CHAPTER 4

ANAEMIA IN EAST AFRICAN SHORT-HORN ZEBU CALVES:
THE HAEMATOLOGICAL PROFILE FROM NEONATE TO 51 WEEKS

1. INTRODUCTION

Most reference ranges for the haematological parameters for cattle found in literature have been compiled for European breeds (Jain 1993; Knowles, Edwards, Bazeley, Brown, Butterworth & Wariss 2000; Brun-Hansen, Kampen & Lund 2006; Mohri, Sharifi & Eidi 2007). Studies on haematology of cattle in the tropics have indicated that there are differences in baseline values for the various breeds (Oduye & Okunaiya 1971). The haematological profile of the East African short-horn Zebu breed living in tropical field conditions in Kenya is described in this chapter, in particular the age-related changes in the blood parameters from neonate to 51 weeks.

The calves in this study were kept under field conditions and no controls in a disease-free environment were available. Therefore, in addition, a cohort of relatively healthy calves from the study population was selected, based on a set of criteria, to indicate the baseline values of the haematological parameters of healthy short-horn Zebu calves in the field. Using these data on healthy calves as a reference sample, the significance of anaemia in the general study population was further investigated.

2. MATERIALS AND METHODS
* General methodology (sampling and diagnostics) is discussed in Chapter 2

2.1 Age-related changes in the haematology of East African short-horn Zebu calves
The 5-weekly routine samples from October 2007 to September 2010 from calves of the IDEAL project were used to investigate the age-related changes in the haematological profile of East African short-horn Zebu calves. The haematological parameters investigated included: red cell count (RCC), haemoglobin concentration (HGB), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), red cell distribution width (RDW), total white cell count (WCC), absolute lymphocyte count (Lymph), absolute eosinophil count (Eos), absolute total neutrophil count (Neut), absolute monocyte count (Mono), platelet count (Plt), mean platelet volume (MPV)

and total serum protein (TSP). Graphs are used to illustrate population median values and standard errors as they change over time for each parameter.

2.2 "Good" calves – haematology of relatively healthy calves

"Good" calves, representing relatively healthy, well-adapted calves that performed well under the environmental and nutritional constraints in the field, were identified by the following criteria:

- They survived to 51 weeks with a final weight above the median for the population at 51 weeks.
- No clinical episodes occurred during the 51-week follow-up period.
- No diarrhoea was present at any visit.
- FAMACHA© scores less than 4 (non-anaemic) at each visit.
- The calves tested negative for trypanosomosis on microscopy at each visit.
- No *Anaplasma* spp. or *Babesia* spp. were detected on microscopy at any visit.
- Eggs per gram faeces (EPG) < 1 000 for strongyle and strongyloides type eggs for all visits.
- Oocysts per gram faeces (OPG) < 1 000 for coccidian oocysts for all visits.
- Faecal samples tested negative for *Fasciola* spp. for all visits.

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Thirty-seven calves were identified retrospectively after they had finished their follow-up period of 51 weeks. Sampling was thus similar to the other calves in the study. The haematological parameters investigated include RCC, HGB, PCV, MCV, MCHC, RDW, WCC, Lymph, Eos, Neut, Mono, Plt and TSP. Graphs are used to illustrate the changes in the values for each parameter with age in comparison to the values for the total study population.

2.3 The level of anaemia in the population

"Good" calves were used as a reference sample to identify cases in the study population with anaemia. Conventionally, cut-off values are often determined by calculating the mean ± 2 standard deviation (SD) of a clinically healthy, disease-free reference population. However, the reference sample of "good" calves is not from a disease-free, nutritionally controlled environment. Therefore, cut-off values for PCV were measured both conservatively as the mean ± 1SD , as well conventionally as the mean ± 2SD to identify anaemic cases. These cut-off values were calculated for each 5-week age interval.

2.4 Statistical analysis

Descriptive statistics (mean and standard error) were used to describe the age-related changes in haematology parameters of the total calf population as well as the "good calf" subset. The changes with age are plotted in graphs.

Student's t-test was used to determine the significance (p<0.05) in the difference in means of the total calf population and the "good calf" subset for each haematological parameter at each sampling point (week 1 to week 51).

Cumulative hazard rates were plotted to illustrate the risk of a calf developing anaemia. Data from the routine visits as well as clinical visits were used to construct the graph. Censoring of the date was done to account for calves that died before the end of the follow-up period. Because the visits to the calves were not at the exact same age in days the graphs were constructed using intervals of 10 days.

3. RESULTS

3.1 Age-related changes in the haematology of East African short-horn Zebu calves

Figures 4.1-4.14 illustrate the changes for all parameters between week 1 and week 51 for the total calf population. Trendlines for European neonatal Holstein calves [adapted from Mohri *et al*. (2007) and Knowles *et al*. (2000)], are indicated where the trends in certain parameters for these breeds differ from the population in the present study.

The calves showed a significant increase in PCV, RCC and HGB from week 1 (means of 30 %, 7.73 x10^6/μL and 10g/dL) to week 6 (means of 36%, 10.23 x10^6/μL and 12 g/dL). From 6 weeks, all three parameters decreased gradually until 51 weeks. Red cell distribution width was relatively high between 1 and 6 weeks (mean 34, 9 and 35.9 fL for each point), indicating a significant variation in the size of red blood cells which may be suggestive of either the presence of foetal red blood cells, which are larger than adult-type red blood cells, or a high number of immature adult-type red blood cells. Between 6 and16 weeks RDW decreased significantly to where it remained between 31.2 and 31.8 fL up to 51 weeks. MCV was relatively high at week 1 (mean 39.8 fL), confirming the presence of a high number of larger red blood cells, but decreased gradually from week 1 up to week 21 (mean 33.6 fL), and then increased gradually until week 51 (mean 36.0 fL). The MCHC showed a similar but more gradual trend, where it decreased between week 1 (mean 32.2 g/dL) and week 11 (median 31.6 g/dL), and then increased up to 51 weeks (mean 33.05 g/dL).

The WCC and Lymph showed very gradual increases from week 1 (mean 9.00 x10³/dL and 3.7 x10³/µL, respectively) to week 51 (mean 11.40 x10³/dL and 7.6 x10³/µL, respectively). The Eos increased considerably from week 1 (mean 0.27 x10³/µL) up to week 46 (mean 0.75 x10³/µL). The Neut showed a gradual decrease from week 1 to week 16, after which they remained between 2.4-2.55 x10³/µL (mean) until week 41 and increased again to week 51.

The Plt also showed a steady decrease from week 1 (mean 611 x10³/µL) up to week 16 (mean 445 x10³/µL) from where the decrease was more gradual up to week 51 (mean 385.5 x10³/µL). The MPV was relatively high at week 1 (mean 6.5 fL), decreased gradually up to week 16 (mean 5.8fL) and increased up to week 51 (mean 6.2 fL).

The TSP was relatively high at week 1 (mean 9.8 g/dL), after which it decreased up to week 16 (mean 7.6 g/dL) but then remained between 7.6-8 g/dL (mean) up to week 51.

Figure 4.1 Age-related changes in the mean (SE) red cell counts of East African short-horn calves, from birth to 51-weeks of age (n=548)
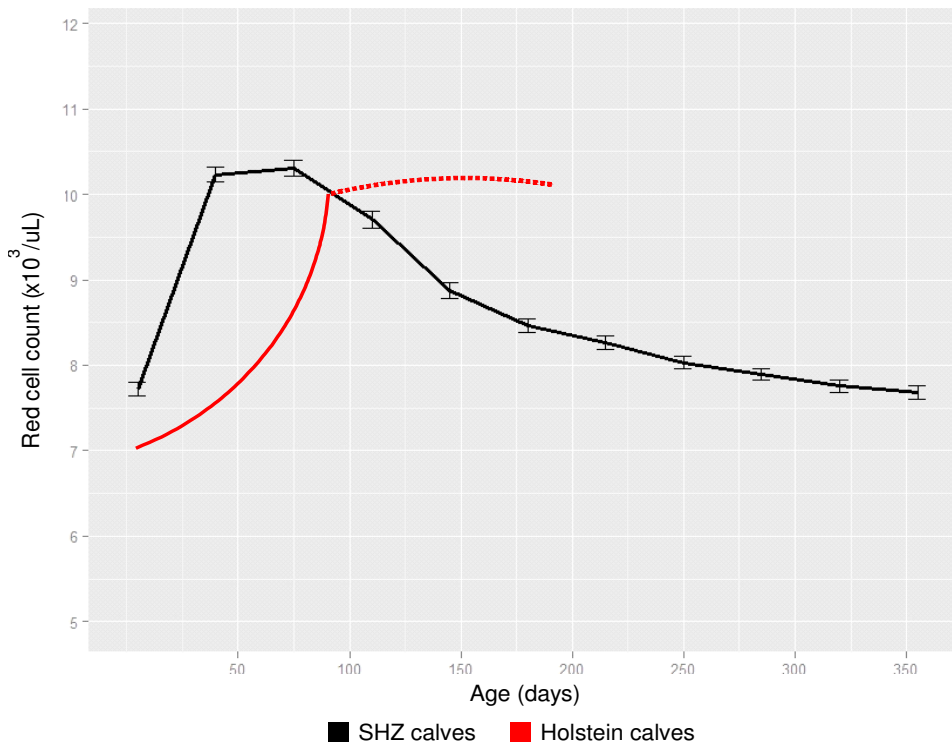
Figure 4.2 Age-related changes in the mean (SE) packed cell volume of East African short-horn calves, from birth to 51-weeks of age (n=548)
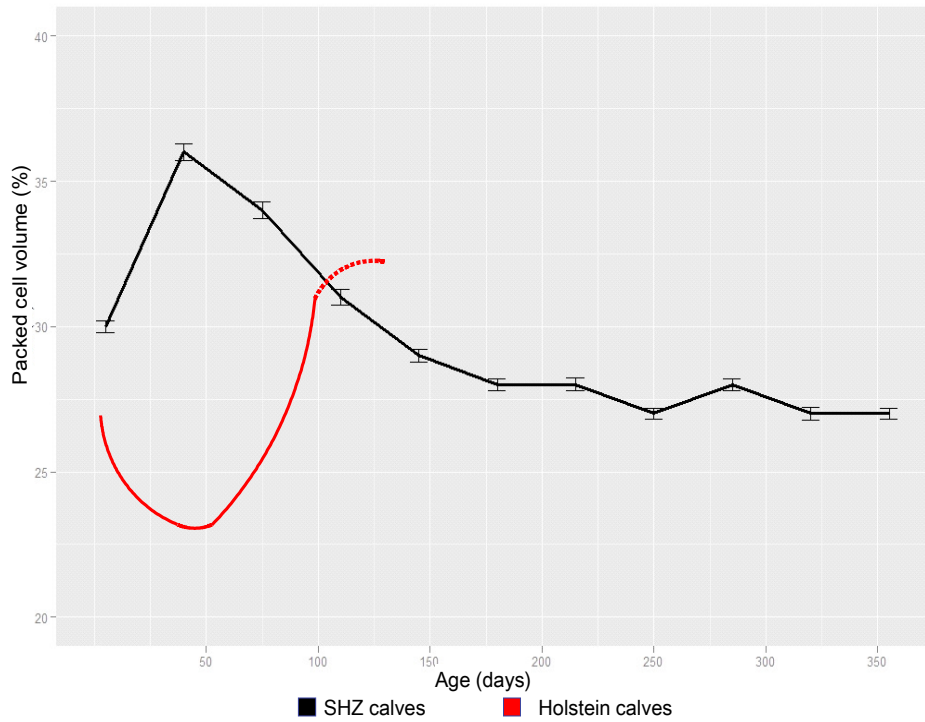

