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Contents of the Volume

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Septicemic Mannheimiosis in Sahiwal Cattle

By B. S. M. Ronald, S. Hemalatha, R. Mahaprabhu, P. Tensingh Gnanaraj, P. Kavitha Rani & K. Kumanan

Tamilnadu Veterinary and Animal Sciences University, India

Abstract- A 9 year old sahiwal cow as subitted for postmortem following death in a farm housing 100 animals of various breeds of India. Grossly, the animal showed subcutaneous adipose tissue gelatinisation and oedema with streaks of haemorrhage in the submaxillary space, pharyngeal region, neck, dewlap and brisket region. Fibrinous adhesions between the pericardium of heart and ventral aspect of lungs. Thoracic cavity revealed yellow fluid with fibrin shreds. Pericardial sac showed thickening with thick dirty white fluid. Samples collected from different organs were cultured followed by multiplex and species specific Polymerase chain reaction which consistently showed Mannheimia haemolytica in all the organs. Histopathology showed that the alveolar spaces were diffusely filled with sero-fibrinous exudates admixed with neutrophils and red blood cells. Interlobular septa were thickened and markedly distended with fibrinous exudation. None of the other animals housed showed and symptom or mortality. This isolated case of mannheimiosis could be due to unknown stress which has led to the multiplication of the organism leading to death of the animal.

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Septicemic Mannheimiosis in Sahiwal Cattle

B. S. M. Ronald [α], S. Hemalatha [σ], R. Mahaprabhu [ρ], P. Tensingh Gnanaraj [ω], P. Kavitha Rani [¥] & K. Kumanan [§]

Abstract- A 9 year old sahiwal cow as subitted for postmortem following death in a farm housing 100 animals of various breeds of India. Grossly, the animal showed subcutaneous adipose tissue gelatinisation and oedema with streaks of haemorrhage in the submaxillary space, pharyngeal region, neck, dewlap and brisket region. Fibrinous adhesions between the pericardium of heart and ventral aspect of lungs. Thoracic cavity revealed yellow fluid with fibrin shreds. Pericardial sac showed thickening with thick dirty white fluid. Samples collected from different organs were cultured followed by multiplex and species specific Polymerase chain reaction which consistently showed *Mannheimia haemolytica* in all the organs. Histopathology showed that the alveolar spaces were diffusely filled with sero-fibrinous exudates admixed with neutrophils and red blood cells. Interlobular septa were thickened and markedly distended with fibrinous exudation. None of the other animals housed showed and symptom or mortality. This isolated case of mannheimiosis could be due to unknown stress which has led to the multiplication of the organism leading to death of the animal.

I. Introduction

Respiratory tract infections are common in farm animals throughout the world. Pneumonic mannheimiosis is a highly contagious disease among intensively reared cattle especially beef cattle and results in high morbidity and mortality. This disease is highly infectious with severe clinical symptoms and is often fatal [1].The incubation period of the disease ranges from 3 to 5 days, however, the onset usually occurs after stress like transport [2]. It is widespread in prevalence in ruminants and results in severe economical losses to the livestock industry [3]. The disease is caused by *Mannheimia haemolytica,* a pathogenic Gram-negative, non-motile coccobacillus belonging to the family *Pasteurellaceae,* is a normal inhabitant of the upper respiratory tract as commensal. These opportunistic bacteria can multiply exponentially producing leukotoxin in stressed animals leading to pneumonia and death. The outbreaks of mannheimiosis can occur throughout the year in the endemic areas [4]. Though usually mannheimiosis is recorded as an outbreak in farm conditions, we report an isolated case which was presented for postmortem to identify the cause of sudden death.

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a) Case Details

An organized dairy farm housing around 100 native cattle of different breeds maintained under intensive system of rearing reported sudden death of a Sahiwal cow aged 9 years. The animal was anorectic with fever prior to death. Gross examinations showed subcutaneous adipose tissue gelatinisation and oedema with streaks of haemorrhage in the submaxillary space, pharyngeal region, neck, dewlap and brisket region. Fibrinous adhesions between the pericardium of heart and ventral aspect of lungs. Thoracic cavity revealed yellow fluid with fibrin shreds.Pericardial sac showed thickening with thick dirty white fluid. Epicardium was congested.Tracheal mucosa was congested and lumen contained frothy exudate extending up to the bronchi of both lungs. Kidneys were congested and intestinal mucosa showed haemorrages. Lungs revealed generalized congestion along with massive haemorrhages. The interlobular septa were prominent, widened and massively filled with either fibrinous or fibrino-purulent exudation. The lesions were most severe in the cranial and middle lung lobes. On cut section, blood tinged frothy exudate oozing-out from small bronchi and bronchioles was evident. Other organs such as kidneys, spleen, liver, heart, lymph nodes, stomach and intestines revealed mild to moderate congestion or occasional haemorrhages.

Peripheral blood smear, smear and swab from oedematous fluid, heart blood, trachea, lungs, pericardium were collected for bacteriological studies. Tissue samples were collected in 10% buffered formalin for histological studies.

II. Discussion

a) Isolation and Identification

The swab materials were streaked onto different media viz.Brain heart infusion agar, Mac Conkey agar, Blood agar, Anaerobic agar, Herrolds egg yolk medium after processing the samples. After incubation at 37°C overnight, the plates showed the presence of circular, slightly raised colonies with an entire margin in blood agar from heart blood, trachea, lungs, pericardial fluid, liver and kidney swabs. The surface of the colonies is smooth, shiny and non- transparent with a greyish tinge. A diameter of approximately 2 mm colony with a narrow zone of ß-haemolysis is observed. Pure colonies were obtained by subculturing and subjected to phenotying as per [5]. Biochemical characterization of the isolates showed they belong to *Mannheimia haemolytica*.

b) Mannheimia Haemolytica Specific PCR

Suspected single colonies of bacteria were lysed by incubating in 40µl of TE buffer at 98°C for 5 min. The lysate was centrifuged at 13,000x g for 5 min, after which 2µl of supernatant was added to the PCR reaction as template DNA. To confirm M. haemolytica, species-specific primers were used as described by [6] targeting O-sialoglycosidase endopeptidase. Following PCR, 10µL of product was visualized on 1.0% (w/v) agarose gel containing ethidium bromide (Fig.I). A product size of 267bp was noticed.

c) Multiplex PCR

Multiplex PCR was used to enable specific identification and differentiation of Mannheimia haemolytica from other species of the genus as described by [7]. Following PCR, 10µL of product was visualized on 2.0% (w/v) agarose gel containing ethidium bromide (Fig.2). The primer set consisted of four primers specific for 16 s rDNA gene, Lkt- region of the Leukotoxin gene specific for *M. haemolytica and M.glucosida*, Lkt 2 –region of Leukotoxin gene specific for *M.glucosida* and HP – region of unknown hypothetical protein specific for Mannheimia *haemolytica.* An amplicon of 304, 206 and 90 bp specific for Mannheimia haemolytica was observed.

d) Histopathology

Microscopically, tissue sections obtained from lungs revealed massive dilatation and engorged blood vasculature. The inter-alveolar spaces were completely filled with red blood cells. Numerous haemorrhages were observed in lung parenchyma. The alveolar spaces were diffusely filled with sero-fibrinous exudates admixed with neutrophils and red blood cells. Interlobular septa were thickened and markedly distended with fibrinous exudation (Fig.3). The alveoli and bronchioles were massively packed with variable proportions of neutrophils, macrophages, fibrin, exudation, erythrocytes and necrotic cellular debris (Fig.4). The heart revealed fibrovascular thickening of the pericardium (Fig.5). Liver showed extensive congestion of veins and sinusoids with diffuse mild fatty changes in hepatocytes. The intestinal mucosa revealed congestion and haemorrhages in mucosa with infiltration of lymphocytes in submucosa. Necrosis of intra-alveolar leukocytes mainly neutrophils leading to appearance of oat shaped inflammatory cells was conspicuous finding. The cranio-ventral distribution of lesions, massive fibrinous/suppurative exudation, necrotic changes in lung parenchyma including necrosis of inflammatory leucocytes with the formation of characteristic oat shaped cells are strongly suggestive of pneumonic mannheimiosis [8,9].

In domestic animals, *M. haemolytica* is responsible for causing various pathological conditions and respiratory disease is an important manifestation. Harsh climatic conditions, stocking density, onset of other viral or bacterial diseases act as predisposing factors. However, the manifestation of mannheimiosis is also reported without the involvement of any predisposing factor [10]. The manifestation of the disease occurs possibly due to the transfer of *Mannheimia* microorganisms from the nasopharynx into the lungs by draining along the trachea and settling into the bronchi, bronchioles and alveoli. This consequently results in release of *Mannheimia* endotoxins which infect lung lobules and causes thromboses along with occlusion of lymphatics, capillaries, and veins; thereby causing ischemic necrosis [11]. In spite of face to face housing, isolated case of Septicemic mannheimiosis suggests that native breeds of cattle are more resistant to Mannheimia infection. Screening of all the animals in the farm for *Mannheimia haemolytica* revealed 10% of the healthy animals harbored this organism in the upper respiratory tract (Data not shown). Hence the possible reasons attributed for the isolated case could be the age of the animal and extreme summer stress which could have led to mannheimiosis.

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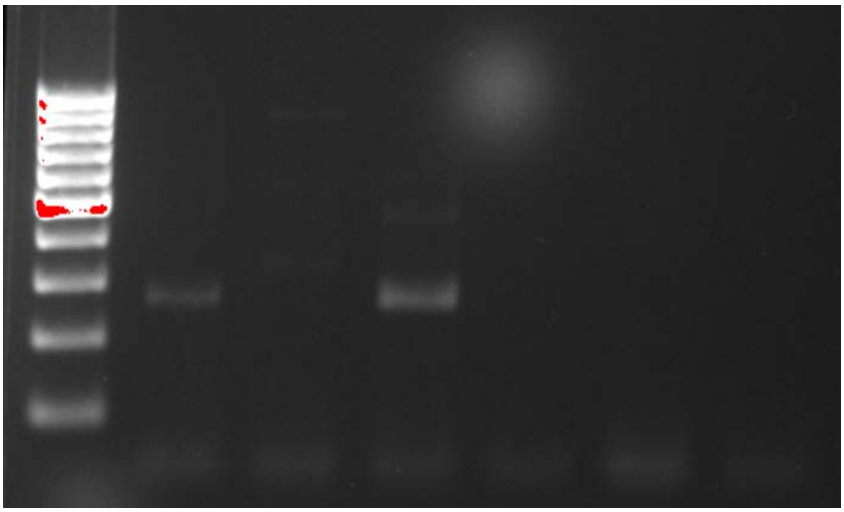

Fig. 1 : Mannheimia haemolytica specific PCR

Lane 1 DNA ladder; Lane 2 – 6 samples; Lane 7 – Negative control

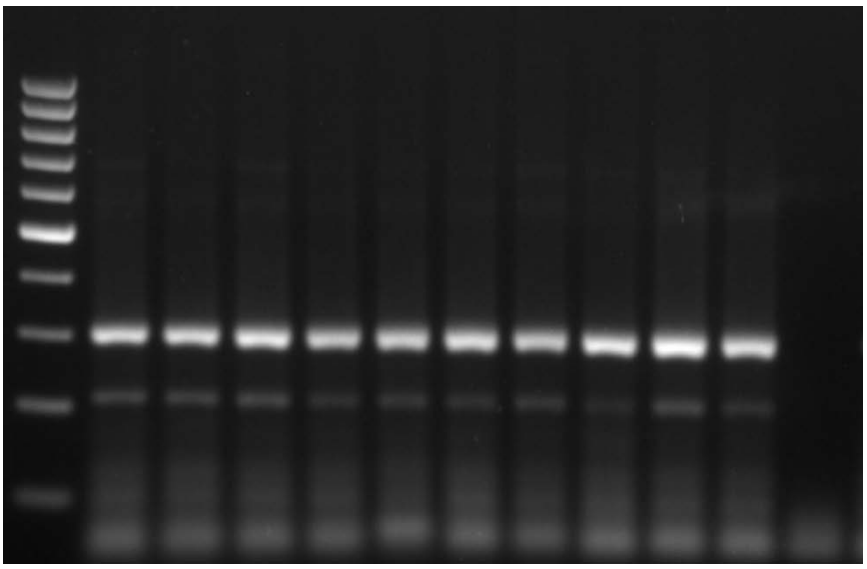

Fig. 2 : Multiplex PCR for Mannheimia haemolytica

Lane 1 – DNA ladder; Lane 2- 11 – samples from heart, trachea, lung, liver and kidney in duplicate. Lane 12 – Negative control

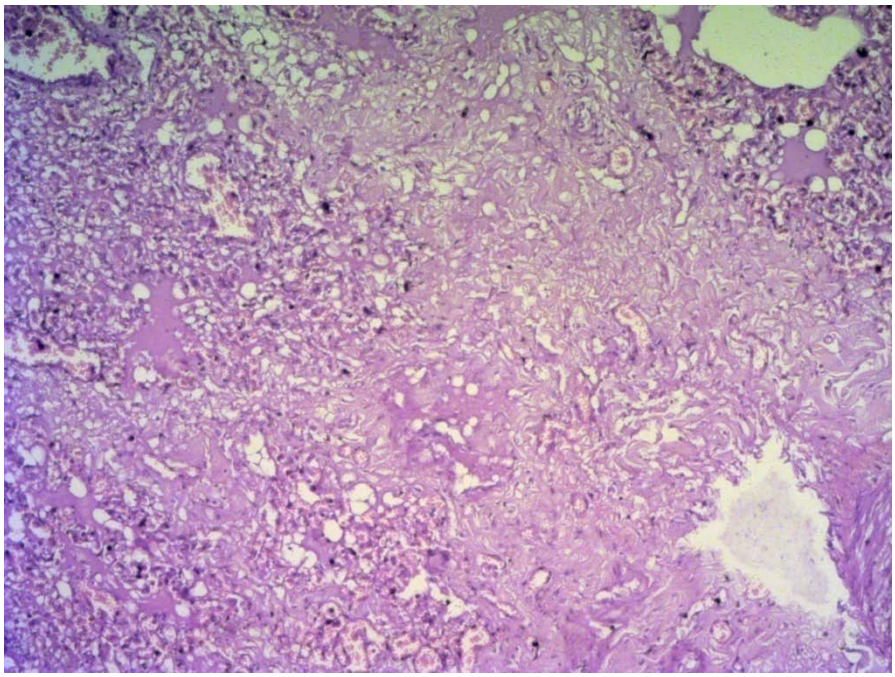

Fig. 3 : Haemotoxylin Eosin Staining.

Lung- Interlobular septa thickened with fibrinous exudation\

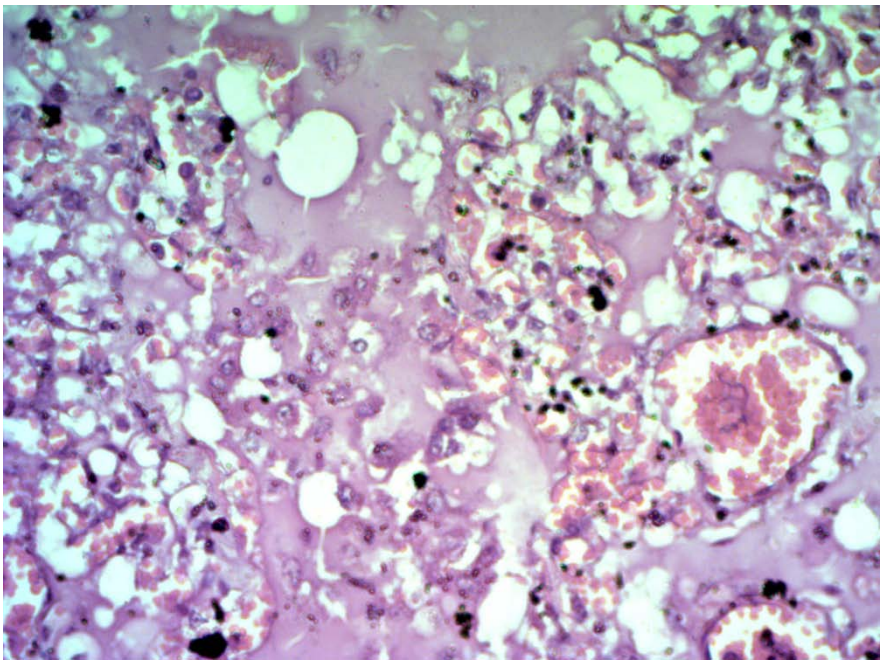

Fig. 4 : Haemotoxylin Eosin Staining.

Alveoli and bronchioles– infiltrated with neutophils, macrophages, fibrin

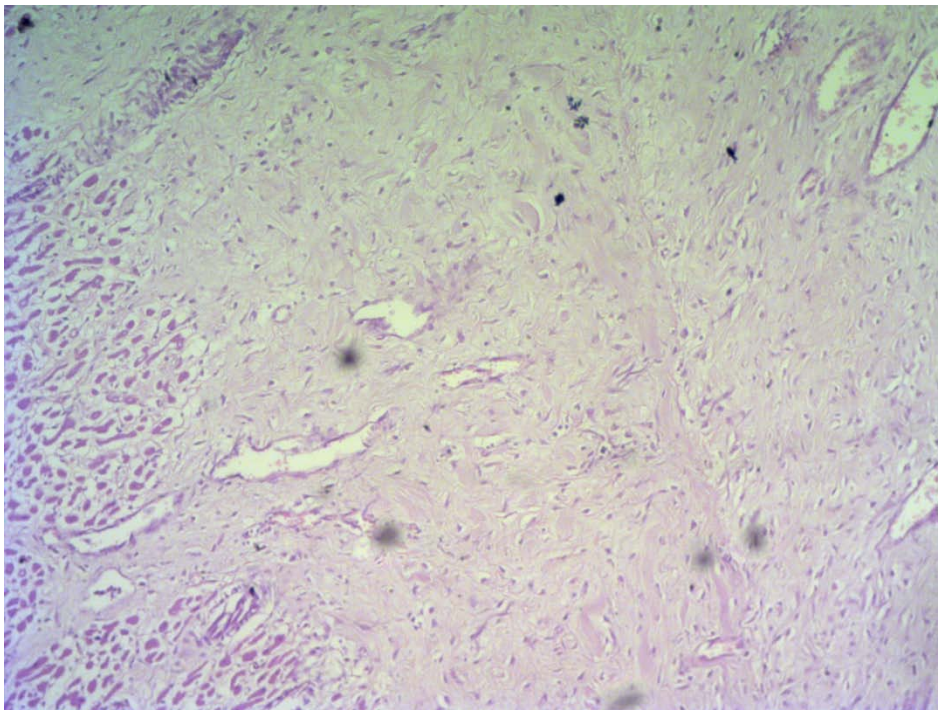

Fig. 5 : Haemotoxylin Eosin Staining.

Heart- Fibrovascular thickening of the pericardium

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Satellite Techniques and its Possible Application in Foot and Mouth Disease Control in Nigeria: A Review

By Olabode H. O. K., Kazeem H. M, Raji, M. A., & Iwuchukwu, K
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Summary- Satellite techniques have been used in disease epidemiology for decades in the western world. However, its application in developing countries like Nigeria is under exploited but highly desirable especially in the livestock sub sector that is heavily laden with numerous diseases of economic value. The economic burden of Bovine Foot and Mouth disease on the livelihood of livestock owners and trade is on increase with the emergence of seemingly more virulent viruses, as evidenced by genetic diversification of serotypes in recent phylogenetic studies. Creating awareness on satellite application especially Geographic Information system (GIS) in Foot and Mouth disease surveillance and control would aid in alleviating the aforementioned negative impact. The purpose of this review is to summarize our current understanding of bioinformatics on its applications to livestock disease control with a chronological review of prevailing scientific tenets and practices as described in scientific veterinary journals and textbooks is as discussed. To promote awareness and use of GIS and other satellite applications in the control of livestock diseases especially Foot and Mouth disease, training and re-training of veterinary personnel in the field of veterinary bioinformatics and satellite techniques is therefore advocated.

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Olabode H. O. K [α]., Kazeem H. M [σ], Raji, M. A [ρ]., & Iwuchukwu, K [ω]

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I. Introduction

Satellites techniques are new and modern methods that are largely technologically driven. These techniques include: remote sensing, geographical information system (GIS) and global positioning system (GPS). Although, these satellite techniques started as technological tools, they are rapidly evolving in a systematic form into science in their own right (Rothman, 1986). A parallel exist between these techniques and epidemiology; their tenets have been established piecemeal with contributions coming from a number of disciplines, particularly the earth sciences (Rothman, 1986). It is now accepted that the use of satellite techniques in health systems of developing countries is a need and a fashion (Sepulveda et al., 1992). Several tools such as computers, satellites, aerial cameras, radars systems and scanners have made satellite technique possible and their introduction into the management of disease control programmes is feasible. These techniques uses spatial variation, analysis of data obtained from extrapolation of measurements made at local levels to regional scales, ecological variations, automation and analysis of aerial photography and bio-geographical and bio-climate studies to predict the transmission and prevalence patterns in control of diseases (Sepulveda et al., 1992). In Nigeria, an earth observation satellite called Nigeria sat 1 was successfully launched into space on 26th September 2003 in Siberia, Russia. By this, it is hoped that there will be improvement in the availability of data from satellite to enhance integration with GIS for problem solving applications. Nigeria sat 1 satellite is a low resolution equipment suitable for large scale mapping only and not for detailed small scale mapping that could show individual buildings, such as homes, streams, roads, and built cities clearly (NigeriaSat-1, 2003). This may not be useful without adaptation, for precise animal health risk studies but could be regarded as a fore runner of technology awareness (Esuruoso et al., 2005). However, in order to carry out geographical mapping of cattle herds' movement pattern and their problems, across the country on a GIS, one would require a high resolution equipment like the Ikonos satellite capable of producing 0.5 to 1m pixel resolution images (Adewale and Olugasa, 2005). This will effectively aid in visualization of spatial distribution of cattle and their movement pattern especially in relation to land use, vegetation cover, water resources and annual seasonal changes within the country (Esuruoso et al., 2005). Spatial data can then be integrated with obtained non-spatial data (Longley et al., 2001). Since satellite data can be made available continuously, it would permit for examination of short-term changes in the study of diseases like FMD. With the consciousness of the many likely benefits derived from the use of satellite techniques in disease control, several attempts have been made to apply them in the management and control of some parasitic diseases in Africa (Njemanze, 1996; Dozie et al., 2007). Beside the fact that Africa has the largest burden of diseases in comparison to other continent in the world, it is also the continent where several environmental factors contribute significantly to disease prevalence, intensity and distribution (WHO, 1990). This therefore, makes the application of satellite techniques in disease surveillance, control and

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prevention particularly relevant. A few studies have shown that satellite techniques permit the planning of interventions where the need is greatest and sustainable success is mostly likely. In spite of a few constraints, satellite techniques hold considerable promise for the control of veterinary diseases especially FMD and other zoonosis as well as management of other health research in Africa including Nigeria. For the purpose of this review, Geographic information system is being considered and highlighted.

