CENTRAL STATISTICAL AUTHORITY
Ministry of Finance and Economic Development
ETHIOPIA

LIVESTOCK AERIAL SURVEY IN THE SOMALI REGION

November 2003

ECOSYSTEMS CONSULTANTS
London and Nairobi

SAVE THE CHILDREN UK
Addis Ababa

February 2004

USAID Contract No 663-C-00-04-00401-00

1 Introduction

Livestock plays an important role in the economy of Ethiopia. Reliable statistical information on livestock numbers is essential to Government policy makers and other data users. Since 1980/81 the Central Statistical Authority (CSA) has been producing livestock estimates for the sedentary parts of the country based on annual agricultural sample surveys. Although pastoral areas contribute a significant portion of the livestock resources of the country, adequate statistical information is not available and no methodology was established to count the livestock in these areas.

In 2001/02 CSA conducted the first ever national agricultural census, of which a livestock census both in sedentary and pastoral areas of the country is a planned component. For Somali Region, the CSA decided to generate reliable figures of the livestock population (cattle, sheep, goats, camels, and equids) and their distribution by commissioning for the first time an aerial survey with financial support from USAID and the Ethiopian Government.

This report presents the results of the aerial survey of which took place in the period 5-23 November 2003.

2 The Survey Area

The designated survey area is made up of seven of the Somali Region's nine administrative zones as shown Fig.1, which have a combined area of some 242,000 km^2. Liben and Jijiga Zones were excluded, as they had been covered by conventional means.

Also excluded was a band 10km in width extending along all international borders, which was declared out of bounds for security reasons.

3 Approach and Methods

The survey was conducted according to a sampling method called the Systematic Reconnaissance Flight (usually known by its acronym, SRF), details of which may be found in Norton-Griffiths (1978). The present application required the survey area to be overlaid with a 10x10 km sampling frame or grid, as shown in Fig 2.

In order to cover such a large area within a reasonable time, three aircraft were deployed all of which were high-wing Cessnas. Details of these aircraft and their crews are given in Table 1, while the actual areas assigned to each are shown in Fig.2.

Table 1: Details of participating aircraft and crew

	5Y-AHZ	**5Y-BIH**	**5Y-ATS**
Type of aircraft	Cessna 206	Cessna 206	Cessna 182
Operational bases	Dire Dawa, Jijiga, Gode	Gode	Warder
Pilot	Dr R. Olivier	Capt. D. Seton	Capt. A. Lalani
FSO	Ato Melaku Begashaw	Ato Ayenew Legesse	Ato Tesfaye Gezahegn
RSO (L)	Mr C. Chelule	Mr H. Kamulla	Mr J. Wathuo
RSO (R)	Mr G. Muriuki	Mr B. Raburu	Mr P. Nguru