Figure 4.3 Age-related changes in the mean (SE) haemoglobin concentration of East African short-horn calves, from birth to 51-weeks of age (n=548)

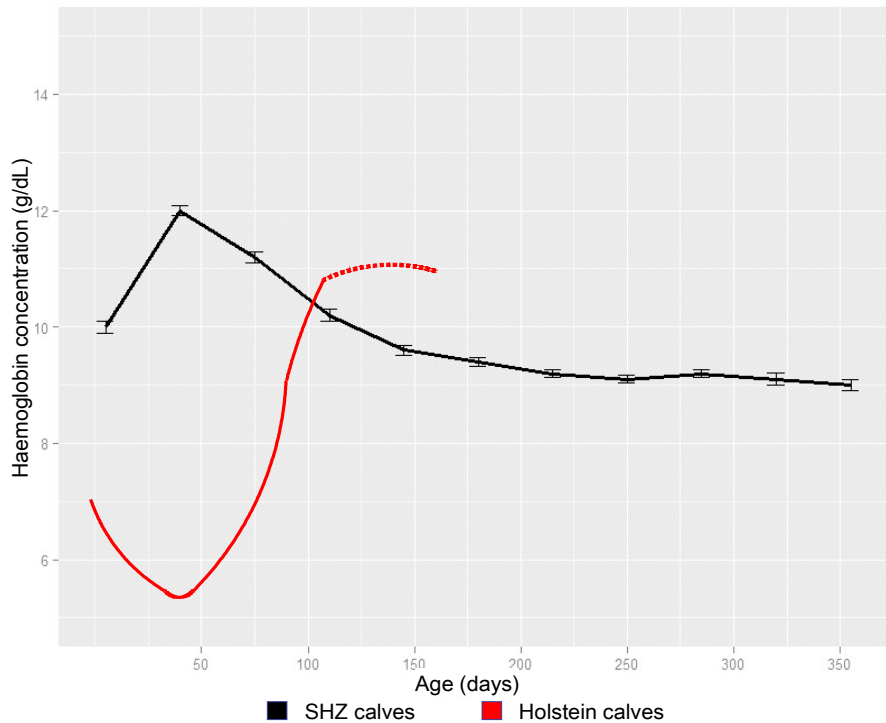**Figure 4.4** Age-related changes in the mean (SE) mean corpuscular volume of East African short-horn calves, from birth to 51-weeks of age (n=548)
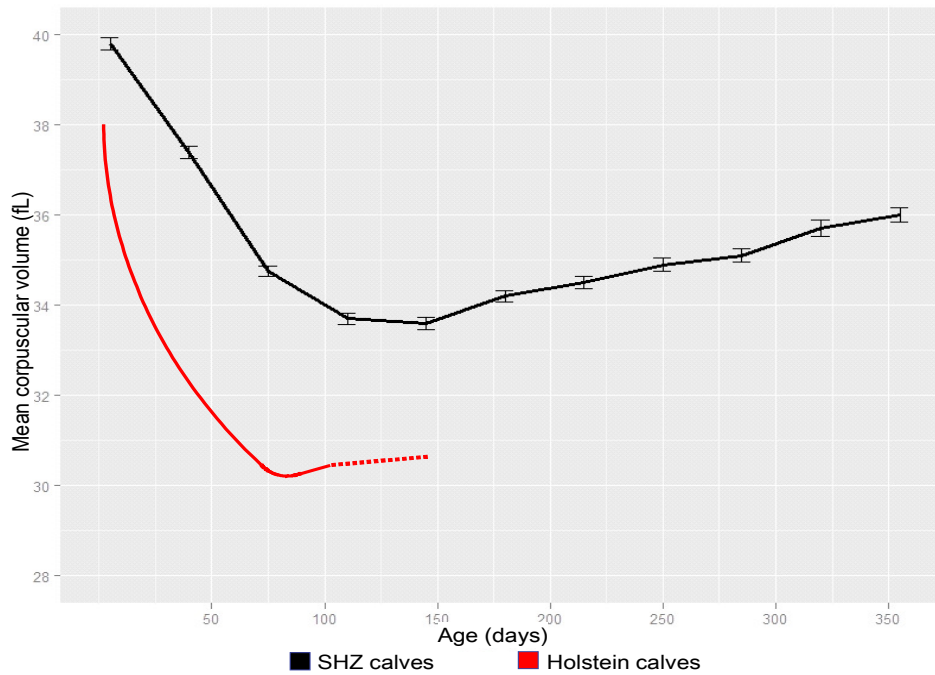

Figure 4.5 Age-related changes in the mean (SE) mean corpuscular haemoglobin concentration of East African short-horn calves, from birth to 51-weeks of age (n=548)
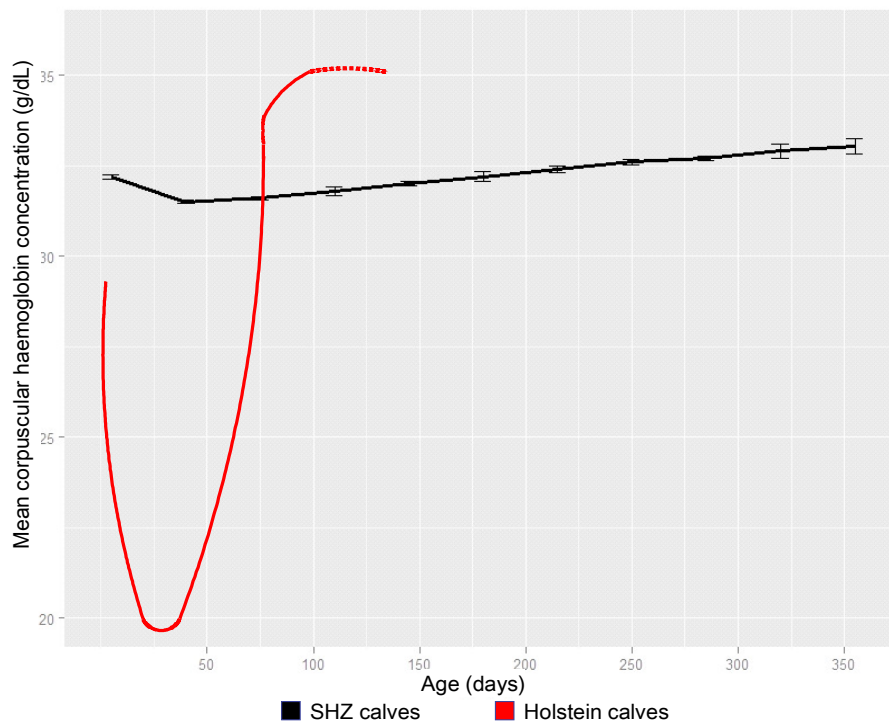
Figure 4.6 Age-related changes in the mean (SE) red cell distribution width
of East African short-horn calves, from birth to 51-weeks of age (n=548)
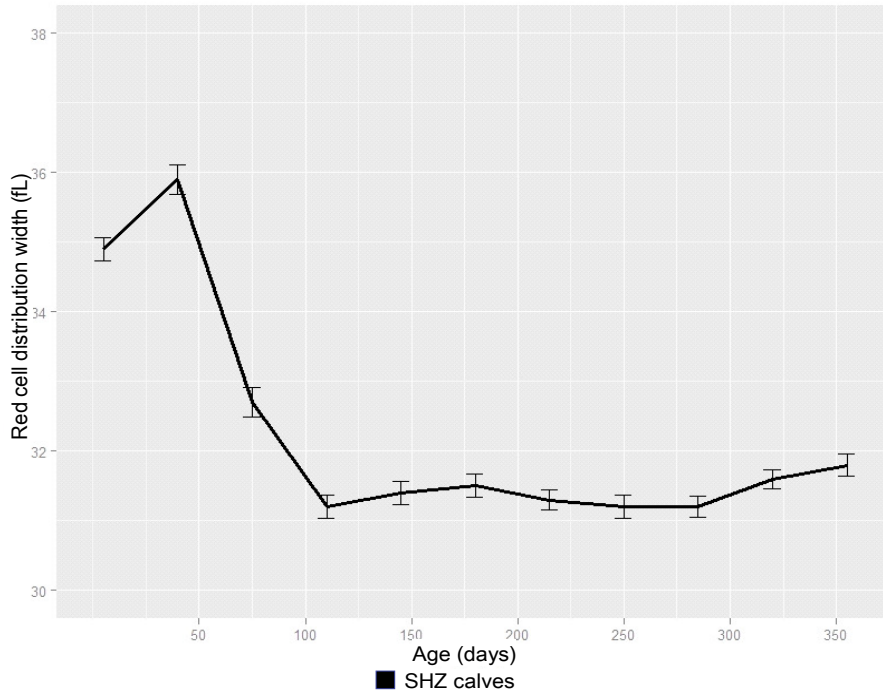

