AN EPIDEMIOLOGICAL STUDY OF ASCITES IN BROILER BIRDS IN THE PERI-URBAN AREAS OF NAIROBI, KENYA.

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

Dedicated to my parents Mr and Mrs Felix Njue, my husband David Nyaga and my daughters Eva Kathi and Ashley Mwendia.

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ABSTRACT

Inability to achieve self-sufficiency in food production, especially protein, in Kenya has necessitated the need to improve agricultural productivity. As a result, poultry production is being used to meet this food requirements although its potential has not been fully exploited due to various constraints such as poor husbandry and disease control.

This study was done with the main objective of ascertaining whether ascites condition is a problem in broiler industries in the peri-urban areas of Nairobi. In this study, prevalence of ascites and potential risk factors associated with its occurrence were examined. The economic impact of ascites in broiler production was also assessed.

The area of study covered the peri-urban districts of Nairobi, namely Machakos, Kajiado and Kiambu districts, which were further categorized according to agro-ecological zones ECZII, EZCIII and EZCIV. Data was gathered from 57 Kenchic Contract farms located in the study area and visited between January and March 1995. Considered also, was a sub-sample of 49 Kenchic Contract farms which were actively followed to slaughter at the kenchic abattoir located at Tigoni in Kiambu District, from January to April 1995. Other data were obtained from kenchic abattoir records for 1992, 1993 and 1994. These data were computerised and analysed.

The farm survey achieved 100% response rate. Ascites was reported singly or in combination with other diseases in 47% of the farms in ECZII, 50% of the farms in ECZIII and 62% of the farms in ECZIV. Overall, the leading causes of broiler poultry condemnations at Tigoni abattoir from January to April 1995 were cadavers (51.5%), ascites (26.1%) and others (22.4%). However, from the 1992 to 1994 abattoir data, ascites was the major cause of broiler poultry condemnations in the three ecological zones.

There existed significant (P=0.0071) annual variations in mean ascites prevalences in 1992, 1993 and 1994, with the lowest (0.52%) annual prevalence in 1994. However there was no significant (P=0.5351) variations in zone-specific mean ascites prevalence. Risk factors associated with prevalence of ascites from this study were age at slaughter, mortality during rearing, month of placing day old chicks, total feed consumed by a broiler during rearing period, brooding time, presence of other diseases, temperature range and inadequate ventilation.

There was evidence of substantial monetary loss attributed to ascites. For instance in 1994, the total market loss was estimated at Ksh 1,677,100.00, while that for the three month study period in 1995 was estimated at Ksh 120,494.67.

From this study, it could be concluded that the prevalence of broiler ascites in Kenya is low and that it is not associated with altitude as in temperate countries. Also changes in farm management aspects and company policies such as feeding regime and age at slaughter have effect on ascites prevalence. The results demonstrate that ascites is a major problem in commercial broiler production at farm and abattoir level especially when monetary losses and opportunity costs are considered.

CHAPTER ONE

1.0 INTRODUCTION

The principal problem facing Africa, especially the sub-saharan countries, is how to achieve self-sufficiency in food production. In most of the sub-saharan countries, food production has not kept pace with population growth (Shane, 1984). Thus, there is an urgent need to improve agricultural productivity so as to meet the food requirements of the ever growing human population, whose current growth rate is 3.0% per annum, compared to 2% of the food production (Masiga, 1994). Livestock and poultry production can be used to significantly reduce the gap between these two rates. In addition, poultry products provide high quality digestible protein.

The importance of poultry production to the food requirements as well as the economy of the developed and developing countries is demonstrated by the increase in the domestic production and consumption of eggs and broilers (Stotz, 1993). The demand for poultry products in developing countries has resulted in the emergence of agribusiness sectors which apply intensive production technologies developed in United states and Europe (Shane, 1984).

The response of the Kenya government in achieving this demand is exemplified by establishment of both Kenya poultry company and National Poultry Development Programme (NPDP) in the middle of 1970's. By 1987, the population of chicken was estimated at 18.04 million and by 1992, the population had risen to 25.2 million (FAO, 1992). Inspite of this increase, the full contribution of poultry protein (eggs and broilers) to the nutritional requirements in Kenya has not been achieved .

Poultry productivity and development have been adversely affected by a variety of factors, mainly physical, economic and political constraints, poor husbandry and diseases. Of these, diseases continue to play the major central role in impending the full development of the poultry industry in Kenya. However, recent advances in diagnostic techniques, microbiology, vaccine production, chemotherapeutics, technical innovations in housing, management, genetic selection and the optimal formulation of rations are expected to effectively control poultry diseases (Blake and Mbugua, 1992). However, diseases of unknown etiologies might be extremely difficult to combat. Ascites is one of such diseases.

Ascites is a cosmopolitan syndrome of an undefined aetiology (Mbugua, 1989). It is a perplexing and economically significant complex of the poultry industry, especially in chicken broiler flocks, characterised by increase of non-inflammatory fluid in one or more of the abdominal spaces (Julian, 1987a). The earliest reports of occurrence of poultry ascites were in USA in 1946 (Maxwell, 1988). Thereafter, the occurrence of this syndrome has continuously been reported in many other countries. In Kenya, the syndrome was first reported in 1977 (Kaminjolo *et al.*, 1977). Since then, it has been reported in various parts of the country. The prevalence of the disease in Kenya has coincidentally increased with successful developments of new intensive broiler flocks (Mbugua, 1989). The losses caused by this syndrome include lowered growth rates, mortalities, impaired fertility, reduced feed conversion efficiency and condemnation of whole carcass at slaughter.

Ascites is a biologically complex syndrome with varying morbidities and distributions from country to country as well as within countries (Julian, 1993). It's etiology is unknown and it is predisposed by various determinants. In many countries, these determinants have been elucidated either singly or in combination in determining how they influence the occurrence of this syndrome (Julian, 1993). In Kenya, knowledge regarding these determinants is lacking. Identification of the determinants and quantification of their effects, their distribution and their associations with the risks of the occurrences of ascites should assist in designing effective control programmes in Kenya. Therefore, this study was designed with the following objectives.

1. To estimate the prevalence of ascites in commercial broiler flocks in the peri-urban areas of Nairobi.
2. To identify and quantify the risk factors associated with the occurrence of ascites in commercial broiler flocks.
3. To assess the economic impact of ascites in broiler production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

2.1.1: Livestock industry in kenya

The population of livestock in the country is estimated at 12 million cattle, 19 million sheep and goats, 875,000 camels, 18 million poultry and 113,000 pigs (Anon, 1989). Distribution of these livestock species in the country is determined by the climatic conditions and prevailing production systems (Stotz, 1993). However poultry are distributed in all parts of the country.

The economic importance of livestock industry is illustrated by it's enormous contribution to wealth generation in the country (Anon, 1991). It is estimated that 43% of the total labour force in the agricultural sector is employed in the livestock industry (Anon, 1991). This contributes significantly to the employment opportunities outlined in the National Development Plan (1989-1993) (Anon, 1991).

During the last two decades, small holder farming has greatly developed in Kenya due to intensification and application of new technologies adopted from developed countries (Shane, 1984). Such technologies include: high yielding grade dairy cattle, arable fodder crops, and introduction of hybrid poultry varieties (Blake and Mbugua, 1992).

2.1.2: Poultry industry in kenya

In general, the poultry industry in Kenya is vastly underdeveloped compared to other livestock industries (Blake and Mbugua, 1992), producing only 25.2 million birds in 1992 (FAO, 1992). This may be attributed to it's relative young age compared to dairy, beef and swine industries. Furthermore, it is only in the last twenty years that commercial poultry production has been undertaken by a few large scale producers (Gitao, 1988).

The infrastructure necessary for development of the industry such as feed mills, vaccine production units and hatcheries are available (Mbugua, 1990). Nonetheless, there are constraints such as shortages of feed supplies, lack of public live bird markets and inability to control diseases fully especially diseases of unknown etiology such as ascites which seem to be a specific problem in broiler production and which have adversely affected the development of this industry (Mbugua, 1989; Blake and Mbugua, 1992). The different poultry production systems are described below.

2.1.2.1: Traditional system.

This is common in rural areas and is the least capital intensive poultry production system (Stotz, 1983). The average flock size is usually 10 which consists of indigenous birds kept mainly for meat (Mbugua, 1990). The birds are let free during the day and are only confined during the night as a result of which they are exposed to predators (Stotz, 1983). They scavenge for their own food and are watered irregularly. These poor management practices predispose the birds to diseases like coccidiosis and newcastle of which control is poor; hence significant farm losses (Stotz, 1983). Under this production system, birds weigh 1.5 - 2 kg at 5 -6 months (Stotz, 1983).

2.1.2.2: Semi-commercial system

Genetically improved birds such as cross breeds of local birds and Rhode island red and light sussex are kept under improved husbandry methods (Stotz, 1983). Under this system, birds range over the fields during the day where they are expected to get most of their feed, and are properly confined in a chicken house at night (Stotz, 1983). They are supplemented with grain and have free access to water. Preventive measures are taken against diseases such as Coccidiosis and New castle which include use of coccidiostats and vaccination, respectively. The aim is mainly to produce eggs and meat in surplus amounts for household consumption and sale (Stotz, 1983). Average flock size is 20 birds, consisting of 10 adult hens, 2 cocks and 8 young birds. Production level achieved is 125 eggs per hen housed and 1.9 kg carcass weight (Stotz, 1983).

2.1.2.3: Commercial egg production

This is a type of poultry production which is highly specialised and capital intensive (Stotz, 1983). On average, farmers keep 200 layers of exotic stock acquired from specialised hatcheries. They are permanently confined and dependent completely on manufactured feeds which accounts for 70% of production costs (Stotz, 1983). Disease control programmes consists of vaccination against Marek's disease, New castle disease, fowl typhoid and fowl pox. Chemoprophylaxis is carried out for prevention of coccidiosis. Average production is 220 eggs per hen housed with average mortality of 8%.

2.1.2.4: Commercial Broiler production

Small holder broiler production in Kenya falls in two broad categories:-

(i) Semi-integrated production system as seen for Kenchic Company Limited (Contracting farmers).

(ii) Non integrated Units which are not contracted to

Kenchic Company Limited (Non-contracting farmers). The latter keep upto 1000 broilers of hybrids (Stotz, 1983), whereas the former keep from 1000 to 10,000 birds (Anon, 1994). Houses are made of various locally available materials, but the upper part of one side wall usually consists of wire mesh for sufficient ventilation (Stotz, 1983). Usually the floor system is deep litter and the area allows for $0.0929m^2$ per bird (Stotz, 1983). Broilers are fed on high quality manufactured feed which contains adequate energy and protein nutrients to facilitate fast growth, so that they can achieve slaughter weight of 1.5 kg - 2 kg at 42 days (Anon, 1994). Non-contracting farmers usually market their birds at 55 days with 1.8 kg liveweight (Stotz, 1993).

Disease control measures consist of: vaccination against New castle disease, Gumboro and Fowl pox and installation of foot disinfection bath at the entrance of the broiler house, (Anon, 1994). For small holders, vaccination is only done against New castle disease (Stotz, 1993). Mortality rate for small holder broiler production is 11% on average (Stotz, 1993).

2.2 Poultry diseases

Health problems affecting the poultry industry are common in many African countries including Kenya (Blake and Mbugua, 1992). Among these problems, diseases mainly bacterial, viral, parasitic, mycotic and nutritional deficiencies and miscellaneous conditions remain the major constraints to poultry productivity and development (Gordon, 1977). However, management strategies which include prevention, control and/or eradication of these poultry health problems are available in most countries, except for the miscellaneous conditions. Of the latter, ascites ranks as the most important health problem especially in broiler production (Jordan, 1990).

2.3 Ascites

Ascites is a syndrome characterised by an increase in the amount of non-inflammatory fluid in one or more of the abdominal spaces (Mbugua, 1989). This syndrome has no well defined aetiology (Julian, 1985). However, several causes and predisposing factors have been incriminated (Julian, 1993). The documented causes include obstruction of lymph drainage, decreased plasma oncotic pressure, increased vascular permeability, increased hydraulic pressure in the blood vascular system, valvular insufficiency and right ventricular failure and pulmonary hypertension syndrome (Julian, 1993). These causes are described in more detail in the sections that follow.

2.4 Causes of ascites

2.4.1: Obstruction of lymph drainage

Increased venous pressure at the thoracic duct outlet may impair lymph drainage, which may lead to fluid accumulation in peritoneal cavity (Julian, 1993). In mammals, majority of the blockages of the thoracic duct and other lymphatics are caused by neoplasia (Julian, 1985), unlike in poultry. In poultry ovarian carcinomas occasionally occur and ascites is a frequent complication in advanced cases (Helmbodt and Fredrickson, 1972). Ovarian carcinomas may as well be occurring in broilers but the poultry husbandry practices tend to slaughter most birds at a relatively young age before tumours have a chance to develop or when they are microscopic and may be thus overlooked. Broiler chickens with right ventricular failure from pulmonary hypertension develop ascites very rapidly due to interference with lymph return into the vena cava by high venous pressure, where the thoracic duct opens into vena cava (Julian *et al.*, 1989b).

2.4.2: Decreased plasma oncotic pressure

Oncotic pressure depends on plasma proteins concentration (Julian, 1993). Physiologically, birds have low concentration of plasma proteins compared to mammals and these proteins are directly related to dietary proteins (Jordan, 1990). Plasma proteins also depend on the strain of bird (Bowes *et al.*, 1989). It has been found that plasma proteins especially plasma albumin are lower in young broilers than in leghorns on the same diet (Bowes *et al.*, 1989). Ascites resulting from low plasma albumin (Wise and Evans, 1975) could be consequential to cachexia and loss of high protein lymph from the liver (Julian, 1985).

2.4.3: Increased vascular permeability

Vascular endothelial damage has been associated with certain agents, such as:- free radicals, chemicals, bacterial toxins and viral infections like Angara disease (Julian, 1990a). Chemicals that damage the endothelium include: chlorinated hydrocarbons (McCune *et al.*, 1962), pentachlorophenol (Prescott *et al.*, 1982), Coal tar derivatives (creolin, carbolineum, etc), biphenyl compounds and dioxin (toxic fat syndrome) (Shoya *et al.*, 1979; Lekkas *et al.*, 1986; Julian, 1991). Due to endothelial damage, there is increased vascular permeability which causes extravasation. This causes changes in oncotic pressure and fluid is drawn into the peritoneal spaces (Scott and Krook, 1972). If fluid accumulates in abdominal spaces, ascites occurs (Mbugua, 1989).

2.4.4: Increased hydraulic pressure in the blood vascular system.

When blood pressure increases relative to oncotic pressure, there is fluid accumulation in tissues and peritoneal spaces (Julian, 1990a). The imbalances between these two forces is mainly due to a rise in blood flow or increased resistance to flow (Julian, 1993). In both mammals and birds, right ventricular failure results to excess transudation of fluid due to increased blood pressure (Julian, 1990a).

2.4.5: Increased hydraulic pressure due to liver damage

The most frequent cause of ascites in chickens is increased portal hypertension (Julian and Wilson, 1986) due to increases in venous pressure as a result of liver damage. The latter is caused by factors such as: amyloid deposition, hepatic fibrosis and cholangiohepatitis (Julian, 1987a, 1988). Toxic materials reported to cause liver fibrosis and ascites in poultry include monocrotalline compounds from *Crotalaria spectabilis* and Heliotropin when in high proportions in poultry feed (Julian, 1991). Diets containing cotton seed cake have been associated with ascites. This is due to liver damage caused by free gossypol (Kahiri, 1991). Aflatoxin levels of 1.4 to 3.6 parts per million were found to cause chronic hepatitis followed by ascites (Dalvi, 1986). Carlton in 1966 reported liver damage and ascites on experimental coal tar poisoning in white peckin ducks. Liver damage is in form of fibrosis which causes obstruction of venous return (Julian, 1988). This is followed by pooling of blood in visceral organs and accumulation of extravascular fluid in abdominal spaces, hence ascites. Portal hypertension may also be caused by right ventricular failure due to valvular insufficiency (Julian *et al.*, 1987).

2.4.6: Increased hydraulic pressure due to valvular insufficiency and right ventricular failure

2.4.6.1: Primary heart and valvular diseases.

Intra-arterial and intra-ventricular septal defects may cause left to right heart shunts. This may lead to right ventricular dilatation due to increased hydraulic pressure hence right ventricular failure. However ascites which results thereof is of low incidence in broiler chicks (Julian and Wilson, 1986).

2.4.6.2: Right atrio-ventricular valve lesions

Bacterial infections due to *Staphylococcus aureas*, *Streptococcus fecalis* and *Pasteurella multocida* cause endocarditis of mitral and aortic valves (Gross, 1972).

This leads to valvular insufficiency and increased venous pressure leading to ascites. The ascites due to this is usually sporadic and may be as low as 0.5% (Gross, 1972).

2.4.6.3: Degenerative and dilatory cardiomyopathies.

Inflammatory and degenerative disease of the myocardium or valves can cause right ventricular failure and ascites (Julian, 1993). These diseases include: round-heart disease, furazolidone-induced cardiomyopathies, toxic, nutritional and infectious cardiomyopathies. Such naturally occurring lesions however are rare in birds (Julian, 1993). Of importance is a dilatory cardiomyopathy, round heart disease which was first described by Magwood and Bray (1962). Since then, it has continued to gain prominence in causing 3-6% mortality in commercial turkey flocks (Julian, 1993).

Round heart disease has been strongly associated with cardiac muscle hypoxia in late embryo or young poultry (Mirsalimi *et al.*, 1990). This is supported by the fact that myocardial fibres develop very fast thus requiring high oxygen concentration (Mirsalimi *et al.*, 1990; Julian and Mirsalimi, 1992). High oxygen requirement is also associated with cold or excessive heat (Julian and Mirsalimi, 1992). This may explain why incidences of ascites are higher in colder months of the year (Mbugua, 1989). Cardiac muscle hypoxia causes cardiac muscle cardiomyopathies, hence right ventricular failure and ascites.

Furazolidone, a feed additive, has been used to experimentally induce round heart disease in turkeys (Mirsalimi *et al.*, 1990) and cardiomyopathies in ducks (VanVleet and Ferrans, 1983) and chicken (Orr *et al.*, 1986). Orr and associates (1986) induced myocardial degeneration by feeding broilers on starter diet containing furazolidone. Feeding high levels of rapeseed oil to chickens, ducks and turkeys causes heart muscle damage which leads to ascites (Ratanasethakul, 1976). Monensin, a coccidiostat for poultry, may result in ascites via a similar mode (Julian, 1990a), as many other toxic compounds in the diet (Dale and Villacres, 1986c). Vitamin E-selenium deficiency in turkey poults and waterfowl has been associated with heart lesions (Wilson *et al.*, 1988; Austic and Scott, 1991) and right ventricular failure. Feeding experiments done in ducklings determined levels required to induce selenium-Vitamin E deficiency and hydropericardium which culminates to ascites (VanVleet and Ferrans, 1983).

Cardiomyopathies caused by viral infections have been delineated by Maxwell and associates, (1986). Adenovirus has been isolated from affected broilers suffering from Angara disease in Pakistan (Qureshi, 1989; Anjum *et al*, 1989), Iraq (Abdul-Aziz and Al-Attar, 1991) and North America (Cowen *et al.*, 1988). Other viruses have also been reported to cause myocarditis and ascites (Reed and Winterfield, 1985). Myocarditis leads to right ventricular failure, which then causes increased portal hypertension and ascites.

In toxic fatty syndrome, hydropericardium is very common. In such cases myocardial vascular damage is possible and in combination with increased hydraulic pressure from right ventricular failure and endothelial damage it may lead to ascites (Julian, 1993).

2.4.7: Pulmonary Hypertension Syndrome (PHS).

Ascites in broiler chickens is mainly caused by pulmonary hypertension as a result of induced right ventricular failure (Julian and Wilson, 1986; Julian, 1990b). Increased pulmonary pressure results from increased blood flow or increased resistance to flow in the pulmonary vascular system (Julian, 1987b, 1990a,b).

Pulmonary hypertension may result from increased blood flow causing both a volume and pressure overload. Increased blood flow may be due to increased oxygen requirement (tissue hypoxia) ((Julian, 1990b), high energy diets (Dale and Villacres, 1988), exposure to excessive cold and heat during brooding (Huchzermeyer *et al.*, 1989; Lubritz, 1995), low haemoglobin oxygen saturation (Cueva *et al.*, 1974) and high dietary salt

(Julian, 1987b).

2.4.7.1: Increased oxygen requirement (Tissue hypoxia)

High energy broiler diets coupled with the rapid growth rates of birds, have led to increased requirements of oxygen (Dale and Villacres, 1988). Due to this there has been a marked increase in pulmonary hypertension in broiler chickens (Julian, 1990b) at both low and high altitudes (Dale and Villacres, 1988). Factors which increases oxygen requirements also increases the incidence of ascites due to pulmonary hypertension (Julian *et al.*, 1987). Genetic selection of fast growing broiler chicken that goes with improved production, has led to emergence of birds with fast growth rates and high muscle yield, but with insufficient lung capacity for blood flow to supply the body with the high oxygen requirements. This is because the large liver, the abdominal fat and the intestines compress the air sacs. There is also interference with respiration brought about by increased weight of breast muscle mass (Julian, 1990c).

