17	n = 0
Mean manure sold (kg/head)	31 (119)	0
Price of manure/kg (Z$)	0.04 (0.03)	0
Skins		
No. of hhs reporting skins	n = 128	n = 16
Mean number home used	2 (2)	2 (1)
No. of hhs selling skins	n = 26	n = 2
Mean number of skins sold	2 (1)	1 (0)
Mean sale price/skin (Z$)	7 (9)	3 (0)
Sales		
No. of hhs selling	n = 64	n = 15
Mean number sold	2 (1)	1 (1)
Flock sold (%)	4.8	12.4
Mean sale price (Z$/head)	122 (46)	140 (30)
Purchases		
No. of hhs purchasing	n = 31	n = 5
Mean number purchased	3 (2)	2 (1)
Flock purchased (%)	2.8	5.9
Consumed		
No. of hhs consuming	n = 144	n = 18
Mean number consumed	3 (2)	1 (1)
Flock consumed (%)	13.8	15.7
Total input and output		
Total variable costs (Z$/head)	15 (51)	17 (36)
Gross output (Z$/head)	55 (124)	60 (75)
Gross margin (Z$/head)	40 (113)	44 (91)

Table VIII

Production parameters of sheep owning smallholder households, Zimbabwe, 1995

Agro-ecological region	Lowveld	Highveld
No. of sheep owners	n = 47	n = 2
Mean number of sheep owned (SD)	9 (7)	9 (1)
Manure production		
No. of hhs producing manure	n = 18	n = 2
Total manure produced (kg/head)	209 (147)	48 (45)
No. of hhs selling manure	n = 1	n = 0
Total manure sold (kg/head)	18 (75)	0
Price of manure/kg (Z$)	0.02	0
Skins		
No. of hhs reporting skins	n = 18	n = 2
Mean number home used	2 (1)	2 (1)
No. of hhs selling skins	n = 3	n = 0
Mean number sold	3 (1)	0
Price/skin (Z$)	6 (3)	0
Sales		
No. of hhs selling	n = 9	n = 0
Mean number sold	2 (1)	0
Flock sold (%)	3.2	0
Mean sale price (Z$/head)	137 (83)	0
Purchases		
No. of hhs purchasing	n = 2	n = 0
Mean number purchased	4 (1)	0
Flock purchased (%)	1.8	0
Purchase price (Z$/head)	137 (83)	0
Consumed		
No. of hhs consuming	n = 20	n = 2
Mean number consumed	2 (1)	2 (1)
Flock consumed (%)	9.5	17.6
Total input and output		
Total variable costs (Z$/head)	10 (24)	1 (1)
Gross output (Z$/head)	12 (19)	38 (19)
Gross margin (Z$/head)	2 (32)	37 (18)

■ DISCUSSION

This study has used gross margin analysis to provide a comprehensive assessment of the economic productivity and profitability of the major livestock production systems in Zimbabwe. The study has also assessed how different broad categorizations of heartwater epidemiological states (endemically stable, epidemic, heartwater and non-heartwater) may influence the economic performance of livestock enterprises. Previous studies on the performance and productivity of SH and LSC production systems in Zimbabwe, respectively, have been performed by the Farm Management Research Section in the then Ministry of Lands, Agriculture and Water Development (12) (last Farm Management Report was for 1991-1992 season) and the Commercial Farmers' Union (4). This study is the first to attempt to include heartwater epidemiological state in assessing important livestock production indicators both within and between regions and production systems.

The herd composition in both the LSC and SH farms varied both within and between agro-ecological locations and production systems. The higher composition of breeding cows on the highveld LSC beef farms than in the lowveld was likely due to the trend towards intensive, high turn-over production with pen-feeding of weaners for sale at approximately 2 years of age (6). In the lowveld, production is less intensive and animals are finished and sold at 3.5 years of age. In highveld SH areas, oxen comprised a larger proportion of each herd than in the lowveld, partly due to the greater requirement for draft power for crop-growing in the highveld (5).