II. Geographic Information System

Geographic information system (GIS) is a new cutting edge technology that is being used as a biological risk visualization, management and tracking tool in veterinary epidemiology (Esuruoso et al., 2005). The use of GIS in veterinary medicine and epidemiology dates back to early 1970s when a Canadian scientist Dr. Rowland R. Tinline applied GIS retrospectively to the pattern of spread of FMD epizootic during 1967-68. He applied the GIS technology to generate data from which the incubation period of FMD was obtained. Thus gaining a better understanding of the disease pattern and how it spread from herd to herd (Ramirez et al., 2004), much was learned about FMD by using GIS which could be applied to focus the control of future outbreaks worldwide (Ramirez et al., 2004). Capturing of spatial and non-spatial data related to animal population, distribution, and their problem was a major component of GIS project on risk study. This application of GIS in health risk studies (Fite, 2000) comprises of visualization, measurement (evaluation), assessment and management aspects, when conducted effectively the visualization aspect the technology made its use in epidemiology the exact science. Animal health risk visualization is therefore a scientific visualization method that incorporates computer (especially graphics) that can transform data into visual models which cannot be seen ordinarily (Dent, 1999). The application of scientific visualization to the study of locational and spatial data is termed GVIS (Dent, 1999). This animal health risk may then be described as the application of Geographic Visualization methods to an assessment of health risk in animal groups/population at a specific location and time.

Geographic information system (GIS) provides computerized capture, storage, management, analysis, retrieval and display of spatial and descriptive data that are geographically referenced to common coordinates system. GIS comprises database (spatial and attribute), data input (digital and image), cartographic display system, database management and geographic analysis system (overlay process and buffer zone creation) (Njemanze et al., 1999). The spatial database contains information held in the form of digital coordinates, which describe spatial features (Loslier, 1995). The use of points for homes, lines for roads, or squares for local government areas is well illustrated (Njemanze et al., 1999). The digitalizing system allows existing paper maps to be converted into digital format. The image processing system allowed conversion of remotely sensed imagery into maps. Data from other sources can be interfaced with the GIS database. The cartographic display system produces maps, and allows the user to select spatial features and attributes for display and printing. The database management system is used for creation, maintenance and accessing of the GIS database. The process called "overlay" provides comparison of different entities based on their common geographical occurrence, which is overlaying transparent maps of two entity groups on top of one another (Eastman, 1992). Buffer zone creation is of particular benefit in investigation of disease at or near pollution and other hazardous sites (Openshaw et al., 1987). GIS software that was found suitable for the assessment of animal group/population health risk in a place is the community Viz (The Orton Family Foundation, 2003; Ramirez et al., 2004; Adewale and Olugasa, 2005), while scenario constructor (SC) (Ramirez et al., 2004) is used to analyze the potential impact of accidental release of biological agents on a cattle farm in form of incidence. SC enables the epidemiologist to estimate the number of ill cattle that would result and visualize the necessary decontamination areas providing information needed for cost effective practices of animal health and production, thus making the community Viz software a suitable efficient tool (Olugasa, 2004). Other GIS hardware and software and their benefits in risk studies include personal digital assistant (PDA (Ashok, 2000; Ron, 2003) in form of hand help computers are hardware that run mobile GIS and GPS software and allow field data to be collected and re-laid back to a central GIS, where analysis could be made up to date and validate risk predictive models (Ashok, 2000) such as the probability of outbreak of FMD and success of ring vaccination strategies against the disease in a part of the country. These mapping tools which include laser range finders are now available with much easier user-friendly software and at much lower costs than in the past few years (Ron, 2003). The use of this device provide a system that relies on GPS positioned control points and a laser range finder to remotely position farms, abattoir, veterinary laboratories, veterinary clinics, quarantine stations and wildlife locations (Ramirez et al., 2004). These devices can enable identification of risk areas, active disease areas and convalescent carrier animal group or population or reservoir host animal areas in order to benefit animal health and the veterinary institution in the country by enhancing risk studies and implementation of disease and other problem control strategies. Two types of mobile hardware that could be used to run GIS and GPS software concurrently are the

Dell Axiom PDA (Dell, 2003) and Tremble GeoXT PDA (TGE, 2003). Summarily, these other GIS/GPS hardware and software when used with a central GIS hardware and software like a desktop PC running community Viz on Arc view, is capable of making animal health service delivery positive at community level in a developing country (Dent,1999) like Nigeria due to its flexible capabilities in health risk studies.

GIS is applied for understanding the distribution and diffusion of disease and its relationship to environmental factors, and also for monitoring and evaluation of health programmes (Njemanze et al., 1999). Probability case study of accidental release of FMDV and or deliberate use in quantifying the spatial spread and disease impact on a group of cattle as well as FMD vaccination status of herds has been well demonstrated (Olugasa, 2004). Other application of GIS to studies of parasitic diseases was also well highlighted (Dozie et al., 2007). The African Programme on Onchocerciasis Control (APOC) identified onchocerciasis endemic communities that qualify for mass treatment with ivermectin using GIS (Noma et al., 2002) and was integrated with data from Rapid Epidemiological mapping of Onchocerciasis (REMO), which then allowed the priority areas for mass distribution of ivermectin to be visualized. On that basis endemic areas were delineated into three operational areas for ivermectin treatment namely; "definite community-directed treatment with ivermectin (CDTI)" area; "no-CDTI" areas and lastly "possible-CDTI areas (Nwoke and Dozie, 2001). GIS has been applied in the control of schistosomiasis in Botswana where it was used to monitor the trend in prevalence rate reduction in relation to changing environmental factors (Nkambwe, 1994). GIS has also been used to generate models of malaria occurrence (WHO, 2002a) seasonality (Transer et al., 2002) and transmission (Thomson et al., 1996) using climate and remotely sensed data. The outputs of such data have been combined with population data to estimate population exposure, mortality and morbidity and analyze and project effects of climate on malaria (Hay et al., 2002). The mapping of vectors of malaria and their habitats as well as transmission intensity has been possible with GIS (Omumbo et al., 1998).

III. Other Techniques Relevant to Satellite Research

A number of complimentary techniques relevant to the use of satellite techniques in disease research in Africa including human and robotic teams and telemedicine are at various stages of development. Space robots are being developed which would be integrated in human and robotic team (Erickson, 1995; Njemanze, 1996). Supervised intelligent robotics with vision guidance and dexterous grasp of objects and living organisms can be utilized to acquire samples from remote and dangerous areas where the risk of infection of medical personnel is possible or areas not accessible to humans (e.g wildlife habitats). Human and robotic teams would approach remote areas and via telemedicine workstations (Simmons and Billicia, 1995) and provide their findings to regional, command, and control centers. Telemedicine is a technology dedicated to improving access to medical care from remote areas on the earth and in space. This technology being developed by the US military (Edwards, 1995; Jenkins, 1995) comprised of patient, consultant, on site personnel, sample collection, transport system and the communication connection (Njemanze, 1996). To acquire the data required remote diagnosis, audiovisual capture of patient 's physical findings, biotelemetry of vital signs including electrocardiogram waveforms, blood pressure reading and still images of the patients are recorded in comprehensible form (Njemanze, 1996).

IV. Constraint in the use of Satellite Techniques in Disease Research

The absence of adequately trained personnel has prevented many satellite techniques especially GIS projects from surviving the donor-involvement phase in Africa (Taylor, 1991). Satellite projects in Africa are currently supported and funded by international aid agencies or initiative and many are pilot or research projects as opposed to fully operational systems. In this case, the operators are foreigners and non African scientist who understand both the technological and socio-economic context in which the system operates (EIS-AFRICA, 2002). The initial cost of providing the technology is high for majority of impoverished countries in Africa. Remote sensing projects require satellite and radar systems to be fully operational. Lack of GIS data set is a major impediment to the growth of GIS in Africa. The access to spatial data continues to be difficult and expensive (Briggs and Elliot, 1995). The in ability to convince government, policy makers and other stakeholders of the cost benefit /effectiveness in the health sector is the striking challenge (Clarke et al., 1996). Even though these technologies are in use in the international scientific community, some skepticism still exists surrounding their use in the health sector.

V. Conclusion

Foot and mouth disease (FMD), is a highly contagious, viral trans-boundary, List A, disease of both domestic and wild cloven hoofed animals being transmitted through multiple routes and hosts, which makes it one of the most important diseases affecting trade in livestock. The disease is characterized by high morbidity and decreased livestock productivity, while affected countries are being excluded from international animal trade. In the dynamic of FMD virus (FMDV) dispersal across the globe, phylogenetic inference from

molecular sequences of isolated viruses made significant contribution to the investigation of the evolutionary and spatial pathways underlying the source of FMD epidemics (Di Nardo, et al., 2011). However, the epidemiology of this disease has been poorly understood and utilized in Nigeria despite enormous contributions of several researchers with little applications of satellite imaging and bioinformatics techniques in their studies. However, reports on the geo-spatial distribution and spread of FMD serotypes in outbreaks have been documented (Olabode, 2014) using GIS. These techniques which are capable of predicting disease occurrence and transmission in order to provide early warning signs to stem trans-boundary animal disease transmission and zoonosis. It is therefore hoped that with increased awareness and development of Geo-informatics epidemiology database, satellite applications especially GIS holds forth a promising breakthrough in the control of Foot and Mouth disease and other economic disease of both human and livestock importance in the country.

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Input Cost Saving and Technical Efficiency Improvement in Shrimp Poly-Culture Production – An Application of Data Envelopment Analysis

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Abstract- This study aims to analyze the production efficiency and identify scale properties of shrimp poly-culture farms in Tam Giang-Cau Hai Lagoon, Thua Thien Hue Province, Vietnam by applying Data Envelopment Analysis under input-orientated approach. In addition, the extension Cross Efficiency Method was undertaken to have better ranking of farm performance, to which the comparisons of the uses of inputs between the truly efficient and inefficient farms were made in order to help farms to properly adjust their input combination to optimal level. It is found that if farmers follow the recommendation by this study, the optimization of inputs configuration tends to decrease the total costs of production by 141.85%, and increase the benefit-cost ratio by 58.79%.

Keywords: *shrimp poly-culture production, data envelopment analysis, cross efficiency method.*

GJSFR-D Classification : *FOR Code: 070199*

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Quynh Chi Thi Nguyen [α] & Mitsuyasu Yabe [σ]

Abstract- This study aims to analyze the production efficiency and identify scale properties of shrimp poly-culture farms in Tam Giang-Cau Hai Lagoon, Thua Thien Hue Province, Vietnam by applying Data Envelopment Analysis under input-orientated approach. In addition, the extension Cross Efficiency Method was undertaken to have better ranking of farm performance, to which the comparisons of the uses of inputs between the truly efficient and inefficient farms were made in order to help farms to properly adjust their input combination to optimal level. It is found that if farmers follow the recommendation by this study, the optimization of inputs configuration tends to decrease the total costs of production by 141.85%, and increase the benefit-cost ratio by 58.79%.

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I. Introduction

Aquaculture has become the key economic sector of Thua Thien Hue Province in Vietnam. Being richly endowed with 22,000 ha natural water surface of Tam Giang-Cau Hai Lagoon which is considered as one of the largest lagoon systems in Southeast Asia, Thua Thien Hue Province has great potentialsto develop aquaculture activities, especially in the early years of twentieth century. This is because a historical flood that took place in 1999 helped change the water environment in Tam Giang-Cau Hai Lagoon to one that are disease-free, diverse aquatic species, and suitable for aquaculture activities. Hence, since then, shrimp monoculture, which farmers cultivate only a single species (shrimp) in their ponds, has emerged as the prominent model in this lagoon. Within merely a year the total area of aquaculture in the whole lagoon reached 1000 ha by 1999, 1700 ha by mid-2000 and 1850 ha by the end of 2000 (Phap et al., 2002).According to Fishery Department of Thua Thien Hue Province, the corresponding number in 2010 was 5800 ha, which is nearly six times more than that in 1990s - the very early years of aquaculture development (Thua Thien Hue Province People's Committee, 2011). Unfortunately, along with the fact that people have developed aquaculture massively and uncontrollably, in recent years, the productivity of shrimp monoculture productionhasdramatically declineddue to water pollution, the outbreak of shrimp diseases. Along with Vietnam, other countries such as India, Thailand also experienced similar situation of shrimp production (Kutty, 2005).

IMOLA (Integrated Management of Lagoon Activities) project which aims at assisting the Thua Thien Hue Province to promote the livelihoods of local people through the sound and sustainable management of natural resources in the Tam Giang-Cau Hai Lagoon has encouraged farms to apply poly-culture model due to it merits compared to monoculture model (Van, 2010).Therefore, in the current context, shrimp poly-culture has been found as a good solution to deal with risks arisen from shrimp monoculture. Shrimp poly-culture model is the model that farmers feed three kinds of species: shrimp, crab, and fish in their ponds. Accordingly, shrimp, fish and crab together create a good ecosystem in earth pond because fish can eat the algae, dung of shrimp, and uneaten feed. Hence, the water environment can be improved by the poly-culture system itself, there by, lessening the danger of shrimp diseases. Moreover, the initial capital is allocated to three species instead of investing on only shrimp, thus the risk of dead loss, to some extent, could be overcome.

Nevertheless, according to results investigated by Mohan and others, the technical efficiency of freshwater pond poly-culture farms in Vietnam was found to be considerably lower compared to that of China, India, and Thailand (Mohan Dey et al., 2005).The results achieved from poly-culture models in Vietnam so far have not been compatible with the potentials it has. The same story could be found in Tam Giang-Cau Hai Lagoon. Poly-culture techniques are still new to local farms that are used to solely practice shrimp monoculture, henceshrimp poly-culture model is currently characterized as a spontaneous practice performed by the minority farmers in this study area. Even for those who have been applied bravely this new model, the limited knowledge on poly-culture techniques hinders farmers from obtaining the high efficiency and productivity. Therefore, the need for improving efficiency of poly-culture production has become a crucial issue for the improvements of local farms' livelihoods, and

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consequently to achieveaquaculture sustainability developmentin Tam Giang – Cau Hai Lagoon, Thua Thien Hue Province.

Stemming from that reality, this study employs Data Envelopment Analysis (DEA) and Cross Efficiency Method to determine the efficiencies of farmers, segregate efficient farms from inefficient ones, point out the best operating practices for inefficient farms to study, identify the improper uses of inputs of inefficient farmers, and suggest the target input use pattern with respect to shrimp poly-culture production for inefficient farms. Furthermore, scale property of shrimp poly-culture farms is also identified to develop the strategy for these local farms in the long run.

In the current situation of aquaculture activities in Tam Giang – Cau Hai Lagoon when farmers have not accustomed themselves to poly-culture practices yet, the results of this study will be valuable to better farmers 'performance, contributing to improve the efficiency and productivity of their production. Furthermore, to our knowledge, there have not been any studies so far that discusses on the difference in input use pattern between the truly efficient and inefficient farms, nor suggestions made for the optimal combination of inputs in this research site.

The rest of this paper is structured in the following manner. Research method is introduced in section 2, including Data Envelopment Analysis and Cross Efficiency Method. Data sources and variables are mentioned in section 3. Then, section 4 presents the empirical results, which are discussed according to the ideas developed as follows:

- Measuring the efficiency estimates of shrimp poly-culture farms by applying DEA
- Identifying the truly efficient farms by applying Cross Efficiency Method. These results provide the examples of the best operating practices
- Comparing input use pattern between truly efficient farms and inefficient farms in order to identify improper input usage of inefficient farms
- Setting target input levels for inefficient farms individually
- Pinpointing the economic benefits that inefficient farms can achieve if they utilize the target input combination suggested by DEA results
- Orienting the development strategy in the long run for shrimp poly-culture farms based on the property of their returns to scale by applying DEA.

Finally, we conclude the paper with further discussions and policy implications.

II. Methodology

a) *Data Envelopment Analysis*

Two common techniques which are used to measure productive efficiency are parametric and non-parametric. Both of these approaches have their corresponding advantages and disadvantages. The parametric approach assumes a functional relationship between output and inputs, and uses statistical techniques to estimate the parameters of the production function. In contrast, the most advantage of the non-parametric approach is that it does not require specifying the production function. It utilizesmathematical programmingtoconstruct the linear piecewise frontier over a set of empirical observations. Among non-parametric approaches, the most celebrated approach is Data Envelopment Analysis (DEA) proposed by Charnes et al. (1978). It employs linear programming methods to construct a piecewise frontier which floats on the top of a set of decision making units (DMU)[1].

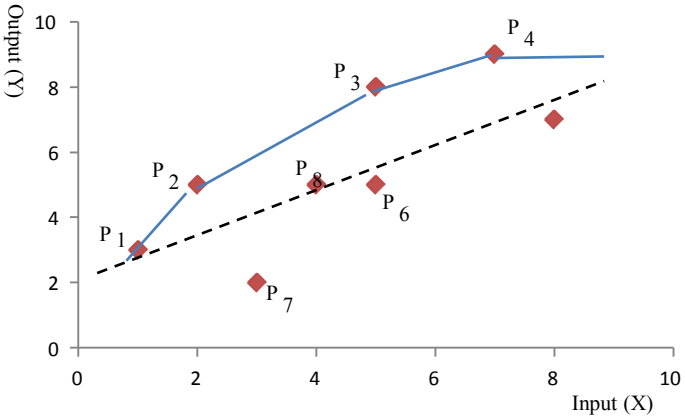

Figure 1: Comparison of DEA and Regression Analysis

Figure 1 visually shows the difference between DEA and one kind of parametric approach- regression analysis. We consider a data set of eight DMUs having single input and single output. In Figure 1, the horizontal and vertical axes depict the quantity of inputs and output, respectively. The dotted line is represented for the linear regression line in the parametric approach, showing the trend in the data points. Regarding DEA, the piecewise frontier over the data set (the solid line) is drawn by joining the boundary points (P_1, P_2, P_3, and P_4) using straight lines. All DMUs lie either on or below the piecewise frontier. For DMUs lying on the piecewise frontier, they are considered as efficient ones (DMU_1, DMU_2, DMU_3, DMU_4), otherwise they are not efficient. As for inefficient DMUs, they will be scaled against to a convex combination of the DMUs, so called their peers in term of DEA terminology, on the piecewise frontier.

Technical Efficiency reflects the ability of a DMU to either obtain the maximum output from a given set of inputs or to produce a given level of output by using the minimum amount of inputs for a given technology (Koopmans, 1951). Two ways for approaching DEA,

[1] "Decision Making Unit" (DMU) is a terminology in DEA. It corresponds to entity to be evaluated as part of a collection that utilizes similar inputs to produce similar outputs. In terms of shrimp poly-culture production, a farmer is considered as a DMU.

thereby, are known as output-orientated and input-orientated models. Farms tend to have more controls over the inputs than over the amount of outputs (Fare et al., 1993). Therefore, applying input-oriented models ismore appropriate than utilizing output-oriented models for evaluating the efficiency of shrimp poly-culture production.

b) Technical Efficiency Estimation using DEA Approach

DEA classifies efficiency into overall technical efficiency, pure technical efficiency, and scale efficiency. Overall technical Efficiency is basically a measure by which DMUs are evaluated for their performance relative to other remaining DMUs in the data set. However, its value also incorporates the effect of the presence of variable returns to scale in the DMUs. In other words, Overall Technical Efficiency estimate is influenced by scale efficiency. Meanwhile, Pure Technical Efficiency is technical efficiency already removed the effect of scale efficiency. The concept of three kinds of efficiencies is graphically depicted in Figure 2.

In Figure 2, the straight line OM passing through the origin and the extreme data points is the frontier with constant returns to scale assumption. The piecewise line joining points (P_1, P_2, P_3, and P_4) is the piecewise frontier with the assumption of variable returns to scale. The DMU lying on line OM and the piecewise line is considered as an efficient DMU in terms of overall technical efficiency and pure technical efficiency, respectively.

We consider DMU_6. It uses AP6 amount of input to produce OA quantity of output. The line AP6 intersects the line OM and the piecewise line at B and C, respectively. Under the constant returns to scale, in order to produce the amount of output OA, DMU_6 only needs AB quantity of input. Meanwhile, if the assumption of variable returns to scale is prevailed, DMU6 is able to use AC instead of AP6 volume of input to produce the same level of output (OA). The horizontal distance between the frontiers under constant returns to scale and under variable returns to scale represents the scale effect, for instance the distance BC in case of DMU6. Therefore, the efficiency measures of DMU6 can be defined as follows:

Overall Technical Efficiency = AB/AP_6
Pure Technical Efficiency = AC/AP_6
Scale Efficiency = AB/AC

Point B and point C are projected horizontally from P6 to frontier under constant returns to scale and under variable returns to scale, respectively. DMUs located at point B and point C are considered as the virtually or hypothetically efficient DMUs of DMU6. The purpose of DEA approach is to determine analytically the position of points B and C.