2.4.7.2: Diet

High energy density rations have been associated with high growth rate (Dale and Villacres, 1986a; Julian, 1987a; Julian *et al.*, 1989a; Dale, 1990). Recently, spent hens have been used as an ingredient for broiler breeder feed (Bachmann, 1995). Though this is a good protein source, feed trials resulted in high mortalities from pulmonary hypertension related ascites in birds fed on poultry by-products (Julian *et al.*, 1990). To prevent pulmonary hypertension syndrome related ascites, restricted feeding without affecting production characteristics has been tried (Huchzermeyer, 1986; Lopez-Coello *et al.*, 1987). Recovery has also been observed following skip feeding programme, change of feed texture, change of feed density and change in feed energy level (Julian, 1993).

2.4.7.3: Cold and heat.

Optimal temperatures required for brooding start at 32°C in order to achieve maximal growth (Harns *et al.*, 1975). However, feed intakes are reduced as brooding temperatures are increased (Harns *et al.*, 1975). It has been shown that feed conversion efficiencies improved with increase in temperatures within 13°C - 24°C after brooding period (Charles *et al.*, 1981). Poultry house temperatures should therefore not go beyond 27°C as this is likely to depress weight gain and feed intake (Charles *et al.*, 1981). Reduction in feed intake associated with high temperatures within 25°C - 30°C lead to reduced pulmonary hypertension syndrome, but increases oxygen requirements (Huchzemeyer *et al.*, 1989). Hence the incidence of pulmonary hypertension syndrome at 25°C - 30°C is similar to that at low temperatures.

Cold stress significantly increases the incidence of ascites when low temperatures are used during brooding (Julian *et al.*, 1989b). Low temperatures stimulate high metabolic rate and increases oxygen requirement in fast growing broilers (Julian *et al.*, 1989b; Lubritz, 1995). Cardiac output also increases resulting in pulmonary hypertension. There has been marked increase in ascites at both low and high altitude areas in cold weather (Buys and Barnes, 1981; Huchzermeyer and DeRuyck 1986; Mbugua, 1989).

2.4.7.4: Haemoglobin Oxygen saturation.

Hypoxia-hypoxemic induced pulmonary hypertension syndrome observed at high altitudes culminates to right ventricular failure and ascites (Cueva *et al.*, 1974; Owen *et al.*, 1990). This is because following incomplete haemoglobin oxygen saturation, the body triggers release of erythropoetin as a compensatory mechanism with subsequent polycythemia (Julian 1993). During polycythemia, blood increases in volume and becomes viscid, thereby increasing the capillary resistance (Maxwell *et al.*, 1990), which leads to right ventricular overload and hence ascites.

High dietary cobalt has been used as an experimental model to induce right ventricular failure and ascites in broiler chickens (Diaz *et al.*, 1994). Since cobalt is known to induce polycythemia, it may be working through increased viscosity to induce pulmonary hypertension syndrome. Cold also induces polycythemia (Jordan, 1990)

Agents that interfere with oxygen exchange in lungs may result in polycythemia and hence have been hypothesized to cause increases in incidences of ascites (Lopez-Coello *et al.*, 1985; Dale, 1990; Albers and Farakenhuis, 1990b). However, there is no evidence from research that noxious fumes from poor ventilation or stress causes ascites (Julian, 1989). Researchers experimenting with carbon monoxide (Wilson and Julian, 1985) and high levels of ammonia (Al-Mashhadani and Beck, 1985) were unable to produce ascites.

Interference with lung oxygen capacity due to rib rickets induced by phosphorous deficient diets has been shown to cause pulmonary hypertension syndrome and eventually right ventricular failure (Julian *et al.*, 1986). Pulmonary aspergillosis is the only natural infection that causes respiratory disease and that has been shown to cause pulmonary hypertension syndrome and ascites (Huchzermeyer, 1986; Julian and Boulianne, 1988; Julian and Goryo, 1990). Recent work showed that severe pulmonary aspergillosis causes hypoxic-hypoxemia-induced pulmonary hypertension syndrome. Less severe aspergillosis infection resulted in lung fibrosis, with subsequent pulmonary hypertension syndrome and right ventricular failure (Julian and Goryo, 1990). Severe lung damage caused by toxic levels of di-calcium phosphate in feed can trigger ascites in 3 week old broilers (Bowes, 1990).

2.4.7.5: Increased blood volume

High dietary salt intake has been shown to cause influx of interstitial fluid into blood vessels thereby increasing the blood volume and causing pulmonary hypertension (Julian, 1987b). Right ventricular failure and ascites develop early in broilers on higher level of sodium which has been shown to be the toxic ion in salt poisoning (Mirsalimi and Julian, 1993). Besides, salt also increases vascular resistance in blood flow due to increased rigidity and reduced deformability in red blood cells (Mirsalimi *et al.*, 1992). It should always be considered a common cause of ascites at coastal areas where water is saline (Julian, personal communication). Other factors which increase red blood cell rigidity include: increased corpuscular haemoglobin concentration, (Mirsalimi *et al.*, 1992), hypoxemia (Hakim and Macek, 1988, Mirsalimi and Julian, 1993), and blood parasites (Krogstad *et al.*, 1991). Broilers are more predisposed to this because they have small inelastic blood capillaries which cannot accommodate increased blood cell volume thereby causing significant resistance to flow (Mirsalimi and Julian 1991). The red blood cells of meat-type chickens have been hypothesized to be more rigid than those of leghorn chickens (Mirsalimi and Julian, 1991). Smith *et al.,* (1979) in his study found that with ageing of broilers, the red blood cell haemoglobin concentration increases and becomes less deformable which may interfere with blood flow.

2.4.7.6: Reduced vascular capacity.

This may be caused by pulmonary vascular disease and endothelial cell hypertrophy or hyperplasia. Experimental pulmonary arteriolar vasoconstriction has been shown to increase vascular resistance to blood flow through the lung in hypoxic conditions in birds (Julian, 1993) thereby causing pulmonary hypertension. This is due to reduction in vascular elasticity and increase in vascular resistance to blood flow. It has long been shown that chemical and infectious agents affect endothelial cells of blood vessels supplying the lung by stimulating hyperplasia and hypertrophy (Julian *et al.*, 1989a). Amiodarone has been shown to cause hyperplasia of endothelial cells (Julian *et al.*, 1989a) while dioxin, a dietary factor, has been shown to cause endotheliosis in chicken (Simpson *et al.*, 1959).

2.5 Predisposing factors to ascites

The predisposing factors include growth rate, sex, breed of bird, structural characteristics of the lungs and genetics (Julian, 1990a). These factors are described in more detail in the sections that follow.

At high altitude, growing broiler chickens are more susceptible to the pulmonary pressure that leads to right ventricular failure than leghorns (Hall and Michicao, 1968) and males are more susceptible than females due to their faster growth rate (Mbugua, 1989). It has been shown that if growth rate is not restricted, over 30% of male meat-type chickens raised above 2000m may die from right ventricular failure (Julian, 1990c).

The unique muscular structure of the right atrioventricular valve might result predominantly in right ventricular failure in response to diffuse myocardial disease (Julian *et al.*, 1987). Such diseases might include inherited metabolic abnormalities of myocardium, undetermined nutritional deficiencies, or the effects of unidentified toxic agents (Julian *et al.*, 1987).

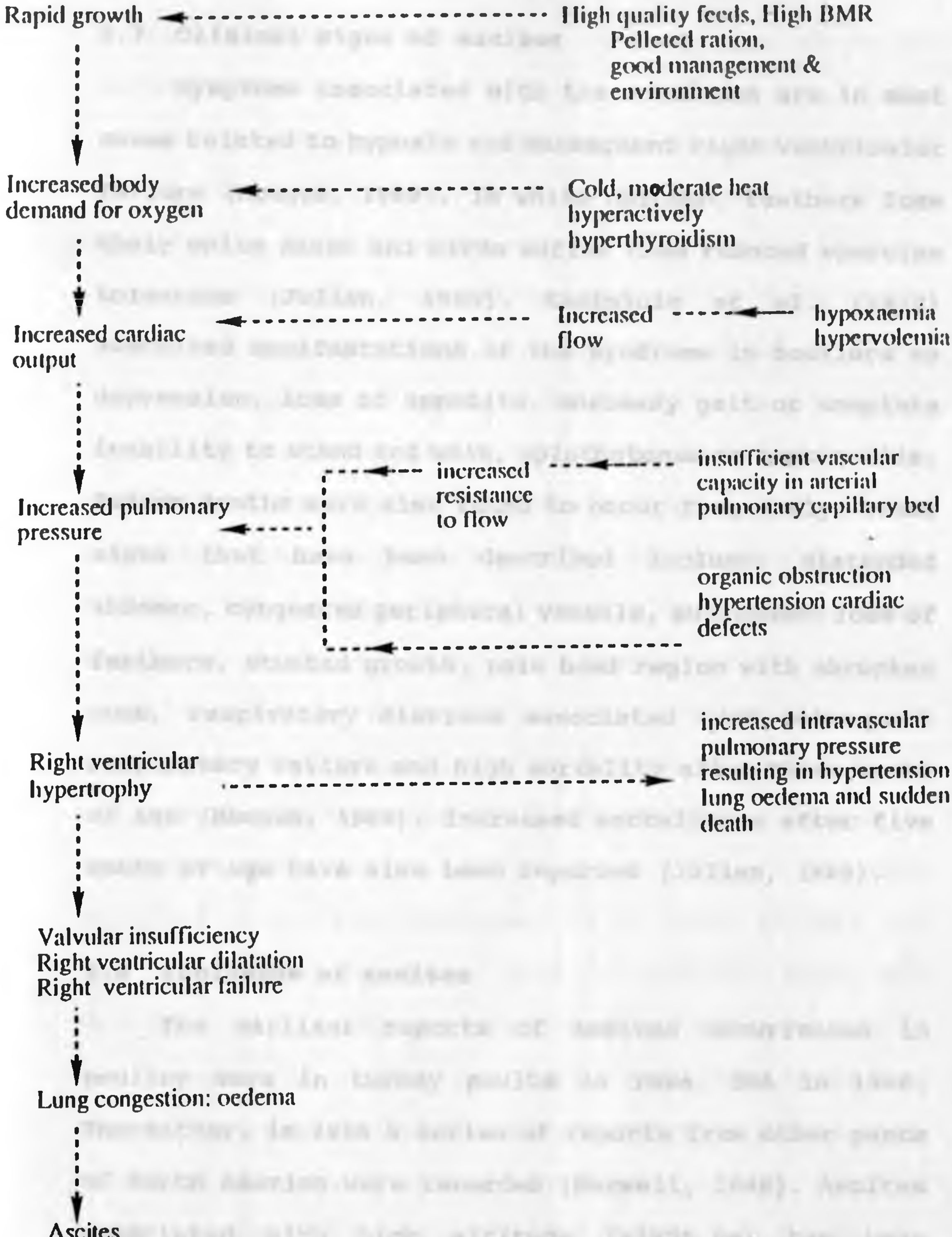
Structural characteristics of lungs of the domestic fowl have been described (Vidyadaras *et al.*, 1990). The lungs are rigid and fixed in the thoracic cavity and have small blood capillary vessels which have limited elasticity to allow for increased blood flow (Vidyadaras *et al.*, 1990). Furthermore, the lungs grow at slower paces than the muscular tissues. Therefore, the lung capacity is unable to keep up with the fast growth of broiler chickens (Julian, 1989). These structural characteristics make the birds more vulnerable to stress factors such as high altitude, heat, cold, and pollution which predispose them to hypoxemia and ascites.

Genetic differences have been associated with occurrence of ascites. It was found that birds with high genetic potential for fast growth and white meat yield had most cases of ascites (Lubritz, 1995). This is because of large abdominal capacity and insufficient lung capacity for blood flow to supply it's body oxygen requirement during periods of rapid growth (Julian, 1990a).

The incidence of ascites has been found to be lower in slower growing male lines due to slow growth and in rapid growing line due to low breast muscle yield (Lubritz, 1995). Differences in susceptibility to ascites which were observed among broilers of four commercial strains reared at an altitude of 1350m were assumed to be of genetic origin (Huchzermeyer *et al*, 1988), although trials conducted at altitudes in excess of 1500m showed no significant association between strain of chicken and the incidence of ascites in commercial broilers (Mbugua, 1989).

PATHOGENESIS OF ASCITES

ig. I: Diagrammatic summary of possible causes of increased pulmonary arterial pressure in broiler chick esulting in increased right ventricular workload.



dapted from: Julian,R.J. The effects of increased sodium in the drinking water on right ventricular hypert ight ventricular failure and ascites in broiler chickens. Avian pathology, 16, 61-71,1987(b)

2.7 Clinical signs of ascites

Symptoms associated with the condition are in most cases related to hypoxia and subsequent right ventricular failure (Mbugua, 1989). In white chicken, feathers lose their white sheen and birds suffer from reduced exercise tolerance (Julian, 1989). Kaminjolo *et al.* (1977) described manifestations of the syndrome in broilers as depression, loss of appetite, unsteady gait or complete inability to stand and walk, opisthotonus or torticollis. Sudden deaths were also found to occur frequently. Other signs that have been described include: distended abdomen, congested peripheral vessels, subsequent loss of feathers, stunted growth, pale head region with shrunken comb, respiratory distress associated with subsequent respiratory failure and high mortality after three weeks of age (Mbugua, 1989). Increased mortalities after five weeks of age have also been reported (Julian, 1989).

2.8 Incidence of ascites

The earliest reports of ascites occurrences in poultry were in turkey poults in Iowa, USA in 1946. Thereafter, in 1958 a series of reports from other parts of North America were recorded (Maxwell, 1988). Ascites associated with high altitude (>1828.8m) has been reported in various countries, with mortality rates of 5-15% (Dale, 1986). It has been reported in Bolona, Peru, Ecuador, Columbia, Mexico and South Africa (Buys and Barnes, 1981).

There has been an increase in the incidences of ascites in endemic areas such as, the savanna of Bogota in Colombia (2438.4m above sea level) where an increase from 9% to greater than 15% has been noted (Dale 1986). Numerous cases of ascites were reported between 1984 and 1986 in regions of lower elevations (below 400m) not previously affected. This coincides with a continuing nutritional and genetic improvement in rate of growth and feed utilisation efficiency. Such regions include USA, Canada, UK, Italy, Cuba, Australia, Germany and Mauritius. In Georgia, ascites accounts for upto one half of all broiler mortality (Dale, 1986). The syndrome has also been described in Ireland and North Yemen (Barret *et al.*, 1986). The syndrome was first reported in Kenya in 1977 (Kaminjolo *et al.*, 1977). Since then, it has been reported in various locations. It is found at both low and high altitude areas, such as Mombasa (15m) and Nairobi (2000m), respectively (Mbugua, 1989).

Ascites is common in broiler breeder flocks and white leghorn pullets (Barrett *et al.*, 1986), meat type duckling (Julian, 1988) and turkeys (Julian, 1987a). While ascites has been reported in turkeys, no cases have been seen at a farm in Naivasha (Kenya) in the last twenty years. This farm is 3000m above sea level (Mbugua, 1989).

The condition is more common in chicks more than 5 weeks old, which is the age at which the growth rate increases rapidly. Also at this age, birds are usually fed on high energy rations which implies that birds are at a higher risk of getting ascites. This trend is changing because ascites is now occurring in chicks, as early as 7 days (Julian, 1987a) and even at 3 days of age (Dale, 1986; Mbugua, personal communication).

2.9 Epidemiology of ascites

2.9.1: Diagnosis of ascites

Various diagnostic techniques are used in diagnosis of ascites. They include: use of clinical signs, clinical pathological changes, gross pathological changes at postmortem and electron microscopy (Mbugua, 1989).

2.9.1.1: Use of clinical signs

The average age when poultrymen could be expected to visually recognise ascitic cases with almost 100% accuracy was at 30.59 days, (Mbugua, 1989) which may be too late to salvage the birds. Furthermore, birds may die from hypoxia emanating from right ventricular failure before ascites develops. In such cases, clinical signs may be associated with ascites rather than hypoxia. This could lead to increased false positives if this test is used.

Under normal circumstances, body size and weight, decrease when right ventricular failure develops preceding ascites condition, which implies that ascitic birds would be missed out before this stage, if these specific clinical signs were to be used as the test (Julian 1987a, 1990b; Maxwell, 1990). There will be lowered specificity of the test.

2.9.1.2: Use of clinical pathological changes

Changes in blood parameters in birds with ascites are similar to those in birds with hypoxemia, associated with high altitude or rickets-induced hypoxia (Julian *et al.*, 1986; Maxwell, 1990; Maxwell *et al.*, 1990). They include increase in red blood cell numbers, haematocrit, mean cell volume and haemoglobin (Maxwell, 1990). Mbugua (1989) compared normoxic and hypoxic birds at day old and got similar haematological results for both groups. However right ventricular failure can't be ruled out during sampling for normoxic birds and it could be that the change in blood parameters, which is observed during hypoxemia is due to right ventricular failure (Yersin *et al.*, 1992).

However basing diagnosis on clinical pathology, the test may not be sensitive from 3rd to 4th week because blood parameters have been shown to be similar in hypoxia related ascites and control groups (Mbugua, 1989).

2.9.1.3: Use of postmortem lesions

Postmortem changes associated with right heart failure are: swollen liver, venous congestion, dilated right atrium and vena cava, as well as thickening of the right heart, marked lung congestion and oedema (Julian, 1989; Mbugua, 1989). However, not all broilers which die from right heart failure have ascites, and as such, the test may not be that sensitive. Besides not all associated postmortem lesions may show up with one particular case.

Sudden death is likely to occur before clinical signs are observed or after respiratory failure (Julian *et al.*, 1987,1989b) in which case ascites cases will be missed out. But with postmortem examination, there is reduction in number of false negatives arising from the clinical signs test, thereby improving on specificity.

2.9.1.4: Use of electron microscopy

Ultrastructural abnormalities observed in ascitic birds at high altitude (Maxwell *et al.*, 1989) and at low altitude (Maxwell *et al.*, 1986) have been described. The tissue abnormalities are similar at the two altitudes, only that they are more severe at high altitude (Maxwell *et al.*, 1989), possibly due to more pronounced hypoxia.

These changes can therefore be used as a reliable diagnostic test, save for hypoxia which may occur in non ascitic birds and with similar changes.

2.9.2: Management of ascites

If various changes can be adopted, incidence of ascites could be reduced drastically. These may include: good house design, proper brooding management, proper feeding management, effective respiratory disease control and genetic improvement.

2.9.2.1: Good house design

Improvement of poultry house design so as to minimise temperature variations and enhance ventilation can help in reducing the incidence of ascites. Poor house design can lead to birds being exposed to cold especially during the cold season. It has been shown that, cold exposure causes increased oxygen requirement due to heat loss (Julian *et al.*, 1989b). Poorly ventilated poultry houses encounter accumulation of noxious gases such as ammonia and carbon monoxide which could predispose birds to lung damage, and hence ascites (Mbugua, 1989).

Floor space of the poultry house determines the stocking density of the birds. Overcrowded birds will usually be stressed and hence be predisposed to varying disease conditions. Moving ascitic birds from an overcrowded house to a less crowded one, cured birds of ascites syndrome (Julian, 1993).

2.9.2.2: Proper brooding management

Use of non-smoky open flame for brooding as well as oxygen supplementation at high altitude has been shown to reduce mortalities related to ascites (Mbugua, 1989).

2.9.2.3: Proper feeding management

Feed restriction to slow growth rate (Albers *et al.*, 1990., Dale, 1990; Moreno and Lopez-Coello, 1991) as well as feeding marsh rather than crumbs or pellets (Agudelo, 1983) have been shown to reduce incidences of ascites. However some workers argue that birds fed on marsh eat more which could interfere with breathing by putting more pressure on the airsacs therefore causing hypoxemia (Julian *et al.*, 1989b; Scheele *et al.*, 1991) which culminates into ascites. It has been shown that feeding less nutritive layer feed to ascitic birds controls ascites (Cerruti-Sola *et al.*, 1988).

Vitamin C is reported to reduce the incidence of pulmonary hypertension syndrome (Al Taweil and Kassab, 1990) though the mechanism is not known. Adding vitamin C to pelleted feed has been shown to increase haematological parameters in South American ascitic birds (Maxwell, 1988). Although Vitamin E-selenium deficiencies have been shown to cause ascites (Dale and Villacres, 1986c), supplementation of Vitamin E and selenium above the levels considered to be adequate failed to reduce the incidence of ascites. There is a possibility that dietary treatment may only be effective if clinical signs are not too advanced (Scott *et al.*, 1978). The failure of the birds in Ecuador to respond to Vitamin E and selenium treatment could have been due to the degree of severity of the deficiency.

Proper feed formulation should include proper choice of fats and right proportions of sodium salts to avoid ascites associated with toxic fats and excess sodium ions respectively (Mbugua, 1989). Sodium salts should not be more than 2000 parts/million in feed and 1000 parts/million in water (Julian, 1987a).

2.9.2.4: Effective disease control tactics

Keeping Mycoplasma-free chicks and vaccinating for common respiratory diseases are worthwhile control measures which have been tried (Mbugua, 1989).Since respiratory diseases predispose birds to ascites (Huchzermeyer, 1986,1989), controlling the diseases would reduce its incidence. Disinfecting poultry houses between flocks reduces the incidence of respiratory conditions, though time has to be allowed after disinfection for disinfectant fumes to be dissipated since they can cause lung damage (Lopez-Coello *et al*., 1985; Dale, 1990; Albers and Farakenhuis, 1990).

2.9.2.5: Genetic improvement

Breeding for resistance to ascites has been tried in South Africa (Barret *et al*., 1986).

2.10 The impact of ascites

Disease is undesirable in livestock farming because it has negative effects. Losses can be distinguished analytically into two components, namely disease (production) losses and disease control expenditure (Willet *et al*., 1982; Mclnerney, 1991; Mukhebi *et al*., 1992).