The results demonstrate that cattle enterprises in both the lowveld and highveld, and within the SH and LSC sectors, were productive and profitable, as shown by the overall positive gross margins estimated. Sheep and goat producing enterprises in both the SH and LSC sector also displayed positive overall gross margins. Overall, large scale commercial beef farms had similar performance in the lowveld heartwater endemically stable, and also in the highveld epidemic zone, respectively, irrespective of whether or not they reported heartwater during the study period. The gross margin on heartwater-reporting dairies, however, was negative, though not significantly different from that in the highveld beef and NH dairy farms. There were few differences in livestock indicators on all LSC farms. These included the apparently slightly higher calving rate on LSC dairy farms. This might be partly attributed to the use of artificial insemination by some dairy farmers. Additionally, cattle off-take rates were higher on highveld and lowveld beef farms than on highveld dairy farms, where cattle sales are usually confined to cull cows and male calves. The further higher off-take rate on highveld beef farms is partly because most of the animals reared are not finished on the farm, but are sold for subsequent pen fattening off-farm, mainly by crop producing farms (6). In the lowveld, cattle are reared and finished off on the farm. The similarity in production indicators on LSC farms, irrespective of heartwater state, suggests that minimal productivity losses are associated with endemic stability and that, within the epidemic zone, heartwater losses on outbreak farms have been limited by intensive control. The epidemic phase on most H farms in the highveld occurred prior to the start of this study and, the subsequent imposition of intensive control measures (dipping) would have resulted in few losses during the study period. As intensive acaricide use is common on most farms in the highveld due to the threat of other tick-borne diseases, i.e. anaplasmosis and babesiosis (*Anaplasma marginale* and *Babesia bigemina*, both transmitted by *Boophilus decoloratus*), and theileriosis (*Theileria parva* transmitted by *Rhipicephalus appendiculatus*), the impact of heartwater and its control on livestock productivity could not be fully established by comparison between the "heartwater" and "heartwater-free" farms in this region. The impact of heartwater control, costs and alternative strategies to control the disease in Zimbabwe has been reported (3, 13). Overall, the cost of heartwater which affects gross profitability of livestock includes the cost of tick control, mortality and morbidity. The impact of tick control and mortality losses were considered while morbidity was not estimated.

The lower profitability observed in dairies was not unexpected due to intensive nature of dairy production and the high susceptibility of exotic dairy breeds to diseases. In addition, dairies had high costs of tick and tick-borne disease control and were located within a heartwater transitional zone (16, 21, 22) where heartwater and other tick-borne diseases were a major threat. Dairy farms experiencing heartwater were likely to have intensified their tick control. This is supported by the observation that the proportion of total costs attributed to acaricides and other related dipping expenses, which is one of the major costs of production, was higher on H dairies than on NH dairies. Suspected heartwater losses due to morbidity and mortality have been reported elsewhere (3, 13).

In the LSC sector, sheep and goats were kept commercially and for on-farm consumption. A greater proportion of sheep on LSC farms were sold in highveld than in the lowveld, possibly due to the proximity of the major sheep abattoir, located on the outskirts of the capital city, Harare. The city also provides the major market and prices realized from sheep sales in the highveld (Z$ 513/head) were substantially greater than those realized from sales in the lowveld (Z$ 166/head). Like sheep, goats on LSC farms were kept for commercial purposes and for on-farm consumption. Four of the highveld LSC study farms and none of lowveld farms had kept goats, an indication that goats are a more important enterprise in the highveld.

In SH areas, profitability was significantly higher in the highveld than in the lowveld. Several reasons could be advanced for this difference. Firstly, due to proximity of major markets, higher prices could be realized for the sale of some of the livestock in the highveld (goat sale price: Z$ 140/head in the highveld compared to Z$ 122/head in the lowveld). Secondly, some of the livestock outputs, such as draft power and manure, which were included in the calculation of gross output to give the true economic value of livestock in SH production systems (23), had a higher value in the highveld than in the lowveld (price of cattle manure: Z$ 0.13/kg and Z$ 0.06/kg, respectively) due to the better potential for crop production in agro-ecological zones I-III (1). Lastly, SH farmers in the highveld experienced lower average costs of production than in the lowveld.