Figure 4.7 Age-related changes in the mean (SE) total white cell count
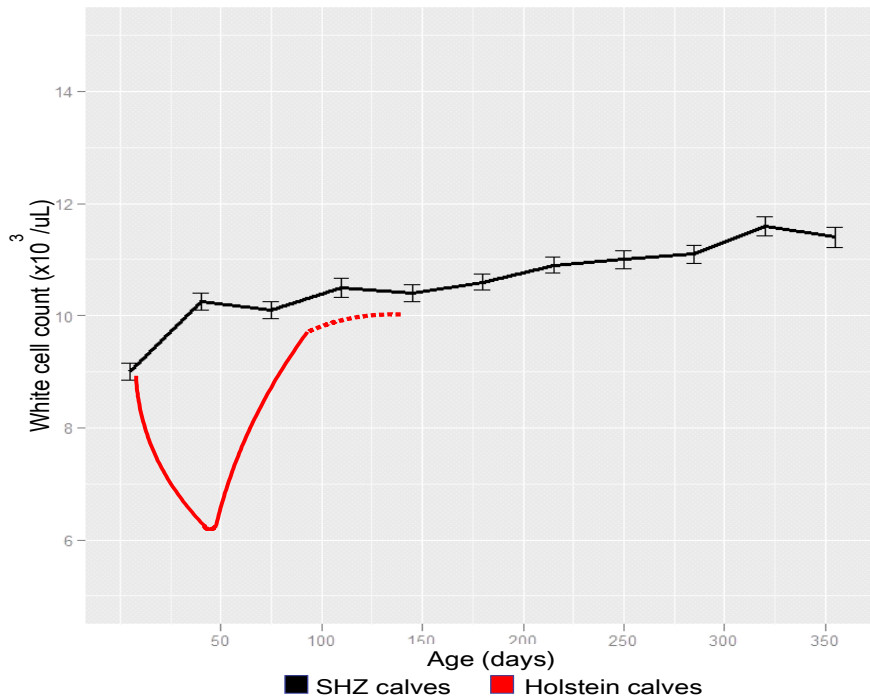of East African short-horn calves, from birth to 51-weeks of age (n=548)

Figure 4.8 Age-related changes in the mean (SE) absolute lymphocyte count of East African short-horn calves, from birth to 51-weeks of age (n=548)
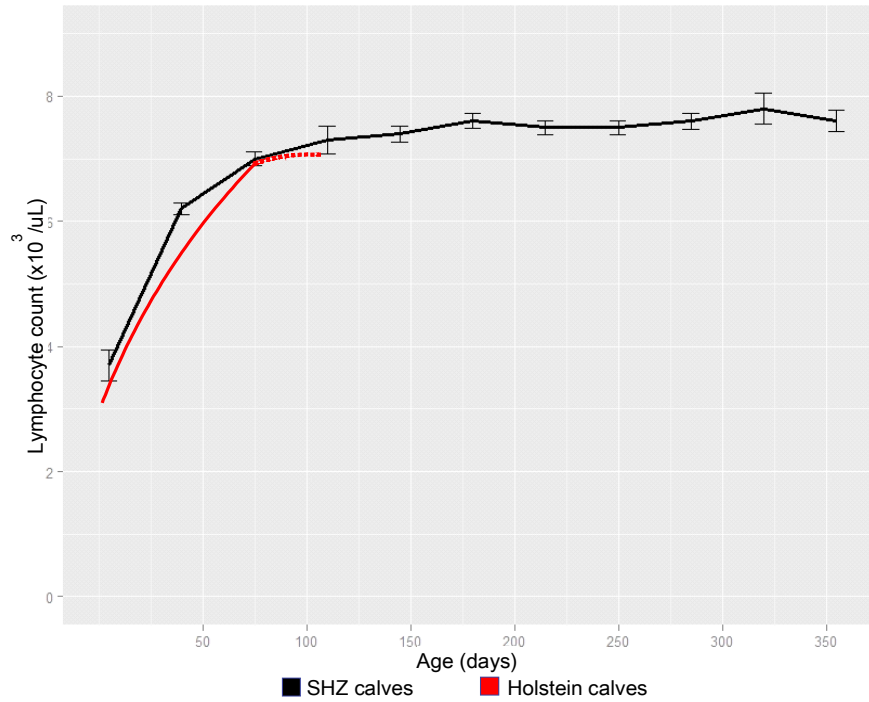

Figure 4.9 Age-related changes in the mean (SE) absolute eosinophil count of East African short-horn calves, from birth to 51-weeks of age (n=548)
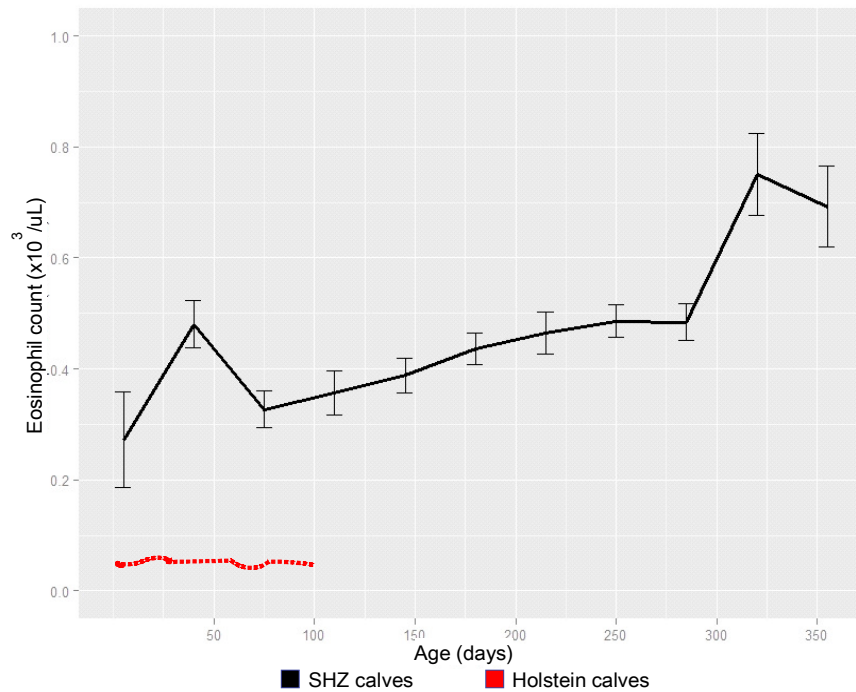
Figure 4.10 Age-related changes in the mean (SE) absolute neutrophil count of East African short-horn calves, from birth to 51-weeks of age (n=548)
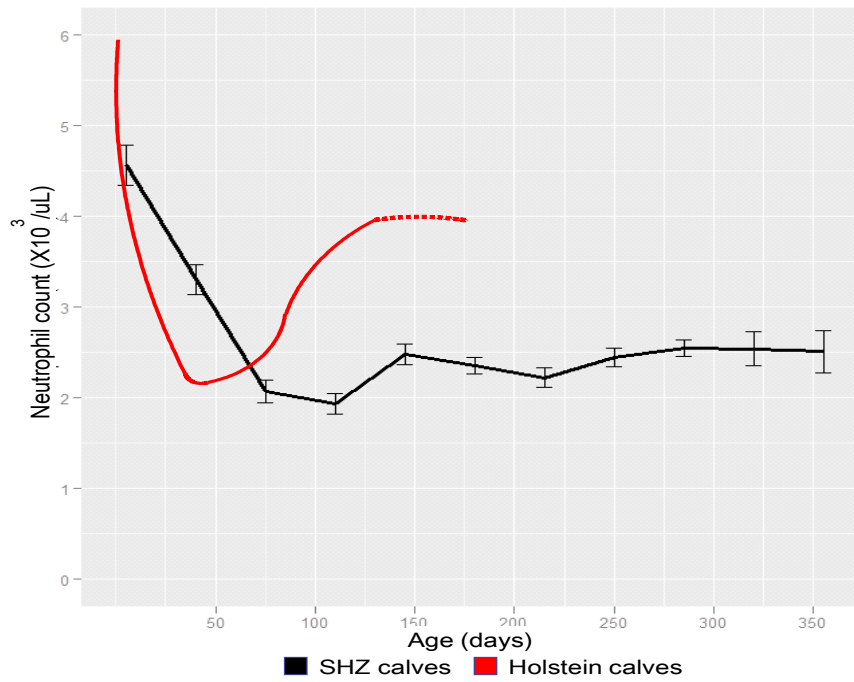