2.10.1: Production losses

Reduction in the value of output due to disease is measured by mortality rates, lowered growth rates, depressed yield, impaired fertility and reduction in product quality (Putt *et al*, 1988; Mclnerney, 1991). Ascites causes production losses through high mortalities, reduced feed conversion efficiencies and condemnation of infected birds at slaughter. It is therefore a serious economic concern in most broiler operations.

Ascites has been shown to cause enormous financial losses, estimated at 675,438.6 US Dollars in 1983 and 59,649,123 US Dollars in 1984, in S.Africa and Mexico respectively (Maxwell, 1990). These losses were attributed to mortalities, reduced feed conversion efficiency and whole-bird condemnation (Maxwell, 1990). The syndrome is the principle cause of mortality and condemnation in the main broiler producing areas, such as the endemic areas of Bogota and Colombia (Dale, 1986). The average mortality rate reported in these two countries was 9-12% (Dale, 1986). Mbugua in 1989 reported high cumulative mortality rate of 18.5% in broilers reared in a farm in Kenya. This was reasonably higher than the 6% which had been reported in healthy birds by Kenchic company Ltd, which shows that ascites is an economic concern in broiler operations in Kenya.

A study carried out in two busy broiler slaughter houses in the United Kingdom showed that ascites is a major cause of condemnation (Hearth *et al.*, 1981). This concurs with what Gitao (1988) found in his six year retrospective study on the major causes of poultry condemnation in Kenya.

2.10.2: Cost of the management of ascites

Treatment is the usual means of moderating the impact after disease has struck, but with ascites syndrome, treatment of affected flocks is empirical. This is because the etiology is not fully known and therefore prevention is left as the more appropriate option to undertake (Peckham, 1972). Prevention costs are incurred through alteration in management practices. Birds may preferably be fed on marsh rather than pellets to slow their growth rate, hence reducing ascites. But feeding marsh leads to reduced slaughter weight or prolonged slaughter age (Lubritz, 1995). Associated with this is extra cost incurred in form of added labour costs and higher feed consumption, since birds are kept longer to achieve the desired slaughter weight (Mbugua, 1989).

Skip feeding, a strategy for reducing growth rate and therefore a means of lowering ascites incidence (Albers *et al.*, 1990) has been adopted by Kenchic Contract Farmers. This management approach subjects the birds to stress leading to high mortalities. The effect of stress may be exaggerated especially if there is concurrent infection, in which case the economic losses from mortality associated with the strategy would outweigh the initial objective of controlling ascites (Mutinda, personal communication).

2.11 Economic analysis

Economic impact of disease has been done by estimating it's cost (Putt *et al.*, 1988). This has been done by quantifying direct losses due to disease either by estimating losses as a function of the value of an animal or itemising losses in terms of effect of disease on final output (Putt *et al.*, 1988). The latter option is more applicable where there is a good knowledge of production parameters of a livestock system. In such a case, a livestock model is used which looks at values of output when disease is present and when it is absent. Where livestock production system is not well understood, informal methods have been used to estimate the economic significance of the disease (Nurhadi *et al.*, 1994).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location and description of the study area

The study was done in areas located in the districts situated around Nairobi. These districts were Kiambu, Kajiado and Machakos. The specific study areas were mainly chosen on the basis of the distribution of the farms contracted by the Kenchic limited company. These farms were specifically chosen because a preliminary survey which was conducted on contracted and non-contracted farms indicated that ascites was mainly a problem of the former. These areas included high (more than 1700m above sea level) potential ones found in Kiambu District and low (less than 1700m above sea level) potential ones located in Machakos and Kajiado districts.

A brief description of each of the three districts (Figure 2) is given in the following subsections.

3.1.1: Machakos District

Machakos District, which is located in the Eastern Province of Kenya, lies within latitude 1°S and 3°S and longitudes 37°E and 38°E. It mainly consists of hills and small plateaus. The district receives annual average rainfall of between 500 - 1300mm. The rainfall has a bimodal distribution with one season occurring from the end of March to May and the other from end of October to December. The annual mean temperature range is between 17°C - 20°C. Based on climatic variation, the district is classified into three agroecological zones (ECZ) namely ECZ III, ECZ IV and ECZ V (Figure 2). The ECZ III covers the hill tops in northern and central parts of the district while the ECZ IV and ECZ V cover the western-central and Southern parts respectively (Jaetzold and Schmidt, 1983b).

The production of food crops (maize, sunflower etc) and livestock are the main agricultural activities in ECZ III. The ecological zone IV is of marginal agricultural potential, dominated by beef and dairy ranching. Sorghum and millet are the main food crops grown in this zone. There is also limited small scale bee keeping and honey production in this area. The area covered by ECZ V is dry and is suitable for goat and honey production. Commercial poultry production is practised in ECZ III and ECZ IV.

3.1.2: Kiambu District

Kiambu District, situated in the Central Province of Kenya, lies within 0°45'S and 1°15'S latitude and 36°E and 37°E longitude (Jaetzold and Schmidt, 1983a). Most parts of the district lie between 1200 - 2550m above sea level. The district receives annual average rainfall of between 600 - 2000mm and it has two distinct rainy seasons, namely long and short rain seasons. The long rains occur from middle March to the end of May while short rains occur from the middle of October to late November. The annual mean temperature range occurs between 14.4°C - 18.9°C (Jaetzold and Schmidt, 1983a).

Climatically, the district is classified into two agroecological zones, namely ECZ II and ECZ III (Figure 2). Ecological zone two (ECZ II) covers a small strip to the western and central parts of the district while ecological zone three (ECZ III) covers the eastern tip of the district (Pratt and Gwynne, 1977). Dominant agricultural activities in the ecological zone two (ECZ II) are dairy, cash crop (mainly tea, coffee and pyrethrum) and food crops (mainly maize, potatoes) productions. In ecological zone three (ECZ III), production of coffee, sunflower, sorghum and livestock keeping are practised. Livestock kept includes dairy and beef cattle. Commercial poultry production is practised in both zones.

3.1.3: Kajiado District

kajiado District is situated in the Rift Valley Province of Kenya. It lies within latitude 1°S and 3°S and longitude 37°E and 38°E. It lies within an altitude of 910 - 2000m above sea level. The annual mean rainfall varies between 300 - 1100mm. It is distributed in two seasons with one occurring between March and June and the other between October and February. The annual mean temperature ranges between 16°C - 23°C. The main agricultural activity is ranching, except small strips near Ngong, Sultan Hamud and foothills of Mountain Kilimanjaro where wheat and maize production is carried out (Jaetzold and Schmidt, 1983a). Agroecological zones in this district are ECZII, III and IV. The agricultural activities in ecological zone two (ECZ II), which is small in area compared to other ecological zones in the district, are mainly growing of wheat, fodder and barley. Dominant agricultural activities in the ecological zone three (ECZ III) are sorghum, maize and sunflower production. Ecological zone four (ECZ IV), which is a marginal cotton zone is underdeveloped due to climate and stony soils, so it only supports beef and dairy ranching. However there are potential areas for millet and sorghum growing in these zones (Pratt and Gwynne, 1977). Commercial poultry rearing is carried out in ECZ IV around Ngong town.

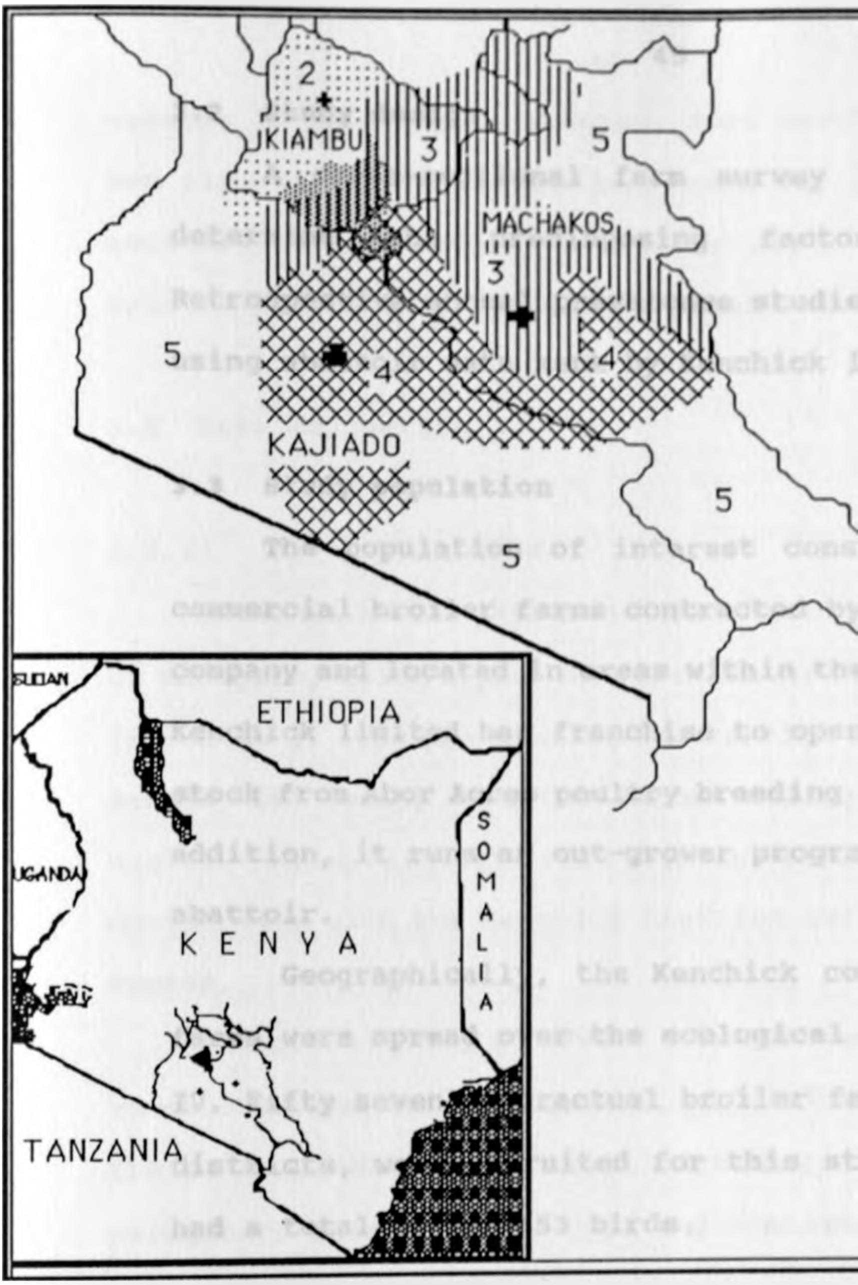


FIG. 2 Map showing the districts in which the study w

KEY:
2 = Ecological zone II
3= Ecological zone III
4= Ecological zone IV
5= Ecological zone V

3.2 Study design

A cross-sectional farm survey was conducted to determine the predisposing factors to ascites. Retrospective annual prevalence studies were determined using abattoir data kept by Kenchick limited company.

3.3 Study population

The population of interest consisted of all the commercial broiler farms contracted by Kenchick limited company and located in areas within the study districts. Kenchick limited has franchise to operate a grandparent stock from Abor Acres poultry breeding company of USA. In addition, it runs an out-grower programme and a poultry abattoir.

Geographically, the Kenchick contractual broiler farms were spread over the ecological zones II, III and IV. Fifty seven contractual broiler farms, in the three districts, were recruited for this study. Overall they had a total of 271,653 birds.

3.4 Ascites cases

These were cases of birds confirmed by either the broiler farmers and or by the Kenchick extension workers as having typical ascitic signs. These included enlargement of abdomen, loss in weight, reddening of the abdominal skin and congestion of superficial blood vessels on the ventral abdomen. Post mortem examination was also done on dead broilers as a way of diagonising ascites. In this study, a broiler farm was considered ascites positive if a case had been diagonised.

3.5 Data collection

3.5.1: Farm data

These data were gathered from either the farm owners or managers, using a pre-tested structured questionnaire (Appendix I), The pre-testing was carried out on a random sample of twenty broiler farms during introductory visits. These initial farm visits were conducted in conjunction with the Kenchick District Extension Poultry worker.

The questionnaire covered a broad spectrum of areas which included farm management, nutrition, diseases and their management practices, housing, inputs, farm parameters (size, years, type and numbers of broilers). The number of interviews conducted per day depended on the distances and accessibilities between farms. On average, six questionnaires were administered per day. They were administered between January 1995 and March 1995.

3.5.2: Other data

To supplement the information gathered with the use of the questionnaire, active follow up of the slaughter of broilers at the Kenchick abattoir located at Tigoni in Kiambu District was done on a sub-sample of 49 farmers. This number of farmers was chosen because it could effectively be followed up within the time frame. The sub-sample was selected using random numbers. The follow up was done between January and April 1995. The data gathered were on the causes of broiler condemnation during antemortem and postmortem inspections. These were broadly classified into ascites, cadavers, machine damage, overscalding, dermatitis, and inadequate bleeding. Cadavers were determined at antemortem inspection and were not cause specific.

Abattoir records for 1992, 1993 and 1994 on broiler birds reared by farmers contracted by Kenchick limited company were obtained. These data provided information mainly on identification of the farmer, number of chicks placed, mortality during rearing, slaughter age of the birds, average liveweight and number of broilers slaughtered (Appendix IIb). The 1994 records were more comprehensive than those of other years. They provided extra information on individual bird's feed consumption, kill date and the month the particular flock of birds was placed on the farm.

3.6 Data management and storage

Questionnaire-derived farm variables and other data were synthesized into appropriate variables (Appendix IIa and 1Ib). Where applicable, these variables were appropriately coded. Each type of datum was entered and stored in separate database (DBASE IV (Ashton Tate, Torrance, California, USA)) file. These files were then screened for proper coding, missing, out of range values and errors in data entry corrected.

3.7 Ascites indices

The essential data needed to calculate ascites index from the field survey was the binary outcome of ascites presence or absence in the flock from the time of placing the day old chicks to the time of farm visit. If a single case of the condition was identified, that flock was regarded ascites positive.

The index for measuring ascites condition from the abattoir survey was ascites prevalence. This was calculated as the number of birds condemned at slaughter due to ascites divided by the number of day old chicks initially placed. Prevalence was calculated for each farm.

3.8 Analysis

3.8.1: Descriptive statistics

An analytical software programme (statistix version 4.0, Analytical software, USA) was used to generate descriptive statistics. From the questionnaire data, descriptive statistics and frequency distributions of variables (Appendix IIa) were calculated. A Chi-square analysis was used on categorical variables to assess differences as well as associations. Analysis of variance (ANOVA) was performed to find out if there existed significant variations in continuous variables stratified by agroecological zones. For the annual abattoir data, descriptive statistics and frequency distributions of prevalence and variables were done.

3.8.2: Statistical modelling of farm and abattoir derived variables

Two regression analysis models were developed using statistical package Statistix version 4.0. Questionnaire derived variables (Appendix IIa) captured during the survey were subjected to logistic regression analysis (Collet, 1983). The dependent variable was occurrence of ascites.

For the annual abattoir data, variables considered for the possible direct or indirect qualitative association with the prevalence of ascites are listed in

Appendix IIb. The dependent variable was ascites prevalence and it was modelled as normally distributed outcome using the forward stepwise multiple regression analysis (Armitage and Berry, 1988).

3.9 Estimation of the monetary losses resulting from the condemnation of broilers due to ascites

The estimation of monetary loss resulting from the condemnation of broilers due to ascites was done using abattoir records maintained by Kenchick limited company. The data used were those of 1994 because they were available and the follow up data of January 1995 to March 1995. They were categorized by ecological zones. For 1994, number of broilers condemned due to ascites was determined. Various causes of poultry condemnation from January to March 1995 were also determined. The total number of birds condemned due to various causes of condemnation including ascites was obtained. The price per kilogramme of broilers was obtained from the Kenchick limited company. The annual market loss resulting from condemnation of broilers due to ascites was calculated using the following formula:

Annual market loss = Tc x P x Wt.

Where Tc = Total number of broilers condemned due to ascites in a year.

P = price in Kenya Shillings per kilogramme liveweight

Wt = Average liveweight of broilers

The actual loss resulting from broiler condemnation due to ascites was calculated using the Consumer Price Index (CPI) obtained from the Statistical Abstracts (Anon, 1995).

The actual loss was calculated using the following formula:

Actual loss = Annual market price/(1+r),

where r = CPI for a particular year (George, 1978).

CHAPTER FOUR

4.0 RESULTS

4.1 Response rate

A structured questionnaire (Appendix I) was administered to 57 Kenchick Contract farms. The latter were located in three ecological zones, namely ECZII, ECZIII and ECZIV, in which 16 farms were in ECZII, 20 in ECZIII and 21 in ECZIV. All the farmers answered the questions resulting in 100% response rate.

4.2 Results of the Statistical analysis of the Questionnaire-derived farm variables, January - March 1995.

The results of the statistical analysis of the questionnaire-derived variables are summarised in Tables 1 to 4. Table 1 gives the results of the analysis of farm-level continuous variables. The mean number of years spent in keeping broiler birds ranged from 7.20 to 8.15 years. Overall, the result of the ANOVA was not significant (P=0.9380) indicating that there were no differences between any two mean number of years.

The mean number of day-old chicks placed ranged from 3286 to 6116 with largest mean (6116) recorded in ECZIV and lowest (3286) recorded in ECZII. The result of the

ANOVA were significant (P=0.0332) indicating that differences existed between some pairs of means. The mean (3286) in ECZII was significantly (P<0.050) different from that of ECZIV of (6116).

The mean brooding time in days was 19.06 in ECZII, 19.95 in ECZIII and 20.57 in ECZIV. No significant (P=0.4678) differences existed between any pair of these means. The percent survivability of the birds during brooding period was 95.16 in ECZII, 90.30 in ECZIII and 91.59 in ECZIV. Overall, no significant (P=0.1255) differences existed between any two percentages.

The mean stocking densities, birds per square metre, reported was 10.67 in ECZII, 12.58 in ECZIII and 13.40 in ECZIV. The result of the ANOVA was not significant (P=0.4597), indicating that no differences existed between any pair of means despite wide ranges among them.

The mean age in days, of broilers at the time of farm visits was 23.21 in ECZII, 24.90 in ECZIII and 29.25 in ECZIV. The result of the ANOVA was not significant (P=0.3706). The mean feed intake, in kilograms per bird, by the time of farm visit ranged from 1.11 to 1.60 with largest mean (1.60) recorded in ECZIII and lowest mean (1.11) recorded in ECZII. Overall, the result of the ANOVA of the feed intake was not significant (P=0.4619).

There was a wide range in the percent mean mortality from the time day-old chicks were placed to the time of farm visit. The lowest mean (5.16) was recorded in ECZII and highest (13.15) in ECZIV. However, the result of the ANOVA was not significant (P=0.1812).

Table 1: Summary results of the statistical analyses of the farm-leve Kenchic contract broiler farms in the peri-urban areas of Nairobi, cat January - March 1995.

Variable	ECZII (n=16) Mean SE	ECZIII (n=20) Mean SE
Number of years spent on poultry keeping	7.92 2.76 (1.83, 14.00)	8.15 1.47 (5.03, 11.26)
Number of day old chicks	3286.10 259.11 (2730.40, 3841.90)	4532.40 539.36 (3403.50, 5661.20)
Brooding time (days)	19.06 1.12 (16.68, 21.44)	19.95 0.81 (18.26, 21.64)
Brooding survival (%)	95.16 2.06 (89.86, 100.46)	90.30 3.45 (82.86, 97.75)
Stocking density (birds/m2)	10.67 1.31 (7.75, 13.58)	12.58 0.96 (10.56, 14.60)
Age (days) of birds at the time of visit	23.21 3.21 (16.28, 30.15)	24.90 3.17 (18.24, 31.55)
Feed intake per bird (kg) by the time of visit	1.11 0.28 (0.49, 1.72)	1.60 0.28 (1.00, 2.19)
Percentage mortality	5.16 1.27 (2.36, 7.97)	7.55 1.49 (4.40, 10.70)

Key: () = Confidence interval of the mean, ECZII = Ecological zone II, E

ECZIV = Ecological zone IV, SE = Standard error of the mean

Table 2 and Appendix IIIa summarize the results of the analysis of the frequency distributions of the characteristics of poultry houses in the study areas. The farms used two types of roofs, namely couple and flat roofs. Couple roofs were used by 31.3% of the farms in ECZII, 75% of the farms in ECZIII and 47.6% of those in ECZIV. These proportions were significantly (P=0.0279) different from each other. The 75% in ECZIII was larger than 31.3% of ECZII and 47.6% of ECZIV. Flat roofs were found in 68.8% of the surveyed farms in ECZII, 25% of the farms in ECZIII and 52.4% of the farms in ECZIV. These proportions were significantly (P=0.0279) different from each other. Both the 68.8% (ECZII) and 52.4% (ECZIV) were each different from 25% in ECZIII. Overall the proportional differences of farms which used couple and flat roofs were significant (P=0.0279).

The commonly used type of walls in all the surveyed farms was offcuts which was used in 47.4% of the farms in all the three zones. Of these farms, 37.5% were in ECZII, 20% in ECZIII and 81% in ECZIV. These zone-specific proportions were significantly (P=0.0003) different from each other. Iron sheets were also used as materials of walls. Overall, they were used in 12.3% of all the farms studied in the three zones. Thirteen percent of the farms in ECZII used iron sheet walls, 15% in ECZIII and 9.5% of the farms in ECZIV. These proportions were not significantly (P=0.8667) different between any two zones. Overall, the proportional differences of farms which used iron sheets and offcuts as walls were not significant (P=0.1831).