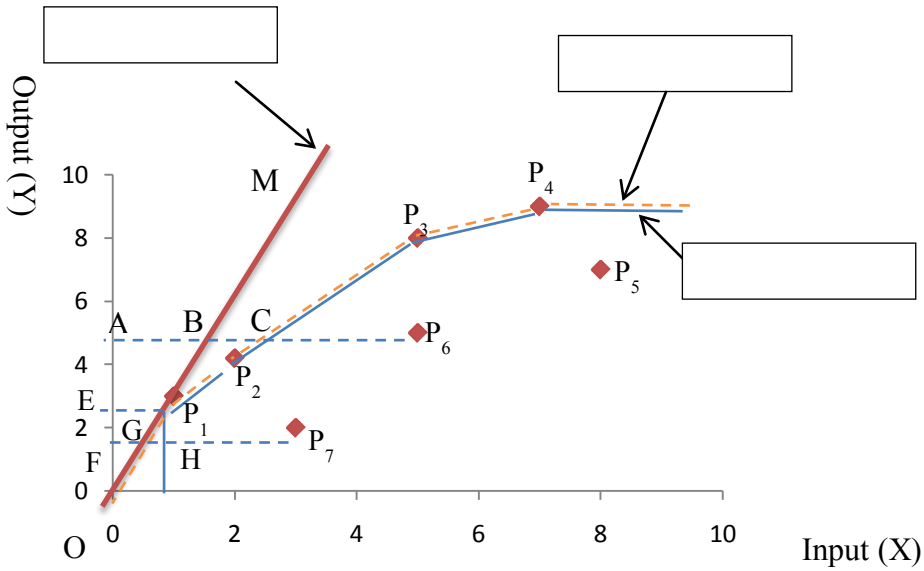

Figure 2 : Technical Efficiency and Scale Effects

In case of DMU_1, it lies on both frontiers. Therefore, its overall technical efficiency is equal to its pure technical efficiency (EP1/EP1 = 1). DMU_1 achieves scale efficiency.

Based on the concept of three kinds of efficiencies presented above, we consider how DEA using linear programming problems to measure Overall Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency.

c) Overall Technical Efficiency

Assume there is a set of n DMUs, in which x_{ip}(i=1,2,…,m) and y_{rp}(r=1,2,...,s) are the quantity of i-thinput and the amount of the r-th output of DMU_p(p=1,2,…,n). The ratio of weighted sum of outputs to weighted sum of inputs used to measure the efficiency of DMU_p is expressed as follows:

$$Max \frac{\sum_{r=1}^{s} u_r y_{rp}}{\sum_{i=1}^{m} v_i x_{ip}}$$

$$s.t.$$

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{s} v_i x_{ij}} \leq 1 \qquad (1)$$

$$j = 1, 2, \ldots, n$$

$$u_r, v_i \geq 0 \forall r, i$$

Where v_i and u_r are the associated input and output weights. This linear programming problem aims to maximize efficiency of DMU under evaluation - DMUp. It is constrained that all efficiencies measures must be less than or equal to 1, and the input and output weights must be more than or equal to 0.

The work of DEA is to calculate an optimal set of weights (v_i*, u_r*) for the DMU under the evaluation. However, the model (1) yields an infinite number of solutions, that is if (v_i*, u_r*) is a solution, then (αv_i*, αu_r*) is another solution (α>0). To avoid this situation, a linear programming problem is introduced by Charnes et al. (1978) and known as the multiplier model:

$$Max \sum_{r=1}^{s} u_r y_{rp}$$

$$s.t.$$

$$\sum_{i=1}^{m} v_i x_{ip} = 1 \qquad (2)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$

$$j = 1, 2, \ldots, n$$

$$v_i, u_r \geq 0 \forall r, i$$

Model (2) deals with the problem of model (1) by adding the constraint that is sum of weighted inputs of DMU under the consideration is unity. Using the duality in linear programming, we can derive an equivalent form of above linear programming problem as follows:

$$\text{Min}_{\theta,\lambda} \ \theta$$

s.t.

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rp}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{ip}$$

$$\lambda_j \geq 0, \forall j$$

Whereλ denotes an Nx1 vector of constant weights which defines the linear combination of the peers of pth farm. The value of λ is used to find the location of the virtually or theoretically DMU of DMU under the evaluation. For instance, model (3) generates the location of the virtually efficient DMU at point B of inefficient DMU_6 in Figure 2 is equal λ times the location of the efficient DMU1from the origin.θ is a scalar and the solution of linear programming problem of model (3), which is named the CCR model - the initial model of DEA approach with the assumption of constant returns to scale (Charnes et al.1978). θ derived from the CCR model is Overall Technical Efficiency score of DMU.

d) Pure Technical Efficiency

The CCR model can be modified to become model (4), which assumes variable returns to scale by adding the convexity constraint $\sum_{j=1}^{n} \lambda$^ n▒λj =1(Banker et al., 1984). Model (4) is so-called the BCC model. θ derived from the BCC model is Pure Technical Efficiency.

$$\text{Min } \theta,\lambda \ \theta$$

s.t.

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rp}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{ip}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, \forall j$$

Taking DMU_6 in Figure 2as an example, Model (4) will yield the location of C by determining λ, which is the convex combination of two efficient farms DMU_2 and DMU_3. In this case, DMU_2 and DMU_3 are called as the peers of DMU_6.

Both linear programming problem (3) and (4) will be solved N times in order to get θ for each DMU.θ ranges from 0 to 1. The DMU is considered to be efficient if θ is equal to 1, otherwise it is inefficient.

e) Scale Efficiency

Scale efficiency is calculated by using equation (5)(Cooper et al., 2006) as follows:

$$\text{Scale Efficiency} = \frac{Overall\ Technical\ Efficiency}{Pure\ Technical\ Efficiency} \qquad (5)$$

If scale efficiency score is equal to 1, DMU has scale efficiency. Otherwise, it has scale inefficiency. In other words, if overall technical efficiency derived from model (3) is equal to pure technical efficiency derived from model (4), DMU operates at constant returns to scale (CRS). Otherwise, there is existence of scale inefficiency, which is on account of either increasing returns to scale (IRS) or decreasing returns to scale (DRS).A DMU operates at constant returns to scale,

increasing returns to scale, and decreasing returns to scale if a given proportional increase in all inputs used in the long run results in the same, greater than, or less than the proportional increase in outputs.

However, the drawback of scale efficiency is that the value is unable to point out whether DMU is operating at increasing returns to scale or decreasing returns to scale. This problem can be solved by running an additional DEA problem with non-increasing returns to scale (NIRS) condition imposed. This is done by replacing the $\sum_{j=1}^{n} \lambda_j = 1$ restriction in model (4) with $\sum_{j=1}^{n} \lambda_j \leq 1$.

The NIRS frontier (dotted line) is plotted in Figure 2 together with the CRS and VRS frontiers (solid lines). The nature of the scale inefficiencies due to increasing returns to scale or decreasing returns to scale for a particular DMU can be determined by comparing the NIRS technical efficiency and pure technical efficiency derived. If they are equal, DMU has the decreasing returns to scale. Otherwise, the increasing returns to scale exist for the DMU (Coelli, 1996). For instance, in Figure 2, DMU_6 operates at decreasing returns to scale, while DMU_7 operates at increasing returns to scale.

f) Cross Efficiency Method

Model (2) allows for the unrestricted factor weights (v_i and u_r) to measure the relative efficiency score. Because of the unrestricted weight flexibility problem in DEA, some DMUs can obtain high relative scores by being involved in a reasonable weight scheme (Dyson & Thannassoulis, 1988; Wong & Beasley, 1990). Consequently, among efficient DMUs, some DMUs perform better than the others. Traditional DEA models do not allow for ranking DMUs, particularly the rank of efficient DMUs(Talluri, 2000), the need to discriminate truly efficient DMUs from other efficient ones with the aim of seeking the best operating practices, however, is still a big concern.

To overcome the above problem, cross-efficiency methodwhich is initially introduced by Sexton et al. (1986) is employed. Cross-efficiency method evaluates the performance of a DMU with respect to the optimal input and output weights (v_i*, u_r*) of other DMUs. This method could effectively rank DMUs and identify good overall performers.

For each DMU_p (p=1,..,n) under the evaluation of model (2), we can obtain a set of optimal weights (v_{ip}*, u_{rp}*). Then, using this set, the cross-efficiency of any DMUj (j=1,…,n) evaluated by the optimal weights of DMU_p is calculated as follows:

$$z_{pj} = \frac{\sum_{r=1}^{s} u_{rp}^{*} y_{rj}}{\sum_{i=1}^{m} v_{ip}^{*} x_{ij}} \qquad (6)$$

$$p, j = 1, 2, ..., n$$

All cross-efficiency scores will be aggregated in a Cross Efficiency Matrix (n x n). In this matrix, the element z_{pj} in the p-th row and j-th column represents the efficiency score of each DMU_j computed using the optimal weights of DMU_p.

$$\begin{bmatrix} z_{11} & z_{12} & .. & z_{1n} \\ z_{21} & z_{22} & .. & z_{2n} \\ .. & .. & .. & .. \\ z_{n1} & z_{n2} & .. & z_{nn} \end{bmatrix}$$

For DMU_j (j=1,…,n), the average cross-efficiency score of DMU_j, , is calculated by averaging the j-th column of cross-efficiency matrix.

$$\bar{z}_j = \frac{\sum_{p=1}^{n} z_{pj}}{n} \qquad (7)$$

$$j = 1, 2, ..., n$$

The efficient farms could be ranked based on their average cross-efficiency score. The higher the average cross-efficiency score the DMU achieves, the higher ranking it has (Zerafat et al., 2012).

Based on the literature review, in recent years, DEA has been started applying extensively in the field of aquaculture such as the study of Sharma et al. (1999), Cinemre et al. (2006), Kaliba et al. (2006), Ferdous Alam et al. (2008). Literature review proves that DEA is an extremely useful tool to evaluate the efficiency of farm production. In case of shrimp poly-culture production, DEA is the most appropriate method because it is considered the only technique available to employ multiple inputs, multiple outputs situation without resort to the aggregation (Charnes et al., 1978).Unlike many previous studies measured the efficiency of aquaculture production by solely applying DEA approach, we utilize Cross Efficiency Method in conjunction with DEA method to overcome the shortcomings of DEA in this study. It is expected to yield more convincing results in segregating the truly efficient and inefficient farms.Cross Efficiency Method has been already applied in some studies ofother fields such as in the study of Chauhan et al. (2006), Zhang et al. (2009), Mohammadi et al. (2011).

III. Data and Variables

The cross-sectional data was caught through questionnaire interview. 70 shrimp poly-culture farms in Tam Giang-Cau Hai Lagoon were randomly selected and face to face interviewed in order to get detailed information on various aspects of shrimp poly-culture production. Five inputs to produce three kinds of output were identified. Farm size represents the cultured area of farm, measured in m2. Labor denotes the number of person-days per m^2. Shrimp seed, Crab seed, Fish seed respectively indicate the amount of shrimp, crab, and fish fingerlings released per m^2. Feed is expressed as the volume of feed used per 10,000 fingerlings. Chemicals represent the quantity of lime and antibiotics used to deal with diseases and water pollution, measured in kilograms per m^2.

Table 1 : Summary Statistics of the Inputs and Outputs of Shrimp Poly-Culture Farms

Variable	Unit	Mean	Std.Dev	Min	Max
Inputs					
Farm size	m^2	5882.800	2551.100	1500.000	12000.000
Labor	person- day/ m^2	0.054	0.032	0.009	0.015
Shrimp seed	fingerlings/ m^2	19.700	9.296	5.000	40.000
Crab seed	fingerlings/ m^2	1.283	1.044	0.125	6.000
Fish seed	fingerlings/ m^2	3.958	3.485	0.625	17.500
Feed	kg/10,000 fingerlings	162.840	67.766	14.268	305.049
Chemicals	kg/ m^2	0.035	0.010	0.010	0.060
Outputs					
Shrimp	kg/ m^2	0.129	0.080	0.003	0.344
Crab	kg/ m^2	0.115	0.009	0.001	0.050
Fish	kg/ m^2	0.082	0.268	0.002	1.805

Table 1 presents the summary statistics of inputs and outputs of shrimp poly-culture farms. The most striking feature, as can be seen, is the large variability of outputs and inputs among farms. These considerable variations reveal that there exist inefficiencies on inputs usage among farms, indicating the need for managerial efficiency.

IV. Empirical Results and Discussion

a) *Measuring the efficiency estimates*

The software DEAP version 2.1 (Coelli, 1996) was utilized to estimate three kinds of efficiency measures. As can be seen in Figure 3, 25 farms out of total 70 poly-culture farms are recognized as overall technical efficient farms, occupying 35.72% (=25/70*100). Meanwhile, the corresponding number of pure technically efficient farms is 32, accounting for 45.72% (=32/70*100).Therefore, it can be inferred that there are only 25 farms obtaining the scale efficiency of unity. The rest of 7 efficient farms are solely pure technical efficiency owing to their disadvantageous conditions of scale size.

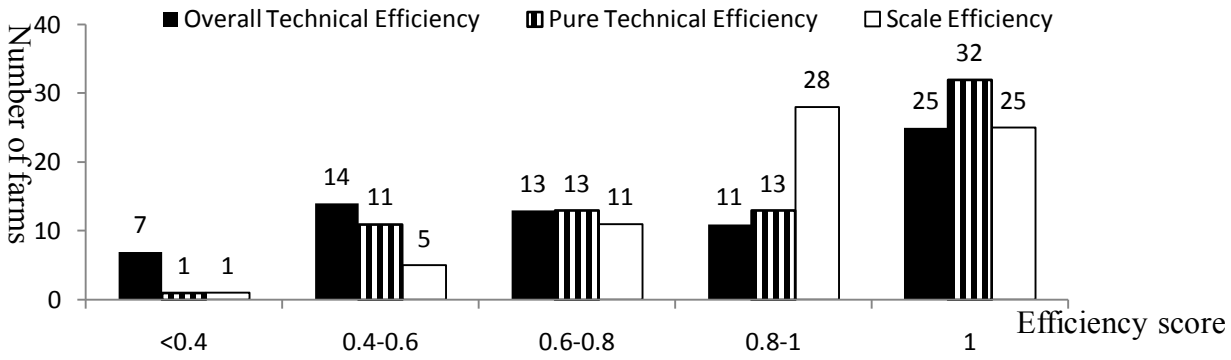

Figure 3 : Efficiency score distribution of shrimp poly-culture farms

The summary statistics of efficiency scores are reported in Table 2. The results reveal that the average values of overall technical, pure technical and scale efficiency were 0.76, 0.84 and 0.88, respectively. The results are quite similar to the study of Ferdous et al. (2008), who found that the overall technical efficiency, pure technical efficiency, scale efficiency of the prawn-carp farmers in Bangladesh were 0.5, 0.85 and 0.88, respectively. By eliminating inefficiency, shrimp poly-culture farms could reduce inputs by 24% (=(1-0.76)*100) with unalterable output. Furthermore, the results imply that there is a 12% (=(1-0.88)*100) potential yield increment earned by achieving the optimal scale.

Table 2 : Average Efficiencies of Shrimp Poly-Culture Farms

	Average	Minimum	Maximum	Std. Dev
Overall Technical Efficiency	0.76	0.13	1.00	0.26
Pure Technical Efficiency	0.84	0.34	1.00	0.20
Scale Efficiency	0.88	0.38	1.00	0.17

The existence of substantial room for efficiency improvement presses the need of seeking and disseminating the efficient operating practices. Therefore, the next section aims to identify truly efficient farmerswho have the best operating practices among 70 poly-culture farmers by employing Cross Efficiency Method.

b) Identifying Truly Efficient Farms

Table 3 presents the average and standard deviation of cross efficiency scores for 10 truly efficient farms.The results indicate that farmers having serial numbers 45, 66 and 37 are identified as those who have the best performance in shrimp poly-culture practices, with the highest average cross efficiency scores of 0.741, 0.73 and 0.729, respectively.

Table 3 : Average Cross Efficiency Score for Truly 10 Most Efficient Farms

Farmer Number	Average Cross Efficiency	Std. Dev
45	0.741	1.703
66	0.730	1.789
37	0.729	2.074
53	0.674	1.664
1	0.646	1.231
41	0.612	1.056
54	0.573	1.053
67	0.572	0.948
40	0.570	0.971
63	0.563	0.938

The information concerning to the production of the truly efficient farms (Appendix 1) should be disseminated to other farms in order to help not only inefficient farms but also other relatively efficient farms to upgrade their efficiency. This is because inefficient farms could be better off their efficiency production by learning from examples of good operating practice in their local area.

With respect to extension service, this information could be used as an effective source for the diffusion of the best practices in term of farm management throughout aquaculture farms. The dissemination of these practices could be conducted by various ways such as broadcasting media of local area, group activities, farm visits or field trips on truly efficient farms, thus farmers can easily catch the information of the best operating practices. In this respect, DEA as well as Cross efficiency method assert themselves as extremely useful tools for extension service.

c) Comparing Input Combination between Truly Efficient and Inefficient Farms

Jaforullah & Whiteman (1999) mentioned that in the absence of environmental differences and errors in measurement of inputs and outputs, technical inefficiency could be derived from the best practice farm management. Adopting the best practice of efficient farms, thus, is the crucial way to eliminate inefficiency. Therefore, it is worthwhile to distinguish the input use pattern between the 10 truly efficient farms and inefficient ones in an attempt to detect the sources of inefficiency.

Table 4 : Amount of Physical Inputs and Output for 10 Truly Efficient Farms and Inefficient Farms

Variable	Unit	10 truly most efficient farms (n=10) (A)	Inefficient farms (n=38) (B)	Difference (%) (B-A)*100/B
Inputs				
Farm size	m^2	3690.000	6184.200	40.33
Labor	person-days/m^2	0.067	0.056	-19.64
Shrimp seed	fingerlings/m^2	11.700	21.763	46.24
Crab seed	fingerlings/m^2	1.801	1.210	-48.84
Fish seed	fingerlings/m^2	3.844	3.170	-21.26
Feed	kg/10,000 fingerlings	138.927	183.200	24.17
Lime	kg/m^2	0.028	0.039	28.21
Outputs				
Shrimp	kg/ m^2	0.238	0.094	-153.19
Crab	kg/ m^2	0.022	0.009	-144.44
Fish	kg/ m^2	0.153	0.016	-89.54

Table 4 exhibits the physical inputs and outputs for truly efficient and inefficient farms. In general, the shrimp, crab, and fish production yield of efficient farms are found to be 153.19%, 144.44%, and 89.54% higher than that of inefficient farms, respectively. The considerable differences in output level are attributed to the difference in the composition of inputs among farms. The results reveal that inefficient farms tend to operate at farm size bigger than that of the truly efficient farms. Meanwhile, the person-days used to take care and oversee shrimp poly-culture practices of inefficient farms are less than that of efficient farms by approximately 19.64%. In spite of the shortage of labor force, the inefficient farms still implement their aquaculture practices with large farm size. This contradiction between farm size and the labor force makes inefficient farms perform poorly. The results reveal that in short run, farms should reduce their farm size to be commensurate with their current labor force, helping farms to better their management ability.

In addition, the results find that inefficient farms over-stock shrimp seed per m^2, releasing the quantity of shrimp fingerlings more than efficient farms do by nearly 46.24%. In contrast, they under-stock crab and fish. Relative to the truly efficient farms, inefficient farms release the number of crab and fish seed less than 48.84% and 21.26%, respectively. In other words, farms tend to densely release shrimp per m^2, while the stocking density of two others species is not as high as it should be. This results stems from the fact that despite of transforming from monoculture into poly-culture techniques, most of farms do not dare to make a big change in the combination of 3 species. This is because local farms have a long history attaching to shrimp monoculture, while just accustomed to poly-culture techniques for a short time. Shrimp, thus, is still the main species, accounting for a high stocking density relative to other species. In terms of technical efficiency, DEA results suggest farms to apply the more efficient the stocking density, decreasing the stocking density of shrimp and increasing that of crab and fish.

Table 4 reports that the amount of feed used by efficient farms is less than that of inefficient farms by 24.17%. Investigating the shrimp poly-culture practices, we recognize that due to being bursting to grow up the stock rapidly as well as the lack of poly-culture techniques knowledge, farmers just have simple thinking in rearing their stock that the more feed is provided, the big size and weight of their stock could be achieved. However, this perception brings the completely opposite results to what farms expect. According to Tuan et al. (2009), one of the main reasons deteriorate the water environment into pollution, is feed redundant from aquaculture activities. In fact, over-feeding the stock leads to much redundant feed and then, the accumulation of these uneaten feed at the bottom of the pond will create sediment. This leads to water pollution. Hence, low efficiency is inevitable consequence of improper feeding.

Similarly, the results also reveal that inefficient farms tend to abuse chemicals for improving the environment of pond at the beginning of crop, and treating shrimp diseases. It appears that the inefficient farms apply the higher quantity of chemicals compared to efficient farms. The different percentage in chemical usage is around 28.21%. It seems that farmers do not fully perceive the deep consequences of side-effects from using improper chemicals. By doing so, the efficiency of shrimp poly-culture farm is further reduced. The results accelerate farmers to make changes of their

incorrect awareness of chemicals usage. In case of making good this shortcoming, shrimp poly-culture production could be prevented from not only the increase of input costs but also the harmful effects on environment.

d) Setting Target Input Use Pattern for Inefficient Farms and Economic Benefits Achieved from Applying the Target Input Use Pattern

i. *Setting Target Input Use for Inefficient Farms*

There are two options for inefficient farms to upgrade their efficiency level. The first option is that inefficient farms adopt the best efficient practices. Accordingly, inefficient farms will follow the input use pattern of truly efficient farms, changing both their level inputs used and outputs achieved. The second option is that inefficient farms can minimize the amount of inputs used while still maintain their current production levels by applying the target input use recommended from their peers. In other words, we can set the targets for every inefficient farmindividually and guide them to improved performanceby collating their current performance with the performance of their peers from DEA results (Boussofine et al., 1991). The precise and concrete solutionshown in Appendix 2 will provide farms individually with the feasible target input use associated with their current situations.

ii. *Economic Benefits Achieved from Applying the Target Input Use Pattern*

Table 5 reports the perspective of economic indices of inefficient farms if they all utilize the optimal input combination recommended by DEA results from Appendix 2. By minimizing the quantity of inputs, on average, the total cost is found to be 66,404.53 thousand VND, indicating 141.85% reductions compared to that of the current situation. Figure 4 shows that the highest potential savings within input costs was feed cost, followed by labor cost and pond preparation cost. In fact, the optimization of the quantity of feed can substantially reduce the cost by the highest percentage of 66.11%. The results emphasize the important role of using feed properly.