Figure 4.11 Age-related changes in the mean (SE) absolute monocyte count of East African short-horn calves, from birth to 51-weeks of age (n=548)
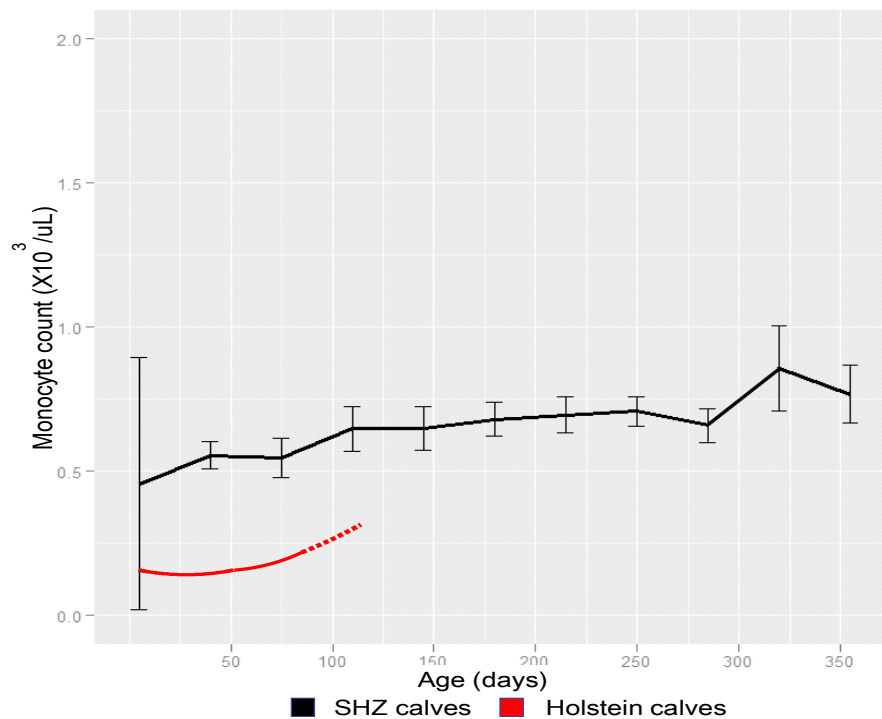
Figure 4.12 Age-related changes in the mean (SE) platelet count
of East African short-horn calves, from birth to 51-weeks of age (n=548)
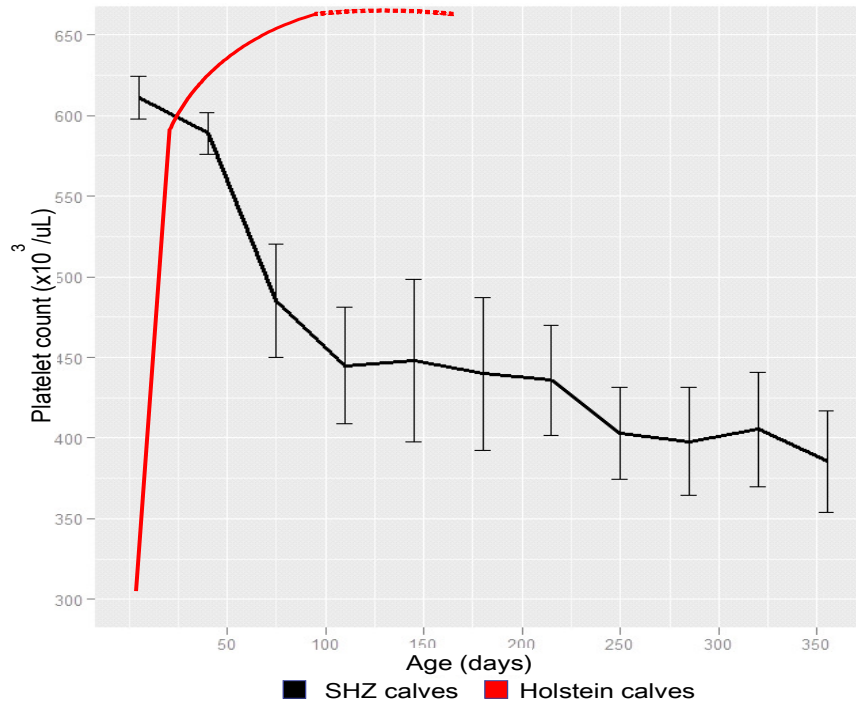

Figure 4.13 Age-related changes in the mean (SE) mean platelet volume levels
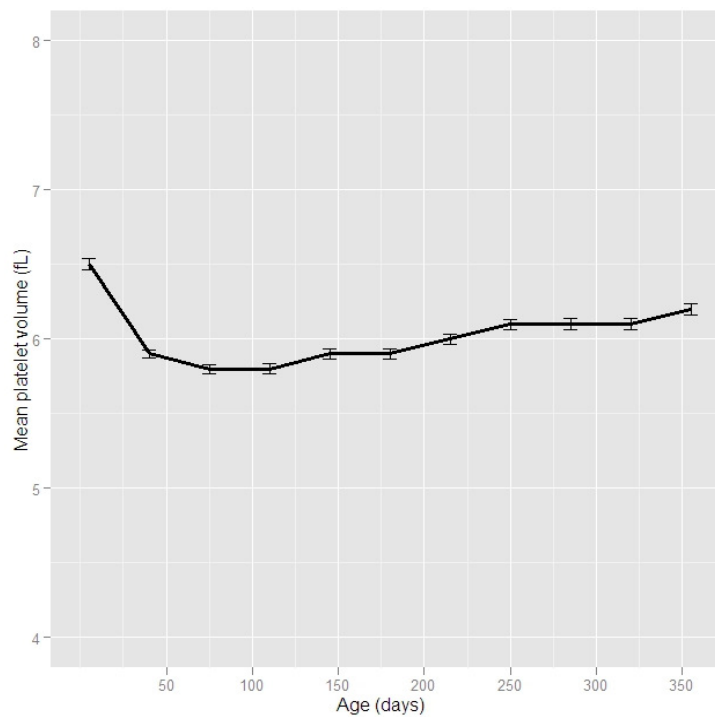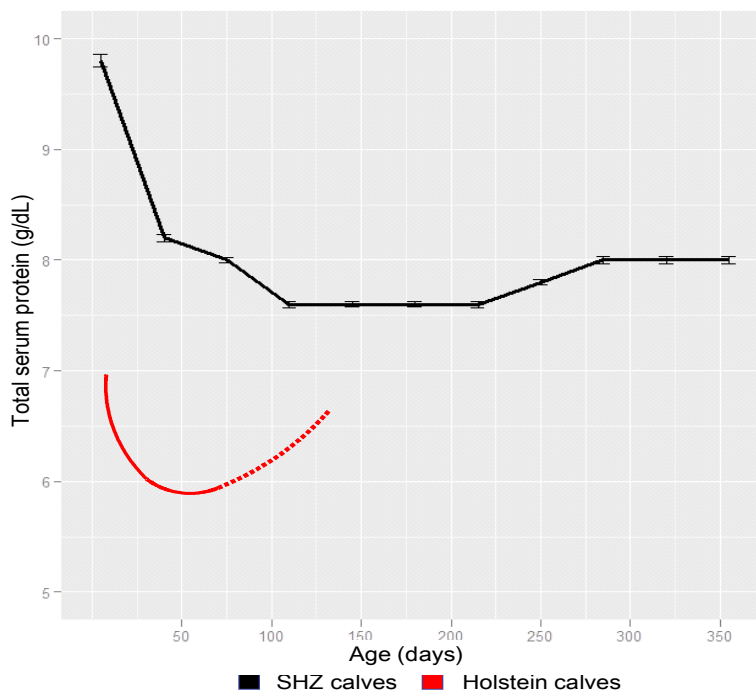of East African short-horn calves, from birth to 51-weeks of age (n=548)

Figure 4.14 Age-related changes in the mean (SE) total serum protein levels of East African short-horn calves, from birth to 51-weeks of age (n=548)

3.2 "Good" calves – haematology in relatively healthy calves

Age-related changes for "good" calves are illustrated using graphs for each parameter (Fig. 4.15-4.23). "Good" calves had significantly (p<0.05) higher values than the total population for RCC, HGB and PCV from week 6 and lower values for RDW (weeks 6 and 21). The total population had higher MCV values than the "good" calves at all sampling points, with significant differences (p<0.05) at week 6, 16-21 and 36-51. The total population had significantly (p<0.05) lower MCHC than the "good" calves at all visits except week 11. The difference in means for all white blood cell parameters between "good" calves and the total population were generally not significant (p>0.05), except for WCC at week 6-36 where "good" calves had higher values and eosinophil counts at week 1 where "good" calves had significantly lower counts (p<0.05). There were significant (p<0.05) differences in Plt between the two groups from week 36 up to week 51 with "good" calves showing a lower Plt than the total population for that period. "Good" calves has significantly (p<0.05) lower TSP at week 1, 11 and 36-46.