Curtains made from nylon bags and nylon papers were used in poultry houses. In ECZII, 81% of these houses had curtains made from nylon bags, 70% in ECZIII and 85.7% in ECZIV. However there were no significant (P=0.4509) differences among these proportions. Nylon paper curtains were used in 18.8% of the poultry houses in ECZII, 25% in ECZIII and 14.3% in ECZIV. No significant (P=0.6841) differences existed among these proportions. Overall, no significant (P=0.6294) proportional differences were observed between curtains made from nylon bags and nylon papers.

It was observed that most poultry houses in the three zones had "adequate" litter (2 ≤ inches thick). Seventy three percent of the poultry houses in ECZII, 73.7% in ECZIII and 57.9% in ECZIV had "adequate" litter. These proportions were not significantly (P=0.5046) different among the zones.

Table 2: Summary results of the analyses of the frequency dist 57 Kenchic contract farms in the peri-urban areas of Nairobi, cat January-March 1995.

Characteristic	ECZII Freq	ECZII Perct	ECZIII Freq	ECZIII Perct
Roof types				
Couple	5/16	31.3	15/20	75
Flat	11/16	68.8	5/20	25
Type of wall				
Iron sheets	2/16	12.5	3/20	15
Off-cuts	6/16	37.5	4/20	20
Type of curtains used				
Nylon bags	13/16	81	14/20	70
Nylon paper	3/16	18.8	5/20	25
Availability of litter				
Adequate	11/15	73.3	14/19	73.7
Inadequate	4/15	26.7	5/19	26.3

Key: Freq = Frequency, Perct = Percentage, ECZII = Ecological z

ECZIV = Ecological zone IV

Table 3 and Appendix IIIb summarize the results of the analyses of the frequency distributions of management factors. Overall, majority (67.9%) of the poultry houses were adequately ventilated. In ECZII, it was observed that 56.3% of the poultry houses had adequate ventilation, 80% in ECZIII and 66.7% in ECZIV. No significant (P=0.3061) differences were observed among these zone-specific proportions.

Overall, ninety three percent of the farmers used charcoal to warm the poultry houses during brooding. Specifically, all the farmers in ECZIII used charcoal while it was used by 95.2% and 81.3% of the farmers in ECZIV and ECZII respectively. The differences in these proportions were minimally significant (P=0.0801).

Farmers used *Unga* and *Muus* as the main poultry feeds. Overall, the most commonly used poultry feed was *Unga*. It was used by 70% of the farmers from all the three zones. *Unga* was used by 68.8% of the farmers in ECZII, by 65% of the farmers in ECZIII and by 76.2% of them in ECZIV. There were no significant (P=0.7281) proportional differences among the farmers who used *Unga* as feed. *Muus* was used by 26.3% of the farmers from all the three zones. Of these, 31.3% were in ECZII, 35% in ECZIII and 14.3% in ECZIV. There were no significant (P=0.2800) differences among these proportions. Overall, no significant (P=0.3692) differences existed in proportions of farmers using *Unga* and *Muus* as their major poultry feeds.

The farms used three types of feed formulations, namely crumbs, pellets and marsh. A combination of pellets and marsh was used in 33.3% of the farms in ECZII, 35% in ECZIII and 42.9% in ECZIV. These proportions were not significantly (P=0.8099) different between any two zones. In ECZII, 40% of the farms used crumbs, 30% in ECZIII and 28.6% in ECZIV. No significant (P=0.7447) proportional differences existed in farms which used crumbs as a feed formulation. Marsh was used by 13.3% of the farms in ECZII, 5% in ECZIII and 23.8% in ECZIV. However, these proportions were not significantly (P=0.2259) different despite 5% being less than the rest. Overall, the proportional differences of the farms which used crumbs, pellets and marsh as their feed formulations were not significant (P=0.6594).

There were three water sources for the broiler farms, namely municipal, river and borehole water. The municipal councils in the study areas supplied water to 43.8% of the farms in ECZII, 30% in ECZIII and 38.1% of the farms in ECZIV. These proportions were not significantly (P=0.6891) different. River water was used in 25% of the farms in ECZII, 70% in ECZIII and 9.5% in ECZIV. There were significant (P=0.002) differences in the proportions of farmers who used river as their source of water. The proportion, 70% of farms in ECZIII using river water was different from the proportion, 25% of farms in ECZII and the proportion, 9.5% of farms in ECZIV. Borehole water was used in 18.8% of the farms in ECZII, by 10% of the farms in ECZIII and by 19% of the farms in ECZIV. No significant (P=0.6780) proportional differences existed among these farms which used borehole water. Overall, the proportional differences of the farms which used municipal, river and borehole as their sources of water were barely significant (P=0.0423).

Table 3: Summary results of the analyses of the frequency dis
Kenchic contract farms in the peri-urban areas of Nairobi, categor
1995.

	ECZII		ECZIII	
Factor	Freq	perct	Freq	Perct
Adequacy of ventilation				
Inadequate	7/16	43.8	4/20	20
Adequate	9/16	56.3	16/20	80
Heat source				
Charcoal	13/16	81.3	20/20	100
Other sources	3/16	18.8	0/20	0
Feed brand				
"Unga"	11/16	68.8	13/20	65
"Muus"	5/16	31.3	7/20	35
Feed form				
Pellets and marsh	5/15	33.3	7/20	35
Crumbs	6/15	40.0	6/20	30
Marsh	2/15	13.3	1/20	5
Water source				
Municipal	7/16	43.8	6/20	30
River	4/16	25	14/20	20
Borehole	3/16	18.8	2/20	10

Key: Freq = Frequency, Perct = Percentage, ECZII = Ecological z

ECZIV = Ecological zone IV

Table 4 and Appendix IIIc summarize the results of frequency analyses of the usages of drugs and disinfectants in the broiler farms. Farmers used *OTC**, *Clamoxyl** and *AF20** as their drugs of choice in treating diseases of broiler birds. In the ECZII, 37.5% of the farmers used *OTC* (Oxytetracycline)*, while in ECZIII 50% of the farmers used it and 61.9% of them used it in ECZIV. These proportions were not significantly (P=0.3373) different. Combinations of *OTC** and *Clamoxyl** were used in 31.3% of the farms in ECZII, 10% of the farms in ECZIII and 14.8% in ECZIV. No significant (P=0.2211) differences existed between any two of these proportions. Combinations of *OTC** and *AF20** were used in 12.5% of the farms in ECZII, 10% of the farms in ECZIII and 4.8% of the farms in ECZIV. There was no significant (P=0.6916) proportional differences of farms using the combinations of *OTC** and *AF20** among the zones. Overall, the proportional differences of farms which used *OTC**, *Clamoxyl** and *AF20** as their drugs of choice was not significant (P=0.4183).

Two types of disinfectants were commonly used in the farms. These were *Kerol** and *Pynol5**. In ECZII, 37.5% of the farms used *Kerol*, 52.6% of the farms used it in ECZIII and 61.9% of the farms used it in EZCIV. However,

* Trade names

no significant (P=0.3372) proportional differences existed in the usage of *Kerol** as a disinfectant between any two zones. *Pynol5** was used in 6.3% of the farms in ECZII, 5.3% of the farms in ECZIII and 4.8% of the farms in ECZIV. No significant (P=0.9801) proportional differences in the usage of *Pynol5** as a disinfectant was observed among the zones. Overall, the proportional differences of farms which used *Kerol** and *Pynol5** as disinfectants were not significant (P=0.8686).

* Trade names

Table 4: Summary results of the analyses of the frequency distributi used in 57 Kenchic contract farms in the peri-urban areas of Nairobi, ca January-March, 1995.

	ECZII		ECZIII	
	Freq	perct	Freq	Perct
Drugs used				
[1]OTC*	6/16	37.5	10/20	50
OTC + Clamoxyl*	5/16	31.3	2/20	10
OTC + [2]AF20*	2/16	12.5	2/20	10
Disinfectant used				
Kerol*	6/16	37.5	10/19	52.6
[3]pynol5*	1/16	6.3	1/19	5.3

Key: Freq = Frequency, Perct = Percentage, ECZII = Ecological zone II,

ECZIV = Ecological zone IV

* = Trade names

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[1]OTC and Clamoxyl are antibacterials

[2]AF20 is a coccidiostat

3 Pynol5 is a phenol based disinfectant

4.3: Results of the analyses of the variables from 49 broiler farms actively followed from January-April, 1995, at Tigoni abattoir, Kiambu District.

A random sample of 49 Kenchick contract farms were prospectively followed at Tigoni abattoir between January and April, 1995. These farms were located in three ecological zones as follows: 21 were in ECZII, 17 in ECZIII, and 11 in ECZIV. The results of the statistical analyses of the abattoir-derived variables are summarised in Table 5. The zone-specific means of the slaughter ages of broilers ranged from 43.05 to 44.00 days. Overall the result of the ANOVA was not significant (P=0.7146).

The average liveweight in kilograms at slaughter was 1.61 in ECZII, 1.57 in ECZIII and 1.52 in ECZIV. No significant (P=0.4670) differences existed among these means. The mean number of birds slaughtered per farm was 3042.90 in ECZII, 3875.40 in ECZIII and 3964.30 in ECZIV. Overall, no significant (P=0.2457) differences existed between any pair of these means despite wide ranges among them. This was probably due to the large standard errors observed in this analysis. The mean number of cadavers was 20.41 in ECZII, 74.18 in ECZIII and 21.76 in ECZIV. The ANOVA result showed that no significant (P=0.2467) differences existed between any pair of these means despite wide ranges among them.

The mean number of birds with wounds ranged from 0.48 to 2.35, with the largest mean (2.35) recorded in ECZII and smallest (0.48) in ECZIV. Overall, no significant (P=0.4244) differences existed between these means. The mean number of birds overscalded was 1.94 in ECZII, 0.73 in ECZIII and 1.76 in ECZIV. No statistical (P=0.2412) differences existed between the means. The means of the number of emaciated birds ranged from 5.91 to 9.52, with largest mean (9.52) recorded in ECZIV and lowest (5.91) recorded in ECZIII. No significant (P=0.4458) differences existed between the means.

The mean number of birds damaged by machine during slaughter was 1.53 in ECZII, 0.91 in ECZIII and 1.19 in ECZIV. Overall, no significant (P=0.5457) differences existed between pairs of these means. The mean number of birds condemned at slaughter due to inadequate bleeding was 1.18 in ECZII, 1.10 in ECZIII and 1.43 in ECZIV. The ANOVA result showed no significant (P=0.8081) differences existed between pairs of these means.

The means of the number of birds with dermatitis ranged from 0.82 to 4.12, with the largest mean (4.12) recorded in ECZII and smallest (0.82) recorded in ECZIII. There were no significant (P=0.5234) differences among the means. The mean number of birds with ascites was 11.81 in ECZII, 14.55 in ECZIII and 21.14 in ECZIV. However the ANOVA result showed that no significant

(P=0.4588) differences existed between pairs of these means.

Table 5: Summary results of the statistical analysis of the abattoir-derived variables from 49 Kenchic contract broiler farms. Actively followed between January-April, 1995, Tigoni, Kiambu.

	ECZII(n=21)		ECZIII(n=17)		ECZIV(n=11)		
Variable	Mean	SE	Mean	SE	Mean	SE	P-value
Age (Days) at slaughter	44	1.29	43.10	0.91	43.05	0.53	0.7146
	(41.26, 46.74)		(41.07, 45.12)		(41.94, 44.16)		
Average liveweight (Kg)	1.61	0.08	1.57	0.03	1.52	0.04	0.4670
	(1.44, 1.78)		(1.51, 1.64)		(1.43, 1.60)		
Number slaughtered per farm	3042.90	262.26	3875.40	538.83	3964.30	463.53	0.2457
	(2487.00, 3598.00)		(2674.80, 5076.00)		(3964.30, 4931.20)		
Number of cadervers	20.41	4.80	74.18	57.62	21.76	5.14	0.2467
	(10.24, 30.59)		(-54.20, 202.56)		(11.04, 32.48)		
Number with wounds	2.35	1.78	0.73	0.51	0.48	0.39	0.4244
	(-1.42, 6.12)		(-0.41, 1.86)		(-0.33, 1.29)		
Number overscalded	1.94	0.52	0.73	0.47	1.76	0.42	0.2412
	(0.84, 3.04)		(-0.32, 1.77)		(0.89, 2.64)		
Number of emanciated	6.56	1.15	5.91	1.95	9.52	2.56	0.4458
	(4.15, 9.03)		(1.56, 10.26)		(4.19, 14.86)		
Number damaged by, machine	1.53	0.37	0.91	0.37	1.19	0.34	0.5457
	(0.73, 2.32)		(0.09, 1.73)		(0.49, 1.89)		
Number damaged due to inadequate bleeding	1.18	0.33	1.10	0.48	1.43	0.36	0.8081
	(0.47, 1.89)		(0.03, 2.15)		(0.67, 2.18)		
Number with dermatitis	4.12	3.46	0.82	0.50	1.19	0.96	0.5234
	(-3.21, 11.45)		(-0.30, 1.94)		(0.80, 3.18)		
Number with ascites	11.81	2.31	14.55	2.76	21.14	5.51	0.4588
	(9.69, 19.49)		(8.39, 20.71)		(9.65, 32.63)		

Key:() = Confidence interval of the mean, ECZII = Ecological zone II,

ECZIII = Ecological zone III,

ECZIV = Ecological zone IV, SE = Standard error of the mean

4.4: Proportional causes of condemnations of broiler birds from 49 broiler farms actively followed, from January to April, 1995 at the Tigoni abattoir, Kiambu District.

The overall results of the analyses of the antemortem and postmortem causes of condemnations of broiler birds from 49 Kenchick limited farms are summarised in Figure 3a. Cadavers accounted for 51.5% of all the condemnations followed by ascites which accounted for 26.1%. Postmortem examination of the cadavers indicated that 70% of them had ascites.

The results of zone-specific analyses of the antemortem and postmortem causes of the condemnation of broiler birds from 49 Kenchick limited farms are summarised in Figures 3b to 3d. In all the three zones, cadavers were the leading causes of broiler condemnations followed by ascites. In ECZII, cadavers accounted for 38.7% of all the condemnations followed by ascites which accounted for 27.7% and in ECZIII, cadavers accounted for 75.0% while ascites accounted for 14.7%. However, in ECZIV, cadavers and ascites accounted for 37.2% and 36.2% respectively.

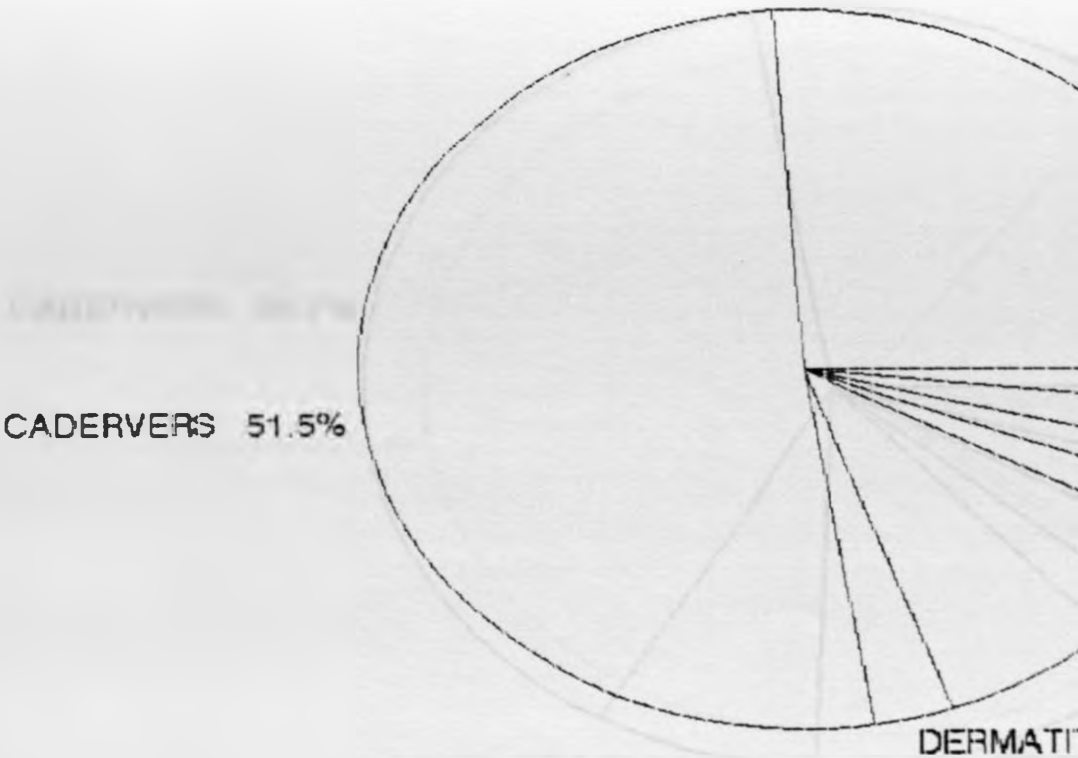

Fig 3a: Proportional causes of br
condemnations at the Tigoni abattoir,
Distict, Kenya, January-April, 19

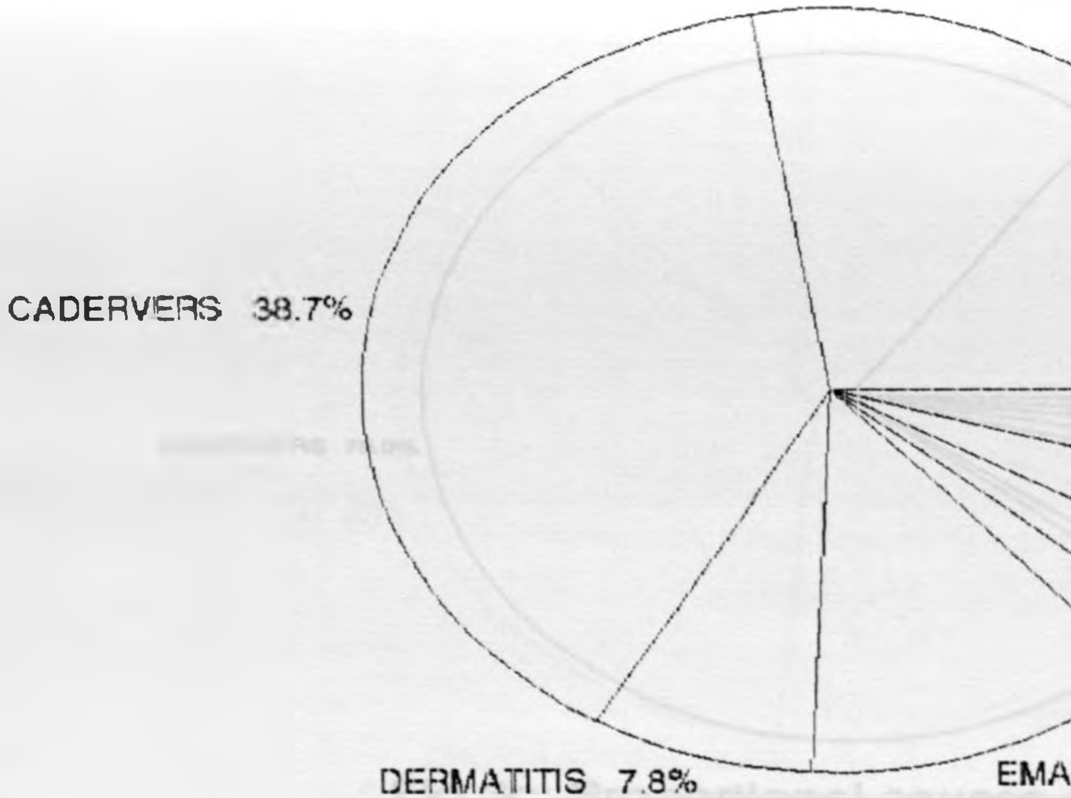

Fig 3b: Proportional causes of b
condemnations at the Tigoni abatto
of birds from ECZII, January-Apr

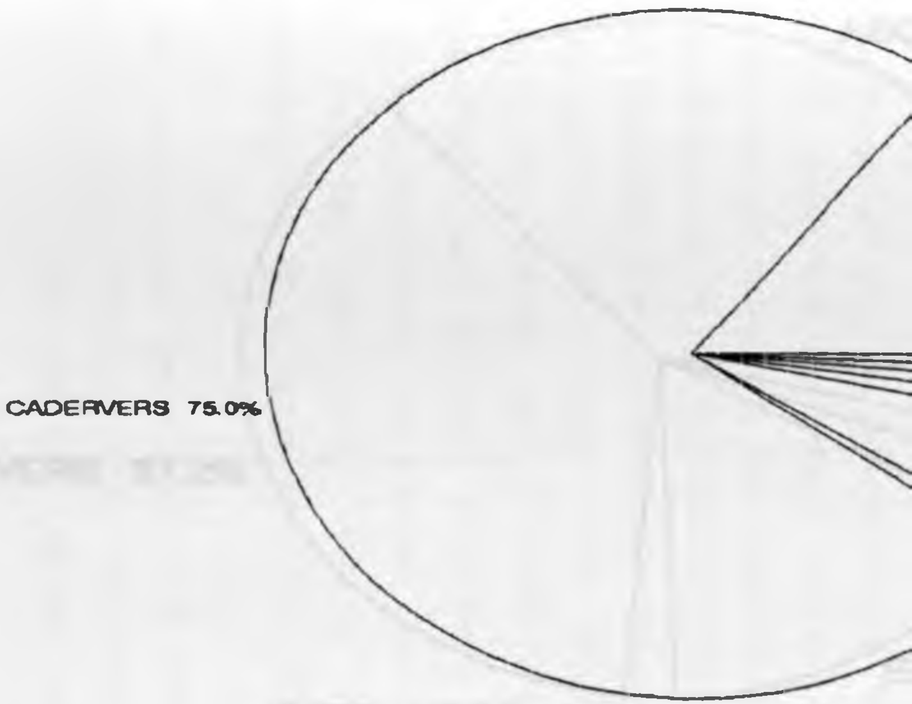

Fig 3c: Proportional causes
condemnations at the Tigoni ab
of birds from ECZIII, January-