Figure 1

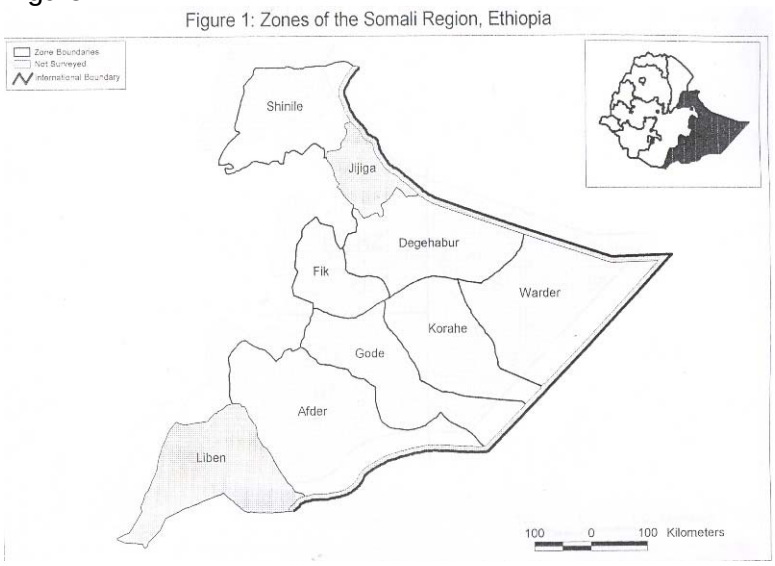
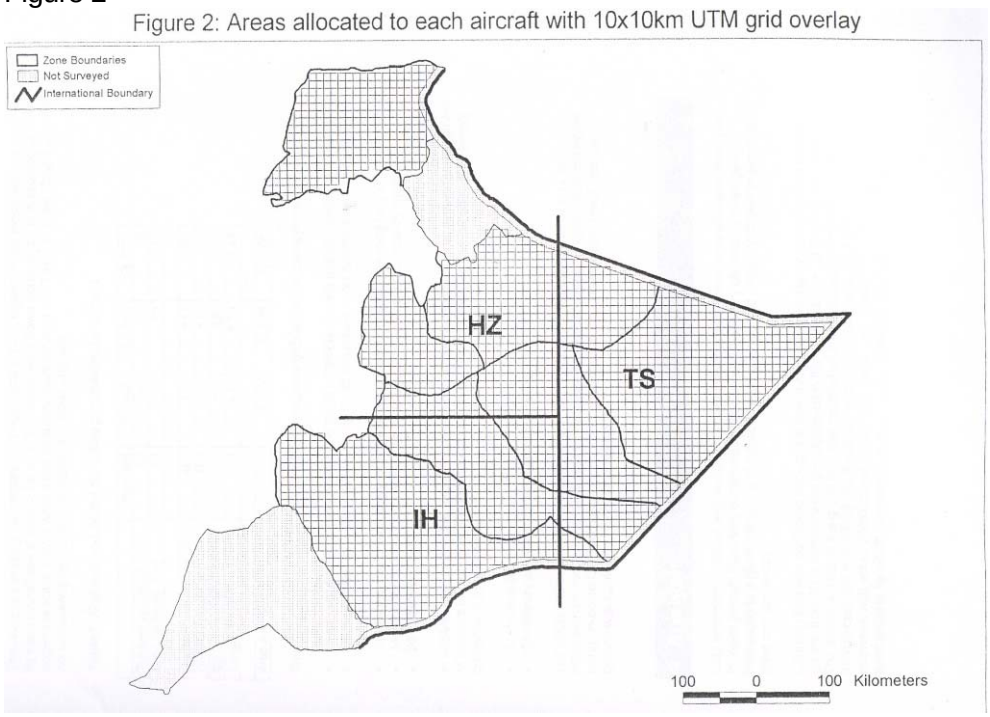


Figure 2



The nominal sampling parameters for the present survey, together with those actually attained by each aircraft are shown in Table 2. Transects were flown north-south at a spacing of 10km across the entire survey area, save for a mountainous area of 700km^2 in Afder Zone that could not be covered because of persistent low cloud and rain.

Table 2: Nominal and actual sampling parameters by aircraft

	Nominal	**5Y-AHZ**	**5Y-BIH**	**5Y-ATS**
Transect spacing (km)	10	10	10	10
Sub-Unit length (km)	10	10	10	10
Height above ground (ft)	400	316	411	386
Ground speed (kph)	160	170	177	185
Combined strip width (m)	300	347	329	348
Sample fraction (%)	3.00	3.47	3.29	3.48
Area surveyed (km^2)		74,500	86,200	80,800

The variables counted by the Rear Seat Observers (RSOs) in their sampling strips were:

- Livestock: Cattle, Shoats (sheep and goats), Camels, Equids (horses, asses and mules)
- Dams and birkas: a composite variable for all manmade water retention and storage devices
- Traditional roofs: structures roofed with thatch, mud or plastic sheeting (usually round)
- Modern roofs: structures roofed with tin sheets, tiles, cement etc (usually square)
- All wildlife species

In addition to recording the aircraft's height above ground at least once in every 10km segment of transect (or sub-unit), the Front Seat Observers (FSOs) recorded the following on a simple presence or absence basis:

- Surface water
- Temporary wells (hand-dug wells in river beds)

Transects and sub-units were defined, and data have been mapped, according to the internationally recognised UTM system. Position, direction and ground speed were controlled using on-board GPS navigation computers configured to the UTM system. Height above ground was controlled using radar altimeters.

4 Analysis

Data collection, collation and analysis involved the creation of three separate databases, one for each aircraft. Each was constructed in such a way that every observation was geo-referenced to a given transect and sub-unit, each of which had unique attributes in terms of zone and strip width.

Counting bias was controlled through the use of oblique photography. Groups of individuals greater than 10 in number were photographed in flight using 35mm, 200ASA colour slide film. The actual number in the group was later counted off the photograph using a binocular microscope, and was edited into the database for analytical purposes. By comparing visual estimates with actual photo counts, a correction factor was obtained for each observer and each variable for which comparable data sets were available. Because visual estimates of

small groups generally are under-estimates while those of large groups are over-estimates, counting bias is best determined and described through regression analysis (see Appendix 1). The various formulae obtained were applied as appropriate to all groups greater than 10 for which no usable photograph had been obtained (either because the observer "missed", or due to poor quality).