In SH areas, the economic value of cattle include the various functions of livestock (2, 23). The main livestock production output indicators measured included milk, manure, draft power, skins and hides. Milk was produced primarily for home consumption, with surplus sold to other local SH households. The amount of milk sold was significantly lower in the highveld than in the lowveld, however, higher milk prices were realized in the highveld (Z$ 4.22/kg and Z$ 1.75, respectively). Manure forms one of the most important inputs to crop production in SH systems (5). The amount of manure produced was significantly higher in the lowveld than in the highveld, and this can be attributed to several reasons, including the number of times cattle are penned at night and the length of grazing time (23).

The main source of income for the lowveld SH households is livestock sales due to the limited potential for crop production in the lowveld (2). In the highveld, a higher proportion of total household income is derived from the crop enterprises due to the higher crop production potential of this region. The high livestock sales and consumption figures reported in both the lowveld and highveld demonstrates that livestock provide a ready source of cash and protein.

In SH areas, goats and sheep were kept by more households in the lowveld than in the highveld. The contribution of small ruminants to the economy of SH households included cash income from sales, meat, manure, milk and skins. The outputs from these enterprises are supplementary and of relatively low importance compared to cattle. Goat milk production and utilization was only reported in the lowveld, possibly due to the higher average number of goats kept per household. Very few households kept sheep in the highveld, possibly because of the relative profitability of this species. The gross margin for sheep was generally lower than that reported for goats in both the lowveld and highveld.

There were several limitations to this study. Firstly, there are limitations associated with bias common to cross-sectional studies, such as recall, participation and selection biases. In addition, epidemiological distinctions between LSC farms reporting or not reporting heartwater were based on passively collected data and on farmer knowledge. Due to the difficulty of diagnosing heartwater in the field, particularly in the lowveld under extensive ranching conditions, cases may have gone unnoticed or have been misdiagnosed during the one year study period. However, in the absence of simple and reliable field tests for heartwater, there is little alternative to farmer diagnosis for assessing the disease. The results and heartwater states presented, therefore, give the farmers perception of the impact of the disease. There was also a poor response in the lowveld. The poor response in the lowveld may have been because questionnaires were distributed at a time when farmers were particularly sensitive to the release of financial data on their farms. In the lowveld, questionnaires were distributed randomly and it is likely that those farmers with a history of heartwater problems would have responded, as suggested in a previous cross-sectional survey of heartwater losses in Zimbabwe (11).

While this study attempted to assess livestock productivity on the basis of performance indicators based on costs and returns, there are several limitations that may arise in the use of such indicators. The limitations of costs and benefits analysis in livestock disease analysis have been reported (9, 10). The performance indicators are also influenced by other factors such as land tenure and management practices. In Zimbabwe, SH and LSC have distinct land tenure systems, communal and freehold, respectively. Management practices are highly advanced in the LSC compared to the SH areas. The results of the study should therefore be interpreted cautiously since not all factors could be considered in this study. Besides these limitations, the study has attempted to show the impact of epidemiological states and productivity of livestock enterprises in different regions and production systems in Zimbabwe.

In conclusion beef, sheep and goat enterprises overall were profitable in both the lowveld and highveld areas as shown by the positive estimated gross margins. The minimal differences observed in production indicators and profitability between farms irrespective of reported heartwater suggests that endemic stability was not associated with high production losses and that heartwater was intensively controlled within the epidemic highveld region. Nevertheless, the profitability of livestock production can be increased if more cost effective methods of tick control (which is one of the major costs of production), such as those based on endemic stability and immunization, are made available.