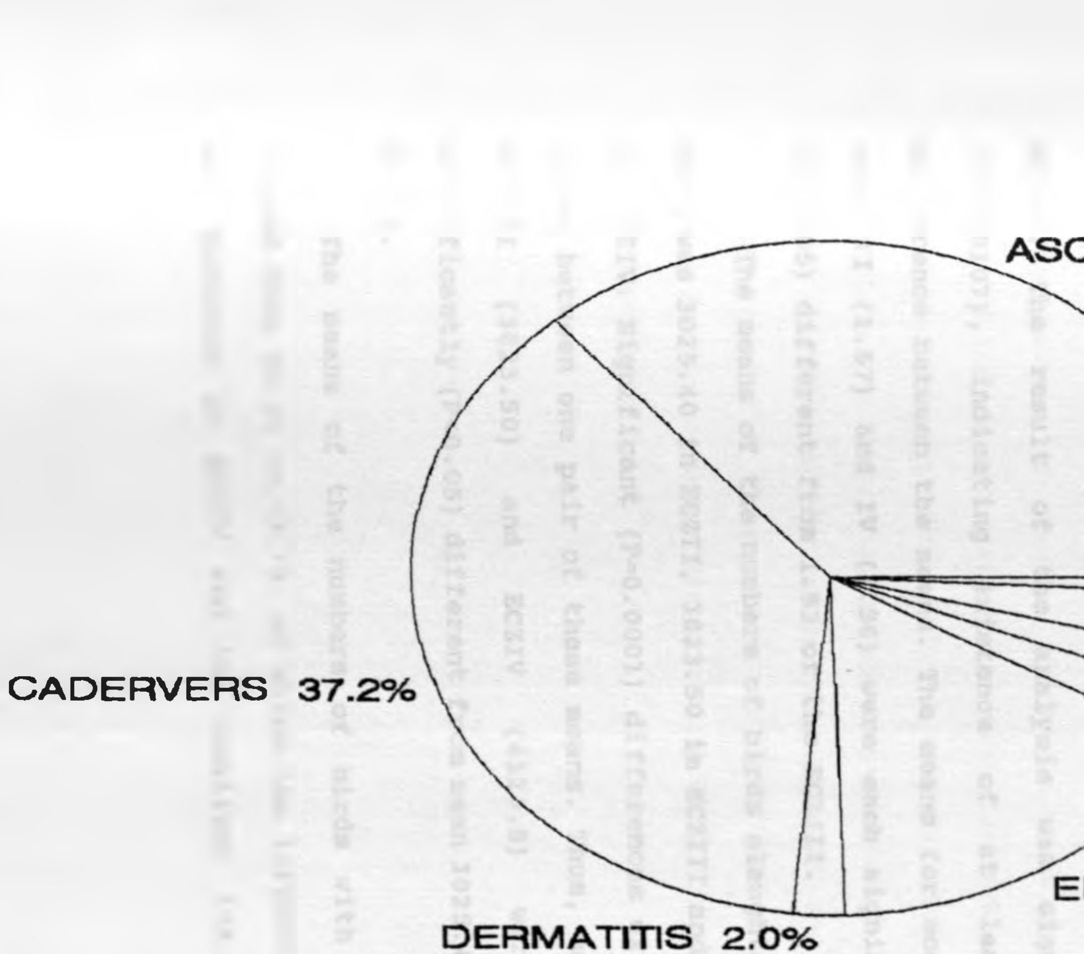

Fig 3d: Proportional causes o
condemnations at the Tigoni abat
of birds from ECZIV, January-A

4.5: Results of the analyses of the abattoir-derived variables from broiler farms contracted by Kenchick limited, 1992 - 1993.

The results of the analyses of the abattoir-derived variables are summarised in Table 6. The means of the slaughter age in days, of broilers ranged from 42.10 to 42.36. Overall the ANOVA result was not significant (P=0.7063) indicating that there were no differences between the means.

The mean average liveweight in kilograms at slaughter was 1.57 in ECZII, 1.53 in ECZIII and 1.56 in ECZIV. The result of the analysis was significant (P=0.0107), indicating existence of at least one difference between the means. The means for ecological zone II (1.57) and IV (1.56) were each significantly (P<0.05) different from 1.53 of the ECZIII.

The means of the numbers of birds slaughtered per farm was 3025.40 in ECZII, 3823.50 in ECZIII and 4120.50 in ECZIV. Significant (P=0.0001) differences existed at least between one pair of these means. Thus, means for ECZIII (3823.50) and ECZIV (4120.5) were each significantly (P<0.05) different from mean 3025.40 of the ECZII.

The means of the numbers of birds with ascites ranged from 28.03 to 53.79, of which the largest (53.79) was recorded in ECZIV and the smallest (28.03) was recorded in ECZIII. But, no significant (P=0.1679) differences were observed among these means despite wide ranges between them. Further, all the ascitic birds were condemned. The means of the numbers of cadavers were 22.19 in ECZII, 27.96 in ECZIII and 28.98 in ECZIV. The ANOVA result was not significant (P=0.1042). The means of the numbers of broiler birds condemned due to "other" reasons were 11.38 in ECZII, 11.16 in ECZIII and 13.20 in ECZIV. The ANOVA result was not significant (P=0.1666) indicating that no differences existed between these means.

The number of broiler birds which were condemned during both antemortem and postmortem inspections at the Tigoni abattoir in 1992 and 1993 due to various causes are depicted in Figure 4. In the three ecological zones, ascites was the leading cause of condemnation, followed by cadavers. The "other" causes included emaciation, machine damage, overscalding, inadequate bleeding, wounds and dermatitis.

Table 6: Summary results of the statistical analyses of the abattoir derived-variables from records of Kenchic contract broiler farms in the peri-urban areas of Nairobi, catagorised by ecological zones, 1992 to 1993.

	ECZ11 (n=332)		ECZIII (n=330)		ECZIV (n=372)		
	Mean	SE	Mean	SE	Mean	SE	P-value
Age (days) at slaughter	42.36 (41.96, 42.77)	0.20	42.10 (41.83, 42.36)	0.13	42.23 (41.68, 42.78)	0.28	0.7063
Average liveweight, (kg)	1.57 (1.55, 1.59)	0.01	1.5278 (1.51, 1.54)	0.0078	1.5635 (1.54, 1.59)	0.0113	0.0107
Number slaughtered per farm	3025.40 (2818.90, 3231.90)	104.96	3823.50 (3421.30, 4225.80)	204.47	4120.50 (3880.80, 4360.20)	121.90	0.0001
Number condemned due to							
Ascites	34.10 (29.92, 38.28)	2.12	28.03 (24.56, 31.51)	1.77	53.79 (21.74, 85.84)	16.30	0.1679
Cadervers	22.19 (19.80, 24.59)	1.22	27.96 (20.93, 34.99)	3.57	28.98 (25.05, 32.91)	2.00	0.1042
Other reasons	11.38 (8.96, 13.80)	1.23	11.161 (10.00, 12.33)	0.5922	13.20 (11.95, 14.46)	0.64	0.1666

Key: () = Confidence interval of the mean, ECZII = Ecological zone II, ECZIII = Ecological zone III, ECZIV = Ecological zone IV, SE = Standard error of the mean

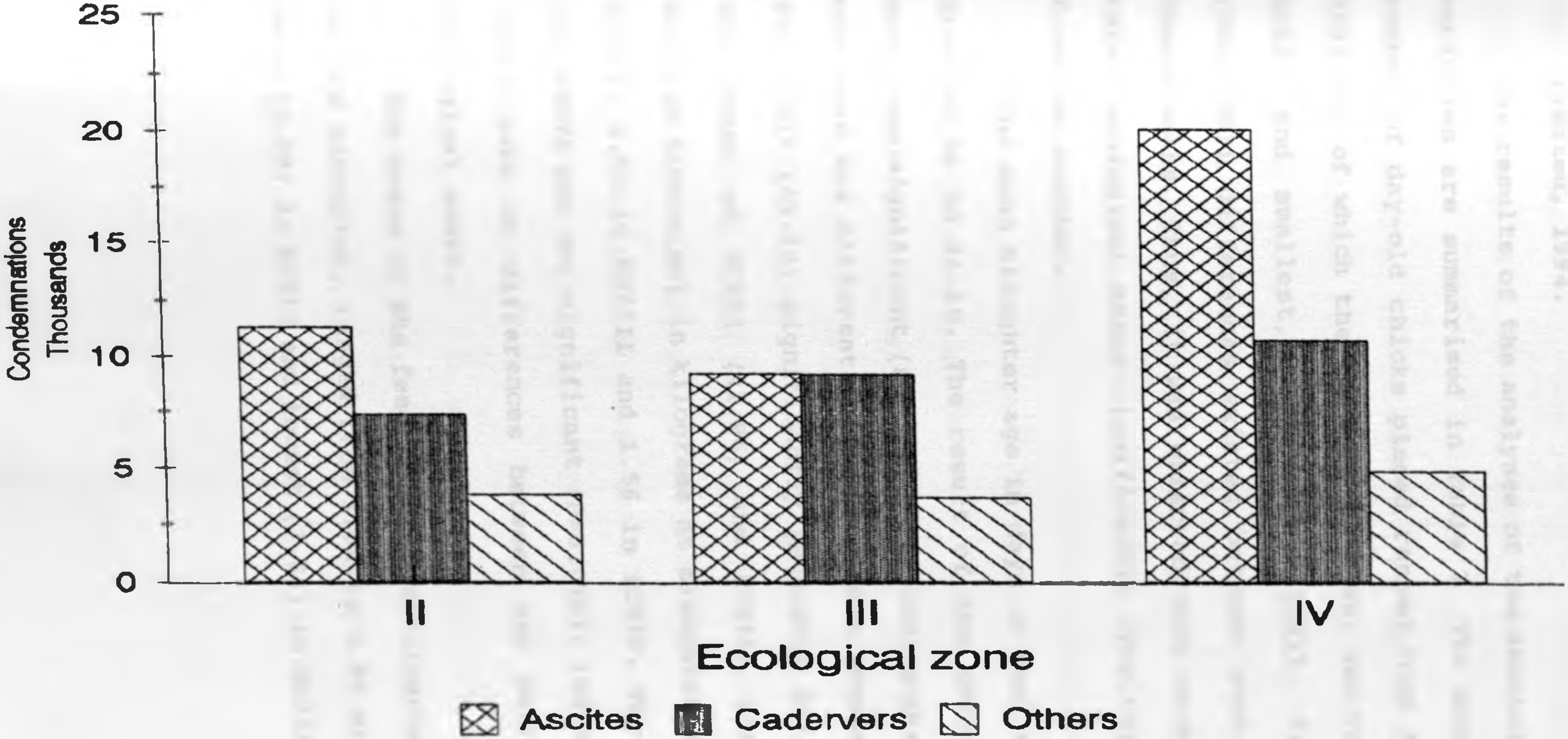

Fig 4: Causes of broiler condemnations for 1992 and 1993 in the three ecological zones located in Kiambu,Kajiado and Machakos districts

4.6: Results of the analyses of the abattoir-derived variables from broiler farms contracted by Kenchick limited, 1994.

The results of the analyses of the abattoir-derived variables are summarised in Table 7. The means of the number of day-old chicks placed ranged from 3799.10 to 5491.90, of which the largest, 5491.90, was recorded in ECZIV and smallest, 3799.10, in ECZII. Significant (P=0.0001) differences existed between some pairs of these means. Thus, it was observed that each of these three ecological means significantly (P<0.05) differed from one another.

The mean slaughter age in days of broilers ranged from 41.96 to 43.10. The result of the ANOVA of these means was significant (P=0.0001) indicating that at least one mean was different from the others. Hence the mean for ECZIV (43.10) significantly (P<0.050) differed from the means of ECZII (41.96) and ECZIII (42.35). The average liveweight in kilograms at slaughter was 1.55 in ECZII, 1.52 in ECZIII and 1.56 in ECZIV. The result of the ANOVA was not significant (P=0.0701) indicating that there were no differences between any pair of these ecological means.

The means of the feed intake, in kilograms per bird before slaughter, ranged from 3.84 to 3.99 with largest mean (3.99) in ECZII and lowest (3.84) in ECZIII. Overall the result of the ANOVA was significant (P=0.0153) indicating that there were differences between some two means. The mean feed intake per bird in ECZIII (3.84) was significantly (P<0.050) different from that of ECZII (3.99).

The means of the percentages of the mortalities of the birds during rearing was 18.02 in ECZII, 14.30 in ECZIII and 14.31 in ECZIV. Significant (P=0.0001) differences existed between some pairs of these means. The mean of the ECZII (18.02) was significantly (P<0.05) different from that of ECZIII (14.30) and ECZIV (14.31).

The mean number of birds slaughtered per farm was 3086.10 in ECZII, 3874.00 in ECZIII and 4680.70 in ECZIV in 1994. The significant (P=0.0001) results observed from the ANOVA showed that the three ecological means were each significantly (P<0.05) different from one another.

The mean number of ascites cases was 29.65 in ECZII, 18.51 in ECZIII and 21.86 in ECZIV. The ANOVA result showed that significant (P=0.0120) differences existed between some pairs of these means. The mean number for ECZII (29.59) was different from ECZIII (18.72) at 0.05 significant level.

The means of the number of cadavers ranged from 18.38 to 24.30 of which the largest (24.30) was recorded in ECZIV and smallest (18.38) in ECZIII. No significant (P=0.2101) differences existed among these means.

In 1994, the mean number of birds condemned due to "other" reasons was 5.33 in ECZII, 4.29 in ECZIII and 5.46 in ECZIV. These means were not significantly (P=0.2352) different from each other.

The number of broiler birds which were condemned during both antemortem and postmortem inspections at the Tigoni abattoir in 1994 due to various causes are depicted in Figure 5. In ecological zones II and III, ascites was the leading cause of condemnations, followed by cadavers. However in ECZIV the leading cause was cadavers followed by ascites. The "other" causes included emaciation, machine damage, overscalding, inadequate bleeding, wounds and dermatitis.

Table 7: **Summary results of the statistical analyses of the abattoir-derived variables from records of Kenchic contract broiler farms in the peri-urban areas of Nairobi, catagorised by ecological zones, 1994.**

Variable	ECZII (n=187) Mean	ECZII (n=187) SE	ECZIII (n=147) Mean	ECZIII (n=147) SE	ECZIV (n=167) Mean	ECZIV (n=167) SE	P-value
Day old chick number	3799.10	102.40	4522.20	194.27	5491.90	201.87	0.0001
	(3580.50, 4017.70)		(4138.30, 4906.10)		(5093.30, 5890.50)		
Age (days) at slaughter	41.96	0.16	42.35	0.17	43.10	0.21	0.0001
	(41.65, 42.27)		(42.02, 42.68)		(42.67, 43.52)		
Average liveweight, at slaughter time	1.55	0.01	1.52	0.01	1.56	0.01	0.0701
	(1.53, 1.57)		(1.50, 1.56)		(1.54, 1.59)		
Feed intake per bird, kg (Lifetime)	3.99	0.03	3.84	0.04	3.94	0.05	0.0153
	(3.92, 4.06)		(3.77, 3.91)		(3.85, 4.02)		
Percentage mortality	18.02	0.57	14.30	0.55	14.31	0.46	0.0001
	(16.88, 19.15)		(13.22, 15.37)		(13.41, 15.22)		
Number slaughtered per farm	3086.10	86.90	3874.00	166.63	4680.70	164.46	0.0001
	(2914.60, 3257.50)		(3544.70, 4203.30)		(4359.90, 5001.40)		
Number condemned due to							
Ascites	29.65	3.43	18.51	2.14	21.86	1.98	0.0120
	(22.79, 36.40)		(14.52, 22.93)		(17.94, 25.77)		
Cadervers	21.66	2.14	18.38	2.29	24.30	2.46	0.2101
	(17.44, 25.92)		(13.89, 22.87)		(19.45, 29.15)		
Other reasons	5.33	0.62	4.29	0.43	5.46	0.43	0.2352
	(4.10, 6.55)		(3.46, 5.14)		(4.62, 6.30)		

Key: () = Confidence interval of the mean, ECZII = Ecological zone II, ECZIII = Ecological zone III,

ECZIV = Ecological zone IV, SE = Standard error of the mean

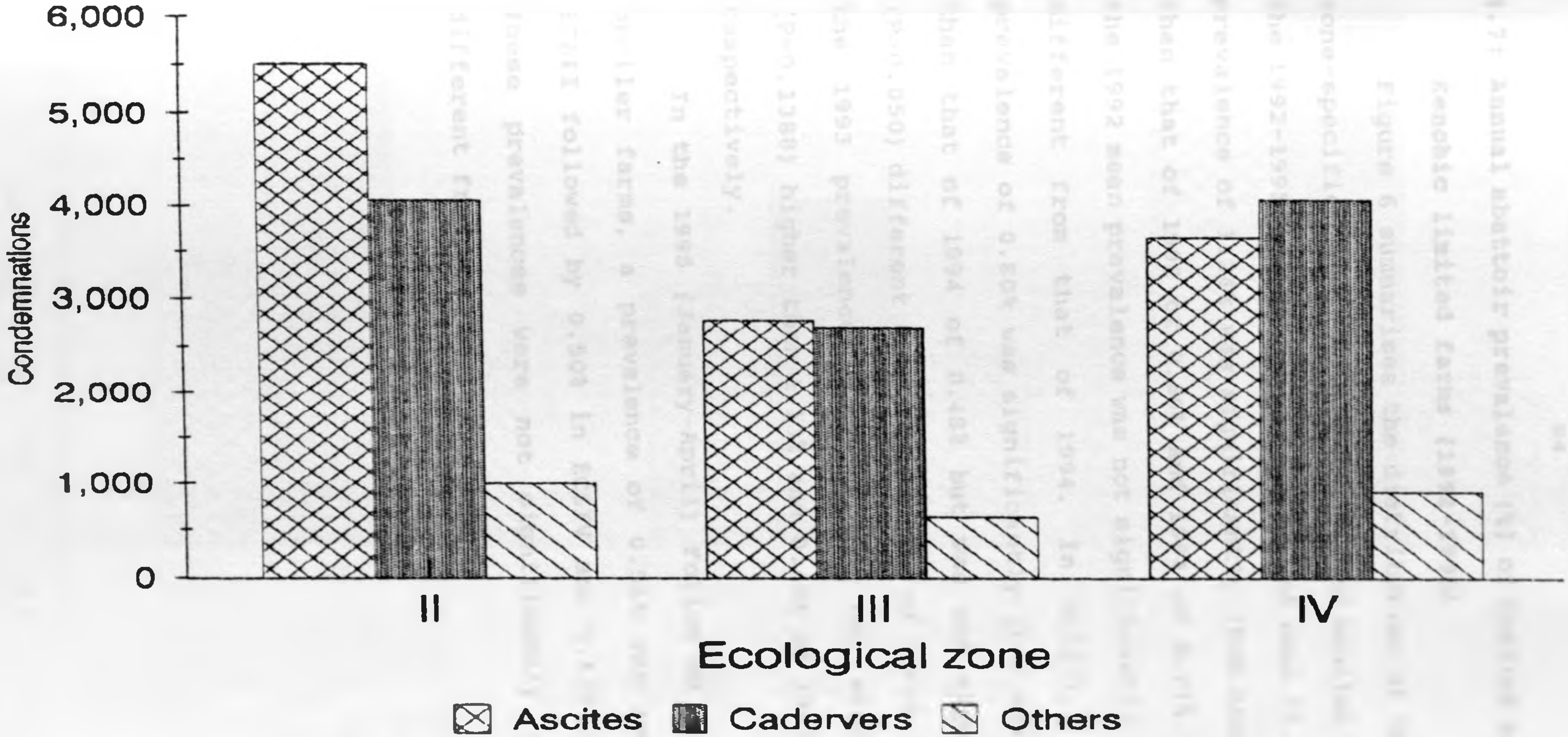

Fig 5: Proportional causes of broiler condemnations at the Tigoni abattoir, Kenya, of birds from the three ecological zones, 1994.

4.7: Annual abattoir prevalence (%) of broiler ascites in Kenchic limited farms (1992-1995)

Figure 6 summarises the distribution of the annual zone-specific prevalences of ascites of broiler birds for the 1992-1995 period. In the ecological zone II, the 1993 prevalence of 1.24% was significantly (P=0.0001) higher than that of 1992 of 0.66% and 1994 of 0.71%. However, the 1992 mean prevalence was not significantly (P>0.050) different from that of 1994. In ECZIII, the 1993 prevalence of 0.80% was significantly (P=0.0032) higher than that of 1994 of 0.48% but was not significantly (P>0.050) different from that of 1992 of 0.61%. In ECZIV, the 1993 prevalence of 1.26% was not significantly (P=0.1388) higher than 1.13% and 0.40% of 1992 and 1994 respectively.