Following the photo-correction process, the three primary databases were separated and re-aggregated by Zone to give seven secondary databases. Because the strip width for each sub-unit was known, this allowed the correct sampling fraction to be calculated even where the zonal data had been collected by more than one aircraft.

Population estimates were derived from each zonal database using the Jolly II Method for unequal sized sample units (Jolly 1969). Following the notation of Caughley (1977) this estimates the population *Y* as *Y=AD* where *A* is the survey area and *D* is density. Density *D* is estimated as $D=\sum y / \sum a$ where *y* is the number of animals counted in *a*, the area sampled. The variance of *Y* is estimated as:

$$Var(Y)=N(N-n)\ \sum y^2+D^2\sum a^2-2D\sum ay\ /n(n-1)$$

where *N* is the total possible transects in the survey area and *n* the number of transects sampled. The standard error of *Y* is $SE(Y)=\sqrt{Var(Y)}$. The precision of *Y* may be expressed as the coefficient of variation (*CV*), which is calculated as $CV(Y)=SE(Y)/ Y$ which may be conveniently expressed as a percentage. Alternatively, precision may be indicated by calculating confidence limits for *Y* at a given degree of probability. The 95% CL of $(Y) = \pm t \times$ SE *(Y)*, where '*t*' = n-1 degrees of freedom. Student's *t*-values are obtained from tables.

In this method, a "sample unit" consists of all the individuals counted by both observers in a given transect. For any analytical stratum therefore, the number of samples equals the number of transects flown within it. The method converts the raw count to a density, based on the length and width of the observers' counting strip, its length being the same length as the transect, and its width dependent on the height above ground. The latter relationship was determined by calibration flights carried out by each aircraft before surveying commenced.

The relevant details for each reporting unit are given in Table 3 below

Table 3: Sampling parameters by analytical stratum

	Afder	**Degehabur**	**Fik**	**Gode**	**Korahe**	**Shinile**	**Warder**
Total area surveyed (km^2)	53,200	34,800	15,800	34,500	31,400	26,900	44,900
Aircraft involved	IH,TS	HZ,IH,TS	HZ	HZ,IH,TS	HZ,IH,TS	HZ	TS
Number of transects	43	31	17	39	27	23	34
Sample fraction (%)	3.37	3.38	3.70	3.32	3.34	3.42	3.49

5 Results

Detailed results are provided as seven Annexes to this report, each specific to a particular Zone as follows:

ZONE	ANNEX
Afder	1
Degehabur	2
Fik	3
Gode	4

ZONE	ANNEX
Korahe	5
Shinile	6
Warder	7

In each case estimates have been generated for the entire zone, including those parts not sampled, on the assumption that average species densities in the non-sampled parts of a zone equal, or at least do not differ significantly from, average densities in the sampled parts. The complete area of each zone was measured off its computer image using the GIS programme, *Arcview*.

The results given in the Annexes are in both tabular and mapped formats. The tables give the estimated population of each variable (Y), its Standard Error (SE) and Coefficent of Variation (CV), together with the upper and lower 95% Confidence Limits. The maps show either density distributions (for quantitative variables) or presence/absence (for qualitative variables).

Using the applicable ratios which the CSA has made available from its contemporary ground surveys, the zonal livestock data are further broken down by species (for shoats and equids), sex and age.

It is widely recognised that the Jolly II method returns very conservative estimates of precision. Despite this, there is a convincing body of evidence that the estimates obtained are relatively accurate. Any result with a CV equal to or less than 20% of the estimate would be considered good even from a 15% sample, let alone a 3% sample as in this survey. Confidence limits probably can most usefully be interpreted as an index of distribution pattern. Highly clumped distributions produce high CVs and wide confidence limits, and vice versa. Wildlife species that are extremely scarce or hard to see are always highly clumped. Such imprecise data are nonetheless useful in comparing different areas at the same time, or the same area at different times.

Summary tables for livestock and other major variables are provided in Tables 4 and 5 below:

Table 4: Summary of livestock estimates by Zone

	Afder	Degehabur	Fik	Gode	Korahe	Shinile	Warder
Cattle	166,471	51,536	17,072	165,277	26,301	207,472	36,146
Sheep	1,152,509	1,395,779	57,561	517,668	362,778	670,956	2,253,550
Goats	722,709	721,925	141,475	985,869	690,891	849,451	1,413,143
All sheep and goats	1,875,218	2,117,704	199,036	1,503,537	1,053,669	1,520,407	3,666,693
Camels	140,454	131,106	25,605	115,498	149,971	103,052	376,183
Horses	16	19	13	0	0	0	1
Asses	4,327	5,415	3,033	10,758	2,504	16,138	460
Mules	63	68	26	58	14	191	7
All equids	4,406	5,502	3,072	10,816	2,518	16,329	468
Livestock/dwelling ratio	41.0	50.9	21.7	51.4	85.8	49.0	199.3

Because the variable "traditional roof" can be equated with a pastoralist's dwelling, the ratio of total livestock to dwellings can be used an index of relative pastoral wealth and, by extension, of food security.