Table 5 : Economic Analysis of Shrimp Poly-Culture Production In the Optimum Level of Inputs Used

Cost and returns components	Unit	Actual (A)	Optimum (B)	Difference (%) (B-A)*100/B
Gross value of production	1,000 VND	120,740.50	120,740.50	-
Production cost	1,000 VND	160,599.30	66,404.53	-141.85
Net return	1,000 VND	-39,858.80	54,335.97	173.36
Benefit to cost ratio		0.75	1.82	58.79

Note: Number of observation n=38inefficient farms

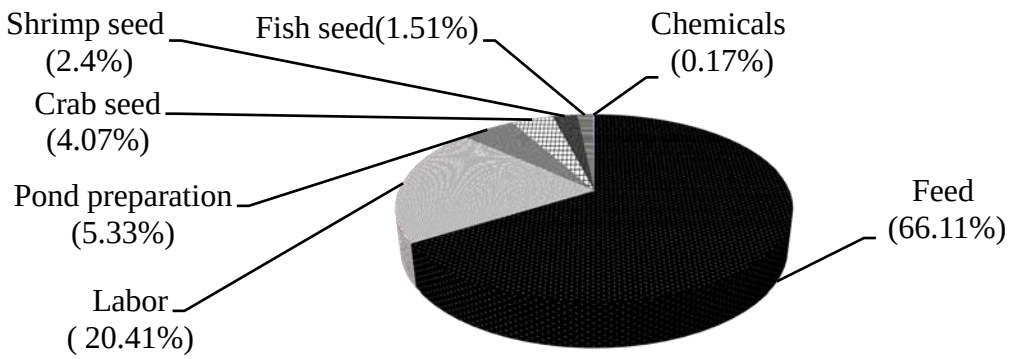

Figure 4 : Potential Reduction of Input Cost of Inefficient Farms

The gross value of production earned from 3 kinds of products: shrimp, crab, and fish is 120,740.5 thousand VND. However, the current input combination leads inefficient farms get loss approximately 39,858.8 thousand VND per crop. If these inefficient farms can apply the target input use, they will get the net return of 54,335.97 thousand VND. Moreover, the benefit to cost ratio of sample farms is computed at 1.82, indicating 58.79% improvement compared to the current benefit to cost ratio index. The high potential for improving the economic indices of shrimp poly-culture production reflected in Table 5 will have powerful motivation

towards farms to change their current practices into more efficient ways, which are recommended by the results presented above. It highlights the importance of the rational utilization and proper allocation of inputs in shrimp poly-culture production.

e) *Scale Properties of Shrimp Poly-Culture Farms and the Development Strategy in the Long Run*

It should bear in mind that the achievement of Pure Technical Efficiency might be a short-run concern. However, in the long-run, farms not only need to obtain pure technical efficiency but also to accomplish scale efficiency. Hence, it is interesting to investigate the sources of inefficiency that farm might have, answering the question whether efficiencies are caused by the inefficient operation of farm itself or by disadvantageous conditions under which farm is operating (Cooper et al., 2005). The advantage of DEA approach is that it is capable of pointing out the returns to scale of farms (Figure 5). It is evident that the dominant scale property of shrimp poly-culture farms is increasing returns to scale, exhibiting that the small scale production seems to be one of critical obstacles of farms. In fact, 52.86% of total sample farms are operating at increasing returns to scale (IRS), followed by 35.71%, and 11.43% for constant returns to scale (CRS) and decreasing returns to scale (DRS), respectively.

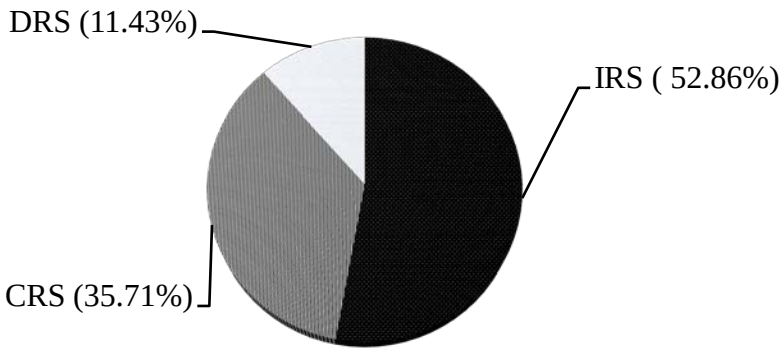

Figure 5 : The scale properties of shrimp poly-culture farms

Regarding constant returns to scale farms, nothing is needed to be adjusted. It would be appear that the largest increase in technical efficiency could be achieved by addressing the problem of increasing returns to scale. Removing increasing returns to scale would contribute to raise the overall technical efficiency by an average of 14.7% from 61% to 75.7%. Furthermore, an improvement of overall technical efficiency that farms could accomplish by removing decreasing returns to scale is around 5.9% from 66.4% to 72.3% (Table 6). From an aquaculture policy view point, the trend of supporting farms to expand the production scale is likely to be better than discouraging this trend. Unfortunately, most of farms in Tam Giang-Cau Hai Lagoon are intrinsically poor people, thus it is difficult for them to have enough capital to make change of their scale production in long run. This obstacle could be settled only if the local government creates more opportunities for farms to approach loans with lower interest rate to fully exploit their potentials to achieve higher efficiency level.

Table 6 : Mean of Technical Efficiency of Shrimp Poly-Culture Farms Classified by Scale Property

	CRS	IRS	DRS
Overall Technical Efficiency	1.000	0.610	0.664
Pure Technical Efficiency	1.000	0.757	0.723

V. Conclusion and Policy Implication

This paper takes advantages of DEA method under the input-orientated approach in conjunction with Cross Efficiency Method to help shrimp poly-culture farms evaluate and improve technical efficiency. Cross efficiency method is applied to identify thetruly efficient farms in order to offer the valuable information sources for aquaculture extension service, and clarify the difference of the input usage between truly efficient and inefficient farms. The optimization of input pattern for inefficient farmsis discovered with the aim of improving technical efficiency and increasing income of local farmers, whose livelihoods are mainly dependent on aquaculture activities. Moreover, this study also utilizes DEA to figure out the returns to scale of shrimp poly-culture farms, which can be used to develop the long-run strategy for their production.

There is the considerable room for enhancing efficiency and productivity of shrimp poly-culture production. In order to help farms improve their efficiency, this study pinpoints the top ten farmers among 70 farmers who have the best operating practices. Accordingly, other farms can learn from these

typical practices to better their performances. In term of farm management, the results prove that the composition of inputs used by truly efficient and inefficient farms is at substantially different levels. It is found that operating at large farm size beyond the available labor force results in the poor supervision of shrimp poly-culture practices. The DEA results also suggest that instead of releasing high shrimp stocking density, farms should spend that capital on raising the density of crab and fish per m^2. By doing so, farm could reduce the risk of shrimp diseases and diversify their outputs in order to meet the high market demand of crab and fish. The findings also emphasize that using the proper amount of feed and chemicals is imperative to not only lowering production cost and, improving farm efficiency but also to reducing negative effects to water environment.

Moreover, by taking advantages of DEA results, this study can provide farms with the target input use pattern individually, by which farms can obtain the same current level of outputs with the minimum of input cost. The proper use of inputs shows the considerable improvement on the net return and benefit to cost ratio of farms. It is predicted that the net return and benefit to cost ratio increases by 173.36%, and 58.79%, respectively. In other words, by following the above recommendations, this research reveals the promising future, in which shrimp poly-culture farms could reach higher efficiency levels given their existing sources and production technology.

The scale properties of shrimp poly-culture farms derived from the DEA results indicate that the expansion of production scale is the tendency needed to be encouraged in the long run. Therefore, the financial support from local government to local farms is needed.

Lastly, although this study offers valuable information, it still has certain limitations. It has not pinpointed the allocative and economic efficiency level of shrimp poly-culture farms yet. Therefore, the extension of investigating allocative and economic efficiency of shrimp poly-culture farms is being researched by the author. It is expected to provide farms and local government with a comprehensive picture of the efficiency of shrimp poly-culture production in Tam Giang – Cau Hai Lagoon.

Appendix

Appendix 1 : The Input Use Pattern of Truly Efficient Farms

Farmer number	Farm size (m2)	Labor (person-days/m2)	Shrimp seed per m2	Crab seed per m2	Fish seed per m2	Feed (kg/10,000 fingerlings)	Chemicals per m2 (kg)
1	3000	0.084	13.000	3.333	10.000	126.364	0.010
37	3500	0.034	10.000	1.171	2.457	144.714	0.030
40	5000	0.096	18.000	0.760	1.840	115.880	0.030
41	4900	0.051	11.000	1.020	1.490	183.806	0.030
45	3500	0.065	10.000	0.543	1.829	153.720	0.020
53	4000	0.053	10.000	1.450	1.500	143.981	0.020
54	4000	0.044	24.000	2.500	12.500	150.048	0.020
63	1500	0.133	5.000	1.800	2.400	95.280	0.040
66	3500	0.060	6.000	3.429	1.429	78.725	0.040
67	4000	0.050	10.000	2.000	3.000	196.747	0.040

Appendix 2 : The actual and target input use for inefficient farms (based on BCC model)

Farmer number	Actual input used							Target (optimal) input used						
	Farm size (m2)	Labor (person-days/m2)	Shrimp seed per m2	Crab seed per m2	Fish seed per m2	Feed (kg/10,000 fingerlings)	Chemicals per m2 (kg)	Farm size (m2)	Labor (person-days/m2)	Shrimp seed per m2	Crab seed per m2	Fish seed per m2	Feed (kg/10,000 fingerlings)	Chemicals per m2 (kg)
2	5000	0.080	12.000	0.600	3.400	258.563	0.020	3692.304	0.054	11.714	0.674	2.917	141.496	0.023
3	4500	0.047	15.000	1.111	1.111	95.786	0.040	3121.694	0.062	12.749	1.486	1.486	140.283	0.040
4	6000	0.064	29.000	1.667	3.333	294.469	0.030	2988.139	0.053	9.548	1.667	3.333	133.680	0.029
5	4000	0.038	25.000	1.750	7.500	161.715	0.040	3824.106	0.038	17.081	1.255	7.500	112.946	0.028
6	12000	0.021	36.000	4.167	4.167	284.211	0.040	4000	0.021	26.000	0.900	3.550	14.268	0.040
7	10000	0.018	40.000	1.500	2.500	201.525	0.040	4601.734	0.037	18.334	1.193	5.276	140.289	0.033
8	5000	0.088	18.000	1.000	4.100	123.194	0.040	2362.495	0.088	9.113	0.999	4.102	117.457	0.027
9	9000	0.022	37.000	0.778	2.778	77.404	0.040	4423.119	0.022	23.746	0.737	2.779	49.813	0.039
10	4000	0.033	20.000	0.750	7.000	102.436	0.040	3917.734	0.032	18.557	0.750	4.296	75.496	0.035
11	8500	0.069	31.000	0.706	2.059	205.530	0.040	4406.851	0.065	15.183	0.865	2.521	127.172	0.030
12	10000	0.035	40.000	0.700	1.900	241.352	0.040	4983.054	0.038	19.307	0.751	2.039	203.558	0.027
13	10000	0.025	26.000	0.450	2.900	228.136	0.050	5339.254	0.025	26.084	0.451	2.909	145.581	0.032
14	7500	0.024	35.000	1.133	1.333	151.177	0.050	4736.402	0.028	20.891	0.473	1.556	110.054	0.040
15	7800	0.032	28.000	1.282	2.179	124.472	0.050	3824.895	0.032	12.191	0.993	2.180	147.715	0.032
16	5000	0.050	12.000	0.640	1.800	255.956	0.050	2884.707	0.062	14.917	0.797	2.239	133.405	0.039
17	9000	0.028	22.000	0.222	1.944	281.916	0.050	6672.305	0.036	27.003	0.288	2.519	201.314	0.027
18	7500	0.060	25.000	0.560	3.587	121.806	0.050	3588.796	0.060	11.561	0.560	3.586	139.040	0.023
19	12000	0.039	31.000	0.550	3.083	223.370	0.060	5079.892	0.039	21.182	0.549	3.083	190.941	0.025
20	5000	0.080	14.000	1.600	6.900	129.970	0.040	2749.52	0.077	10.729	1.029	6.899	109.916	0.022
21	7000	0.043	24.000	1.114	3.571	179.061	0.040	3181.799	0.043	13.257	1.116	3.454	91.114	0.033
22	4000	0.064	10.000	1.250	3.250	150.820	0.040	2828.598	0.055	9.524	1.252	3.249	136.371	0.033
23	5000	0.064	16.000	2.000	5.200	111.284	0.040	3295.34	0.064	11.841	2.000	5.201	135.584	0.029
25	6000	0.041	30.000	0.833	1.667	305.049	0.040	3662.948	0.041	15.026	0.762	1.665	141.305	0.037
26	3200	0.133	8.000	1.250	1.563	138.935	0.040	1506.954	0.133	5.103	1.805	2.455	95.224	0.040
31	5000	0.040	16.000	0.800	1.360	193.754	0.040	3820.8	0.042	16.667	0.623	1.416	142.109	0.039
32	4000	0.048	11.000	1.750	2.000	204.846	0.040	3057.008	0.049	11.452	1.079	2.084	143.505	0.034
33	5000	0.150	10.000	3.400	6.000	78.403	0.040	2796.216	0.078	7.721	3.151	3.877	103.130	0.032
34	6000	0.020	29.000	0.417	4.100	116.443	0.040	5173.834	0.021	22.185	0.445	3.879	83.068	0.037
35	4000	0.125	9.000	0.925	5.000	149.101	0.030	2417.946	0.086	9.413	0.968	5.232	110.629	0.026
38	7000	0.036	15.000	0.471	1.857	272.671	0.030	4713.853	0.034	15.870	0.509	2.009	152.411	0.032
39	3500	0.126	9.000	1.543	2.257	174.003	0.030	2274.274	0.083	9.106	1.579	2.308	145.263	0.031
47	4000	0.094	20.000	1.250	2.500	122.536	0.020	2631.274	0.069	10.128	1.714	3.428	143.044	0.027
52	4000	0.070	8.000	1.075	2.325	129.144	0.020	2319.34	0.086	8.576	1.509	3.268	129.843	0.028
59	5000	0.028	35.000	0.640	5.400	214.375	0.040	4259.908	0.028	22.134	0.641	5.399	55.871	0.036
62	4000	0.050	20.000	1.375	2.250	128.455	0.040	3740.412	0.050	10.472	1.374	2.251	161.421	0.031
64	5000	0.041	14.000	1.380	1.500	201.399	0.040	3915.422	0.048	16.719	1.093	1.790	181.010	0.030
68	5000	0.042	19.000	1.800	2.000	287.292	0.040	4170.624	0.045	20.282	1.043	2.134	194.350	0.034
70	6500	0.050	28.000	1.538	3.077	241.098	0.040	4242.226	0.052	11.098	1.605	3.213	170.744	0.032

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Study on Impact of Post Harvest Losses and Post Harvest Technology in Ganye Southern Adamawa State-Nigeria

By D. A. Mada, D. I. Hussaini, A. I. Medugu, & I. G. Adams
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Abstract- This paper is devoted on impact of post harvest losses at stages of operations. The data balances of food supplied were analyzed and quantified to indicate poor processing and storage facilities in the study Zone Post harvest losses significantly endanger the livelihood of stakeholders and farmers across the value chain by reducing valuable income and profitability.

Research has shown that reduction of just one percent in post harvest losses can lead a gain of 40 million USD annually.

Government investment will lead to huge reduction in post harvest and increase income levels of actors across various agricultural value chain.

Over the past half a century in developing countries with the exception of Ganye, Adamawa State-Nigeria had seen labor saving post harvest system engineering, adopted at unprecedented levels. Post harvest activities in the zone had created power bottle around threshing/shelling of maize, cowpea and groundnut but with adoption of post harvest machines, it had helped and enhance low unit cost with economic impact of 40 percent in the study. Information revealed from the study that farmers sale 20 percent of their grain due to problem of storage facilities. The general grain losses and waste responded by 52 percent of famers is 15-20 percent in the study zone. Quality of grain after post harvest operation with photo type machines is recorded fairly good.

GJSFR-D Classification : *FOR Code: 070307*

Strictly as per the compliance and regulations of :

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I. Introduction

The study highlights the losses occurring along the entire food chain and makes assessments of their food magnitude. It identifies causes of food losses and possible ways of preventing them.

Ahmed, O.A. (2013) reported that post harvest losses is making Nigeria farmers poorer. For a very long time, Nigerian farmers have lamented the situation without getting meaningful assistance.

The result of the study suggest that roughly one third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion of tones per year. This inevitably also means that high amount of the resources used in food production are used in vain.

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Patrick, T. [2013] reported that Nigeria records over 40 percent post harvest losses, which has led to an unprecedented hike in food importation in the country. In which significant losses occurs early in the food supply chain in industrialized regions. While in low-income countries, food is lost mostly during the early and middle stages of the food supply chain. Food supply is mostly wasted at the consumer's levels.

The main causes of food losses and waste in low-income countries are connected to financial management and technical limitation in harvesting, storage and processing techniques. The study revealed that there are major data gaps in the current knowledge of global food losses and waste in the study Zone. Further research in this area is urgent [Jenny Gustavasson et al 2011]. Food security is a major concern in a large part of the developing world. Food production must clearly increase significantly to meet the future demand of an increasing world population. Economically, food losses have a direct and negative impact on the income of both farmers and consumers. How much food is lost in the world today? How can we prevent food losses? There is no precise answer to this question and there is no much ongoing research in the area.

The federal government has been assisting farmers in mopping up excess farm produce and storing them at strategic reserves, which are sold to people at reduced prices during periods of need food scarcity. Farmers and stakeholders also argue that storage facilities alone cannot conquer the problems of post harvest losses in Nigeria. Processing facilities are directly required across the country so as to add value to agricultural products for local consumption and export. Agro cottage, industries and factories should be established to take care of excess farm produce that farmers will make profit.

For instance, the Dangote group has invested 4 billion USD in sugarcane, pineapple and tomato. In addition Dansa food has committed £36 million to process sorghum and transform to high value.

Adesina [2013] reported that about 2 million USD has been committed by the World Bank to support agricultural transformation agenda.

Government and private companies should develop new staple crop processing in the study zone to attract youth back to land and creation of job opportunity.

Thus, processing activities are undertaken to provide a greater yield from raw farm produce by either increasing the amount of finished product or to improve the net economic value of the product.

Post harvest system Engineering deals with threshing, shelling and processing with machine required to accomplish the stages of operation of finish consumer's goods. It involves cleaning, cooling, size reduction and other processing operations. The material has to be conveyed from one point to another, especially in processing industries.

Post harvest multipurpose machine are relatively scare in the study zone as shown in figure3.

Post harvest system engineering activities in cereal, legumes and oilseed in Nigeria is mostly comprised of traditional technique by growers' traders and the processor, resulting in considerable deterioration of physical and nutritional qualities of harvested crops. (Oni and Abiaka, 2000)

II. Materials and Method

The survey was aimed at investigating the levels and cause of post harvest losses of selected crops: cereal, legume and oil seed in Ganye, southern Adamawa state.

The survey was conducted in march 2013, using the method of investigate survey research approach (ISRA) (Anazodo etal, 1986). Information was collected using structured questionnaire which sought for the following information; types of post harvest losses, information on post harvest losses activity and post harvest Enginery system in the study.

The tools of analysis use in this study is descriptive statistic of the explanation variable both qualitative and quantitative

a) Food Losses Supply Chain

The Swedish institute for food a and biotechnology (SIK) has reconstructed mass flow of food aim to human consumption using available data in order to quantify food losses and waste

Food losses refer to decrease in edible food mass throughout the part of the supply chain that specially lead to edible for human consumption. Food losses take place at production, post harvest and processing stages in the food supply chain (Parfait at all 2010).

b) Food Losses Categories in the Study Zone

Five system boundaries were discovered in food supply chain in study zone. Food losses were estimated and quantified along each segments as followings;

1. Agricultural production: losses due to mechanical damage/spillage during harvest operations.
2. Post horst handling and storage: handling during transportation and distribution from farm, storage and market.
3. Processing: including losses due to spillage and degradation during industrial or domestic processing.
4. Distribution includes losses and waste in the market system
5. Consumption: including losses during consumption at the household level.

III. Result and Discussion

The result of this study has shown that post harvest losses due largely to absence of viable storage and processing facilities in the study zone.

Farmers and stakeholders have been impoverished and discouraged their enthusiasm for farming as show table I:

Table 1 : Annual Impact of Post Harvest Losses in Ganye

S/N0	Activities	percent losses
1	Post harvest losses on maize	10
2	Post harvest losses on cowpea	20
3	Post harvest losses on groundnut	30
4	Sold grain due to storage problem	20
5	Grain losses and waste	15-20

Major post harvest losses largely arose from pest, disease, natural disaster, careless human action, inadequate storage facilities and processing (Foluke O, 2011). Government should provide storage facilities the minimize post harvest losses and make food available all year round.

Post harvest losses in Africa is limited, for instance 50 percent of Banana is wasted while Nigeria situated in sub-Sahara estimate one-third of annual harvest is lost due largely to poor storage management (Hartman, 2011)

Thus, processing is very vital part of Agriculture; it extends life span of produce after harvest. However, federal government should broaden the strategic grain reserved program and construction of silos.

A huge volume of farm produce is lost and wasted a long five boundaries of supply chain as shown in table 2.

Table 2 : Types of Grain Losses /Waste in Ganye

s/NO	Types of grain losses	Percent losses	Percent of farmers responded
1	Mechanical damage/ spillage during operation	15-20	62
2	Transport / distribution	5-10	60
3	Processing	10-15	70
4	storage	15-20	42
5	Consumption at household level	5-10	46

Source: Field Survey 2014

Table 2 shows data of grain losses and waste in the study zone. Food security is major concern in large parts of developing countries, especially in Ganye. The main causes of grain losses and waste in low income countries are connected to financial management and technical limitation. Figure 1 indicates mechanical damages on grain after post harvest operation with photo type machines.