In the 1995 (January-April) follow up study of 49 broiler farms, a prevalence of 0.51% was recorded in ECZII followed by 0.50% in ECZIV and 0.47% in ECZIII. These prevalences were not significantly (P=0.9787) different from each other.

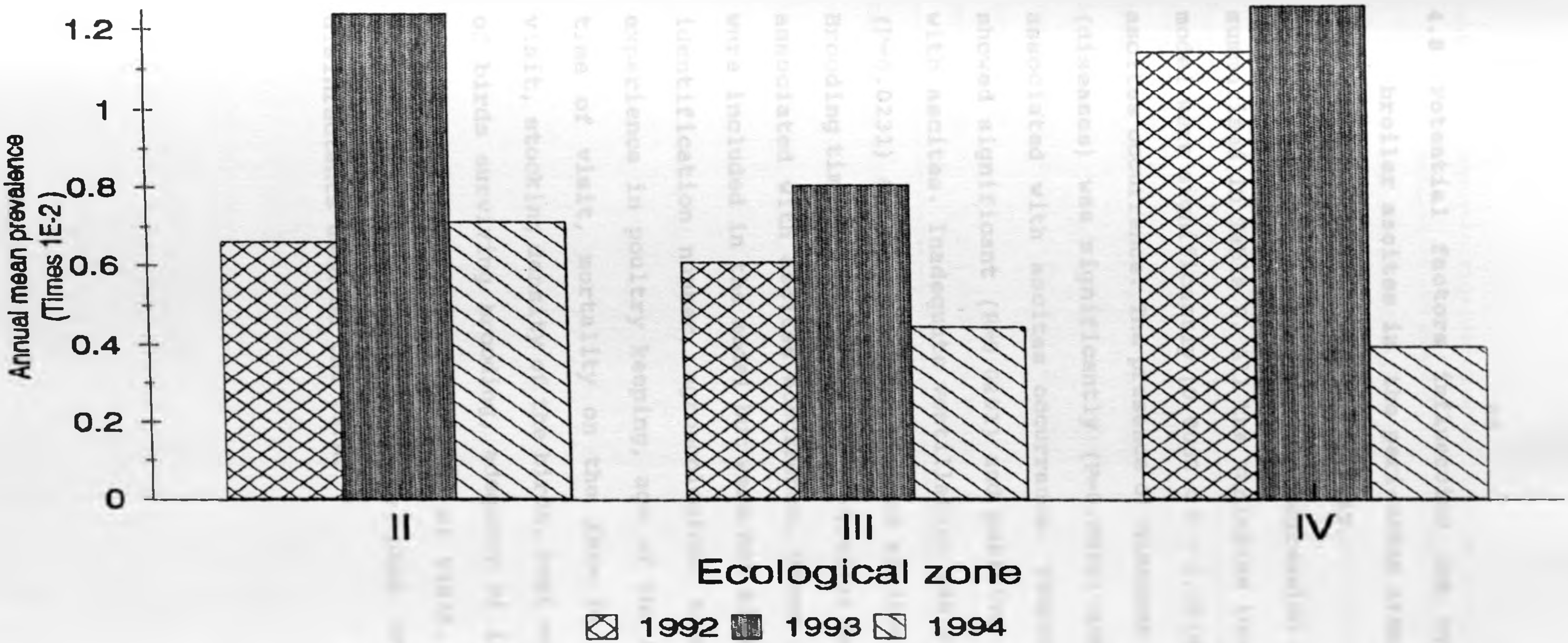

Fig 6: The distribution of the annual means of zone-specific ascites prevalences of broilers in Kiambu, Kajiado and Machakos districts.

4.8 Potential factors influencing the occurrence of broiler ascites in the peri-urban areas of Nairobi between January and March 1995.

The results of the logistic regression analyses are summarised in Table 8. All the variables included in the model were significantly ($0.0062 < P < 0.0519$) related to ascites occurrence. The presence of diseases in the flock (diseases) was significantly ($P=0.0062$) and positively associated with ascites occurrence. Temperature range showed significant ($P=0.0201$) and positive relationship with ascites. Inadequate ventillation was significantly ($P=0.0231$) and positively associted ascites occurrence. Brooding time was significantly ($P=0.0519$) and negatively associated with ascites occurrence. Other factors that were included in the model but were not significant were identification number, agroecological zone, years of experience in poultry keeping, age of the birds at the time of visit, mortality on the farm by the time of visit, stocking density of the birds, heat source, number of birds surviving brooding, adequacy of litter, total feed intake per bird by the time of visit, feed brand, feed form, water source, drugs used on the farm, disinfectants used on the farm.

Table 8: Logistic regression model based on clinical signs test results of the diagnosis of broiler ascites in the peri-urban areas of Nairobi, 1995.

Risk factor	Logistic coefficient	Standard error	P-value	OR
Intercept	1.15607	2.47139	0.6399	-
Brooding time	-0.25496	0.13114	0.0519	0.77
Diseases	0.01741	0.00637	0.0062	1.02
Temperature range	1.16242	0.50002	0.0201	3.20
Inadequate ventilation	2.11982	0.93318	0.0231	8.33

Key: OR = Odds ratio

4.9 Potential factors influencing the prevalence of ascites in broiler birds in 1994.

The overall results of the multiple linear regression analyses are summarised in Table 9. Each variable included in the regression model had a significant (0.0001 < P < 0.05) relationship with the prevalence of ascites. The slaughter age in days ("Dayskill") and the percent mortality showed significant (P=0.0001) and negative relationships with the ascites prevalence. The magnitudes of these two variables were almost similar. The month ("month placed") day old chicks were placed on the farm was significantly (P=0.0001) and positively associated with ascites prevalence. Total feed intake ("Totalfeed") in kilograms per farm was positively and significantly (P=0.0436) associated with ascites prevalence. Overall, these variables accounted for 36.2% (adjusted R^2=0.3618) of the total variation in the ascites prevalence in 1994. Other variables that were included in the model but were not significant were Agroecological zone, identification number, number of birds at slaughter, average liveweight and the day chicks were placed. Total feed intake was highly correlated to feed conversion ratio.

The results of zone-specific multiple linear regression analyses are summarised in Tables 10 to 12. In the ECZII, the percentage mortality showed significant

(P=0.0001) and negative relationship with ascites prevalence. The number of chicks placed was positively and significantly (P=0.0070) associated with ascites prevalence. The month ("month placed") chicks were placed on the farm was significantly (P=0.0140) and positively associated with ascites prevalence. The slaughter age in days ("Dayskill") showed significant (P=0.0199) and negative relationship with ascites prevalence. Overall, these variables accounted for 31.9% (adjusted R^2=0.3185) of the total variation in the ascites prevalence.

In ECZIII, the month ("month placed") chicks were placed on the farm and the percentage mortality showed significant (P=0.0001) and positive relationship with ascites prevalence. The number of chicks placed was positively and significantly (P=0.0029) associated with ascites prevalence. The contract farm in which the birds were reared ("IDNO") was significantly (0.0071) and positively associated with ascites prevalence. The day chicks were placed ("Daypl") showed significant (P=0.0141) and negative relationship with ascites prevalence. Overall, these variables accounted for 35.3% (adjusted R^2=0.3529) of the total variation in the ascites prevalence.

In ECZIV, the percentage mortality showed significant (P=0.0001) and positive relationship with ascites prevalence. The month ("month placed") chicks were placed on the farm was positively and significantly (P=0.0009) associated with ascites prevalence. Overall, these variables accounted for 19.5% (adjusted R^2=0.1950) of the total variation in the ascites prevalence.

Table 9: Summary results of the overall multiple linear regression analysis of the 1994 prevalence of broiler ascites on various study variables in the peri-urban areas of Nairobi, Kenya.

Risk factor	estimate(β_o)	standard error	P-value
Intercept	0.01274	0.00450	0.0048
Dayskill	-4.124×10^{-4}	1.072×10^{-4}	0.0001
Mortality percentage	-4.296×10^{-4}	3.430×10^{-5}	0.0001
Month placed	3.046×10^{-4}	6.869×10^{-5}	0.0001
Total feed intake (Kg/farm)	6.843×10^{-8}	3.382×10^{-8}	0.0436

Adjusted R^2 = 0.3618

Table 10: Summary results of zone-specific multiple linear regression analysis of the ECZII of the 1994 prevalence of broiler ascites on various study variables in the peri-urban areas of Nairobi, Kenya.

Risk factor	estimate(β_o)	standard error	P-value
Intercept	0.01536	0.01042	0.1421
Mortality percentage	-4.965×10^{-4}	6.579×10^{-5}	0.0001
Day old chicks placed	9.369×10^{-7}	3.433×10^{-7}	0.0070
Month placed	3.690×10^{-4}	1.487×10^{-4}	0.0140
Dayskill	-5.584×10^{-4}	2.377×10^{-7}	0.0199

Adjusted R^2 = 0.3185

Table 11: Summary results of zone-specific multiple linear regression analysis of the ECZIII of the 1994 prevalence of broiler ascites on various study variables in the peri-urban areas of Nairobi, Kenya.

Risk factor	estimate(β_o)	standard error	P-value
Intercept	-0.00350	0.00111	0.0021
Mortality percentage	$2.040x10^{-4}$	$4.095x10^{-5}$	0.0001
Month placed	$3.715x10^{-4}$	$7.469x10^{-5}$	0.0001
Day old chicks placed	$3.427x10^{-7}$	$1.130x10^{-7}$	0.0029
Farm identification	2.536x10-7	9.279x10-8	0.0071
Day placed	$-7.386x10^{-5}$	$2.970x10^{-5}$	0.0141

Adjusted R^2 = 0.3529

Table 12: Summary results of zone-specific multiple linear regression analysis of the ECZIV of the 1994 prevalence of broiler ascites on various study variables in the peri-urban areas of Nairobi, Kenya.

Risk factor	estimate(β_o)	standard error	P-value
Intercept	-0.00221	0.00105	0.0377
Mortality percentage	$2.963x10^{-4}$	$5.861x10^{-5}$	0.0001
Month placed	$3.258x10^{-4}$	$9.658x10^{-5}$	0.0009

Adjusted R^2 = 0.1950

5.0: Estimated monetary losses due to condemnation of broiler birds as a result of ascites at the Tigoni abattoir in 1994.

The estimation of the monetary losses which resulted from the antemortem and postmortem condemnations of broiler birds due to ascites was carried on the 1994 records (Table 13) and the follow up data gathered between January and April, 1995 in 49 farms. The 1994 records kept by Kenchick limited company were used because they were complete.

In 1994, the actual loss in ECZII was estimated to be KSh 732,299.47 while in ECZIV it was KSh 487,209.42 and in ECZIII KSh 355,083.13 (Table 13). Overall, the actual loss attributed to these condemnations for the year 1994 was estimated to be KSh 1,574,592.02.

In January to April 1995, the actual loss in ECZIV was estimated to be KSh 57,315.54 while in ECZII it was KSh 33,992.40 and in ECZIII KSh 21,419.78 (Table 14). Overall, the actual loss attributed to these condemnations for the three months in year 1995 was estimated to be KSh 112,727.72.

Table 13: Total losses resulting from condemnations of ascitic birds at Tigoni abattoir, Kiambu District, Kenya, 1994.

Zone	Total number of birds condemned	Average liveweight (Kg)	Price per Kg (Ksh)	CPI	Total loss market price (Ksh)	Actual loss (Ksh)
II	5545	1.55	91.00	6.59	780,558.01	732,299.47
III	2730	1.52	91.00	6.59	378,483.00	355,083.13
IV	3650	1.56	91.00	6.59	519,316.53	487,209.42
Total					**1,677,100.00**	**1,574,592.02**

Key: CPI = Consumer price index for 1994

Table 14: Total losses resulting from condemnations of ascitic birds at Tigoni abattoir, Kiambu District, Kenya, January-April 1995.

Zone	Total number of birds condemned	Average liveweight (Kg)	Price per Kg (Ksh)	CPI	Total loss market price (Ksh)	Actual loss (Ksh)
II	248	1.61	91.00	6.89	36,334.48	33,992.40
III	160	1.57	91.00	6.89	22,895.60	21,419.78
IV	444	1.52	91.00	6.89	61,264.59	57,315.54
Total					**120,494.67**	**112,727.72**

Key: CPI = Consumer price index for 1995

CHAPTER FIVE

5.0 DISCUSSION AND CONCLUSION

In this study, ascites accounted for 26.1% of all the condemnations of broiler birds delivered for slaughter at the Tigoni abattoir, relative to 51.5% condemnations due to cadavers and 22.4% due to "others" (Figure 3a). These compared well with the findings of Gitao, (1988), who singled out the causes of broiler birds condemnation to have been cadavers (48%), ascites (27.7%) and others (24.3%). Similarly, the results of zone-specific (Figures 3b-3c) analyses of antemortem and postmortem causes of broiler condemnations followed similar trends. However, in the Federal Republic of Germany (Gitao, 1988), the causes of broiler birds condemnations were as follows, emaciation (43.8%), skin lesions (15.8%), cadavers (15.3%), bruises (13.4%) and others (11.7%). Since at least 70% of cadavers in Tigoni abattoir had ascites (Anon, 1994), it could therefore be singled out as an important cause of these condemnations. Furthermore, the results of the analyses of the abattoir data obtained for 1992 and 1993, showed that ascites was the leading cause of poultry condemnation (Figure 4). These results contrasted those obtained by Gitao, (1988) and Mbugua, (1989) who found out that the leading cause was cadavers. This increase in the number of ascites cases may possibly have been due to the relative increase in the number of broiler birds placed during the 1992 to 1993 period. For example in 1982 to 1983 period, the number of broiler birds sent for slaughter at the Tigoni abattoir was 2,661,894 (Mbugua, 1989) while in 1992 to 1993 period, the number rose to 4,803,446 (Anon, 1994).

There were variations in farm mortalities, ages at slaughter, numbers of ascitic birds and feed intakes per bird among the ecological zones in 1994 (Table 7). Crude farm mortality was highest (18%) in ECZ II. This contrasted the percent mortality of 7.74 obtained by Mbugua (1989) in his study of the Kenchick limited farms and also the 6% reported by Kenchick limited (Anon, 1994). The high mortality obtained in this study may be explained by the high oxygen requirement associated with low temperatures (Mirsalimi et al., 1990) at high altitude. This is because ECZII is located at high altitudes (more than 1700m above sea level). It has been reported that at high altitudes, hypoxic-hypoxemic induced pulmonary hypertension syndrome tends to cause right ventricular failure and ascites (Cueva *et al.*, 1974; Owen *et al.*, 1990). In his study, Mbugua (1989) indicated that ascites is an important cause of mortality at farm level, which agrees with the mortality results due to ascites obtained for farms in ECZII.

Broiler birds in ECZII were "killed" at less than six weeks of age (Table 7). Thus, by the time of slaughter, there were still ascites cases in ECZII unlike in ECZIII and IV where culling occurred through death since birds in these two zones were sent for slaughter at ages 42.35 and 43.10 days respectively. This agrees with the findings of Julian (1989), who found out that mortalities which resulted from ascites increased after five weeks of age.

Feed intake per bird was higher in ECZII compared to other zones (Table 7). Several investigators have reported that increased feed intakes enhanced growth rates (Dale, 1990; Julian, 1987a; Julian *et al.*, 1989b) which in turn increased oxygen demands (Dale and Villacres, 1988). These factors which increase oxygen requirements have been positively associated with increased incidences of ascites due to pulmonary hypertension (Julian *et al.*, 1987). Thus, the results of zone-specific ascites prevalence obtained in 1994 could have been due to the same reason advanced by Julian and associates (1987).

There is scanty information regarding prevalence of ascites in Kenya. Mbugua (1989) followed broilers reared in Kenchick limited farms between March and June 1986 and obtained a prevalence of 2.72%. In this study, the mean annual ascites prevalence was highest (1.11%) in 1993 and lowest (0.52%) in 1994. The lower prevalence in 1994 could have been due to control measures undertaken by the company to reduce the number of ascites cases, such as skip feeding programme and frequent alterations in feed formulations which, have been reported by poultry health extension workers to reduce incidences of ascites.

There was no significant variation in zone-specific mean ascites prevalences over the entire three year study period despite the fact that the zones are located in different altitudes. Therefore, from this observation, it can be concluded that altitude on which the classification of zones was based, does not have effect on the occurrence of ascites cases. This conclusion agrees with the results of Dale (1986), who reported that ascites occurs at both high and low altitudes.

The results of logistic regression analyses showed that brooding time, diseases, temperature range and inadequate ventillation were significantly associated with ascites condition. Longer brooding time had a sparing effect on the occurrence of ascites possibly because chicks were not subjected to low ambient temperatures too early in life. Low temperatures predisposes birds to ascites through increased oxygen requirement (Julian *et al.*, 1989b).

Presence of diseases in the flock was positively associated with ascites. This is probably because some of these diseases could have compromised the functioning of the lungs. Lung infections have been shown to lead to right ventricular failure and ascites (Julian and Goryo, 1990). The wider the ambient temperature range during rearing, the higher was the chance of birds developing ascites. This could have possibly been due to exposure to high and low temperatures. High temperatures and low temperatures lead to increased oxygen demand (Huchzermeyer *et al.*, 1989, Lubritz, 1995) and hence ascites.

Birds housed in poorly ventillated houses were more likely to get ascites than those housed in well ventillated ones. Agents that interfere with oxygen exchange in the lungs may result in polycythemia and hence have been hypothesized to increase incidence of ascites (Albers and Farakenhuis, 1990b).

The results of linear regression analyses showed that age at slaughter, percent mortality, month of placing day old chicks and total feed intake were significantly related to ascites occurrence. These results indicated that old birds had low occurrences of ascites at slaughter time. This is because by six weeks when the birds were taken for slaughter, ascitic birds had already been culled. This observation agrees with other reports that mortality emanating from ascites is highest after five weeks of age (Julian, 1989). Percent mortality spontaneously increased with prevalence of ascites during rearing period. This suggested that mortalities on the farms were mainly related to ascites and hence most broiler birds on the farms died from ascites.

Percent mortality was positively correlated to "broodsurvival", "house size" and "number of day-old chick placed". Farms with large numbers of "day old chicks placed" had high prevalences of ascites due to large numbers of susceptible birds being exposed to predisposing factors. Such factors included inadequate ventilation. It has been suggested that excessive ammonia gas accumulation due to inadequate ventilation in poultry houses damage the lungs and hence interfere with the pulmonary functions (Julian, 1993). Inadequate oxygen supply to the blood leads to hypoxic induced pulmonary hypertension syndrome and ascites (Julian *et al.*, 1987).

Farms with large numbers of broilers that survived brooding had high prevalences of ascites. This is probably due to the relatively large numbers of birds which might have been exposed to factors associated with ascites during brooding time, such as cold/hot temperatures, feed contaminated with mycotoxins and poor ventilation. It has been shown that low brooding temperatures subject broilers to stress which significantly increase the incidences of ascites (Julian *et al.*, 1989b). In addition, high brooding temperatures of between 25°c - 30°c have been shown to increase oxygen requirements which in turn increased incidences of ascites and pulmonary hypertension syndrome (Huchzermeyer *et al.*, 1989). It is possible that feed bought in bulk for this large number of birds could be exposing them to aflatoxins hence ascites (Dalvi, 1986) due to poor storage.

The larger the poultry house floor area was, the higher the chance was of birds developing ascites probably because of low stocking density. With large rooms, it may have been difficult to keep houses warm enough especially in cold weather, hence ascites.

The month when birds were placed was significantly and positively associated with the prevalences of ascites. Seasonal variations in prevalences of ascites were also observed. Broilers placed in cold months of June and July had high prevalences of ascites. This could have been due to poor brooding management which included short brooding periods and high or low brooding temperatures. The high temperatures may also explain why high prevalences of ascites were observed in the relatively hot months of August and September. The high prevalences in October and November could have been due to large numbers of birds placed. Most farmers had a tendency to place birds towards the end of the year because of the existence of a wide and special market for capons over Christmas and New Year seasons. These observations require long term prospective studies to clearly discern these temporal variations as well as define the risk factors influencing these occurrences.

The higher the plane of nutrition, the higher the chance was of broiler birds developing ascites. This was probably due to the fast muscle growth associated with high feed intake. Usually in broiler birds, muscles grow at a faster rate than the lungs and therefore there was a possibility of development of tissue hypoxia which often leads to pulmonary hypertension syndrome and ascites (Julian, 1993). The high feed intake could have predisposed to ascites if it was contaminated with toxic fats, excess sodium ions or feed additives (Simpson *et al*, 1989a, Julian, 1987a, Mirsalimi *et al*., 1990).

From the results obtained in this study, there is evidence of substantial monetary losses resulting from condemnation of broilers due to ascites. A total market loss of KSh 1.677 million was incurred in Kenya in 1994. Although it might not compare favourably with developed countries, it is quite significant in Kenya considering the small scale broiler production. For example in S.Africa, financial losses were estimated at KSh 38.5 million in 1983 and in Mexico KSh 3,400 million in 1984 (Maxwell, 1990). However the economic losses due to ascites were underestimated in this study because they were solely based on records kept by Kenchick limited and data were gathered for a short period (January-April, 1995). Also data on losses from ascites at farm level was left out in the economic analysis computations because it was not available from the company records. In order to improve on these estimates it is recommended that the company improve on the disease recording systems at the farm and abattoir levels.

While the study sheds some light on the monetary losses resulting from condemnation of broiler birds, there still exists a need to evaluate the total losses occurring over a long period of time. This would be helpful in obtaining data that would be useful to Kenchick limited and others for making major decisions on farm management aspects that are likely to affect ascites control programmes.