Table 5: Summary of estimates for dwellings, dams and birkas, and principal wildlife by Zone

	Afder	Degehabur	Fik	Gode	Korahe	Shinile	Warder
Traditional roofs	53,297	45,318	11,282	34,937	14,357	37,734	20,474
Modern roofs	3,104	1,622	196	651	31	5,911	1,840
Dams and birkas	668	8,332	279	341	768	835	5,286
Dikdik	-	636	168	155	154	-	-
Gazelle	-	-	-	-	369	11,454	-
Gerenuk / Dibatag	668	572	419	1,054	1,013	3,840	335
Lesser Kudu	167	-	56	-	184	234	-
Ostrich	-	-	279	341	737	468	34
Warthog	1,268	668	168	713	553	568	402

A full list of the wildlife species observed during the survey is given in Appendix 2.

Because the zones vary in size (see Annexes 1 to 7), a comparison between them based on total numbers can be deceptive. Densities provide a more meaningful comparison, as given for livestock in Table 6.

Table 6: Livestock densities by Zone (n/km^2)

	Afder	Degehabur	Fik	Gode	Korahe	Shinile	Warder
Cattle	2.8	1.4	1.0	4.7	0.8	6.8	0.7
Sheep & Goats	31.3	56.6	12.2	42.4	32.7	49.5	69.9
Camels	2.3	3.5	1.6	3.3	4.7	3.4	7.2
Equids	0.1	0.1	0.2	0.3	0.1	0.5	0.01
ALL	36.5	61.6	15.0	50.6	38.3	60.1	77.8

6 References

Caughley, G.C. 1977 Sampling in aerial survey. *Journal of Wildlife Management* 41(4): 605-614

Jolly, G. M. 1969 Sampling methods for aerial census of wildlife populations. *East African Agricultural and Forestry Journal* 34: 46-49

Norton-Griffiths, M. (1978) *Counting Animals*. Handbook No.1 in a series of handbooks on techniques currently used in African wildlife ecology (Ed: J. Grimsdell). African Wildlife Foundation, Nairobi.

Appendix 1

Correction of Counting Bias

Visual estimates of groups with more than 10 individuals for which there was no corresponding photograph were corrected according to the formula:

$$y = mx+b$$

Where y = corrected value
x = visual estimate

and m and b are constants derived from the regression analysis of visual estimate-photo count data pairs as shown in the table below.

Aircraft	Observer	Species	No of data pairs	m	b
5Y-AHZ	**CC**	Cattle	51	0.715	15.225
		Shoats	332	0.958	6.251
		Camel	14	1.226	-2.944
	GM	Cattle	39	0.548	8.280
		Shoats	383	0.514	21.950
		Camel	14	0.476	14.302
5Y-BIH	**BR**	Cattle	56	0.740	5.876
		Shoats	328	0.881	-1.862
		Camel	8	0.702	5.007
	HK	Cattle	74	0.742	6.977
		Shoats	265	0.802	15.914
		Camel	66	0.844	3.485
		Trad roof	10	0.593	12.422
5Y-ATS	**PN**	Cattle	9	1.075	6.178
		Shoats	364	1.033	11.237
		Camel	19	1.068	-1.143
	JW	Cattle	13	0.871	1.877
		Shoats	536	0.717	16.789
		Camel	45	0.817	3.916

Appendix 2

Wildlife species observed by Zone

		AD	DH	FK	GD	KR	SH	WD
Dibatag	*Ammodorcas clarkei*		4					4
Dikdik	*Madoqua* spp		4	4	4	4		
Gazelle	*Gazella soemmerringi*					4	4	
Gerenuk	*Litocranius walleri*	4	4	4	4	4	4	
Grevy's Zebra	*Equus grevyi*						4	
Jackal	*Canis* spp		4					
Leopard	*Panthera pardus*						4	
Lesser Kudu	*Tragelaphus imberbis*	4		4		4	4	
Ostrich	*Struthio molibdophanus*			4	4	4	4	4
Warthog	*Phacochoerus aethiopicus*	4	4	4	4	4	4	4
Wild Dog	*Lycaon pictus*				4			

AD Afder; DH Degehabur; FK Fik; GD Gode; KR Korahe; SH Shinile; WD Warder