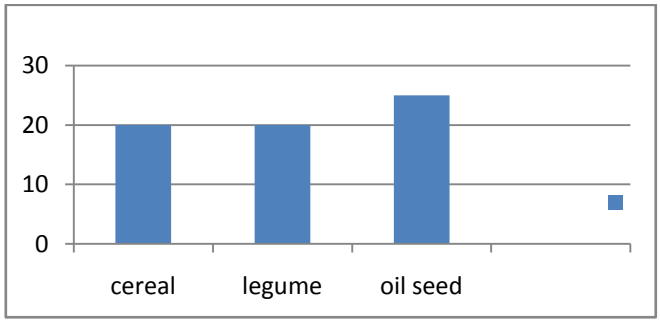

Fig. 1 : Post Harvest Losses of Grain in Ganye-Nigeria

Source: Field Survey 2014

Post harvest machinery are relatively scarce in developing country especially in the study zone few existing one are prototypes machine as shown in Figure 3.

Mechanized post harvest activities are classified into man, Animal and engine power technology. It is on the basis of sophistication, capacity to work, cost and in some cases precaution and effectiveness as shown in table 3.

Table 3 : Agricultural Power by Source and Geographical Region

Region	Total kw/ha	Percent available Kw/ha		
		engine	man	Animal
Asia	0.16	23	26	51
Africa	0.08	58	35	7
Latin America	0.19	71	24	26

Source: Giles (1975)

Patrick, O. (2013) reported that Nigeria record over 40% post harvest loses, which has lead to an unprecedented hike in food importation in the country. Whereas the geographical region for Nigeria in table 3 is using the highest percent human power which is located in Africa.

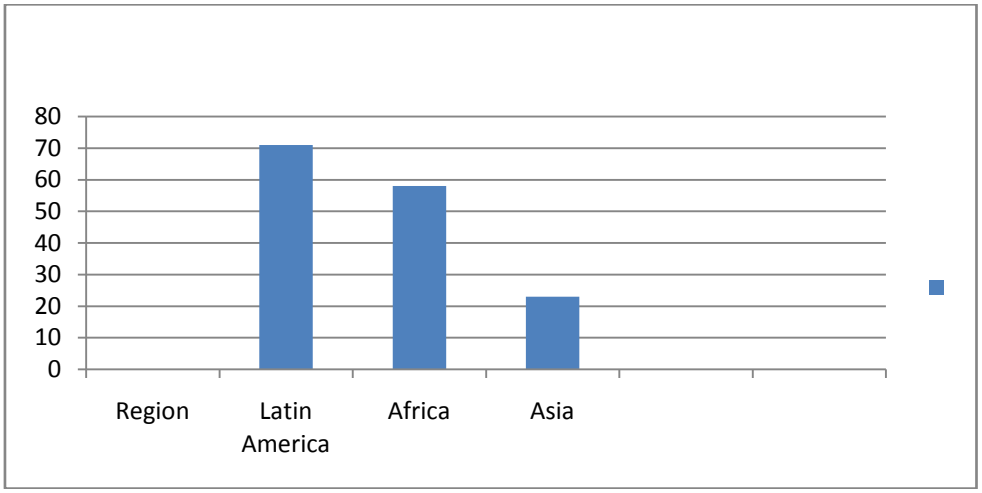

Fig 2 : Source of Engine Power for Agricultural Transformation

Source: Fundamental of Engineering for Agriculture (2006)

For mechanized post harvest operation to succeed in Nigeria especially in study zone, there must be adequate electric motors, diesel and petroleum Engine for threshing, shelling and processing produce. The source of power for overall agriculture is shown in table 4.

Table 4 : Source of Power for Overall Agricultural Production.

Source of power	Africa %	Nigeria %	USA %
Human	89	90	4
Animal	10	8	7
Engine	1	2	95

Source: Odigboh and Onwualu (1994).

Whereas 2% of power for agricultural activities in Nigeria comes from Engine, it is up 95% in the U.S.A

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IV. Conclution

This study has summarized and analyzed a magnitude of data reported on food Losses. The result in the study must be inter preted with great caution. The study revealed the major quantitative data in current knowledge with regard to post harvest machines in the study zone.

Another point to be stressed is losses /waste of food supply chain in boundary system which should be minimized, transformed and consumed in different part of the world as export commodities the economic impact of using post harvest machines is recorded 40 percent. Photo type machines were introduced 6-10 years in the study zone. The Farmers in the study zone sale 15-20 percent of their grain due to storage facilities.52 percent of farmers responded losses 20% of grainand food waste.

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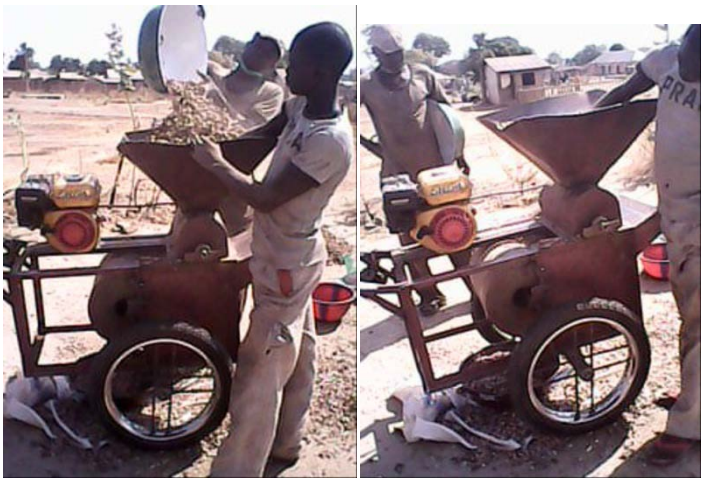

Figure 3 : Photo Type of a Multipurpose Post Harvest Machine for Shelling and Threshing Maize, Cowpea and Groundnut. It Was Introduced In 2009 Reduce Excess Post Harvest Losses in the Study Zone.

(Source: Authors'file)

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Longitudinal Study of Bovine Mastitis in Hawassa and Wendo Genet Small Holder Dairy Farms

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Keywords: *bovine mastitis, prevalence, incidence, hawassa, wendo-genet, major pathogens.*

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Longitudinal Study of Bovine Mastitis in Hawassa and Wendo Genet Small Holder Dairy Farms

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Abstract- A longitudinal study was carried out to determine the prevalence and incidence of mastitis in lactating dairy cows from November 10, 2011 to June 25, 2012 in six purposively selected smallholder dairy farms in Hawassa and Wendo-Genet districts, Ethiopia. The study was carried out through field screening surveys by California mastitis test for each quarter milk sample, followed by retesting negatives group for mastitis twice a month during the study period to estimate the incidence of mastitis. At the time bacteriological examinations to identify the causative agents from mastitis positive cows were carried out. A total of 122 milking cows were examined, out of which 77 (63.1%) and 152 (31.1%) were found positive for mastitis on the basis of California mastitis test at cow and quarter level, respectively. Out of the total quarters examined, 25 (5.12%) were recorded as a blind teats. The incidences of mastitis were seen to be 0.49 in three month study period. Slight variations in incidence rate between different farms were revealed. Higher incidence rate of 0.54 was recorded in cows kept in bad concrete in comparison to cows kept in good concrete which is 0.41. On the other hand, higher incidence rate was recorded in single and three or above parity; in early and late stage of lactation. Proportion of bacterial isolates isolated from mastitis cows showed high proportion of Staphylococcus species (52.9%) followed by Streptococcus species (23.5%), Bacillus species (9.8%), E. coli (7.8%) and Corynebacterium species (5.9%). It was concluded that there was a higher incidence and prevalence of mastitis, mainly caused by Staphylococcus species and Streptococcus species. Based on the findings, recommendations were made accordingly to concerned organs.

Keywords: bovine mastitis, prevalence, incidence, hawassa, wendo-genet, major pathogens.

I. Introduction

Ethiopia is believed to have the largest livestock population in Africa. This livestock sector has been contributing considerable portion to the economy of the country, and still promising to rally round the economic development of the country. It is eminent that livestock products and by-products in the form of meat, milk, honey, eggs, cheese, and butter supply provide mainly the needed animal protein that contributes to the improvement of the nutritional status of the people. The total livestock population for the country is estimated to be 50.8 million cattle, 25.9 million sheep, 21.9 million goats, 1.9 million horses, 5 million donkeys, 0.3 million mules, 0.8 million camels and the total poultry population at country level is estimated to be about 42 million (CSA, 2009). In Southern Nations Nationalities and People Regional States (SNNPRS), the total cattle population is estimated at about 8.8 million. Nearly all the cattle population (98.41%) is found in rural areas while a small proportion (1.59%) is found in urban areas (CSA, 2003).

Even though Ethiopia is the most populous country in cattle than any African country; up to 1997 the per Capita milk consumption was 16 kg, which was lower than other countries in the region (Asfaw, 1997). This is partly due to the low genetic milk production potential of the indigenous zebu cattle. To increase milk production cross breeding of indigenous zebu with exotic breeds particularly with Holstein Friesian is widely practiced in the country which resulted in a larger portion of the dairy cattle population especially in urban areas to be with a high level of exotic blood. However, this market oriented dairy production, a rapidly growing system in many African countries, is subjected to diseases of intensification including mastitis and reproductive disorders (Lemma et al., 2001).

Ethiopia holds large potential for dairy development due to its large cattle population and the favorable climate for improved high yielding animal breeds (Bishi, 1998). Considering the potential if smallholder income and employment generation, development of dairy farming can make significant contribution to the poverty reduction and nutritional improvement in the country (Staal, 1996). Given the considerable potential for income and employment generation from high value dairy product (Bishi, 1998). Dairy production is a biological efficient system that converts large quantities of roughage which is the most abundant of fed to milk (Reugg, 2001). In Ethiopia where access to market dairying is preferred to meet production since it makes more efficient use of feed resource and provides a regular income to the produces. Milk is very nutritional food that is reach in carbohydrate, protein, fat, vitamin and minerals. The increase in human populations, accessibility to technology input and high demand for animal product

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purchasing power in urban center had helped the urban and per-urban dairy farm in the country to flourish (Yoseph et al., 1998).

Mastitis is one of the most important disease affecting dairy cows. It is a multi-factorial disease with worldwide distribution accounting for major economic losses in dairy cattle (DeGrave and Fetrow, 1993) which incurs serious economic losses to dairy industry. A number of previous reports from different part of the country indicated that mastitis is a serious problem in the dairy industry of Ethiopia (Bishi, 1998). Bovine mastitis can reduce milk yield, increase culling rate, incur treatment cost, occasionally result in death from sever infection (Radostitis et al., 2007).

Mastitis had been known to cause a great deal of loss or reduction of productivity, to influence the quality and quantity of milk yield, and to cause culling of animals at an unacceptable age (Singh and sigh, 1994). Most estimates have shown a 30% reduction in productivity per affected quarter and a 15% reduction in production per cow per lactation (Radostits et al., 1994). The disease generally involves interplay between management practice and infection agent. Among various infectious agents, bacterial pathogens have been known to be widely distributed in the environment of dairy cows, constituting threat to the mammary gland (Schalm et al., 1989).

Mastitis is a management related disease whose prevention and control depends among other factors on the type of management employed. If management is improved; there is a reduction in the incidence of clinical mastitis and vice versa. As with most infectious disease, mastitis risk factors depends on three components i.e. exposure to the microbes, cow defense mechanism, and environment and management factors (Suriyasathaporn et al., 2000).

Therefore, the objectives of this study were:

- To estimate the prevalence and the incidence of mastitis in the study area
- To isolate major pathogen and to identify the associated risk factors

II. Materials and Methods

a) Study Area

The study was carried out in small holder dairy farms in Hawassa and Wendo-genet. Hawassa which is the capital town of SNNPRS is located at 275 km South of Addis Ababa. It lies geographically between 4o27', and 8o 30', latitude North and 34o 21', and 39o 1', East longitude. The annual rain fall and temperature varies from 800 - 1000 mm and 20.1 - 25oC, respectively. Wondo-genet is located 264 km from Addis Ababa and 30 km from Hawassa (SZPEDD, 2001).

b) Study Population

The study population constitutes of lactating government and private owned cross breed cows found in Hawassa and Wendo-Genet small holder dairy farms. Cows are kept in exclusive stalls and provided with supplementary diets in addition to the pasture and agricultural by-products.

c) Study Design

The study was a longitudinal observational study in which all the study animals were tested at the beginning of the study period for clinical and subclinical mastitis by physical examination of the udder and by CMT (California Mastitis Test), respectively. Each farm was visited for three consequetive months at two weeks interval and screening of CMT negative cows was done throughout the study period using California Mastitis Test (CMT) to detect the presence of new cases of mastitis.

Information regarding the potential risk factors for both clinical and sub clinical mastitis such as age, parity, stage of lactation, udder injury, frequency of milking, tick infestation and hygiene of the farm were collected. To identify the major bacterial pathogens milk samples were collected from mastitic cows and subjected to bacteriological examination.

d) Sample Size and Sampling Method

From both study sites a total of 122 animals from the target population were first tested for mastitis and those negative for mastitis at the first screening was followed and checked in two weeks interval during the study period and those positive for CMT removed from the study and recorded as new case.

e) Sample Collection and Laboratory Analysis

i. *Physical Examination of the Udder and Milk*

The udder was first examined visually and then palpated to detect possible fibrosis, inflammatory swelling, and atrophy of the tissue. The size and consistency of the mammary quarter were inspected for the presence of any abnormalities such as disproportional symmetry, swelling, firmness, and blindness. In addition milk from each quarter was inspected by visual inspection for presence of any flakes, clots and color change.

f) California Mastitis Test

Every two weeks after a visit to the farm all lactating dairy cows, which are negative for subclinical mastitis at the first visit, were tested with CMT during the study period. Subclinical mastitis was diagnosed based on CMT result and the nature of coagulation and viscosity of the mixture, which show the presence, and the severity of the infection respectively (Radostits et al., 1994). CMT grades were evaluated and the results graded as 0 and 1 for negative and 2 and 3 for positive (Kerro Dego and Tareke, 2003). Then milk sample was collected from CMT positive cows for bacteriological examination.

g) Milk Collection

The udder of the animal was thoroughly cleaned with water (Chauhan and Argawal, 2006). The teat orifice was also cleaned using cotton soaked in 70% ethyl alcohol (Quinn et al., 1999). After discarding a few streams of milk, by holding the sterile collection bottle nearly horizontal, about 3 to 4 ml milk was collected (NMC, 1990). Then the samples were labeled and transported in ice-packed cool box to microbiology laboratory of the school of Veterinary Medicine, Hawassa University.

h) Bacteriological Examination of Milk Sample

In the laboratory a loopful of the milk samples were streaked on to the blood agar base enriched with 7% sheep blood and MacConkey agar. The plates were incubated at 37oC aerobically and examined after 18 to 24 hours for the presence of fast growing organism and then returned to the incubator for at least another 24 hours and reexamined (NMC, 1990). Identification of the bacteria isolate was done according to NMC (1990) and Quinn et al (2002) Colony morphology, Gram staining, catalase test, motility test, triple sugar iron reaction, CAMP test, IMViC (Indole, Methyl red, Voges-Proskauer, Citrate) and coagulase test were conducted to identify the isolates.

III. Statistical Analysis

a) Result

From the total 122 lactating cows examined for mastitis, prevalence of 63.1% (77) and 31.1% (152) were recorded at cow level and quarter level, respectively. The prevalence at each farm levels is shown in Table 1. From 77 mastitis positive cows 33 (42.9%), 19 (24.7%), 19 (24.7%) and 6 (7.8%) cows had one, two, three and four quarters infection respectively (Table 2).

Out of the total 488 quarter examined 25 (5.1%) quarters were blind out of which 3.2% (5/156), 4.2% (3/72), 5.3% (4/76), 2.1% (1/48) and 10.7% (12/112) from HU, SOS, Biniyam, Saron and Wendo- Genet but no blind teat in Eden farm (Table 3).

Out of 45 lactating cows intially at risk for mastitis 22 (48.9%) cows had mastitis in three months period of follow up and the incidence risk of 42.9%, 33.3%, 75.0%, 50.0% and 50.0% were recorded for HU, SOS, Biniyam, Saron and Wendo-Genet farm respectively but no new infection recorded in Eden farm (Table 4).

The incidence risk (IR) and the relative risk (RR) of different risk factors is shown in Table 5.

Among 51 bacterial isolates, Staphylococcus species and Streptococcus species were the dominant isolates. The relative isolation rate of Staphlococcus species was 52.9% (27), Streptococcus species 23.5% (12), that of E. coli 7.8% (4), Bacillus species 9.8% (5) and Corynebacterium species 5.9% (3) (Table 6).

Table 1 : The Prevalence of Subclinical Mastits at Cows Level and Quarter Level

Farm Name	No. of cows examined	No. of CMT positive cows	Prevalence (%)	No. of quarters examined	No. of quarters affected	%
HU farm	39	25	64.1	156	36	23.1
SOS	18	12	66.7	72	30	41.7
Biniyam	19	11	57.9	76	30	39.5
Saron	12	6	50.0	48	15	31.3
Eden	6	5	83.3	24	11	45.8
Wendo Genet	28	18	64.3	112	30	26.8
Total	**122**	**77**	**63.1**	**488**	**152**	**31.1**

Table 2 : The Proportion of Quarters Affected from Mastitis Positive Cows

Farm Name	No. of quarters affected & prevalence								Total	%
	1	%	2	%	3	%	4	%		
HU farm	18	54.5	3	15.8	4	21.1	0	0.00	25	32.5
SOS	2	6.1	4	21.1	4	21.1	2	33.3	12	15.6
Biniyam	1	3.0	2	10.5	7	36.8	1	16.7	11	14.3
Saron	1	3.0	2	10.5	2	10.5	1	16.7	6	7.8
Eden	1	3.0	3	15.8	0	0.00	1	16.7	5	6.5
Wendo Genet	10	30.3	5	26.3	2	10.5	1	16.7	18	23.4
Total	**33**	**42.9**	**19**	**24.7**	**19**	**24.7**	**6**	**7.8**	**77**	**100.0**

Table 3 : The Prevalence of Blind Teat in Different Farms

Farm Name	No. of quarters examined	No. of blind teat	(%)
HU farm	156	5	3.2
SOS	72	3	4.2
Biniyam	76	4	5.3
Saron	48	1	2.1
Eden	24	0	0.0
Wendo Genet	112	12	10.7
Total	**488**	**25**	**5.1**

Table 4 : Incidence Risk of Mastitis in the Study Farms from December, 2011 to April 2012

Farm Name	No. of animals initially at risk	No. of animals affected	Incidence Risk (%)
HU farm	14	6	42.9
SOS	6	2	33.3
Biniyam	8	6	75.0
Saron	6	3	50.0
Eden	1	0	0.0
Wendo Genet	10	5	50.0
Total	**45**	**22**	48.9

Table 5 : The Incidence Risk and Relative Risk of Mastitis in Association with Selected Risk Factors during the Study Period (December, 2011 to April, 2012)

Risk factors	No. of animals initially at risk	No. of animals affected	Incidence Risk (%)	Relative Risk
Floor type				
Good concrete	17	7	41.2	
Bad concrete	28	15	53.6	1.3
Age				
≤ 5 yrs	18	10	55.6	
> 5yrs	27	12	44.4	0.8
Parity				
Single	20	12	60.0	
Two	14	3	21.4	0.4
3 and above	11	7	63.6	1.1
Stage of Lactation				
Early	14	9	64.3	
Mid	9	2	22.2	2.9
Late	22	11	50.0	1.3

Table 6 : Proportion of Bacteria Isolated from Mastitis Positive Cows

Bacterial isolates	No. of isolates	%
Staphylococcus spp.	27	52.9
Streptococcus spp.	12	23.5
Corynebacterium spp.	3	5.9
E. coli	4	7.8
Bacillus spp.	5	9.8
Total	**51**	**100.0**

IV. Discussion

The result of this study showed the prevalence of mastitis in Hawassa and Wendo-genet town to be 63.11% at cows level and 31.15% at quarter level, which is in agreement with the report of Biru (1989) in Ethiopia (63%), Workineh et al (2002) in two major Ethiopian dairies (59.7%), Tolla (1996) in South Wollo (61.11%) and Byarugaba et al (2008) in Uganda (61.3%). However, it was higher than the report of Fekadu (1995) in Caffa valley in Northern Ethiopia (39.65%), Biffa et al (2005) in Southern Ethiopia (34.9%), Kerro Dego and Tareke (2003) in Southern Ethiopia (40.40%), but lower than the report of Mekibib et al (2010) in Holeta town in Centeral Ethiopia (71.05%). The overall quarter prevalence of mastitis was 31.15%. This finding is comparable with the report of Sori et al (2005) which was (30.95%). However, this finding was higher than that of Vecht et al (1989) in the Netherland and Hoyer et al (1991) in Zimbabwe, who reported 10%, 14%, respectively. This variation in the prevalence of bovine mastitis between different reports could suggest the complexity of the disease which involve interaction of several factors, mainly management practice, husbandry system, environment and factors related to causative agent and variation in veterinary service coverage.

Out of 488 quarter examined, 5.12% were blind, which may be an indication of serious mastitis problem on the herd and lack of screening tests and treatment of subclinical mastitis , and inadequate follow up chronic mastitis were considered to be the major reason for the development of quarter blindness (Biffa, 2005).

In this study there was one cow with clinical mastitis but the rest of the cases were subclinical. This may be due to ease of detection of clinical mastitis and treatment of only clinical cases. Moreover absence of dry cow therapy in all farms might be the cause of higher prevalence of subclinical mastitis in the study area.

The overall incidence risk mastits in the three months period of follow up is 0.49, this finding is in agreement with the report of Roy et al (1999) in India which had the incidence of 0.47. This result was higher

than the report of Bartlett et al (1991), Rajala et al (1999), Barkema et al (1998), Lucey et al (1996) which were 0.097, 0.18, 0.24 and 0. 26 respectively.