Figure 4.15 Comparison between the age-related changes in mean (SE) red cell count of "good" calves (n=37) and the total study population (n=548)

Figure 4.16 Comparison between the age-related changes in mean (SE) packed cell volume of "good" calves (n=37) and the total study population (n=548)

Figure 4.17 Comparison between the age-related changes in mean (SE) haemoglobin concentration of "good" calves (n=37) and the total study population (n=548)

Figure 4.18 Comparison between the age-related changes in mean (SE) mean corpuscular volume of "good" calves (n=37) and the total study population (n=548)
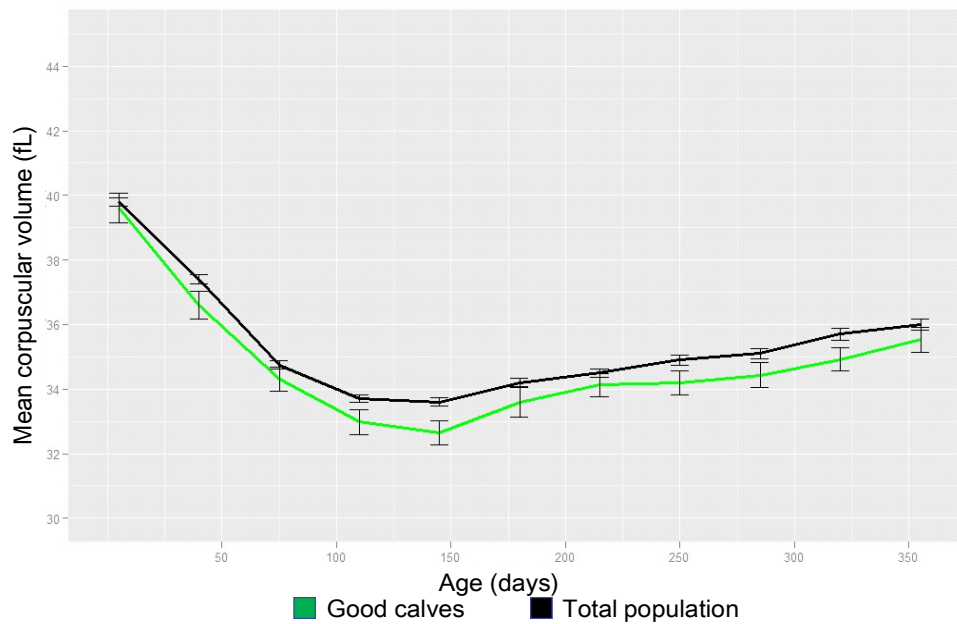
Figure 4.19 Comparison between the age-related changes in mean (SE) mean corpuscular haemoglobin concentration of "good" calves (n=37) and the total study population (n=548)
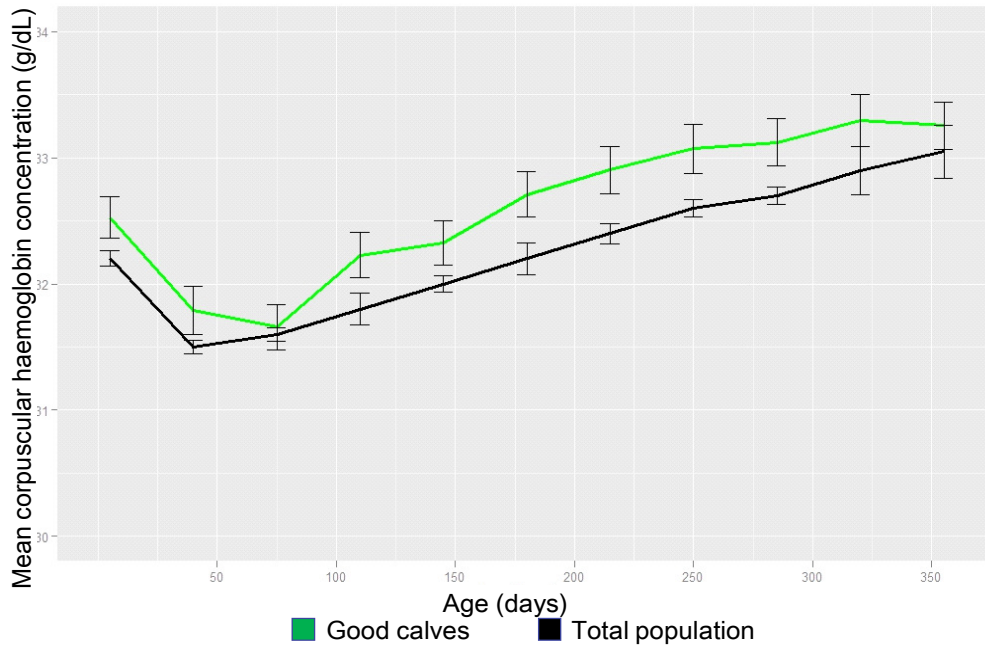
Figure 4.20 Comparison between the age-related changes in mean (SE) red cell distribution width of "good" calves (n=37) and the total study population (n=548)
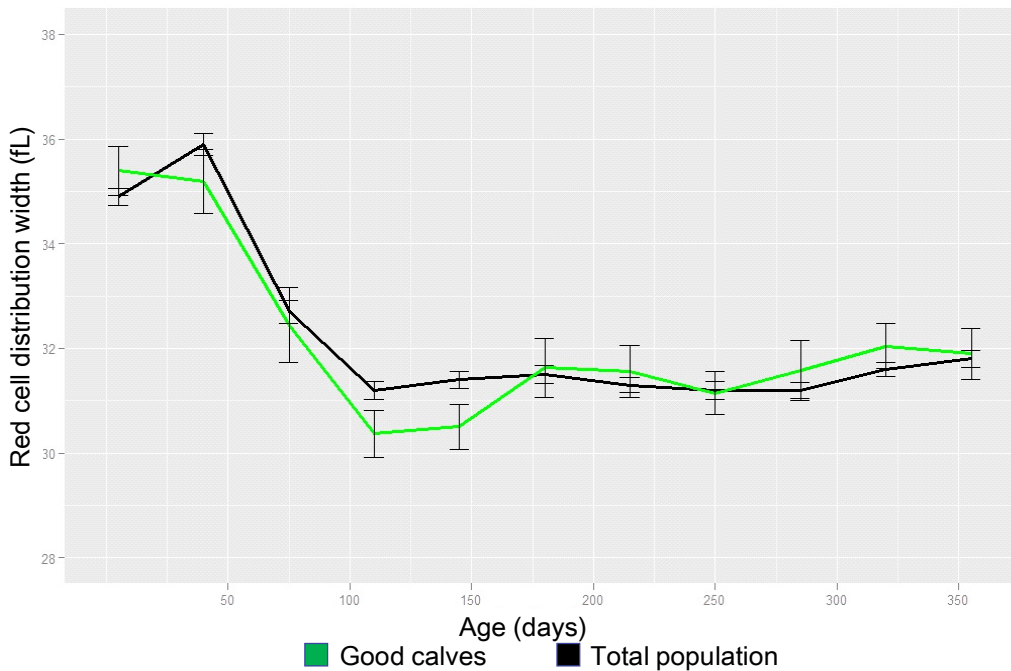
Figure 4.21 Comparison between the age-related changes in mean (SE) total white cell count of "good" calves (n=37) and the total study population (n=548)
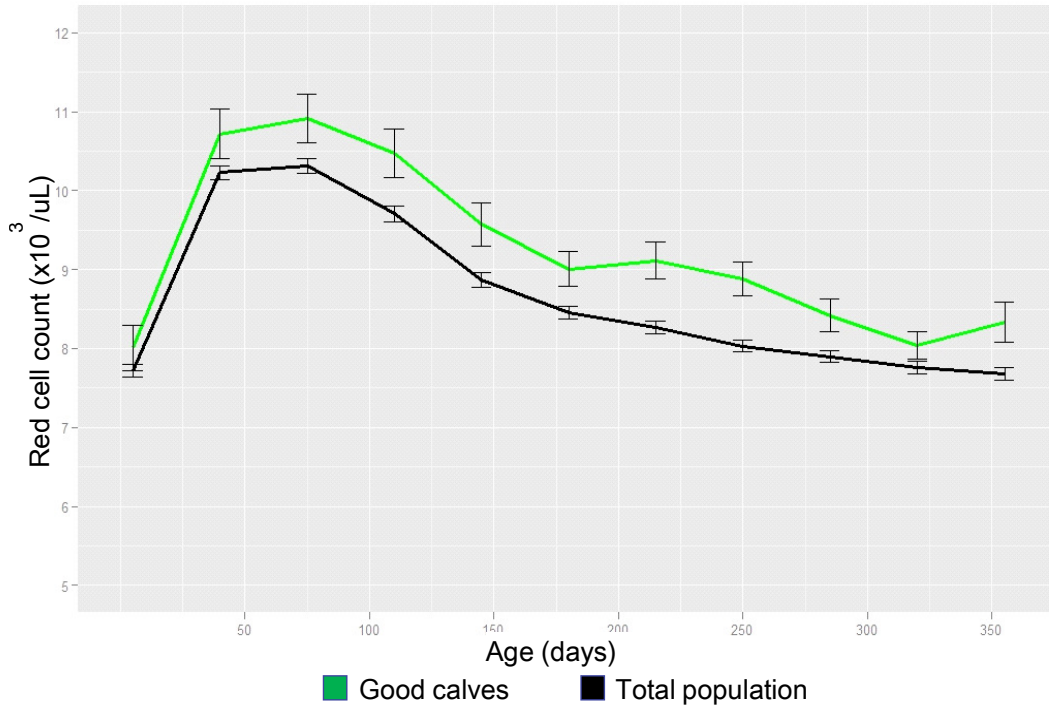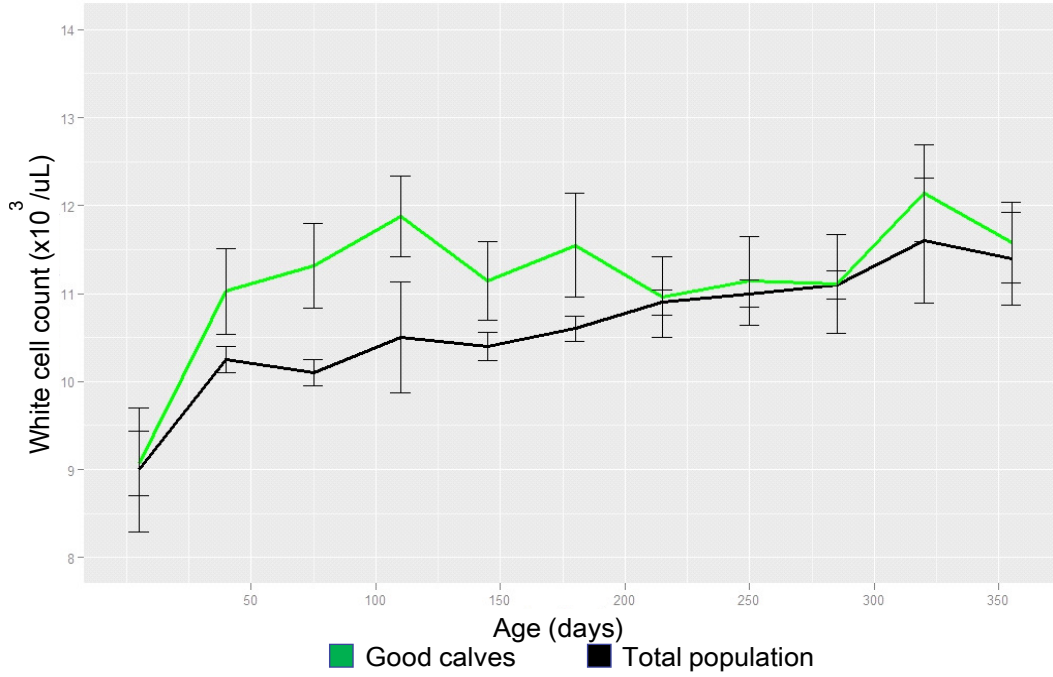