Within the limits of data collected and information volunteered by the farmers in this research project, the following conclusions could be drawn:-

a) Ascites prevalence in Kenchick limited farms is low, although significant when monetary losses as well as opportunity costs are considered.

b) Ascites exists as an economic problem in broiler birds reared under Kenchick limited farms located in the three zones. It significantly increases with overall mortality during rearing and it is an important cause of poultry condemnations at the Tigoni abattoir.

c) Important risk factors associated with ascites included the scale of production (Number of day old chicks placed), age at slaughter, the month day old chicks were placed and mortalities on the farm, brooding time , presence of other diseases in the flock temperature range during rearing and ventillation.

d) Reduction in ascites prevalence could be achieved through :-

i) development of a more sensitive and specific diagnostic test of broiler ascites;

ii) rigorous research on suitable ration formulations to cater for the rapidly growing broiler birds under the prevailing management practices;

iii) further research is needed to devise better ways of controlling ascites other than those currently in use;

iv) educating farmers on good farm management practices especially proper stocking density and brooding management.

REFERENCES

Abdul-Aziz, T.A. and Al-Attar, M.A. (1991). New syndrome in Iraqi chicks. *Veterinary Record,* **129**: 272.

Agudelo, L.G. (1983). Possible causes of avian oedema. *Poultry International* July: 8 - 14.

Al-Mashhadani, E.H. and Beck, M.M. (1985). Effect of atmospheric ammonia on the surface ultrastructure of the lung and trachea of broiler chicks. *Poultry Science*, **64**: 2056 - 2061.

Al-Taweil, R.N. and Kassab, A. (1990). Effect of dietary vitamin C on ascites in broiler chicks. *International Journal of Vitamin and Nutrition Research*, **60**: 307-313

Albers, G. and Farakenhuis, M. (1990). Ascites, a high altitude disease in the lowlands. *Poultry (misset)*, February/March: 24-25.

Albers, G., Barranon-Zurita and Ortiz. (1990). Correct feed restriction prevents ascites. *Poultry (misset)*, April/May: 22-25.

Anjum, A.D., Sabri, M.A. and Iqbal, Z. (1989). Hydropericarditis syndrome in broiler chickens in Pakistan. *Veterinary Record*, **124**: 247 - 248.

Anon, (1989). Ministry of Agriculture, Livestock development and marketing, Kenya.

Anon, (1991). Kenya Agricultural Research Institute publication. KARI Research Priorities by the year 2000, Kenya.

Anon, (1994). Kenchic Company Limited, Nairobi, Kenya.

Anon, (1995). Leading economic indicators. Central Bureau of Statistics. Ministry of Planning and National development, Kenya.

Armitage, P. and Berry, G. (1988). "*Statistical Methods in Medical Research*" 2nd edition, pp. 559 (London, Oxford, Blackwell scientific publications).

Austic, R.E. and Scott, M.L. (1991). Nutritional diseases. In: B.W Calnek, H.J.Barnes, C.W Beard, W.M.Reed and H.W.Yoder (Eds), *Diseases of poultry*, 9th edition, pp.45-71 (Ames,Iowa state university press).

Bachmann, W. (1995). Home made protein: Recycling poultry into feed. *Feed Management*, January, **46**: No 1

Barrett, S.C., Robert, F.W. and Hans Rothenbacher (1986). Avian oedema/Ascites syndrome. In: *Proceedings of the Italian Society of Avian Pathology Conference on Broiler Ascites*, Ischia, Italy.

Blake, J.B. and Mbugua P.N. (1992). Agribusiness and public sector collaboration in Agricultural technology in Kenya. A study of poultry feed processing technology (Unpublished).

Bowes, V.A. (1990). Excess calcium and ascites. *Canada Poultryman*, December, 8.

Bowes, V.A., Julian, R.J. and Stirtzinger, T. (1989). Comparison of serum biochemical profiles of male broilers with female broilers and white leghorn chickens. *Canadian Journal of Veterinary Research*, **53**: 7 - 11.

Buys, S.B. and Barnes, P. (1981). Ascites in broilers. *Veterinary Record*, **108**: 226.

Carlton, W.W. (1966). Experimental coal tar poisoning in white peking duck. *Avian Diseases*, **10**: 484 - 502

Charles, D.R., Groom, C.M. and Bray, T.S. (1981). The effect of temperature on broilers: interactions between temperature and feeding regime. *British Poultry Science*, **22**: 475-481.

Cowen, B.S., Rothenbacher, H., Schwartz, L.D., Braune, M.O. and Owen, R.L. (1988). A case of acute pulmonary oedema, spleenomegaly, and ascites in guinea fowl. *Avian Diseases*, **32**: 151-156.

Cueva, S., Sillau, H., Valenzuela, A. and Ploog, H. (1974). High altitude induced pulmonary hypertension and right ventricular failure in broiler chickens. *Research in Veterinary Science*, **16**: 370 - 374.

Dale, N. (1986). Broiler ascites. *Poultry International*.

Dale, N. (1990). Dietary factors influence ascites syndrome in broilers. *Feedstuffs*, December, pp. 14-16.

Dale, N. and Villacres, A. (1986a). Influence of dietary density, carolie:protein ration and supplemental fat on the incidence of ascites in broilers. *Poultry Science*, **65**, Supp. 1, (Abst.), 163-164.

Dale, N. and Villacres, A. (1986b). Dietary factors affecting the incidence of ascites in broilers. In: *Proceedings of the 1986 Georgia Nutrition Conference for the feed industry*, pp. 79-85. (Athens, Georgia, USA).

Dale, N. and Villacres, A. (1988). Relationship of two-week body weight to the incidence of ascites in broilers. *Avian Diseases*, **32**: 556-560.

Dalvi, R.R. (1986). An overview of Aflatoxicosis in poultry.Characteristics, prevention and reduction. *Veterinary Research Communication*, **10**: 429 - 433.

Diaz, G.J., Julian, R.J. and Squires, E.J. (1994). Cobalt induced polycythemia causing right ventricular hypertrophy and ascites in meat type chickens. *Avian Pathology*, **23**: 91 -104.

FAO (1992). Production yearbook, Rome. Italy.

George, I. (1978). Cost benefit analysis, pp. 87 (London, Oxford University Press).

Gitao, C.G. (1988). The major causes of poultry condemnation in Kenya, 1983-1988. In: *proceedings of the IXth International congress of the world Veterinary association*. Brighton, Great Britain. 13^{th}-17^{th} August 1989.

Gordon, R.F. (Editor) (1977). Introduction. In: *Poultry diseases*, pp.395 (London, Cassell and Collier, MacMillan publishers Ltd).

Gross, W.B. (1972). Miscellaneous bacterial diseases (Bacterial endocarditis). In: Hofstad, M.S., Barnes, H.J., Calnek, B.W., Reid, W.M. and Yoder, H.W. (Eds) *Diseases of Poultry*, 6th edition, pp. 389 - 392 (Iowa state university press).

Hakim, T.S. and Macek, A.S. (1988). Effect of hypoxia on erythrocyte deformability in different species. *Boirheology*. 25: 857 - 868.

Hall, S.A. and Michicao, N. (1968). Myocarditis in broiler chickens reared at high altitude. *Avian Diseases*, 12: 75.

Harns, G,C., Nelson, G,S., Dodgen, W.H. and Seay, R.L. (1975). The influence of air temperature during brooding on broiler performance. *Poultry Science,* **54:** (2) 571-577.

Hearth, G.B.S., Watt, D.J., Waite, P.R. and Ormond, J.M. (1981). Observations on poultry slaughter. *Veterinary Record,* **108:** 97

Helmbodt, C.F. and Fredrickson, T.N. (1972). In: Hofstad, M.S., Calnek, B.W.,Helmbodt,C.F., Reid, W.M., Yoder, Jr. H.W. (Eds) *Diseases of Poultry,* 6th edition, pp. 572 (Ames, Iowa state university press).

Huchzermeyer, F.W. (1986). Causes and prevention of ascites. (SAPA) *Poultry Bulletin,* August, pp.346.

Huchzermeyer, F.W. (1989). Broiler ascites research: where are we? (SAPA) *Poultry Bulletin,* June, pp.378.

Huchzermeyer, F.W. and De Ruyck, A.M.C. (1986). Pulmonary hypertension syndrome associated with ascites in broilers. *Veterinary Record,* **119:** 94.

Huchzermeyer, F.W., De Ruyck, A.M.C. and Van Ark, H. (1988). Broiler pulmonary hypertension syndrome. III. Commercial broiler strains differ in their susceptibility. *Onderstepoort Journal of Veterinary Research*, 55: 5 - 9

Huchzermeyer, F.W., Van Der Cole. W.J. and Guinane, P.R. (1989). Broiler ascites: increased oxygen demand with cold may explain high winter incidence. (SAPA) *Poultry Bulletin*, September, pp.474 - 483.

Jaetzold, R. and Schmidt, H. (1983a). Farm Management Handbook of Kenya (Vol.IIB).pp. 450 - 455., 514 - 521., 572 - 577. Ministry of Agriculture, Kenya and German Agency for Technical cooperation (GTZ)

Jaetzold, R. and Schmidt, H. (1983b). Farm Management Handbook of Kenya (Vol.IIC).pp. 156 - 165. Ministry of Agriculture, Kenya and German Agency for Technical cooperation (GTZ)

Jordan, F.T.W. (Editor) (1990). Bacterial, Viral, Parasitic, nutritional, fungal diseases, cardiovascular diseases and miscellaneous conditions. In: *Poultry Diseases*, 3rd edition, pp.497 (London, Bailliere Tindall).

Julian, R.J. (1985). The peritoneum, retroperitoneum and mesentery. In: Jubb, K.V.F., Kennedy, P.C. and Palmer, N.C. (Eds) *Pathology of Domestic Animals*, 3rd edition, vol. 2, pp. 329 - 342 (New York, Academic press)

Julian, R.J. (1987a). Are we growing them too fast? Ascites in meat type chickens. *Highlights of Agricultural Research in Ontario*. **10**: 27 - 30.

Julian, R.J. (1987b). The effect of increased sodium chloride in the drinking water on right ventricular hypertrophy, right ventricular failure and ascites in broiler chickens. *Avian Pathology*, **16**:(1) 61 - 71.

Julian, R.J. (1988). Ascites in meat type duckling. *Avian Pathology*, **17**: 11 - 21.

Julian, R.J. (1989). Ascites in meat type chickens caused by right heart failure. Ministry of Agriculture and food, Ontario.

Julian, R.J. (1990a). Cardiovascular disease. In: Jordan, F.T.W. (Ed.) *Poultry diseases*, 3rd edition, pp.345 - 353 (London, Bailliere Tindall).

Julian, R.J. (1990b). Pulmonary hypertension: A cause of right heart failure in meat type chickens. *Feedstuffs*. January 29, 19 - 22.

Julian, R.J. (1990c). The influence of genetics on right heart failure and ascites caused by the pulmonary hypertension syndrome. In: *Proceedings National Breeders Roundtable*, May, pp. 14-19. (St. Louis, Missouri, USA).

Julian, R.J. (1991). Poisons and Toxins. In: Calnek, B.W., Barnes, H.J., Beard, C.W., Reed, W.M.., Yoder, H.W. (Eds) *Diseases of Poultry*, 9th edition, pp. 863 - 884 (Ames, Iowa state university press).

Julian, R.J. (1993). Ascites in poultry - Review article. *Avian Pathology*, **22**: 419 - 454.

Julian, R.J. and Boulianne, M. (1988). Natural and experimental lung pathology causing pulmonary hypertension, right ventricular hypertrophy, right ventricular failure and ascites in broiler chickens. In: *Proceedings of 30th Annual Mtg.AAAP*. Portland, Oregeon, USA. **209**: 128.

Julian, R.J. and Goryo, M. (1990). Pulmonary aspergillosis causing right ventricular failure and ascites in meat type chickens. *Avian Pathology*, **19**: 643 - 654.

Julian, R.J. and Mirsalimi, S.M. (1992). Blood oxygen concentration on fast growing and slow growing broiler chickens, and chickens with ascites from right ventricular failure. *Avian Diseases*, **36**: 730 - 732.

Julian, R.J. and Wilson, J.B. (1986). Right ventricular failure as cause of ascites in broilers and rooster chickens. In: *proceedings of the IVth international symposium of vet lab diagnosticians* pp.608 - 611 G.H.A. Borst ed. Amsterdam, June 1986.

Julian, R.J., Frazier, J.A. and Goryo, M. (1989a). The effect of cold and dietary energy on right ventricular failure and ascites in broiler chickens caused by amiodarone-induced lung pathology. *Avian Pathology,* **18**: 161 - 174.

Julian, R.J., McMillan, I. and Quinton, M. (1989b). The effect of cold and dietary energy on right ventricular failure and ascites in meat type chickens. *Avian pathology,* **18**: 675 -684.

Julian, R.J., Friars, G.W., French, H., and Quinton, M. (1987). The relationship of right ventricular hypertrophy, right ventricular failure and ascites to weight gain in broiler and rooster chickens. *Avian Diseases,* **31**: 130 -135.

Julian, R.J., Leeson, S., Caston, L.J. and Mirsalimi, S.M. (1990). Ascites in broiler chickens increased by poultry by-product. In: *Proceedings of 62nd Northeastern conference on Avian diseases*, Guelph, Ontario, Canada, June 1990.

Julian, R.J., Summers, J., and Wilson, J.B. (1986). Right ventricular failure and ascites in broiler chickens caused by phosphorus deficient diets. *Avian Diseases,* **30**: 453 - 459.

Kahiri, G.K.S. (1991). Cotton seedcake for broilers. Msc Thesis, University of Nairobi pp. 63 - 65.

Kaminjolo, JR.J.S, Wamukoya, J.P.O., and Nyaga, P.N. (1977). A preliminary report on the occurrence of a disease condition in broilers in Kenya. *Bulletin of Animal Health Production in Africa,* **25**: 431 - 434.

Krogstad, D.J., Sutera, S.P., Boylan, C.W., Gluzman, I.Y., Quan, Z.F. and Rao, P.R. (1991). Intraerythrocytic parasites and red blood deformability: *Plasmodium berghei* and *Babesia microti*. *Blood Cells,* **17**: 209 - 221.

Lekkas, S., P. Iordanidis and E.Artopios (1986). Intoxication by creolin in broilers. *Israel Journal of Veterinary Medicine,* **42**: 114 - 119.

Lopez-Coello, C., Odom, T.W. and Wideman, R.F. (1985). Ascites major cause of mortality in broilers. *Poultry Digest,* **44**: 284 - 288.

Lopez-Coello, C., Odom, T.W and Bailey, C.A. (1987). Observations on the incidence of ascites in a commercial flock of broilers in Mexico. *Poultry Science,* **66**, Supp.1 (Abst.) 84.

Lubritz, D. (1995). An ascites overview. In: *Arbor Acres Service Bulletin,* March 1995.

Magwood, S.E. and Bray, D.F. (1962). Disease condition of turkey poults characterised by enlarged and rounded hearts. *Canadian Journal of Comparative Medicine,* **26**: 268 - 272.

Masiga, W. (1994). The role of Veterinary medicine and the veterinarian in Africa animal agriculture. *Whydah*. September, pg 13.

Maxwell, M.H. (1988). Ascites in the young broilers. *Agricultural and Food Research Council*.

Maxwell, M.H. (1990). Ascites in broilers. *Poultry International*, February, pp.32-38

Maxwell, M.H., Dolan, T.T. and Mbugua, H.C.W. (1989). An ultrastructural study of an ascitic syndrome in young broilers reared at high altitude. *Avian Pathology*, **18**: 481 - 494.

Maxwell, M.H., Robertson, G.W and Spence, S. (1986). Studies on an ascitic syndrome in young broilers. 2. Ultrastructure. *Avian Pathology*, **15**: 525-538.

Maxwell, M.H., Spence, S., Robertson, G.W. and Mitchell, M.A. (1990). Haematological and morphological responses of broiler chicks to hypoxia. *Avian pathology*, **19**: 23 - 40.

Mbugua, H.C.W. (1989). Ascites. <u>In</u>: KVA/"Food animal medicine" held at KETRI, Muguga, Kenya. 19th-

21st April 1989.

Mbugua, P.N. (1990). Rural small - holder poultry production in Kenya. In: *proceedings of International CTA - Seminar on Rural small - holder poultry production*. October 1 - 5, 1990, Thessaloniki, Greece.

McCune, E.L., Savage, J.E. and O'Dell, B.L. (1962). Hydropericardium and ascites in chicks fed a chlorinated hydrocarbon. *Poultry Science*, **41**: 295 - 299.

McInerney, J.P. (1991). Cost-Benefit analysis of livestock disease: A simplified look at it's economic foundations. In: *Proceedings of the 6th ISVEE symposium*. Ottawa, Canada. 12th-16th August 1991.

Mirsalimi, S.M. and Julian, R.J. (1991). Reduced erythrocyte deformability as a possible contributing factor to pulmonary hypertension and ascites in broiler chickens. *Avian Diseases*, **35**: 374 - 379.

Mirsalimi, S.M. and Julian, R.J. (1993). Effect of excess sodium bicarbonate on the blood volume and erythrocyte deformability of broiler chickens. *Avian Pathology,* **22**: 495 - 507.

Mirsalimi, S.M., O'Brien, P.J. and Julian, R.J. (1992). Changes in erythrocyte deformability in sodium chloride-induced right sided cardiac failure in broiler chickens. *American Journal of Veterinary Research,* **53**: 2359 - 2363.

Mirsalimi, S.M., Qureshi, F.S., Julian, R.J. and O'Brien, P.J. (1990). Myocardial biochemical changes in furazolidone-induced cardiomyopathy of turkeys. *Journal of Comparative Pathology,* **102**: 139-147.

Moreno, C.L. and Lopez, C.C. (1991). Evaluation of compensatory growth in broilers by use ofdifferent programmes of feed restriction for the ascitic syndrome's control. *Poultry Science,* **70**: Supp. 1, (Abst.) 75.

Mukhebi, A.W., Perry, B.D., and Kruska, R.L. (1992). Estimated economic cost of theleriosis control in Africa. *Preventive Veterinary Medicine,* **12**: 73-85.

Nurhadi, A., Martindah, E. and Holden, S.J. (1994). Informal methods of assessing the economic cost of malignant catarrhal fever on small scale farms in West Java, Indonesia. In: *proceedings of the 7th international symposium on veterinary epidemiology and economics*, held in Nairobi, Kenya, 15th-19th August 1994.

Orr, J.P., K.S.Little, M.Schooderwoerd and Rehmtulla, A.J. (1986). Ascites in broiler chicks. *Canadian Veterinary Journal,* **27**: 99 - 100.

Owen, R.L., Wideman, R.F., Jr, Hattel, A.L. and Cowen, B.S. (1990). Use of a hypobaric chamber as a model system for investigating ascites in broilers. *Avian Diseases*, **34** (3):754 - 758.

Peckham, M.C. (1972). Vices and miscellaneous diseases. In: *Diseases of Poultry.* (M.S. Holfstad *et al* eds). Pp.1088 - 1091 (Ames, Iowa state press, USA).

Pratt, D.J. and Gwynne, M.D. (1977). *Rangeland management and ecology in East Africa*, pp 40 - 70 (New york, Robert E. Krieger publishing company Huntington).

Prescott, C.A., Wilkie, B.N., Hunter, B. and Julian, R.J. (1982). Influence of purified grade of pentachlorophenol on the immune response of chickens. *American Journal of Veterinary Research*, **43**: 481 - 487.

Putt, S.N.H., Shaw, A.P.M., Woods, A.J., Tyler,1. and James, A.D. (1988). *Veterinary epidemiology and economics in Africa.* A manual for use in the design and appraisal of livestock health policy.

Qureshi, A.A. (1989). Hydropericardium and ascites. *Poultry International*, **28** (6): 44-48.

Ratanasethakul, C., C. Riddell, R.E. Salmon and J.B. O'Neil (1976). Pathological changes in chicken, duck and turkeys fed high levels of seed oil. *Canadian Journal of Comparative Medicine,* **40**: 360 - 364.

Reed, W.M. and Winterfield, R.W. (1985). Ascites in white leghorn pullets: Isolation of a virus and reproduction of the disease. *Poultry Science*, **64**: Suppl. 1, (Abst.), 167.

Riddell, C. (1985). Ascites. An emerging problem. In: *Proceedings of 20th National Meeting on Poultry Health and condemnations*, pp.92-93, (Ocean city, Maryland, USA).

Scheele, C.W., De Wit, W., Frankenhuis, M.T. and Verejken, P.F.G. (1991). Ascites in broilers. 1. Experimental factors evoking symptoms related to ascites. *Poultry Science*, 70: 1069 - 1083.

Scott, M.L. and Krook, L. (1972). Nutritional deficiency diseases (exudative diathesis in chicks). In: *Diseases of poultry*. Holstad,M.S., H.J.Barnes., B.W.Calnek, W.M.Reid and H.W.Yoder (editors), 6th edition, pp.62 - 63 (Ames, Iowa state university press, USA).

Scott, M.L., Austic, R.E. and Gries, G.L. (1978). Nutritional deficiency diseases (exudative diathesis in chicks). In: *Diseases of poultry*. Holstad,M.S., H.J.Barnes., B.W.Calnek, W.M.Reid and H.W.Yoder (editors), 7th edition, pp. 62. (Ames, Iowa state university press).

Shane, S.M. (1984). The impact of infectious diseases of poultry in selected African countries. *Preventive*

Veterinary Medicine, **3**: 277 - 285.