In this study relatively higher incidence risk (0.75) was recorded in Binyam farm when compared with other farms. This might be due to improper washing of hands and teats before milking and use of one towel for each cow. According to Rice and Bodman (2004) sanitary milking habits are important to avoid the spreading of bacteria or their proliferation.

The result of the present study also revealed higher incidence of mastitis (0.54) in cow kept under bad concrete as compared to cows kept in good concrete (0.41). The relative risk of mastitis in cows kept under bad concrete is 1.3 times higher than that cows kept in good concrete. This might be due to the favorable environment created for survival and multiplication of bacterial pathogens.

In this study there were higher risk of mastitis in cows with single parity (0.60) and cows with more than two parity (0.64) when compared with cows with two parity (0.21). However studies conducted by Houben et al (1993), Lucey et al (1994) and Rajala et al (1999) showed incidence risk of 6.6%, 17%, 12.1% for parity one, 9.0%, 22%, 14.3% for parity two and 14.2%, 24%, 14.9% for parity three respectively.

The finding of this study also showed higher incidence risk of mastitis in early (0.64) and late (0.50) stages of lactation as compared to mid (0.22) stage of lactation. The finding of higher incidence risk in early stage of lactation is in agreement with Barkema et al (1998). This increase in incidence risk of mastitis at early stage might be due to high milk yield at this stage of lactation (Bartlett et al., 1991; Grohn et al., 1995; Smith et al., 2000).

The finding of higher proportion of Staphylococcus species (52.9%) from total isolates is in consistent with that of Wokineh et al (2002) who reported 57% of the total bacterial isolates. The finding of higher proportion of Staphylococcus species might be due to lack of effective udder washing and drying, post milking teat dip and drying and hand washing (Radostits et al.,1994). It is also attributed to the wide distribution of the bacteria on the skin of teats and udder (Mac Donald, 1997).

The staphylococci have adapted to survive in the udder, they usually establish chronic, subclinical, infection and are shed in the milk which serves as a source of infection for other health cows during the milking process (Radostits et al., 1994).

In this study Streptococcus species accounted for 23.5% of the total isolates next to Staphylococcus species. This finding was in agreement with Zerihun (1996) which was (27%), but lower than the report of Kingwill et al (1991) which was (80.95%), Tolosa (1987) (53.55%). The lower isolation rate of Streptococcus species might be due to wide spread use of penicillin in the area for the treatment of mastitis. The finding of E. coli in this study may be associated with poor hygienic condition in the farm, unimproved management, wet and muddy stall were cows are kept.

V. Conclusion and Recommendation

Generally, mastitis is one of the complex diseases of dairy cows which involve an interaction between management practice and infectious agent occurring throughout the world. The disease has also been reported in different parts of Ethiopia with varying prevalence. But incidence of mastitis in the country has not been studied like that of prevalence and the spreading of mastitis among cows was not determined. Inadequate hygienic condition of dairy cow's stalls, poor milking procedure, poor animal health service and lack of proper attention to the heath of the mammary gland were important for the high prevalence and incidence of mastitis in the study area. The present study showed that the occurrence of mastitis at cow and quarter level is high and the incidence of mastitis also high, which can interfere with efficiency of milk production and has high economic importance. From this study the most important pathogens causing mastitis in the study area was Staphylococcus species and Streptococcus species, which were isolated from the milk sample in higher proportion, which is associated with unhygienic milking practice and poor herd management, whereas the finding of other bacteria such as E. coli is associated with poor hygiene of the stall and bedding.

Based on this study, to reduce the incidence risk of mastitis the following recommendations are forwarded:

- ✓ Standard milking procedure, such as pre and post milking udder washing should be applied to reduce the risk of transmission.
- ✓ Regular screening of subclinical mastitis for early detection and treatment, and culling of chronically infected cows should be practiced.
- ✓ Dry cow therapy should be applied to reduce the occurrence of new infection after parturition.
- ✓ Adequate housing with proper sanitation of the cow's barn and bedding to reduce environmental mastitis.
- ✓ To reduce the prevalence of the disease, different epidemiological factors that interplay in mastitis occurrence should be studied routinely.

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Haematological and Biochemical Indices of Rabbits Fed Graded Levels Browse Forage *(Balanites aegyptiaca)* in Semi Arid Environment

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Abstract- The study was conducted to assess the effects of graded levels of browse forage (Balanites aegyptiaca) leaves inclusion in the diets of growing rabbits on haernatological and biochemical indices. Five diets were formulated, treatment 1(control), 2 3 4 and 5 in which Groundnut haulm was replaced with Balanites aegyptiaca at 0%, 5%, 10%, 15%, and 20% respectively. Thirty (30) four weeks old weaner rabbits of different breeds (chinchilla x California x New Zealand) used for the experiment were allotted to the five treatments (T1, T2, T3, T4, and T5) with two rabbits per replicate and six rabbits per treatment in a randomized complete block design. The trial lasted for 9 weeks. Effects of the diets on haematology and serum chemistry were elicited on the results. The result shows that Balanites aegyptiaca supplementation at these levels had no adverse effect on red blood cell counts, white blood cell counts, packed cell volume and haemoglobin. All the parameters differ significantly ($P<0.05$) with the exception of mean corpuscular haemoglobin which show a significant difference among treatments. The cholesterol, creatinine and the blood urea levels were significantly \aried.

Keywords: *balanites aegytiaca, rabbits, haematology, biochemistry.*

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Abstract- The study was conducted to assess the effects of graded levels of browse forage (Balanites aegyptiaca) *leaves* inclusion in the diets of growing rabbits on haernatological and biochemical indices. Five diets were formulated, treatment 1(control), 2 3 4 and 5 in which Groundnut haulm was replaced with Balanites aegyptiaca at 0%, 5%, 10%, 15%, and 20% respectively. Thirty (30) four weeks old weaner rabbits of different breeds (chinchilla x California x New Zealand) used for the experiment were allotted to the five treatments (T_1, T_2, T_3, T_4, and T_5) with two rabbits per replicate and six rabbits per treatment in a randomized complete block design. The trial lasted for 9 weeks. Effects of the diets on haematology and serum chemistry were elicited on the results. The result shows that Balanites aegyptiaca supplementation at these levels had no adverse effect on red blood cell counts, white blood cell counts, packed cell volume and haemoglobin. All the parameters differ significantly ($P<0.05$) with the exception of mean corpuscular haemoglobin which show a significant difference among treatments. The cholesterol, creatinine and the blood urea levels were significantly \aried. In conclusion, Balanites aegyptiaca leaves supplementation in the diets of weaner rabbits could be included from 5% upto 20% without any adverse effects on the blood parameters, However, 20% inclusion was found to be the optimum, and there for recommended.

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I. Introduction

The need to increase livestock production as a means of alleviating the overwhelming shortage of animal protein is very vital to humanity, Fielding (1991). The demand for protein of animal origin in Nigeria is greater than the supply, Akinmutimi and Onwukwe (2002). There is therefore acute shortage of animal protein in the diet of many Nigeria, demanding that effort should be directed to livestock that are prolific and have short gestation interval such as rabbit. Fielding(1991) reported that in Nigeria, the rabbits are being used as a valuable source of animal protein in rural communities, and for' scientific research in academic institutions. Their small sizes with maximum weight less than 1.5 kg each make llemconsenient rations for one meal in a small family and invaluable laboratory animals for scientific research.

Browses are important in providing nutrient to grazing ruminants in arid and semi-arid environments where inadequate feeds are a major constraint for livestock production (Aganga and Tshwenyane, 2003). Tree fodders maintain higher protein and mineral contents during growth than grasses, which decline rapidly in quality with maturity (Shelton, 2004). Tree fodders are important source of nourishment for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feeds. Browse forages form part of the complex interactions between plants, animals and crops (Aganga and Tshwenyane, 2003), the positive aspect of which is to help balance a plant-animal-soil ecosystem from which there is sustainable source of feeds (Devendra, 1994).

Balanites aegyptiaca is a specie of tree growing in different ecological conditions. It can thrive well in areas with 100 to 1000 mm annual rainfall and mostly distributed in semi arid and arid zones of tropical Africa (Von Maydell, 1983). This specie of tree is available in the Northern part of Nigeria with highest number in the Northeastern Nigeria. Balanitesaegyptiaca have been reported to have anti-inflamatory and analgesic, anthelmintic, antioxidant, antidiabetic, antinoceptic, hepatoprotective, antibacterial and larvicidal activities in animals (Dubey*et al.,* 2011). Balanites aegyptiaca like AcaciaSenegal, (Diallo, 1997) and *A.* nilotica (Tybirk, 1989) shows a synchronization between male (internal stamina cycle) and female phase (Ndoye*et al.,* 2004). Balanitesaegyptiaca being a browse plant have been reported to improve the feeding potential of ruminant animals in the semi arid (Njidda and Ikhimioya, 2010).

Haematological parameter is an important and reliable medium used to monitor and elevate health and nutrition status of animals, Gupta et al. (2007). Blood composition of animal might be influenced by certain factors such as nutrition, management, and great of

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animals, sex, age diseases and stress factors that might affect blood values (Schalm*et al.,* 1975).The hematological and biochemical indices are an index and reflection of the effects of dietary treatment on the animals in terms of the type and amount of feed ingested and were available for the animals to meet its physiological geochemical and metabolically necessities (Ewuola *et al.,* 2004) and also the level of anti-nutritional element of or factors present in the feed also influence the hematological and biochemical values (Akinmutimi, 2004).

This present study is therefore carried out to determine the effects of graded levels of inclusion of Balanites aegvptiaca in the diets of weaner rabbits on their haematological and serum biochemical parameters.

II. Materials and Methods

Thirty rabbits (New Zealand white breed), 6-10 weeks of age, were randomly assigned to four dietary treatment groups with four rabbits per treatment.These rabbits in each treatment were housed in hutches measuring 45 x 30 x 42 cm. These rabbits were randomly divided into four equal groups and assigned to four experimental diets designed as T_1, T_2, T_3, T_4 and T_5 contained0 (control), 5, 10, 15, and 20% Balanites aegytiaca inclusion levels. (Table 1). The experimental diets were analyzed for dry matter (DM), crude fiber (CF), crude protein (CP), ether extract (EE) and ash according to AOAC (2002) methods (Table 2). The feeds were also analysed for neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) according to Van Soest*et al.,* (1991). The experimental diets and clean drinking water were supplied to the rabbits ad libitumthroughout the experimental period of nine weeks.

Blood samples with (EDTA) and without anticoagulant were collected from marginal ear veinbefore slaughter. From each treatment, the blood samples were collected in triplicate. Blood samples collected with EDTA were sued to determine packed cell volume (PCV), red blood cell counts (RBC), white blood cell (WBC) counts and the hemoglobin in blood samples. The PCV,

RBC, WBC and Hb values were determined using the Wintrobe'smicrohaematocrit, improved Neubauerhaemocytometer and cyanomethae- moglobin method respectively (Coles, 1986). The mean corpuscular hemoglobin (MCH) was calculated according to Bush (1991). Blood samples collected without anticoagulant were subjected to serum procurement which were then used to determine the biochemical components. Serum glucose and urea were estimated by methods described by WHO (1980) while total cholesterol was determined by colorimetric enzyme method as outlined by Bush (1975). Similarly, serum total protein, albumin and globulin concentration were determined by Biuret reactions (Bush, 1975).

III. Experimental design and treatments

Five experimental diets were compounded with diet 1 (control) containing 0 kg of Balanites aegyptiaca while diets 2, 3, 4 and 5 contained 5, 10. 15 and 20% of Balanites aegvptiaca respectively as shown in Table 1. Thirty Weaner Rabbits of mixed breeds (chinchilla x California x New Zealand white) of 4 to 5 weeks of age and weighing averagely 0.6 kg (0.5-0.7 kg) were randomly divided into five groups of six per group. The animals were assigned to the experimental diets in a complete randomized block design..

IV. Results and Discussion

The results of the chemical composition of the experimental diets are shown in Table 2. The results shows that the five diets adopted for the feeding trials had comparable chemical components despite the dietary inclusion of Balanites aegyptiaca at graded levels (0, 5, 10, 20%) in the diets fed to weaner rabbits. The values of crude fibre (CF), Acid detergent fibre (ADF), Neutral detergent fibre (NDF) and Dry matter (DM) digestibility were higher in Treatment 3. The Ether extract (EE) levels (4.49 to 6.35 g kg^{-1} DM) increased with increase in level of Balanites aegyptiaca leaves in the diets. The crude protein content (CP) ranged from 178.60 in T1 to 278.00 g kg^{-1} DM in T5 which is adequate for for growing rabbits. The values are similar to those reported by Njidda and Isidahomen (2010). The crude fibre levels of the diets were higher than the 25% recommended by Irbeck (2001) for growing rabbits though higher levels in this study does not seem to pose any problem. The fat component of the diets as represented by the Ether extract values were not within the range (20-25%) fat levels recommended for young rabbits by Irlbeck (2001). The dry matter content of the diet was observed to be higher in all the treatments with the highest value in T_3 (90.75%). The ADL values ranged from 51.6 to 62.6 g kg^{-1} DM. The values were much lower than those reported by Okoli*et al*. (2003) for southeastern browses of Nigeria. The values for NDF were observed to be significantly higher ($P<0.05$) in T_3. The NDF values are however lower compared to the values reported by Njidda (2011) for semi arid browse forages.

The results of the haernatological indices are presented in Table 3. There was significant difference ($P< 0.05$) among treatment groups for all the haernatological parameters except for mean corpuscular haemoglobin (MCH). The PCV values (37.40 to 47.90%) were within the range of 33 to 50% reported by Hillyer (1994) for growing rabbits. The values obtained for all the treatment groups indicate

nutritional adequacy of all diets since values did not indicate mal-or-under nutrition (Church *et al*. 1984). The RBC values were within the range 3.07 to7.50 x10^6/mm3 as reported by Fudge (1999). The WBC ranges from 6.40 to 12.90 x10^3 mm^3 as reported by Hillyer (1994) for healthy young rabbits. This shows that the animals were healthy because decrease in number of WBC below the normal range is an indication of allergic conditions, anaphylactic shock and certain parasitism, while elevated values (leucocytosis) indicate the existence of a recent infection, usually with bacteria (Ahamefule *et al.,* 2008). The Hb values falls within the range of 9.0-17.4 g/dl by Njidda *et al*. (2006). Hackbath*et al*. (1983) found that there was a strong influence of diet on haernatological traits with PCV and Hb being very strong indication of nutritional status of animals. The value for MCV and MCHC were higher in T_2 and T_5 respectively. This may be due to the negative interaction between protein and energy levels in the diets. The values for MCH showed no significant difference among treatments.

The results of the blood chemistry arc presented in Table 5. The Globulin values, Albumin, Blood urea, Total protein, Creatinine and Cholesterol all showed significant difference ($P<0.05$) among treatments. The blood urea ranged from 2.5 to 4.2 mmol/l. The values were within the range (2.50 to 5.80 mmol/l) reported by Njidda and Isidahomen (2011) and 2.60 to 4.90 mmol/l reported by Njidda and Isidahomen (2010) who fed sesame seed meal and grasshopper meal to rabbit in tropical environment. The values were lower compare to that obtained in temperate regions (4.6 to 10.4) reported by Duncan and Prasse (1986). For cholesterol, T_3 has the highest mean value of 199mmol/l and differ significantly ($p<0.05$) from other treatments. The Globulin values for T_2 (0.2 g/dl) and T_3 (0.8 g/dl) were much lower than the values reported by Duncan and Prasse (1986) while that of T_1 (2.9 g/dl) falls within the range (1.94 to 2.26 g/dl) reported by Onifade and Tewe (1993) who fed various tropical energy feed resources to growing rabbits. The total protein values (4.0 to 7.2 g/dl) were within the range reported by Anon (1980) and the range (5.81to 6.75 g/dl) reported by Onifade and Tewe (1993). The normal values for albumin, total protein and globulin obtained in this study indicates nutritional adequacy of the dietary proteins for the rabbits. Abnormal serum albumin usually indicates an alteration of normal systematic protein utilization, Apata (1990), low dietary protein intake, Onifade and Tewe (1993). The cholesterol level (87 to 199 g/dl) was higher than the range (20 to 83 g/dl) reported by Njidda *et al.* (2006). The results for sodium, potassium, calcium, phosphorus and magnesium showed significant difference ($p<0.05$) among treatments. The values of these minerals in the blood were generally higher than the reported values of PGCVS (1990) and Njidda *et al.* (2006). The higher values may be attributed to high content of minerals in the browse forage. Tree and shrub fodders are an important source of supplementary protein, vitamins and minerals in developing countries and also important in providing nutrient for grazing ruminants in arid and semi-arid environments where inadequate feeds are a major constraint for livestock production (Aganga and Tshwenyane, 2003). These fodders maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity (Shelton, 2004).

V. Conclusion

The results obtained in this study suggest that inclusion of Balanitesaegyptiaca up to 20% in the diets does not have any negative effect on haematological and biochemical indices of growing rabbits.

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Table 1: Composition of Rabbits Experimental Diets (%)

	Treatments				
Ingredients (%)	T_1	T_2	T_3	T_4	T_5
White maize	37.35	37.35	37.35	37.35	37.35
Groundnut cake	15.00	15.00	15.00	15.00	15.00
Groundnut haulm	20.00	20.00	20.00	20.00	20.00
Maize bran	10.00	10.00	10.00	10.00	10.00
Fish meal	5.00	5.00	5.00	5.00	5.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Balanites aegyptiaca	0.00	5.00	10.00	15.00	20.00
Wheat Offal	10.00	10.00	10.00	10.00	10.00
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100

**Composition of premix (Bio-mix) supply the following per kg diet: Vitamin A 500,000 I.U. Vitamin D, 800,00IU, Vitamin E, 12,000mg Vitamin K, 5000mg, Biotin 10,000mg, Vitamin B, Biotin 10,000mg, Vitamin B2 200mg, Vitamin B6 15000mg, Niacin, 12,000mg, Panthothenic Acid, 20,000mg, Biotin 10m000mg, Vitamin B12, 30,000mg, Folic Acid, 150,000mg, Cholride, 60,000mg, Manganese 10,000mg, Iron 15,000mg, Zinc 80,000mg Copper 400mg, Iodine 80,000mg Selenium 8,000mg.*

Table 2 : Chemical Composition of Experimental Diet (G Kg^{-1} DM)

	Treatments					
Ingredients (%)	T_1	T_2	T_3	T_4	T_5	Ba
Dry matters	898.60	889.60	907.50	912.30	896.20	92.20
Ash	76.80	81.10	79.20	82.30	81.00	18.00
Crude Protein	178.60	269.30	262.80	267.50	278.00	183.10
Ether Extact	44.90	56.20	58.70	61.80	63.50	20.00
Crude Fibre	284.70	291.60	300.90	296.20	287.60	145.00
Acid Detergent Fibre	331.10	352.40	361.20	342.60	333.00	257.40
Neutral Detergent Fibre	416.40	442.30	451.10	431.60	421.80	364.30
Acid detergent Lignin	61.10	57.60	54.30	51.60	62.60	137.50

Ba=Balanites aegytiaca

Table 3 : Haematological Parameters of Weaner Rabbits Feed Balanite Aegyptiaca

	Treatments					
Parameters	T_1	T_2	T_3	T_4	T_5	SEM
RBC ($x10^6$ /mm^3	5.55^b	4.84^b	4.68^b	4.55^b	7.04^a	2.02
WBC ($x10^3$/mm^3)	12.90^a	6.40^b	5.20^{bc}	6.50b	12.90^a	1.39
PCV (%)	38.20^c	43.80^b	41.70	37.40^c	47.90^a	2.68
Haemoglobin (g/dl)	11.70^b	10.00^b	10.40^b	10.20^b	15.50^a	2.11
MCV (fl)	68.80^b	90.00^a	89.00^a	82.20^a	67.90^b	3.12
MCH (pg)	21.0	20.7	22.1	22.5	22.0	2.32^{NS}
MCHC (%)	30.6^b	22.9^d	24.9^d	27.4^c	32.5^a	1.14

a, b, c means in the same row with different superscript are significantly different (P<0.05), NS = Not Significant different (P<0.05).

Table 4 : Biochemical Parameters of Weaner Rabbits Fed Balanites Aegyptiaca

	Treatments					
Parameters	T_1	T_2	T_3	T_4	T_5	SEM
Blood Urea (mmol/L)	4.0^{b}	3.1^{d}	3.3^{c}	2.5^{c}	4.2^{a}	0.46
Total Protein (g/dl)	6.3^{b}	5.3^{c}	4.9d	7.2a	4.0^{c}	0.27
Cholesterol (mmol/L)	162^{b}	155^{c}	199^{a}	100^{d}	87^{e}	2.06
Albumin (g/dl)	3.4^{c}	5.1^{a}	4.4^{b}	3.1^{c}	3.2^{c}	0.33
Globulin (g/dl)	2.9^{c}	0.2^{c}	0.5^{b}	4.1^{b}	0.8^{a}	0.02
Potassium (mmol/L)	4.8^{a}	5.5^{a}	3.3^{b}	4.0^{a}	3.6^{b}	0.94
Sodium (mmol/L)	132^{c}	144^{a}	129^{d}	137^{b}	140^{a}	2.36
Calcium(mmol/L)	7.3bc	9.1a	8.8b	10.0a	5.3d	0.76
Phosphorus (mmol/L)	4.0a	$3.1a^{b}$	4.3^{a}	2.9^{c}	3.8^{a}	0.89
Magnesium (mmol/L)	5.0^{a}	4.7^{b}	3.8^{c}	4.8^{b}	5.3^{a}	0.34

a, b, c means in the same row with different superscript are significantly different ($p<0.05$)

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Haematological and Serum Biochemical Indices of Sheep in Semi-Arid Environment of Northern Nigeria

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Abstract- The hematological and biochemical parameters of 140 apparently healthy sheep consisting of 70 adults (35male and 35 female) comprised of 3 indigenous and popular brzzeeds of sheep of northern Nigeria were studied. Data were analyzed for the effect of breed, sex and season packed cell volume (PCV) was significantly higher ($P<0.05$) for Ouda ram of the north west. Haemoglobin (Hb) values was higher ($P<0.05$) for Balami sheep. Red blood cell count (RBC) was significantly ($P<0.05$) for Balami ewes. The mean corpuscular hemoglobin (MCH) was higher in Balami ram (17.89 Pg) while the values were much higher in Yankasa ewe lamb. The mean corpuscular hemoglobin concentration (MCHC) was significantly higher ($P<0.05$) for adult sheep than in lambs. The mean corpuscular volume (MCV) was observed to be higher for Ouda ram (98.8 fl) while the values were much higher in Yankasa ram lamb. Yankasa ewe had the highest white blood cell count (WBC). White blood cell differential shows that lymphocytes was significantly higher ($P<0.05$) for Yankasa sheep (adult). Neutrophils was significantly higher ($P<0.05$) for Balami ewe (adults and lambs). Eosinophils was observed only in Yanksa goats (adult and lamb). Monocytes was observed only in Ouda ram. The serum sodium ranged from (140.0 to 156.0 mmol/l) for adult sheep of all breeds, (140.0 to 160.0 mmol/l) for sheep lambs of all breeds.