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Résumé

T. Chamboko, A.W. Mukhebi, C.J. O'Callaghan, T.F. Peter, R.L. Kruska, G.F. Medley, S.M. Mahan, B.D. Perry. La cowdriose et l'économie de la production animale dans les fermes commerciales et traditionnelles au Zimbabwe

Afin d'évaluer l'impact économique de la cowdriose (infection par *Cowdria ruminantium*) et de créer un modèle pour l'impact des vaccins améliorés contre cette maladie, une étude sur le terrain a été conduite pour fournir des données sur les indicateurs de productivité du bétail au Zimbabwe. Des études transversales ont été réalisées dans les deux principales régions agro-écologiques, *lowveld* et *highveld*, où la cowdriose est supposée être endémique stable et épidémique, respectivement. Ces études ont été conçues pour fournir des données sur la productivité et la rentabilité du bétail et des principaux indicateurs de production dans le secteur traditionnel et commercial (pour des entreprises productrices de viande bovine, de lait, d'ovins, de caprins). Les résultats prouvent que la rentabilité des fermes commerciales de viande bovine, comme l'indiquent les marges brutes globalement positives, était identique ($p > 0.05$), indépendamment de la présence et de la localisation de la cowdriose. Seules les fermes laitières commerciales qui ont enregistré des cas de cowdriose ont montré une marge brute négative, bien que ce ne soit pas sensiblement différent des exploitations laitières qui n'ont pas enregistré de cowdriose ou des fermes de viande bovine. Le secteur traditionnel dans les *highveld* et *lowveld* a affiché des marges brutes positives, bien que la marge ait été significativement ($p < 0.001$) plus élevée dans le *highveld* que dans le *lowveld*. Cette étude indique que les pertes associées à la cowdriose sont minimales lorsque la maladie est endémique stable ou épidémique avec un contrôle efficace des tiques. De plus, la rentabilité de la production animale, dans les secteurs commercial et traditionnel, pourrait être améliorée si des méthodes plus rentables pour le contrôle des tiques et des maladies transmises par les tiques (qui représentent un des principaux coûts de production) étaient disponibles.

Mots-clés : Bétail - Cowdriose - Economie - Productivité - Marge brute - Rentabilité - Performance - Zimbabwe.

Resumen

T. Chamboko, A.W. Mukhebi, C.J. O'Callaghan, T.F. Peter, R.L. Kruska, G.F. Medley, S.M. Mahan, B.D. Perry. La cowdriosis y la economía de la producción animal a gran escala comercial y en pequeñas fincas en Zimbabwe

Con el fin de asesorar el impacto económico de la cowdriosis (infección por *Cowdria ruminantium*) y de modelar el impacto de vacunas mejoradas contra la enfermedad, se condujo un trabajo de campo, cuyo fin fue de proveer datos sobre indicadores de la productividad animal en Zimbabwe. Se realizaron estudios cruzados en dos regiones agroecológicas principales *lowveld* y *highveld*, en donde la cowdriosis se consideraba endémicamente estable y epidémica, respectivamente. Estos estudios fueron diseñados para proveer datos sobre la productividad y la rentabilidad animal, así como indicadores clave de producción del pequeño productor (SH) y de los sistemas de producción comercial a gran escala (LSC), en establecimientos de carne, leche, ovinos y caprinos. Los resultados muestran que la rentabilidad de las fincas LSC de carne, como indican los márgenes brutos positivos, fueron similares ($p > 0.05$), independientemente de la localización y de la presencia o no de reportes de casos de cowdriosis. Solamente las lecherías LSC que reportaron casos de cowdriosis mostraron un margen bruto negativo, sin embargo éste no fue significativamente diferente de las lecherías que no reportaron cowdriosis o de las fincas de carne. Las SH en áreas de *highveld* y *lowveld* , ambas supuestamente endémicamente estables para cowdriosis, mostraron márgenes brutos positivos, aunque el margen fue significativamente ($p < 0,001$) más elevado en el *highveld* que en el *lowveld* . El presente estudio indica que las pérdidas asociadas con la cowdriosis fueron mínimas bajo condiciones endémicas estables y en áreas epidémicas en donde el control de la garrapata se implemento eficientemente. Aún más, la rentabilidad de la producción animal, tanto en sectores de producción SH como LSC, podría aumentarse mediante la implementación de métodos más eficientes de control de la garrapata y de enfermedades transmitidas por la garrapata (lo cuál representa uno de los mayores costos de producción).

Palabras clave: Ganado - Cowdriosis - Economía - Productividad - Beneficio bruto - Rentabilidad - Desempeño - Zimbabwe.