Shoya, S., T. Horiuchi and M.Kohanawa (1979). Poisons and toxins; In: *Diseases of poultry.* Holstad,M.S., Calnek,B.W., Hemboldt, C.F., Reid, W.M. and Yoder,H.W. (editors), pp.919 - 921 (Ames, Iowa state university press, USA).

Simpson, C.F., Pritchard, W.R. and Harma, R.H. (1959). An endotheliosis in chicken and turkeys caused by an unidentified dietary factor. *Journal of the American Veterinary Medical Association,* **134**: 410 - 416.

Smith, J.E., Mohandes, N. and Shohet, S.B. (1979). Variability in erythrocyte deformability among various mammals. *American Journal of Physiology,* **236**: H725 - H730.

Stotz, D. (1993). Farm management handbook of Kenya volume IV: Production techniques and economics of small holder livestock production systems in Kenya. Ministry of livestock development, Animal production division, Nairobi.pp.140.

Vanvleet, J.F. and Ferrans, V.J. (1983). Congestive cardiomyopathy induced in ducklings fed graded amounts of furazolidone. *American Journal of Veterinary Research*, **44**: 76-85.

Vidyadaras, M.K., King, A.S. and Kassim, H. (1990). Quantitative comparisons of lung structure of adult domestic fowl and red jungle fowl, with reference to broiler ascites. *Avian Pathology*, **19**: 51 - 58.

Willet, G.S., Dan, J.K., Fluharty, D.M. and Rogers, L.F. (1982). *An economic analysis of mastitis control measures for selected dairy herds*. Agricultural Research Centre, Washington university. Research Bulletin XB 0919.

Wilson, J.B. and Julian, R.J. (1985). Ascites in broiler chickens caused by right ventricular failure. In: *Proceedings of North Eastern Conference on Avian Diseases*. Columbia, Maryland. June 16 - 19, 1985.

Wilson, J.B., Julian, R.J. and Barker, I.K. (1988). Lesions of right heart failure and ascites in broiler chickens. *Avian Diseases*, **32**: 246 - 261.

Wise, D.R. and Evans, E.T.R. (1975). Turkey syndrome 65, oedema syndrome and Mycoplasma meliagridis. *Research in Veterinary Science*, **18**: 190 - 192.

Yersin, A.G., Huff, W.E., Kubena, L.F., Elisslde, M.H., Harvey, R.B., Witzel, D.A. and Giroir, L.E. (1992). Changes in haematological, blood gas, and serum biochemical variables in broilers during exposure to stimulated high altitude. *Avian Diseases*, **36**: 189 - 196.

AppendixPOULTRY RESEARCH - ASCITES QUESTIONNAIRE

GENERAL INFORMATION

Division____________Location____________Sublocation______

1.1 Name of respondent..................

1.2 Household composition: Men:.....Women ....Children...

1.3 Farm size..................

1.4 Enterprises on the farm, ranked in terms of income generated (a =highest and e = lowest)

(a)........(b)........(c).........(d)..........(e).......

1.5 Who owns the poultry enterprise ? ....

1.6 Who manages the poultry enterprise? ....

1.7 Who makes management decisions affecting the poultry enterprise? ....

1.8 Has the farmer had any training in poultry keeping?

Yes............No...........

1.9 If yes, what sort of training?

(a) FTC.........

(b) Poultry course (NPDP).........

(c) Others..........

1.10 Reason for keeping birds

(a) food ....(b) source of income ....

(c) culture ....(d) prestige ....

1.11 When did you start keeping birds? ....

COMPOSITION OF FLOCK

2.0 What is the number and age of birds?

chicks (0-8 weeks) (no) .... age(weeks)......

Growers (9-20 weeks) (no).......age(weeks)......

Layers (no) ....age (weeks).....

Broiler starters (< 4 weeks) (no)......age.......

Broiler finishers (> 4 weeks)(no) .....age.......

2.1 What is the source of birds ?....................

2.2 If commercial, name the hatchery ....

POULTRY MANAGEMENT/HOUSING/EQUIPMENT

3.0 Are birds confined? Yes ....No.............

3.1 If yes, are they confined: Permanently?..........

: Only at night?........

3.2 System of keeping birds

(a) deep litter (b) raised floor (c) battery

3.3 What materials are used for the walls?.........

3.4 What is the size of the house used for the following?

(a) broiler starters (0 - 4 weeks) ....m^2

(b) broiler finishers (4 - 8 weeks) ....m^2

(c) chicks (0-8 weeks) ....m^2

(d) Growers (8-20 weeks) ....m^2

(e) Layers ....m^2

3.5 How is ventilation? Good .... Fair.... Poor.....

3.6 Are:-

	Yes	No	Number
feeders present	......	....	....
Drinkers present	......	....	....
Nests present	......	....	....
Litter present	......	....	....

BROODING MANAGEMENT FOR COMMERCIAL BIRDS

4.0 How many day old chicks (D.O.C) are purchased as a batch?................

4.1 Are D.O.C raised in different houses from the other birds? Yes .... No ....

4.2 For how long do you brood chicks? ....(weeks)

4.3 How many survive the brooding period? ....

4.4 What is heat source?

(a) Electric infred lamps:.......

(b) Kerosine stove:...........

(c) charcoal stove:..................

FEED

5.0 What is the level of feed consumption by the following birds?

Class of birds	Daily feed consumption (2kg kimbo tin/ day)	how many times per day is feed provided
chicks (0 -8 weeks)	....	....
growers (8 - 20 weeks)	....	....
Layers	....	....
Broiler starters (<4 weeks)	....	....
Broiler finishers (>4 weeks)	....	....

5.1 What is the expected total consumption (bags)/month for:-

chicks (0-8 weeks).................................

growers (8-20 weeks)...............................

Layers ....

Broiler starters (<4 weeks).........................

Broiler finishers (>4 weeks) ....

5.2 Source of feed: (a)produced on farm ....

(b)commercial feeds ....

5.3 What is the brand name of the commercial feeds you use?

broiler starter..................

broiler finisher.......................

chicks ....

Growers ....

Layers ....

5.4 Are any feed additives put in feed? Yes ....No.....

5.5 If yes, which ones? ....

5.6 Is feed given as pellets or marsh? ....

5.7 How many times per day is water provided?

Ad lib ...... once ...... twice ..... thrice ......

5.8 Are birds supplemented with any type of green vegetables? ....

5.9 If so, which ones? ....

DISEASES

6.0 Of the birds you have, how many did you start with and how many do you have now?

	chicks	growers	layers	Broiler starters	Broiler finishers
Initial Number:	......	....	.....	....	....
mortality in last 1 month	......	....	.....	....	....

6.1 Is the farmer aware of poultry diseases which kill a large number of birds? Yes .... No ......

6.2 If yes, can the farmer identify major poultry diseases affecting his flock? Yes ...... No . ....

(Let the farmer name, then tick against the box. if in local name - translate to the relevant veterinary disease)

(a) New castle disease ....
(b) Gumboro..............................
(c) fowl typhoid..........................
(d) E.coli septicaemia(gastroenteritis)......
(e) Marek's disease.......................
(f) chronic respiratory disease.............
(g) Endoparasites (worms) ....
(h) Ectoparasites (mites, ticks) ....
(i) Water belly............................
(j) Other diseases (name them) ....

6.3 What is the frequency of occurrrence of most poultry diseases?

Year round (endemic)	Seasonal	Dry season	Rainy season	Sporadic	New disease
....	....	....	......	....	....

6.4 Can the farmer describe the most common symptoms of the major diseases affecting his flock? Yes.......No........

6.5 If yes, what are they? (let farmer mention them. Tick against box)

Dull..................................

Atypical behaviour..........................

Enlarged abdomen............................

diarrhoea...................................

respiratory stress..........................

off-feed....................................

Other (specify).............................

6.6 What does the farmer do to prevent mortalities related to disease occurrence within the flock?

(a) preventive health care....................

(b) seek veterinary assistance during disease outbreaks.......

(c) Nothing at all..............................

6.7 Are any health management practices followed?

Yes..........No.........

6.8 What health management practices are carried out?

Vaccinations..........

Deworming...........

Chemoprophylaxis.........

(Coccidiosis/Antibacterial)

6.9 If vaccination is done, at what age are birds vaccinated against the following diseases?

disease	age at which vaccination is done (weeks)			
	1st vacc	2nd vacc	3rd vacc	4th vacc
Marek's	....	....	....	....
New castle	....	....	....	....
Fowl typoid	....	....	....	....

Gumboro ....

6.10 Has there ever been a disease occurrence affecting unusually large number of birds in the flock at any one time? Yes.......... No..........

6.11 If yes, name the disease(s).......................

6.12 Does the farmer buy other medicines apart from vaccines?

Yes........... No ....

6.13 If yes, name them and state the purpose for which they are used

Name of medicine	purpose
....	....
....	....
....	....
....	....

6.14 What is your source of medicine/vaccines for poultry?

(a) local veterinary officer............

(b) Chemist.................

(c) private veterinary clinic.........

(d) animal health assistants.........

6.15 Who carries out health programmes?

(a) Self (husband/wife).........(b) AHA..........

(c) poultry extension officer..................

6.16 Does the farmer reckon that if health programmes are initiated, poultry production will increase?

Yes...... No..........

6.17 When a bird dies, are you able to establish the cause of death? Yes........No..........

6.18 Do you have post mortem done by a Veterinarian?

Yes...... No...........

6.19 What disinfectant(s) do you use for cleaning poultry house?..............

6.20 What drugs do you use to control endoparasites ?........

6.21 What chemicals do you use to control ectoparasites?.........

6.22 What do you use to control coccidiosis?.........

6.23 How regulary do you administer coccidiostats?.......

PRODUCTION

7.0 Broilers

Average age at slaughter.............weeks

Average weight at slaughter..............kg

7.1 Where do you sell your birds..................

7.2 What % of the birds that you send for slaughter are condemned?....

7.3 What% of the birds that you send for slaughter are down graded?...............

7.4 What is the price per kg of dressed weight for

i) first grade...............Ksh

ii) second grade.............ksh

7.5 Did you experience marketing problems during the last 12 months? Yes.............No.............

7.6 If yes, which month(s)?..................

7.7 Could you sell more birds than you did last year?........

7.8 How many birds are laying?............

7.9 How many trays of eggs did you collect from these birds in the last one week?................

8.0 Of the eggs collected in the last one week, how many were?

outlet	% of total production
a) Sold?	....
b) Broken?	....
c) Home consumption?	....

8.1 Of the eggs set aside for sale, how many trays breakdown when being transported for sale?........

8.2 Of the eggs collected last week, how many broken eggs were used for home consumption?..............

8.3 Where and what price do you sell your eggs?...

outlet	% total sold	Ksh per tray
....	....	....
....	....	....
....	....	....

8.4 What could be done to step up your poultry production?

Give comments...

....

8.5 What do you do with manure?...........................

8.6 If you sell manure, how much do you get?.........Ksh (specify flock size.................value of manure.........)

8.7 What problems do you encounter generally in poultry production?.......................................

....

....

INPUT

8.8 What is the cost of a 70kg bag of each of these feeds?

chick feed ....

growers feed ....

Layers feed ....

Broiler starter feed............

Broiler finisher feed ....

8.9 Does this include transport fee?

Yes.........No.............

If not what is the cost of transporting the feed from the source to the farm?............Ksh.

9.0 How much money do you spend on vaccination, drugs and other medicines?

9.0 How much money do you spend on vaccination, drugs and other medicines?

classs of poultry	Total cost of disinfection	total cost of other drugs	total cost of vaccination	total cost of medication
chicks	....	....	....	....
growers	....	....	....	....
layers	....	....	....	....
Broilers starters	....	....	....	....
Broiler finishers	....	....	....	....

Appendix IIa: Questionnaire-derived variables captured during the survey of broiler ascites in the peri-urban districts of Nairobi between January-March, 1995.

- Farm (identification number)
- Agro ecological zones (ECZ)
- Years spent in poultry keeping
- Age of the birds at the time of visit (days)
- Mortality percentage by the time of visit
- Stocking density (birds/metres^2)
- Ventilation (Good/Bad)
- Brooding time (days)
- Heat source
- Number surviving brooding
- Total feed intake by the time of visit (kg)
- Feed brand
- Feedform (pellets, marsh, crumbs)
- Water source
- Diseases reported in the flock
- Drugs used
- Disinfectants used
- Temperature range

Appendix IIb: Variables derived from abattoir records kept by Kenchic Company Limited, 1992-1994.

- Owner
- Farm, identification
- Chicks placed, number
- Birds per crop taken for slaughter, number
- Percentage mortality
- Feed intake (kg)
- Feed conversion ratio (FCR)
- Average liveweight (kg)
- Age at slaughter (days)
- Month placed
- Day placed

Appendix IIIa: Summary results of the frequency distribution of house characteristics on 57 Kenchic contract farms in the peri-urban districts of Nairobi, categorized by ecological zones, January-March 1995.

	ECZII		ECZIII		ECZIV		All zones		
Factor	Freq	Perct	Freq	Perct	Freq	Perct	Freq	Perct	P-value
Roof types									
Couple	5/16	31.3	15/20	75	10/21	47.6	30/57	52.6	0.0279
Flat	11/16	68.8	5/20	25	11/21	52.4	27/57	3.5	0.0279
Type of wall									
Iron sheets	2/16	12.5	3/20	15	2/21	9.5	7/57	12.3	0.8667
Off-cuts	6/16	37.5	4/20	20	17/21	81	27/57	47.4	0.0003
Bricks	-	-	8/20	40	2/21	9.5	10/41	24.4	-
Stone	5/16	31.3	3/20	15	-	-	8/36	22.2	-
Timber	3/16	18.8	2/20	10	-	-	5/36	13.9	-
Type of curtains used									
Nylon bags	13/16	81	14/20	70	18/21	85.7	45/57	78.9	0.4509
Nylon paper	3/16	18.8	5/20	25	3/21	14.3	11/57	19.3	0.6841
Sisal bags	-	-	1/20	5	-	-	1/20	0.05	-
Adequacy of litter									
Adequate	11/15	73.3	14/19	73.7	11/19	57.9	36/53	67.9	0.5046
Inadequate	4/15	26.7	5/19	26.3	8/19	42.1	17/53	32.1	0.5046

key:

Freq = frequency

Perct = Percentage

ECZ11 = Ecological zone II

ECZIII = Ecological zone III

ECZIV = Ecological zone IV

Appendix IIIb: Frequency distribution of management factors on 57 Kenchic contract in the peri-urban areas of Nairobi, January-March 1995.

	ECZII		ECZIII		ECZIV		All zones		
Factor	Freq	perct	Freq	Perct	Freq	perct	Freq	perct	P-Value
Adequacy of ventilation									
Inadequate	7/16	43.8	4/20	20	7/21	33.3	18/57	31.6	0.3061
Adequate	9/16	56.3	16/20	80	14/21	66.7	39/57	68.4	0.3061
Heat source									
Charcoal	13/16	81.3	20/20	100	20/21	95.2	53/57	93.0	0.0801
Infrared bulb	1/16	6.3	-	-	-	-	1/16	6.3	-
Charcoal+bulb	2/16	12.5	-	-	-	-	2/16	12.5	-
Charcoal and Electric coil	-	-	-	-	1/21	4.8	1/21	4.8	-
Feed brand									
Unga	11/16	68.8	13/20	65	16/21	76.2	40/57	70.2	0.7281
Muus	5/16	31.3	7/20	35	3/21	14.3	15/57	26.3	0.2800
Unga+Muus	-	-	-	-	1/21	4.8	1/21	4.8	-
United	-	-	-	-	1/21	4.8	1/21	4.8	-
Feed form									
Pellets and marsh	5/15	33.3	7/20	35	9/21	42.9	21/56	37.5	0.8099
Crumbs	6/15	40.0	6/20	30	6/21	28.6	18/56	32.1	0.7447
Marsh	2/15	13.3	1/20	5	5/21	23.8	8/56	14.3	0.2259
Marsh+crumbs	2/15	13.3	4/20	20	-	-	6/35	17.1	-
Pellets	-	-	2/20	10	1/21	4.8	3/41	7.3	-
Water source									
Municipal	7/16	43.8	6/20	30	8/21	38.1	21/57	36.8	0.6891
River	4/16	25	14/20	20	2/21	9.5	20/57	35.1	0.0020
Borehole	3/16	18.8	2/20	10	4/21	19.0	9/57	15.8	0.6780
Dam	-	-	-	-	1/21	4.8	1/21	4.8	-
Stored rain	1/16	6.3	-	-	-	-	1/16	6.3	-
Dam and stored rain	-	-	-	-	2/21	9.5	2/21	9.5	-
River + Municipal and stored rain	-	-	2/20	10	-	-	2/20	10.0	-
River+ borehole	-	-	1/20	5	1/2	14.8	2/41	4.9	-
River+ municipal-	-	-	2/21	9.5	2/21	9.5	-		
River + stored rain	-	-	2/20	10	-	-	2/20	10.0	-
Borehole and municipal	-	-	1/20	5	1/21	4.8	2/41	4.9	-
Borehole and stored rain	1/16	6.3	-	-	-	-	1/16	6.3	-
Municipal + dam-	-	1/20	5	-	-	1/20	5.0		
Municipal + stored rain	-	-	1/20	5	-	-	1/20	5.0	-

Key:

Freq = frequency, Perct = Percentage, ECZII = Ecological zone II,

ECZIII = Ecological zone III, ECZIV = Ecological zone IV

Appendix IIIc: Frequency distribution of drugs used in management of poultry diseases on 57 Kenchic contract farms in the peri-urban areas of Nairobi, January-March 1995.

	ECZII		ECZIII		ECZIV		All zones		P-value
Drugs used	Freq	perct	Freq	Perct	Freq	perct	Freq	Perct	
OTC*	6/16	37.5	10/20	50	13/21	61.9	29/57	50.9	0.3373
OTC + Clamoxyl*	5/16	31.3	2/20	10	3/21	14.8	10/57	17.5	0.2211
OTC + AF20*	2/16	12.5	2/20	10	1/21	4.8	5/57	8.8	0.6916
OTC + amprol*	2/16	12.5	1/20	5	-	-	3/36	8.3	-
OTC + furaxol*	-	-	1/20	5	1/21	4.8	2/41	4.9	-
OTC + AF20 and baytril*	1/16	6.3	1/20	5	-	-	2/36	5.6	-
OTC + baytril*	-	-	-	-	1/21	4.8	1/21	4.8	-
OTC + AF20 and amprol*	-	-	1/20	5	-	-	1/20	5.0	-
OTC + Vit and electrolyte	-	-	1/20	5	-	-	1/20	5.0	-
OTC + AF20 and furaxol*	-	-	1/20	5	-	-	1/20	5.0	-
OTC + AF20 and Clamoxyl*	-	-	-	-	1/21	4.8	1/21	4.8	-
OTC + furaxol + skajvit* + others	-	-	-	-	1/21	4.8	1/21	4.8	-

AF20, Amprol and Furaxol are coccidiostats

OTC, Baytril, skajvit and clamoxyl are antibacterials

Key: Freq = Frequency, Perct = Percentage, ECZII = Ecological zone II, ECZI

Ecological zone III, ECZIV = Ecological zone IV.

Appendix IIId: Frequency distribution of disinfectants used in management of poultry diseases on 57 Kenchic contract farms in the peri-urban areas of Nairobi, January-March 1995.

Disinfectant used	ECZII		ECZIII		ECZIV		All zones		P-Value
	Freq	perct	Freq	Perct	Freq	perct	Freq	Perct	
Kerol*	6/16	37.5	10/19	52.6	13/21	61.9	29/56	51.8	0.3372
biosafe*	2/16	12.5	-	-	2/21	9.5	4/37	10.8	-
pynol5*	1/16	6.3	1/19	5.3	1/21	4.8	3/56	5.4	0.9801
kerol+ biosafe	2/16	12.5	1/19	5.3	-	-	3/35	8.6	-
kerol+ virkon*	-	-	-	-	2/21	9.5	2/21	9.5	-
kerol+ dettol*	-	-	1/19	5.3	1/21	4.8	2/40	5.0	-
lysol*	-	-	1/19	5.3	-	-	1/19	5.3	-
kerol+ pynol5*	-	-	1/19	5.3	-	-	1/19	5.3	-
malathion*	1/16	6.3	-	-	-	-	1/16	6.3	-
kerol+ phenesal*	1/19	5.3	-	-	1/19	5.3	-		
phenesal*	-	-	1/19	5.3	-	-	1/19	5.3	-
kerol+ municipal*	-	-	1/19	5.3	-	-	1/19	5.3	-
pynol5+ malathion	1/16	6.3	-	-	-	-	1/16	6.3	-
biosafe+ dettol*	-	-	-	-	1/21	4.8	1/21	4.8	-
morning fresh*	1/16	6.3	-	-	-	-	1/16	6.3	-
municipal+ pynol5*	-	-	1/19	5.3	-	-	1/19	5.3	-
dimethoate+ virkon	1/16	6.3	-	-	-	-	1/16	6.3	-
aldrin+ dettol	1/16	6.3	-	-	-	-	1/16	6.3	-
pynol5+municipal and antec	-	-	-	-	1/21	4.8	1/21	4.8	-

Biosafe, pynol5, phenesal and municipal are phenol based disinfectants

Virkon and dettol are chlorhexidine based disinfectants

Dimethoate and antec are organophophates

Key: Freq = Frequency, Perct = Percentage, ECZII = Ecological zone II,

ECZIII = Ecological zone III, ECZIV = Ecological zone IV.