Keywords: *hematology, blood chemistry, breeds, sheep, lamb, ewe, ram.*

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A. A. Njidda [α], A. A. Shuai'bu [σ] & C. E. Isidahomen [ρ]

Abstract- The hematological and biochemical parameters of 140 apparently healthy sheep consisting of 70 adults (35male and 35 female) comprised of 3 indigenous and popular brzzeeds of sheep of northern Nigeria were studied. Data were analyzed for the effect of breed, sex and season packed cell volume (PCV) was significantly higher (P<0.05) for Ouda ram of the north west. Haemoglobin (Hb) values was higher (P<0.05) for Balami sheep. Red blood cell count (RBC) was significantly (P<0.05) for Balami ewes. The mean corpuscular hemoglobin (MCH) was higher in Balami ram (17.89 Pg) while the values were much higher in Yankasa ewe lamb. The mean corpuscular hemoglobin concentration (MCHC) was significantly higher (P<0.05) for adult sheep than in lambs. The mean corpuscular volume (MCV) was observed to be higher for Ouda ram (98.8 fl) while the values were much higher in Yankasa ram lamb. Yankasa ewe had the highest white blood cell count (WBC). White blood cell differential shows that lymphocytes was significantly higher (P<0.05) for Yankasa sheep (adult). Neutrophils was significantly higher (P<0.05) for Balami ewe (adults and lambs). Eosinophils was observed only in Yanksa goats (adult and lamb). Monocytes was observed only in Ouda ram. The serum sodium ranged from (140.0 to 156.0 mmol/l) for adult sheep of all breeds, (140.0 to 160.0 mmol/l) for sheep lambs of all breeds. Serum potassium ranged from (4.60 to 12.4 mmol/l) for adult sheep (4.70 to 13.70 mmol/l) for sheep lamb. The chloride and HCO-3 values was higher for sheep lambs than in adults for all the breeds, values for urea, creatinine, glucose, total protein, cholesterol, globulin and albumin was observed to be higher for adults sheep than in lambs. The enzymes Asparttate Aminotranferase (ASP) and Alanine aminotransferase (ALT) were significantly (P<0.05) higherin Ouda sheep (adults and lambs).

Keywords: hematology, blood chemistry, breeds, sheep, lamb, ewe, ram.

I. Introduction

Small ruminants such as sheep and goats play important role in the livestock subsector of the Nigerian agricultural economy (Lakpini et al., 2002). Nigeria hosts 21,230 million sheep (Adu et al., 1979) and over 70% of the sheep population in Nigeria is found in the sahelo savanna regions where three of the four breeds of sheep (Balami, Yankasa and Ouda) predominant (Adu and Ngere, 1979).

Blood is an important index of physiological and pathological changes in an organism (Mitruka and Rawnshey, 1977). The primary function of the blood is to transport oxygen from respiratory organs to body cells (Duke, 1975) distributing nutrients and enzymes to cells and carrying away waste products (Slaker and Suverton, 1982) thereby maintaining homeostasis of the internal environment (Bentrick, 1974). The various functions of the blood are carried out by the individual and collective actions of its constituents – the haemotological and biochemical components (Akinmutimi, 2004).

Haematological tests have been widely used for the diagnosis of various diseases and nutritional status of animal. The information gained from the blood parameters would substantiate the physical examination and together with medical history provide excellent basis for medical judgment (Schalm et al., 1975).

In addition, it would help determine the extent of tissue and organ damage, the response of defence mechanism of the patient and aid in the diagnosing the type of possible anemia (Schalm, 1975).

A quantifiable variation was reported in blood parameters due to altitude, management, feeding level, age, sex, breed, health status, method of blood collection, hematological techniques used, diurnal and seasonal variation, ambient temperature and physiological status (excrement, muscular exercise, pregnancy, estrus, parturition, time of sampling, water balance and transportation.(Kausslish and Arora, 1977; Schalm et al., 1975; Ewuola et al., 2004).

Physiologic and pathological changes can be best evaluated when normal blood values are available for comparison. Even though considerable information is available on the normal blood parameters of domestic animals, the values are that of exotic breeds kept under different environment and management conditions (Tibbo et al., 2004).

This study was therefore an attempt to come up with normal hematological and biochemical reference values in indigenous sheep breeds found in the semi-arid zones of Nigeria raised under free ranged system as influenced by breed, sex and age. The present study was undertaken to evaluate the haematological and

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biochemical indices in sheep on natural grazing land in semi arid region of Nigeria.

II. Material and Methods

a) Experimental Location

The sheep breeds used in this study were obtained from different locations in the semi-arid region of Northwest Nigeria. The climate of the region is characterized by long dry (October to May) and short rainy (June to September) seasons and reaches maximum in August, with mean annual rainfall of 680-50mm minimum and maximum respectively. It has annual maximum and minimum temperatures of 40^{0}C and 15^{0}C respectively (Arnborg, 1988). The natural vegetation of the area is sudan savanna characterized by few trees and grasses.

III. Data Collection

Blood samples were collected from the jugular vein of apparently 140 healthy sheep of different breeds consisting of 70 adults (35 rams and 35 ewes) and 70 young ones (35 rams lambs and 32 ewe lamb) from different locations in the semi-arid region of Nigeria. The live weights of the adult and young sheep were 21.5±0.94 and 7.5±0.23 Kg respectively. The sheep were bled through jugular vein and 10ml of blood collected. 3ml of the blood samples were collected into plastic tube containing EDTA for haematological studies. The remaining 7ml of blood samples were deposited in anti-coagulant free plastic tube and allowed to clot at room temperature within 3hrs of collection. The serum samples were stored at -20^{0}C for biochemical studies. Total erythrocytic counts and total leukocytic counts were determined with the aid of Haemocytometer (Neubaur counting chamber) and Hb concentration was determine by Sahl's (acid haematin) method (Benjamin, 1978).

Mean corpuscular Haemoglobin concentration (MCHC), mean corpuscular Haemoglobin (MCH), Mean Corpuscular Volume (MCV) values were calculated (Patterson et al., 1960). Serum Aspartate Aminotransferase, Serum Aslanine Aminotransferase and Alkaline phosphatase were analysed spectriphotometric linked reaction method (Cheesbrough, 2004). Other biochemical analysis was done using the method described by Ogunsani et al. (2002).

IV. Statistical Analysis

Mean values and standard errors were calculated and the results were treated statistically using t-test assessing the mutual statistical differences between adult and young animals Snedecor and Cochram (1982) and one-way ANOVA was used to assess the statistical difference between male and female.

V. Results

a) Haematology (Adults)

The results of the hematological values for adult sheep is shown in Table 1. The packed cell volume (PCV) was significantly different ($P<0.05$) between breeds with Ouda ram having the highest (64.0%) volume. The haemoglobin (Hb) values ranged from (9.80 to 12.90 g/dl) with Balami having the highest value (12.90 g/dl). The highest value of (9.66 g/dl) was observed in Balami ewe for red blood cell count (RBC) while Ouda ram had the least (6.49 g/dl). MCH values ranged from 10.46 in Balami ewe to 17.89 Pg in Balami ram. Yankasa ram was observed to have the highest mean corpuscular haemoglobin concentration (MCHC). Ouda ram was observed to have the highest mean corpuscular volume (MCV). Yankasa ewe had the highest value for white blood cell count (29.76 x 10 g/l). the lymphocytes values ranged from 52.00% in Balami ewe to 81.00% in Yankasa ewe or all the breeds had lymphocytes values above 70% except for Balami ewe which had below 55% though the highest value for neutrophils was observed in Balami ewe (48.00%). Eosinophils was observed only in Yankasa goats. Monocytes was observed only in Ouda ram.

b) Haematology (Lambs)

The results of the haematological parameters for lambs is shown in Table 2. Yankasa ewe lamb had the highest (PCV) (45.3%) compared to other breed and sex. Haemoglobin values was observed to be highest in the Balami ram and ewe lamb (12.2 and 12.2 g/dl respectively). The RBC values ranged from 4.23 for Yankasa ram lamb to 8.69 g/dl in Ouda ram lamb. Mean corpuscular haemoglobin (MCH) values ranged from 12.8 in Ouda ram lamb and ewe lamb to 20.4 Pg in Yankasa ewe lamb Ouda ram lamb was observed to have the highest mean corpuscular hemoglobin concentration (MCHC). Yanksa ram lamb had the highest mean corpuscular value while Ouda ram lamb had the highest value for white blood count (27.89 x 109/l). The lymphocytes values ranged from 58.00% in Balami ram lamb to 76.00^ in Ouda ram lamb. The lymphocyte value for Balami ewe lamb is low (45.00%), though the highest value for neutrophils was observed in Balami ewe lamb (54.00%). Eosinophils values was observed only in Yankasa ewe lamb.

c) Biochemical Indices (Adults)

The results of biochemical indices of the adult sheep is shown in Table 3. The serum sodium and globulin were significantly higher ($P<0.05$) in Yankasa ewe. The values for serum potassium was highest in Ouda ewe (14.2 mmol/l) the chloride and albumin values were observed to be highest in the Yankasa ram values for hydrogen carbonate (HCO-3) (26.0 mmol/L), creatinine (156.0 mmol/L) and cholesterol (2.5 mmol/l) were higher in Balami ram. Ouda ram was observed to

have the highest value for urea (8.6mmol/L) and total protein (86.0 g/l). aspartate Amino transferase (AST) and Alamnine Aminotransferase ALT was higher in Ouda ram.

d) Biochemical Indices (Lambs)

The result of the biochemical indices for sheep lambs is shown in Table 4. All parameters observed showed significant difference ($P<0.05$) between breeds and sexes. The values for serum sodium and albumin were highest in Yankasa ewe lamb (160.0 and 32.0 mmol/L). The serum potassium, chloride, urea, glucose, total protein and globulin were significantly higher ($P<0.05$) in Ouda ram lamb than any of the breed and sexes. Balami ram lam was observed to have the highest value for hydrogen carbonate HCO-3 (27.0 mmol/l) and creatinine (139.0 mmol/L). aspartate Aminotransferase (ASP) and Alanine Aminotransferase (ALT) were higher in Ouda ewe lamb (143.0 and 45.0l μ/L).

Table 1 : Sheep Haematology (Adult).

	Yankasa		Ouda		Balami	
	Ram	Ewe	Ram	Ewe	Ram	Ewe
PCV (%)	28.90± 0.02^{e}	37.10± 1.0^{c}	64.00± 2.14^{a}	36.10± 1.02^{c}	39.00±0.96^{b}	32.00±0.23^{d}
Hb (g/dl)	9.80± 0.01^{c}	10.70± 0.04^{b}	9.90± 1.4^{bc}	11.90± 1.11^{a}	12.90±0.22^{a}	10.10±0.16^{ab}
RBC (g/dl)	7.80± 0.62^{b}	9.31± 0.78^{a}	6.49± 0.01^{c}	9.25± 0.02^{a}	7.21±0.42^{b}	9.66±1.22^{a}
MCH (Pg)	12.90± 0.02^{c}	11.50± 0.01^{cd}	15.30± 1.12^{b}	12.90± 0.04^{c}	17.89±0.24^{a}	10.46±0.12^{cde}
MCHC (%)	33.90± 1.21^{a}	28.80± 1.04^{c}	15.40± 1.11^{d}	33.00± 2.16^{a}	33.08±1.01^{a}	31.56±0.76^{b}
MCV (fl)	38.00± 3.21^{c}	39.80± 2.04^{c}	98.80± 3.16^{a}	39.00± 1.04^{c}	54.09±2.32^{b}	33.12±1.06^{d}
WBC (x10^{9}/L)	20.3± 0.93^{d}	29.76± 1.11^{a}	22.62± 1.26^{c}	27.70± 2.06^{b}	5.2±0.23^{e}	5.80±0.29^{e}
WBC Differentials						
Lymphocytes (%)	76.00± 2,11^{b}	81.00± 3.26^{a}	71.00± 1.42^{c}	72.00± 1.57^{c}	77.00±1.10^{b}	52.00±0.55^{d}
Neutrophils (%)	20.00± 1.01^{e}	19.00± 1.01^{e}	26.00± 0.92^{c}	28.00± 1.33^{b}	23.00±1.26^{a}	48.00±2.33^{a}
Eosinophils (%)	4.0± 0.02	0	0	0	0	0
Monocytes (%)	0	0	3.0± 0.02	0	0	0
Basophils (%)	0	0	0	0	0	0

a, b, c, means in the same row with different superscript differ significantly ($P<0.05$); PCV=Packed Cell Volume; Hb=Haemoglobin; RBC=Red Blood Cell; WBC= White Blood cells; MCV=Mean corpuscular volume; MCH=Mean corpuscular haemoglobin; MCHC=Mean corpuscular haemoglobin Concentration; Means within the same row with different superscripts are significantly different ($P<0.05$); NS=Not significant.

Table 2 : Haematological Indices of Different Breeds of Lambs.

	Yankasa		Ouda		Balami	
	Ram Lamb	Ewe Lamb	Ram Lamb	Ewe Lamb	Ram Lamb	Ewe Lamb
PCV (%)	43.8± 2.33^{b}	45.3± 1.45^{a}	33.5± 0.66^{e}	34.7± 0.45^{d}	38.00±1.22^{c}	38.00±1.21^{c}
Hb (g/dl)	5.6± 0.62^{d}	9.3± 0.72^{bc}	11.1± 0.04^{b}	10.1± 0.02^{b}	12.20±0.26^{a}	12.20±0.21^{a}
RBC (g/dl)	5.23± 1.0^{c}	4.44± 1.03^{d}	8.69± 1.04^{a}	7.92± 1.06^{b}	8.33±0.04^{a}	7.26±0.02^{b}
MCH (Pg)	13.2± 1.04^{cd}	20.4± 2.14^{c}	12.8± 0.02^{e}	12.8± 0.02^{e}	14.65±0.02^{c}	16.80±0.06^{b}
MCHC (%)	12.8± 0.44^{d}	20.5± 2.06^{c}	33.1± 1.14^{a}	13.5± 1.02^{d}	32.11±1.02^{b}	32.11±0.56^{b}
MCV (fl)	103.5± 1.01^{a}	102.0± 1.11^{a}	38.6± 2.66^{c}	94.3± 3.01^{b}	45.62±2.06^{d}	52.34±3.06^{c}
WBC (x10^{9}/L)	20.44± 1.02^{c}	21.89± 1.01^{c}	27.0± 0.56^{a}	24.39± 0.02^{b}	4.7±0.56^{d}	4.2±0.51^{d}
WBC Differentials						
Lymphocytes (%)	69.0± 2.14^{c}	73.0± 2.92^{b}	76.0± 1.22^{a}	65.0± 0.67^{d}	57.00±0.33^{e}	45.00±0.21^{f}
Neutrophils (%)	30.0± 0.4^{c}	25.0± 0.01^{d}	24.0± 0.03^{d}	30.0± 1.21^{c}	43.00±1.22^{b}	54.00±2.12^{a}
Eosinophils (%)	0	4.0± 0.11	0	0	0	0
Monocytes (%)	1.0± 0.01^{NS}	0	0	0	0	1.00±0.01^{NS}
Basophils (%)	0	0	0	0	0	0

a, b, c, means in the same row with different superscript differ significantly ($P<0.05$); PCV=Packed Cell Volume; Hb=Haemoglobin; RBC=Red Blood Cell; WBC= White Blood cells; MCV=Mean corpuscular volume; MCH=Mean corpuscular haemoglobin; MCHC=Mean corpuscular haemoglobin Concentration; Means within the same row with different superscripts are significantly different ($P<0.05$); NS=Not significant.

Table 3 : Sheep Biochemical Indices (Adults).

	Yankasa		Ouda		Balami	
	Ram	Ewe	Ram	Ewe	Ram	Ewe
Sodium (mmol/L)	144.0± 3.12^{cd}	156.0± 4.11^{a}	140.0± 2.22^{e}	148.0± 3.14^{b}	146.0±0.21^{c}	145.00±0.26
Potassium (mmol/L)	12.4± 0.62	10.8± 0.92^{NS}	7.4± 0.62^{b}	14.2± 0.98^{a}	5.0±0.33^{e}	4.60±0.23^{e}
Chloride (mmol/L)	109.0± 2.16^{a}	108.0± 2.08^{a}	106± 1.33^{b}	108.0± 1.06^{a}	108.0±0.14^{a}	109.00±0.12^{a}
HCO^{-3} (mmol/L)	22.0± 0.62^{c}	20.0± 0.04^{d}	21.0± 0.04^{d}	18.0± 0.08^{e}	26.0±0.21^{a}	24.00±0.11^{b}
Urea (mmol/L)	8.5± 0.04^{a}	7.0± 0.01^{b}	8.9± 0.62^{a}	8.3± 0.83 ^{a}	4.4±0.03^{c}	4.50±0.21^{c}
Creatinine (mmol/L)	97.0± 1.33^{c}	68.0± 1.06^{f}	103.0± 1.04^{b}	76.0± 0.62^{e}	156.0±2.19^{a}	90.00±1.22^{d}
Cholesterol (mmol/L)	2.5± 0.04^{d}	3.1± 0.09^{b}	2.5± 0.66^{d}	2.7± 0.42^{c}	3.5±0.04^{a}	2.00±0.02^{e}
Glucose (mmol/L)	3.0± 1.06^{a}	3.34± 1.04^{a}	2.5± 0.04^{b}	2.78± 0.02^{b}	2.1±0.56^{b}	2.90±0.11^{b}
Total protein (g/L)	73.0± 0.26^{d}	86.0± 2.11^{b}	94.0± 0.23^{a}	83.0± 0.14^{c}	55.0±0.22^{f}	57.00±0.02^{e}
Albumin (g/L)	33.0± 1.12^{a}	29.0± 1.11^{bc}	30.0± 0.56^{b}	23.0± 0.41^{e}	29.0±0.33^{bc}	27.00±0.21^{d}
Globulin (g/L)	40.0± 0.62^{d}	57.0± 1.02^{b}	44.0± 0.11^{c}	56.0± 0.22^{a}	26.00±0.56^{f}	30-00±2.23^{e}
AST (IU/L)	99.0± 2.67^{d}	110.0± 3.23^{b}	126.0± 1.14^{a}	107.0± 0.92^{c}	44.0±0.17^{e}	43.00±0.44^{e}
ALT (IU/L)	32.0± 1.72^{c}	17.0± 0.47^{d}	39.0± 0.62^{a}	38.0± 0.78^{a}	16.0±1.22^{d}	7.00±0.62^{e}
ALP (IU/L)	55.0± 1.34^{d}	29.0± 0.94^{f}	65.0± 1.24^{c}	42.0± 1.10^{e}	184.0±1.32^{a}	178.00±0.23^{b}

a, b, c, means in the same row with different superscript differ significantly (P<0.05); AST=Aspartate Aminotransferase; ALT= Alanine Aminotransferase; ALP= Alkaline Phosphatase; Means within the same row with different superscripts are significantly different (P<0.05); NS=Not significant.

Table 4 : Biochemical Indices of Different Breeds of Sheep lambs.

	Yankasa		Ouda		Balami	
	Ram lamb	Ewe lamb	Ram lamb	Ewe lamb	Ram lamb	Ewe lamb
Sodium (mmol/L)	156.0± 1.01^{c}	160.0± 2.02^{a}	158.0± 2.14^{b}	142.0± 1.03^{e}	148.00±2.13^{d}	140.00±1.44^{f}
Potassium (mmol/L)	10.4± 0.02^{b}	13.4± 0.04^{a}	13.5± 0.04^{a}	9.8± 0.002^{b}	5.00±1.06^{c}	4.70±0.56^{c}
Chloride (mmol/L)	110.0± 0.07^{a}	108.0± 0.05^{b}	110.0± 2.1^{a}	108.0± 2.4^{b}	109.00±3.21^{b}	104.00±2.33^{c}
HCO^{-3} (mmol/L)	25.0± 1.21^{b}	20.0± 1.06^{d}	18.0± 0.62^{e}	22.0± 1.14^{c}	27.00±0.05a	24.00±0.02^{b}
Urea (mmol/L)	7.0± 0.04^{a}	6.1± 0.02^{b}	7.5± 0.45^{a}	7.2± 0.52^{a}	5.70±0.03^{c}	6.10±0.07^{b}
Creatinine (mmol/L)	42.0± 1.04^{f}	86.0± 2.16^{d}	68.0± 1.42^{e}	107.0± 1.73^{b}	139.00±2.09^{a}	98.00±0.98^{c}
Cholesterol (mmol/L)	1.9± 0.01^{c}	3.5± 0.04^{a}	2.5± 0.02^{b}	2.3± 0.45^{b}	1.80±0.04^{c}	2.00±0.01^{b}
Glucose (mmol/L)	3.0± 0.01^{a}	3.0± 0.01^{a}	3.0± 0.48^{a}	2.78± 0.07^{b}	2.40±0.05^{b}	2.20±0.04^{b}
Total protein (g/L)	73.0± 1.41^{b}	69.0± 0.98^{c}	83.0± 1.14^{a}	71.0± 0.21^{b}	64.00±1.02^{d}	60.00±1.03^{e}
Albumin (g/L)	26.0± 0.17^{de}	32.0± 1.01^{a}	27.0± 0.78^{cd}	29.0± 0.01^{b}	30.00±0.66^{b}	28.00±0.23^{bc}
Globulin (g/L)	47.0± 1.04^{b}	37.0± 1.01^{d}	56.0± 1.13^{a}	42.0± 0.52^{c}	34.00±0.56^{e}	32.00±0.32^{f}
AST (IU/L)	47.0± 1.33^{d}	110.0± 2.14^{c}	126.0± 0.16^{b}	143.0± 1.14^{a}	20.00±0.14^{f}	24.00±0.23^{e}
ALT (IU/L)	22.0± 0.74^{c}	44.0± 0.26^{a}	39.0± 1.28^{b}	45.0± 1.92^{a}	8.00±0.12^{e}	9.00±0.33^{d}
ALP (IU/L)	29.0± 1.11^{f}	48.0± 1.26^{e}	65.0± 0.45^{d}	82.0± 0.12^{c}	105.00±1.23^{b}	305.00±3.54^{a}

a, b, c, means in the same row with different superscript differ significantly (P<0.05); AST=Aspartate Aminotransferase; ALT= Alanine Aminotransferase; ALP= Alkaline Phosphatase; Means within the same row with different superscripts are significantly different (P<0.05); NS=Not significant.