Figure 4.22 Comparison between the age-related changes in mean (SE) platelet counts of "good" calves (n=37) and the total study population (n=548)
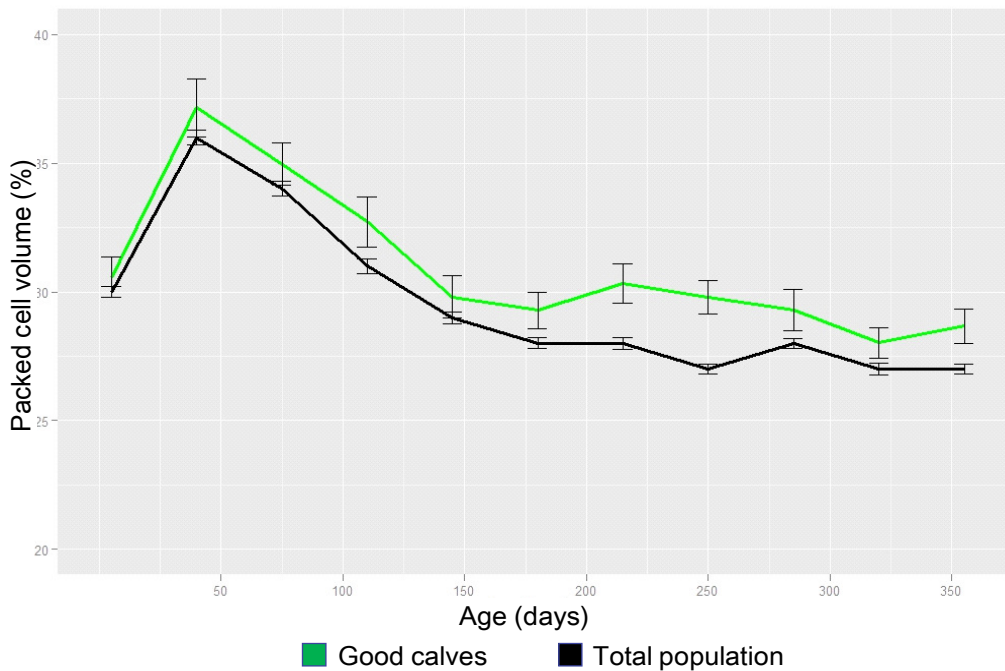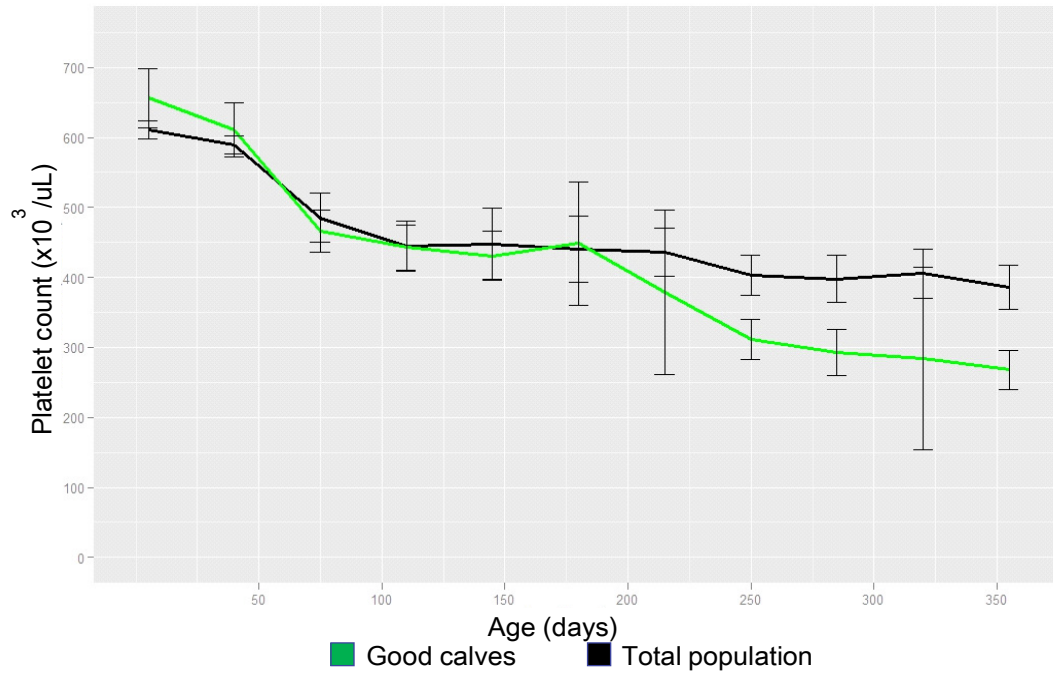
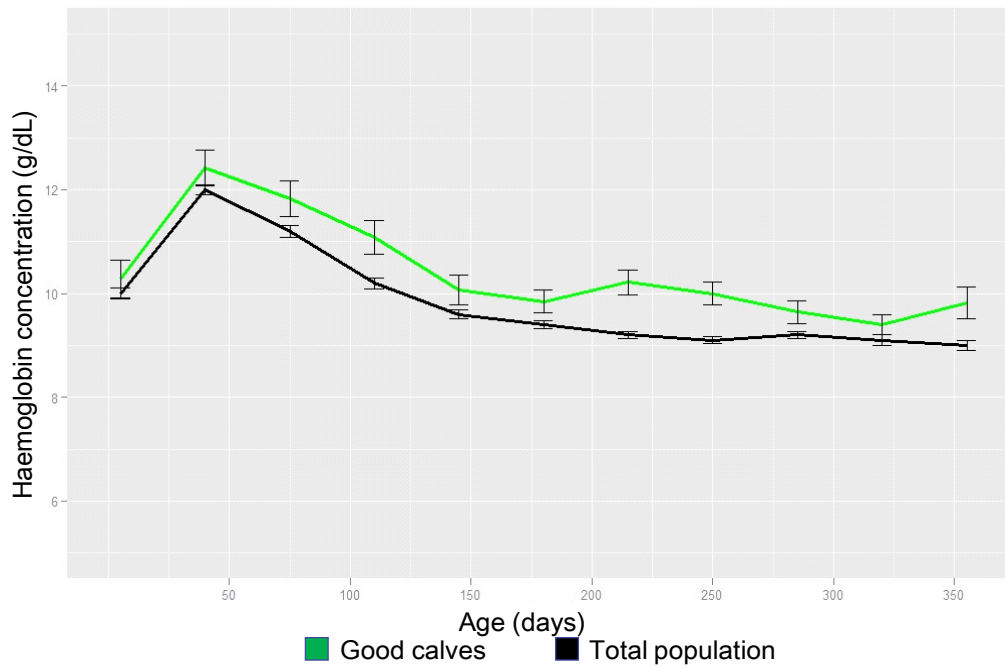**Figure 4.23** Comparison between the age-related changes in mean (SE) total serum protein of "good" calves (n=37) and the total study population (n=548)
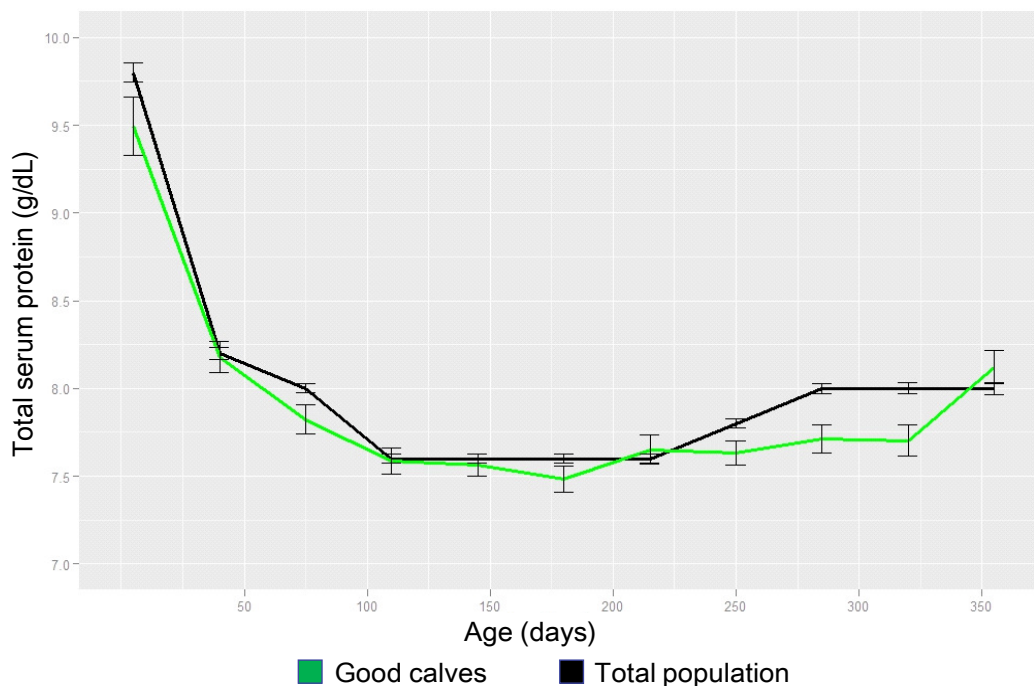

3.3 The level of anaemia in the population

The cut-off values for PCV for each age group, as calculated using the "good" calves as a reference sample, are depicted in Table 4.1. From weeks 21 to 51 the values for (mean PCV – 1SD) and (mean PCV – 2SD) were very similar to what is considered anaemic (PCV<25%) and moderately anaemic (PCV<21%) in the literature for European breeds (Tvedten 2010).

In Figure 4.24 the ages of first detection of an incident of anaemia according to the criteria above is illustrated. Of 548 calves in the study, 468 (85.56%) had at least one episode of anaemia (mean PCV - 1SD) of which 267 (48.81%) had at least one episode of moderate anaemia (mean PCV - 2SD). A total of 1 301 incidents of anaemia (mean PCV – 1 SD) and 372 incidents of moderate anaemia (mean PCV – 2SD) were recorded for the study population during the whole observation period.

More than 50% of calves had an incident of anaemia by the age of 80 days. Fifty percent of calves had an incident of moderate anaemia by the age of 360 days.

Table 4 Cut-off packed cell volume (PCV) values calculated from reference "good" calves sample

Age (weeks)	PCV (%) Mean – 1 SD	PCV (%) Mean – 2 SD
1	28.40	25.42
6	32.49	27.62
11	30.62	25.32
16	28.13	23.55
21	25.27	20.18
26	25.70	21.40
31	26.40	22.81
36	26.35	22.29
41	25.59	21.26
46	24.89	20.48
51	25.46	20.15

Figure 4.24 Cumulative incidences of mild anaemia and moderate anaemia in the calf population
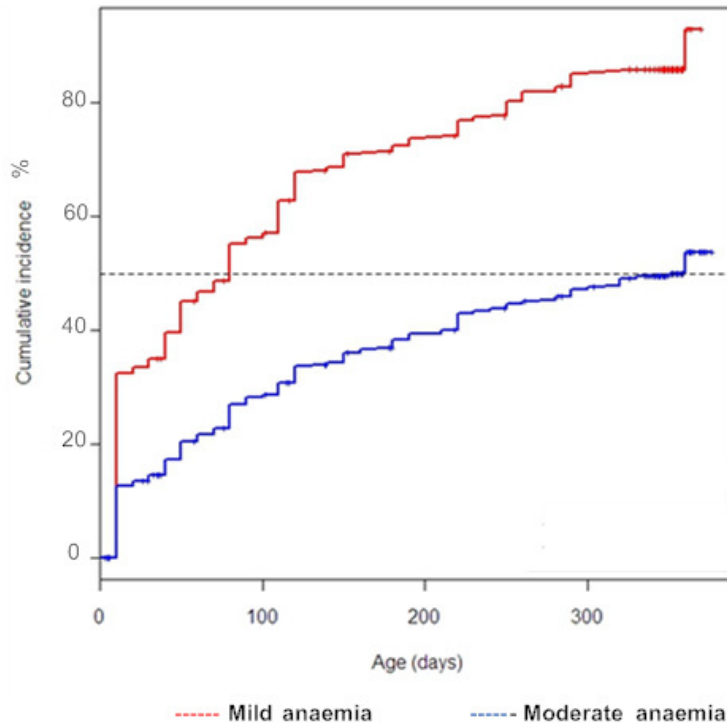
4. DISCUSSION

4.1 Age-related changes in the haematology of East African short-horn Zebu calves
The most significant age-related changes in red blood cell parameters occurred between week 1 and week 16 for the calves in the present study. Concurrent low RCC and PCV with a relatively high or normal MCV and RDW in the first week suggest a macrocytic anaemia. A high RDW value is an indication of anisocytosis which can be either due to an increase in larger cells, typically reticulocytes, as part of a regenerative response, or due to an increase in small red blood cells, often found in cases of iron deficiency. Unfortunately reticulocyte counts were done only on cases with PCV<25%, which excludes almost all observations from week 1 to week 11. A high number of small red blood cells would however, result in a decreased MCV, which is in contrast to what was found in these calves.

When one compares the age-related changes in red blood cell parameters for the calves in this study to the reported values for European breeds (Knowles *et al*. 2000; Mohri *et al*. 2007), there are considerable differences in both the ranges for different age groups, as well as the trends in change over time (Fig. 4.1-14). The reference ranges for European breeds were established in cattle in controlled environments that controlled for disease and nutrition. For this reason a direct comparison to the short-horn Zebus in this study is problematic to interpret, but it is of value since the physiology of age-related changes in these breeds has been studied more extensively than in indigenous African breeds. Red blood cell indices for European breed calves during the neonatal period are much lower than for the short-horn Zebu calves in this study. This may possibly be partly due to haemoconcentration in the short-horn Zebu calves considering their high TSP at week 1 compared to the other breeds. Haemoconcentration falsely increases the values of other blood parameters since these are measured as concentrations per volume of blood. Whether this haemoconcentration is physiological and normal for the short-horn Zebu breed, or pathological, e.g. dehydration due to tropical environmental conditions, or husbandry practices such as tethering, which is a common practice, requires further investigation.

There also appeared to be differences in the trendlines of these parameters over time between the short-horn Zebus and European cattle breeds. In other ruminants, including European cattle breeds, there is a decrease in PCV, HGB and MCV in neonates up to 6 weeks that coincides with an increase in RCC, after which all three parameters increase up to adult levels (Karesh *et al.* 1986; Knowles *et al.* 2000; Mohri *et al.* 2007). These changes are considered physiological and are ascribed to a decline in foetal erythrocytes at a faster rate than the production of adult-type erythrocytes (Karesh *et al.* 1986). This also coincides

with the replacement of foetal haemoglobin by adult haemoglobin (Jain 1986; Mohri *et al.* 2007). Ruminants and primates have a distinct type of haemoglobin during foetal life. In these species embryonal haemoglobin is soon replaced by foetal haemoglobin (Hb F), which in turn is eventually replaced by adult haemoglobin (Hb A). Haemoglobin F has a higher affinity for oxygen than Hb A and its function is to maintain partial pressure of oxygen of foetal blood. The replacement of Hb F with Hb A, referred as "switching", occurs within the first few weeks after birth in ruminants (Boyd & Bolon 2010). Cattle do, however, retain the capacity to synthesize Hb F, and often do in response to anaemia (Boyd & Bolon 2010).