VI. Discussion

The PCV in adult female sheep were generally higher than in adult males while it was observed to be higher in the young males than in young females. The result generally showed adults sheep to have higher values in PCV than in lambs. In the sheep, age and sex exhibited remarkable influence on the PCV values.

The packed cell volume (PCV) obtained in the present study (28.90 to 64.0% for adults) was higher than the normal range (28.47 to 30.25% for adults) reported for sheep (Baneejee, 2007; Rusuff et al. 1954; Bianca 1955). The increase in PCV might be attributed to high environmental temperature. This is similar to the report of Patterson et al. (1960) who reported that increase in environmental temperature cause an increase in PCV. The higher PCV values obtained in this study might likely be a sign of healthier sheep. Adult sheep tend to have higher PCV values than lambs and this agrees with previous work (Schalm et al., 1975). The result of the haemoglobin (Hb) value shows that Balami sheep had higher values than other breeds but the value obtained in this study fall within the normal range reported for sheep (Baneejee, 2007). There was observed difference in adult and young goats which suggest the oxygen carrying capacity of the blood was higher in adult sheep. Generally, increase in the Hb concentration is associated with greater ability to resist

disease infection and low level is an indication of disease infection and poor nutrition (Cheesbrough, 2004; Tambuwal et al., 2002). The RBC values obtained in this study were within the normal values reported by (Campbell et al., 2003). The RBC values was observed to be higher in the ewes than in the in the rams and also it was observed that the RBC values in the rams and ewes were higher than in the ram lamb and ewe lamb. The difference due to age and sex is a signal of the health status of the various age groups and sex among the sheep breed studied which is in agreement with the findings of Schalm et al. (1975) and Addas et al. (2010). The high RBC counts may be associated with conditions that cause the body to make too many red blood cells (Polycythemia) or impaired pulmonary function, while low RBC counts may be associated with iron deficiency, internal bleeding, some types of anemia or some vitamin deficiency.

The values of MCV, MCHC and MCH significantly increased and are very important in the diagnosis of anemia and also serve a useful index of the capacity of the bone marrow to produce red blood cells (Awodi et al., 2005). The increased in MCV, MCHC and MCH are greatly influenced by age and sex (Egbe–Nwiyi, 2000).

The leucocyte count (WBC) was higher in adult female sheep than the values obtained for male sheep breeds. The WBC values of the adults are comparable to the young sheep. This findings is similar to the reports of Egbe-Nwiyi et al. (2000) and Addass et al. (2010) who reported that age has no significant influence but sex had an influence ($P<0.05$) on the total WBC. The higher leucocyte count (WBC) in this study is an indicator of immune response to infections or toxic substances in the organism and a low count is an indication of pathogenic infection or presence of antigens in the organism (Bradbury et al., 1999) but the higher WBC in female adult sheep was not in agreement with (Schalm et al., 1975). The higher values of WBC observed may also be attributed to the extensively managed sheep which makes them face challenges from microbes when on free range. The result also reveals the significant effect of age and sex on the health status of these sheep breeds.

The white blood cell differentials (lymphocytes and neutrophils) levels are comparable among the breed, age and sex groups of animals. There was significant influence of age, sex and breed on lymphocyte count. The value for lymphocytes was higher for Yankasa ewe breed than other breeds. The lymphocytes constituted majority of the WBC counts and the cells increased with age in early life in both sexes of sheep and goats (Egbe-Nwiyi et al., 2000). The high lymphocyte counts in the animals in this study are favoured by the findings of (Milson et al., 1960) and (Wilkins and Hodges, 1962) and it might be attributed to stress and immune response to the environment (Cole, 1980) which harbours various detectable and undetectable parasitic and or bacterial organisms. The value for neutrophils was higher for Balami sheep breed (both adult and lambs). Sex influences was observed for neutrophils with mostly females (adult and lambs) having the higher value than the males which is in contrast with observation made by Egbe-Nwiyi et al., (2000) for sheep and goats in arid zone of Nigeria. The difference may be attributed to specie difference. The values for eosiniphils in the present study was observed to be higher for Yankasa sheep breed (ram) and ewe lamb while the other breeds had no eosinophils. Like neutrophils, they are very effective killing machine (Ganong, 2005). Monocyte generally was not observed in all the breeds except in Ouda ram while yakasa ram lamb and Balami ewe lamb had very low values.

Serum biochemical indices is used to determine the level of heart attack, liver damage and to evaluate protein quality and amino acid requirements in animals as reported by (Harper et al. 1979). The values of serum electrolyte of sodium potassium and chloride ranged from 140.0 to 156.0 mmol/L, 4.60 to 12.4 mmol/L and 106.0 to 109.0 mmol/L respectively. The values obtained in this study are above the normal range reported by Baneejee (2007). The electrolytes are known to regulate osmotic pressure, maintain membrane potentials and acid base balance and transmit nerves impulses sodium and potassium deficiency affect the tubes of kidney resulting in inability to concentrate urine (Latimer et al., 2004). The comparison shows that (lambs) have higher sodium and chloride values than adult sheep. The values show significant variation but are all within range in terms of breed and sex. Yankasa sheep tend to have higher values than the other breeds. The result of hydrogen carbonate ions reveals that there is breed and sex difference with Balami rams having higher values than other breeds.

The urea level in the study shows that Ouda and Yankasa breed (adults) had higher values than balami breeds. The values for adult sheep are higher than the young sheep (lamb). Generally, the values tend to be higher compared to the values 1.5 mmol/L (Oduye and Adedevon (1976). The high level of serum urea has been attributed to excessive tissues protein catabolism associated with protein deficiency (Oduye and Adedevon (1976). The urea value obtained was within the range of 8 to 20 mg/dl (Banejee, 2007) in matured domestic animals and 5.28 mg/dl for free ranging desert big-horn sheep.

The creatinine values in the present study were within normal range and differ ($P<0.05$) among breeds. The values were higher in the adults than lambs in all the breeds. High creatinine is indicative of poor protein and amino acid metabolism that can lead to impaired renal function and cardiac infarction (Gray and Howarra, 1980). Increased creatinine has been associated with

tannin toxicosis in cattle consuming tannin-rich oak fodder (GARG et al, 1992).

For goats in the semi-arid region the cholesterol values show inconsistency for breed, sex and age prolonged, high level of blood cholesterol may result in its deposition on the walls of the blood vessels and these deposits may eventually harden to atheroschlerotic plaque, this may block important blood vessels and result in a myocardial infraction.

The glucose levels show inconsistency for breed sex and age. Serum glucose is an indicator of cito metabolism, in high energy diets (Coles, 1986). When glucose is lower than the normal range is an indication of hypoglycemia while higher levels are indication of hyperglycemia (Olorunnisomo, 2012).

The values for total protein concentration obtained were higher in Ouda ram (adult) than other breed sex and age. This agrees with the report of (Kamatu et al, 1988) and (Duke, 1955) that plasma protein help to transport calcium and phosphorus and other substances in the blood by attachment to the albumin. The albumin level in the studied shows that Yankasa sheep (adult lamb) had higher values than the other breeds. The values were higher in the males than females in all breeds. A reading of albumin less than the normal physical value of albumin usually indicates hypoalbuminemia (Altman, 1979).

The result of the ALT and ALP were higher in the rams than in ewes while for AST the result is in consistent. Contrary to the results obtained for the lambs, all the aminotransferases (AST, ALT and ALP) were higher in the ewee lambs than ram lambs. This clearly shows that there is a significant influence ($P<0.05$) of there parameters on age, sex and breed. AST level is helpful for the diagnosis and following of cases of myocardial infarction, hepatocellular disease and skeletal muscle disorders. In trauma or in diseases affecting skeletal muscle, after a renal infarct and in various haemolytic conditions (Alex and LaVerne, 1983).

The concentration of Serum Alanine Aminotransferase in tissues is not nearly as great as for Serum Aspartate Aminoferase. It is present in moderately high concentration in liver, but is low in cardiac and skeletal muscles and in other tissues. Their uses for clinical purpose are primarily for the diagnosis of liver diseases (DeRitis et al., 1972) and resolve some ambiguous increase in serum Alanine Aminotransfase in cases of suspected myocardial infarction (Aach et al., 1981). When both enzymes (i.e. Alanine Aminotransferase and Aspartate Aminotransferase) are elevated in serum, the liver is the primary source of the enzymes (liver ischemia because of congestive heart failure or other sources of liver cell injury) (DeRitis et al., 1972). If the serum Aspartate Aminotransferase is elevated while the serum Alanine Aminotransferase remains within normal limit in case of suspected myocardial infarction, the results are compatible with myocardial infarction (Alex and LaVerne, 1983).

VII. Conclusion

From the present study, it can be concluded that the haematological and biochemical parameters for sheep studied fall within normal range. The observed differences may be due to nutritional and environmental effect. Age, sex and breed also showed remarkable influence on the haematologiclal values of sheep in the semi arid.

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Pre-Testing of New Hive Technology (Mekonnen/Simeamelak Hive) at Remeda Station, Sidama Zone, SNNPR, Ethiopia

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Abstract- This new bee hive technology was designed, produced and pretested as a creative innovation on its structure and convenience for local bee races as we observed on some hives of this technology, they always work circular comb. The data on this particular work was measurements of the hive parts, construction challenges, and, and opportunities of the hive in the workshop, in my opinion there will be many works in near future on refining of hive parts, size, component number and comparative evaluation based on suggested areas and with other local and modern hives.

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Strictly as per the compliance and regulations of :

Pre-Testing of New Hive Technology (Mekonnen/Simeamelak Hive) at Remeda Station, Sidama Zone, SNNPR, Ethiopia

Simeamelak Mekonnen

Abstract- This new bee hive technology was designed, produced and pretested as a creative innovation on its structure and convenience for local bee races as we observed on some hives of this technology, they always work circular comb. The data on this particular work was measurements of the hive parts, construction challenges, and, and opportunities of the hive in the workshop, in my opinion there will be many works in near future on refining of hive parts, size, component number and comparative evaluation based on suggested areas and with other local and modern hives.

I. Background and Justification

Ethiopia has the largest bee population in Africa with over 10 million bee colonies, out of which about 4.6 million are confined in hives and the remaining exist in the forest (CSA 2007). Currently, the available bee colonies in Ethiopia are grouped in to five different honeybee populations occupying ecologically different areas: Apis mellifera jemenitica in the northwest and eastern arid and semi-arid lowlands; Apis mellifera scutellata in the west, south and southwest humid midlands; Apis mellifera bandasii, in the central moist highlands; Apis mellifera monticola from the northern mountainous highlands; and Apis mellifera woyi-gambella in south western semi-arid to sub-humid lowland parts of the country (Amssalu et al 2004).

Ethiopia is the leader in both bee populations in Africa and in bee product business development. In addition, it far exceeds other African countries in terms of volumes of honey and beeswax harvested and traded, and levels of investment in the formal sector (Aby 2009). Ethiopia produces a total 42,180,346kg of honey per year, of which 40,075,363kg, 467,187kg, and 1,637,796kg are from traditional, transitional and modern hives respectively (CSA 2007). As a result, the per capita consumption of honey is assumed to be 0.57 kg assuming nothing is exported. Eighty-five percent of this honey is locally consumed for the preparation of 'Tej' (a mild alcoholic beverage popular throughout Ethiopia) leaving 15% or 6,330 tons of honey for export. Such an amount of annual honey production in Ethiopia puts the country at first rank in Africa and tenth in world. Ethiopia is also the fourth largest beeswax (3200 tons per year without considering beeswax wasted in the rural areas) producer after China, Mexico and Turkey (Aby 2009).

In Ethiopia, beekeeping is practiced as tradition, which means that most of the farmers in rural areas have hives. As a result, about 4,688,278 beehives are estimated to be found in the rural sedentary areas of Ethiopia, of which, 4,580,303 (97.7%) are traditional hives, 29,421 (0.63%) transitional hive and 78,554 (1.68%) modern beehives (CSA 2007).About 95% of honey production is harvested by means of local methods from traditional hives (CSA 2007). To solve these problems a number of technologies, techniques and management practices have been undertaken. Of these, introduction, evaluation and popularization of modern bee hives is the one from these hives zender hive is known to be highest in honey production, however the technology design and structure did not optimize the local bee hive for which the local bee hives adopt adjust their nature from wildness starting from their domestication era. Thus this proposal is prepared to solve such problem. The prototype picture is presented at the end of this work.

a) Objective

To develop new bee hive which is more convenient for local bee races with high productivity and quality of honey.

II. Methodology

The thought of the technology, designing, prototype development and materials type and specification was produced by the inventor of the technology, Me, Mr. Simeamelak Mekonnen.

a) Technology Designing and Model Hive Construction

i. *New Beehive Technology Design/Structures and Measurements*

The newly designed hive (Mekonnen/ Simeamelak Hive) has a round shape and has three or less distinctly separated sections. Each section has one opening on top side with two fixing bars and two half circled timbers. The bottom part of the section has 10 frames, two frame holder bars, and two fixing bars each at the end of the bottom section. At the joint circle of each section there are one half curved timbers and one

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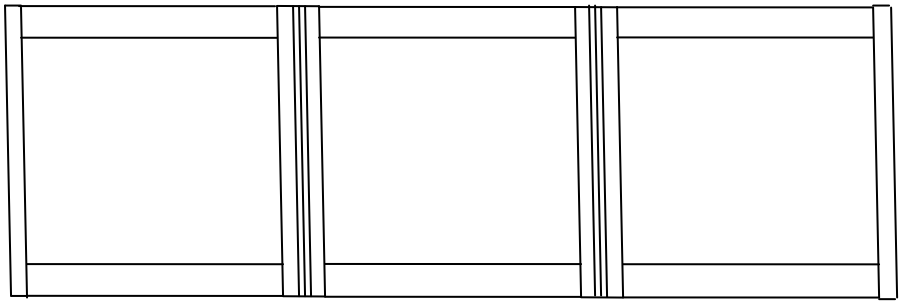
half circled queen excluder attached on the bottom part. The hive externally covered with tine ply wood, and flat corrugated sheet.

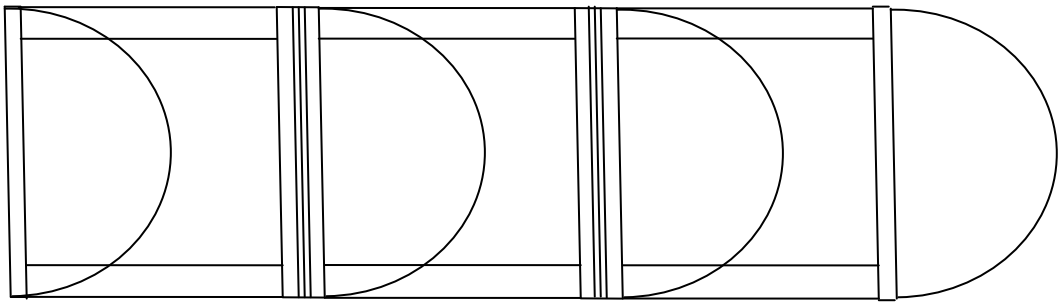
ii. *Model Hive Construction*

After detailed clarification and training the prototype and specification was given to a workshop to produce the model hive.

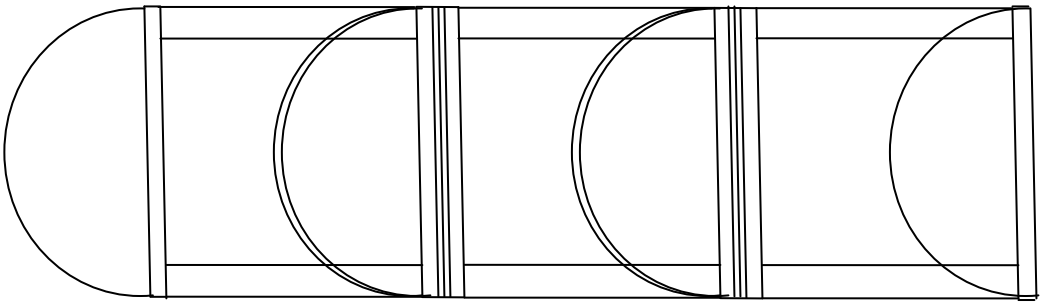
Top view of the main bars of the bottom section



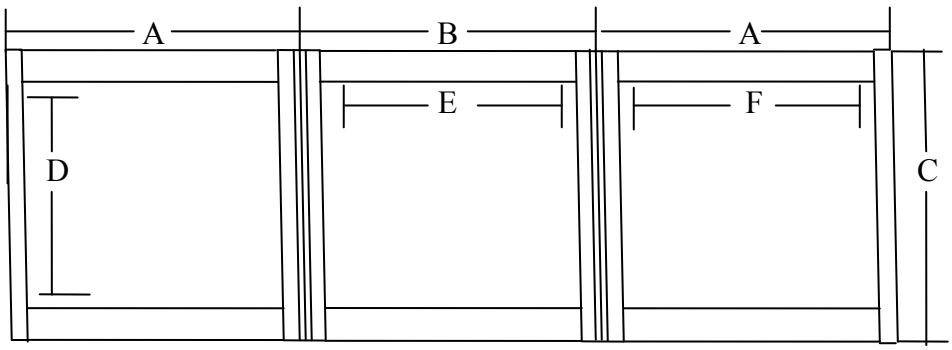
The bottom section with curve structures



The top section with curve structures



iii. *Measures of Each Part of the Hive*



A = 39cm D =35cm
B = 38cm E = 36cm
C = 42.5cm F = 34cm

- ✓ Radius of the frame = 18.5cm, width of the frame = 2cm, thickness of the frame = 0.25cm,
- ✓ Radius of half circled frame = 21cm, width of half circled frame = 2cm
- ✓ Radius of queen excluder = 21cm
- ✓ Vertical bars (length = 42cm, height = 2cm and width = 2cm with the thickness of queen excluder for the middle bars)
- ✓ Horizontal bars = (length = 34cm for the end sections and 36cm for the middle section; height = 3.5cm and width = 3.5cm however the width part had inward curve of 1cm at every 3.2cm distance told the frames which have 2cm width.
- ✓ Externally covering materials are 1) chip wood and 2) flat galvanized iron sheet; the bottom part will be covered with a single chip wood of its length is 116cm , width 67cm and thickness 0.25cm. the upper section have three chip woods of 39cm by 67cm, 38cm by 67cm and 39cm by 67cm, then after the each of the upper section will be covered with galvanized sheet (internally has wood shaving). Galvanized sheet will have additional 3cm length to the outside part and additional covering between the centers of the openings to protect from rain and water leakage
- ✓ The hive has bees landing (4cm by 6cm) and an opening (height = 1cm and width = 4cm) and a door (height = 8cm and width = 6cm).
- ✓ The hive sited on two bars each has 42cm length, 3.5cm width and 2cm height.

iv. *Specific Materials to Construct the Hive*

No.	Items	Quantity	Length (cm)	Width (cm)	Height (cm)	Case
1	ply wood	1	116	67	0.25	For bottom part of the hive
2	Morale (bar)	4	34	3.5	3.5	>>
3	Morale (bar)	2	36	3.5	3.5	>>
4	Morale (bar)	2	42	2	3.5	>>
5	Half circled timber	10	r = 21	-	2	>>
6	Queen excluder	2	r = 21	-	0.2	>>
7	ply wood timber	2	39	67	0.25	For doors
8	Chip wood timber	1	38	67	0.25	For a door
9	Morale (bar)	4	35	2	2	For doors
10	Morale (bar)	2	34	2	2	For a door
11	Morale (bar)	4	12	1	1	Jointer for movable half circled timbers
12	Morale (bar)	2	42	3.5	2	Hive sitter
13	wood timber	30	116	2	0.25	Frame
14	wood timber	30	10	2	0.25	Frame fixer
15	Wire	1	4500	-	-	Printed wax and frame fixer
16	Galvanized smooth iron sheet	2	41	67	-	For doors
17	Galvanized smooth iron sheet	1	40	67	-	For a door
18	Galvanized smooth iron sheet	2	71	3	-	Between doors line
19	ply wood timber	1	8	6	0.25	for bees in and out hole
20	ply wood timber	1	6	4	0.25	bees landing
21	jointer	6	-	-	-	Doors and bottom part fixing
22	Lock	5	-	-	-	For doors and doors line sheets
23	Yellow paint	-	-	-	-	Bottom part
24	Nails	-	-	-	-	On count

v. *Model Hive Construction*

After detailed clarification and training the prototype and specification was given to a workshop to produce the model hive. This new bee hive technology was designed, produced and pretested as the first innovation on its structure and convenience for local bee races as we observed on some hives of this technology, they always work circular comb..

The data on this particular work was measurements of the hive parts, construction challenges, and, and opportunities of the hive in the workshop, in my opinion there will be many works in

near future on refining of hive parts, size, component number and comparative evaluation based on suggested areas and with other local and modern hives. The following pictures illustrate the model hive on front part.

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	A-B	**C-D**	**E-F**
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

INDEX

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