There was no initial decrease of HGB and PCV in the short-horn Zebu calves after birth as in other ruminants. However, there was a significant increase in PCV, HGB and RBC between week 1 and week 6 accompanied by a high RDW that remained relatively high up to 6 weeks which may be suggestive of increased erythropoiesis. The gradual decrease in MCV appeared to be at a slower rate with minimum levels only reached at 21 weeks compared to Holstein cattle which reach a minimum at 10 weeks (Fig. 4.4). It would be of future interest to investigate the switching from Hb F to Hb A in these short-horn Zebu calves. If Hb F replacement by Hb A is more rapid and efficient in reaching adequate Hb A levels before Hb F starts declining, or if there is a delay in the decline of Hb F while Hb A is produced by an increasing number of adult-type erythrocytes, such that the total HGB is maintained or even increased, it would be a possible explanation for the increase in HGB, PCV and RCC during the first weeks after birth.

Prolonged postnatal production of Hb F has been described in humans in certain haemoglobinopathies where production of Hb F continues into adulthood (Pasvol, Weatherall, Wilson, Smith & Gilles 1976; Nagel 1990). It is considered benign, but has been shown to be protective against the effects of malaria in early childhood by retarding the intraerythrocytic growth of *Plasmodium falciparum* (Pasvol *et al.* 1976; Nagel 1990). Other haemoglobinopathies, such as the Hb mutation that causes sickle cell anaemia, have been found to be protective against malaria in humans (López, Saravia, Gomez, Hoebeke & Patarroyo 2010; Pishchany & Skaar 2012). In areas where malaria is endemic there is a high frequency in the gene for these haemoglobinopathies in the local human populations (López *et al.* 2010). Prolonged production of Hb F in humans has also been described in neonates under hypoxic stress (Shiao & Ou 2006). The production of Hb F is also pharmacologically induced in the treatment of sickle-cell anaemia. It makes for interesting speculation whether this adaptive change is present in the short-horn Zebu cattle breeds and will require further diagnostic tests to distinguish between haemoglobin types. Such an adaptation would equip calves with increased tolerance to the effects of the endemic infectious causes of anaemia,

such as trypanosomosis, during the first few months after birth. If such calves become infected early in life they would develop mild symptoms of disease but develop an immunity that is protective into adulthood.

Neonatal anaemia due to delayed switching from Hb F to Hb A has been described in several ruminant species, including Mouflon sheep (Hawkey *et al.* 1984) and roan antelope (*Hippotragus equinus*) (Parsons *et al.* 2006). In these species there is a sharp decline in total haemoglobin due to the delay in the production of Hb A. A possible link between this neonatal anaemia in roan antelope and an increased susceptibility to theileriosis has been suggested (Parsons *et al.* 2006).

Certain blood-borne pathogens have been shown to vary in their affinity for red cells of different sizes. Fandamu *et al.* (2007) found that, in cattle infected experimentally with *T. parva*, parasitized red blood cells were significantly smaller that non-parasitized cells, and that the MCV in cattle with lethal reactions was significantly lower than cattle with non-lethal reactions. *Plasmodium vivax* has also been reported to have a tendency to parasitize smaller red cells, in contrast to *P. falciparum* that can infect red cells of any age (Ghosh & Ghosh 2007). A high number of large red cells during the first weeks of life, as indicated by the high RDW from week 1 to week 6, together with a high MCV, might also have a protective effect against blood-borne pathogens, including *T. parva*, during early calf-hood in the indigenous calves in the study area.

The high MCV with a concurrent decrease in MCHC between week 1 and week 6 could possibly be due to the increasing numbers of immature RBC. Immature RBC do not yet produce haemoglobin optimally since haemoglobin production per cell increases as red blood cells mature (Harvey 1989). Mohri *et al.* (2007) found that the size of erythrocytes decreased in neonatal Holstein calves up to the age of 3-4 months. In this study there was a decrease in PCV and HGB together with a continuing decrease in MCV and MCHC from week 6, while RCC started decreasing from week 11. This may be suggestive of the development of microcytic hypochromic anaemia. Mohri, Sarrafzadeh, Seifi & Farzaneh (2004) found that iron supplementation during the first four weeks after birth corrected the drop in HGB in dairy calves. The iron levels of calf serum were not evaluated in this study but could possibly have added value to explaining the results in this study.

The relatively low numbers of WCC and absolute lymphocyte counts and high absolute neutrophil count around birth are consistent with what is reported for other cattle breeds (Mohri *et al.* 2007; Knowles *et al.* 2000) and is due to perinatal stress and high levels of

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cortisol during partus (Jain 1986). After the first week, levels in WCC, absolute lymphocyte- and eosinophil counts increase as the immune system matures and the animals become exposed to pathogens with resultant cellular responses. Compared to values for neonatal calves of European breeds, the absolute eosinophil and monocyte counts of the short-horn Zebu are considerably higher and possibly related to high parasite burdens in these calves.

The decrease in platelets from week 1 to week 11 is in contrast to what is described for European breeds. The reason for the high value at week 1 followed by the decrease is unclear. The MPV is relatively high at week 1. Together with a high RDW at week 1 this may be suggestive of a regenerative response by the bone marrow at the time around birth.

The initial high levels in TSP in the first week are likely due to the uptake of immunoglobulins from colostrum. The degradation of absorbed immunoglobulins contributes to the decreasing TSP at subsequent sampling points. Chronic blood loss, such as seen in chronic parasitic infections, including heavy helminth infestations, will also results in a decline in TSP over time. Over the whole follow-up period it appeared that the TSP in the short-horn Zebu was higher compared to what is expected in European cattle breeds. One possible reason, as discussed earlier, is their hydration status with possible haemoconcentration. Another possible explanation for the high TSP is high levels of antigenic stimulation resulting in high globulin levels. Exposure to pathogens, even from an early age, is considerable under field conditions in the tropical environment. Unfortunately only total serum proteins were investigated. Without distinguishing between different proteins, in particular albumin and the various immunoglobulins, it is difficult to come to any conclusions with regard to the levels and trends of TSP levels in the calves in this study.

4.2 "Good" calves – haematology in relatively healthy calves
There were no significant differences ($p > 0.05$) between any of the haematology parameters between "good" calves and the rest of the population at week 1. As the calves aged, the difference in red blood cell parameters became more evident. There was an indication that the general population under study tended toward an anaemic state as time progressed. The mean MCV of the total population was higher than the mean MCV of the "good calves" from week 6. In contrast, the MCHC of the total population was lower than the "good calves". The higher MCV and lower MCHC of the total population is suggestive of macrocytic hypochromic anaemia. The high RDW for the total population suggests that many animals had anisocytosis, which is associated with a reticulocytosis and regeneration of red blood cells. The insignificant difference in the white blood cell responses could suggest that the "good" calves were exposed to pathogens at the same rate as the general population and

had similar cellular responses. The platelet count of the total population was higher than that of the "good calves" from week 31. Thrombocytosis develops in response to chronic blood loss, such as haemolysis or haemorrhage as a result of chronic parasitism. There was also no significant difference in TSP at any time-point between "good" calves and the total population. It is thus unlikely that their colostral intake or immunoglobulin responses differed significantly either. It therefore seems that "good" calves were not suffering to the same extent from the development of a progressive anaemia as the general population.

The control of anaemia has been described as a characteristic of trypanotolerance (Naessens *et al.* 2002). It can be speculated that this is true for other haemoparasitic infections as well, and may prove a worthwhile topic to investigate further.

4.3 The level of anaemia in the population

The cumulative hazard rates of anaemia illustrate that anaemia is a significant syndrome in this calf population. Since the calves were from an area with a high prevalence of tick-borne diseases and helminth infections one would expect a high incidence of anaemia. The level of anaemia in the population appeared to be increasing in severity, as shown by the downward trend in PCV for the population from week 6 to week 51 (Fig. 4.3). It would be interesting to investigate the PCV of calves past 51 weeks to see what their blood profile would be in adulthood.

Although most calves suffered from anaemia at least once during their follow-up period, the number of cases of moderate anaemia (PCV< mean - 2SD) was considerably low compared to the total number of cases of anaemia (PCV<mean – 1SD). This is possibly due to the inherent tolerance these calves have to the endemic diseases and their capacity to manage the progressive development of clinical signs. These diseases cause severe clinical signs in other less-tolerant exotic cattle breeds.

One should keep in mind that the reference sample of calves was not from a disease-free nutritionally controlled environment. These "good calves" were alsolikely to be infected with pathogens such as helminths, which are very prevalent in the population (see Chapter 5), and is suggested by the upward trends over time in their white blood cell and eosinophil counts. Although these "good" calves did not show clinical signs of anaemia, some may have had subclinical anaemia, which would have affected the calculated cut-off points.

5. CONCLUSION

Anaemia appears to be an important syndrome in the calf population under study as demonstrated by the high number of calves showing anaemic episodes. Whether these trends and levels in the haematological parameters of the short-horn Zebus play a role in the susceptibility or resistance to infectious disease would be an interesting topic for further investigation.

There is a need to establish breed-specific reference ranges for blood parameters for the East African short-horn Zebu. It is also clearly evident that baseline values differ with age in the neonate and need to be taken into consideration when assessing the health status of an animal. The changes in the red blood cell parameters of the calves under study, especially during the neonatal period, are not explained by what is known about the physiology for other cattle breeds. This warrants further research into the dynamics of blood cell parameters of the East African short-horn Zebu and probably other indigenous cattle breeds.