AZIKHELI BUFFALO BREED, ITS PRODUCTIVE AND REPRODUCTIVE PERFORMANCE UNDER TRADITIONAL MANAGEMENT SYSTEM IN DISTRICT SWAT (N.W.F.P.) PAKISTAN

QUAID-I-AZAM UNIVERSITY
ISLAMABAD

Momen Khan

Department of Animal Sciences
Faculty of Biological Sciences

Quaid-i-Azam University
Islamabad, Pakistan
2011

AZIKHELI BUFFALO BREED, ITS PRODUCTIVE & REPRODUCTIVE PERFORMANCE UNDER TRADITIONAL MANAGEMENT SYSTEM IN DISTRICT SWAT (NWFP) PAKISTAN

QUAID-I-AZAM UNIVERSITY
ISLAMABAD

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE THESIS REQUIREMENT FOR THE
DEGREE OF
DOCTOR OF PHILOSOPHY

BY

MOMEN KHAN

Department of Animal Sciences
Faculty of Biological Sciences

Quaid-i-Azam University
Islamabad, Pakistan
2011

CERTIFICATE

This thesis submitted by Momen Khan is accepted in its present form by the Department of Animal Sciences as satisfying the thesis requirement for the degree of Doctor of Philosophy in Reproductive Physiology.

Supervisor
Prof. Dr. Samina Jalali ____________________

External Examiners:

Prof. Dr. Nemat Ullah ____________________

Dr. Muhammad Mushtaq Aziz ____________________

Chairperson
Prof. Dr. Muhammad Shahab ____________________

Date: 4. 8. 2011

IN THE NAME OF ALLAH, THE BENEFICENT, THE MERCIFUL

Dedicated

To

My parents, uncle, brothers, sister, wife, son and Sommayya

whose prayers, love, wishes and affections are source of my strength in every step of my life.

and

My beloved innocent youngest late Son

Mr Ibadur Rahman

Who died on August 7, 2010 at the age of 11 Months

CONTENTS

ACKNOWLEDGEMENTS

Praise belongs to ALLAH the Lord of the Worlds, Who granted man with knowledge from his unseen treasures. All regards and respects to the Hazrat Muhammad Sallallahu Alaihi Wa Sallam, whose teachings are source of knowledge and blessings for entire creation.

No words can suffice to express my indebtedness to my supervisor, Prof. Dr. Samina Jalali, for her brilliant versatility, devoted guidance and for being so very supportive in all stages of this research work. Her immense knowledge was an inspiration for me and gave me a hope and thought to explore diverse things in my research work.

I am grateful to Dr. M Shahab, Chairman, Department of Animal Science, Quaid-i-Azam University, Islamabad, for providing me all necessary facilities for the completion of this work and Dr. Sajad Aslam Shami for his keen interest and sound advises in all aspects of my research endeavors.

My heartiest thanks are for Dr. Inam-ur Rahim, Mr. Syed Iqmail Hussain, Mr. Muzafar Said, Mr. Muqarrab Ali Khan (EX Director L&DD, KPK), Dr. Sher Muhammad (DG L&DD, KPK) and Dr Javid Iqbal (Research Centre for Conservation of Sahiwal Cattle, Jhang) for their intellectual and moral support.

I am also thankful to DLO and Veterinary Assistants of DL&DD, District Swat particularly of Khwazakhela valley (Azikheil) who accompanied me during my research work in the field. The sincere efforts of Mr. Behramand Kaka and Mr Mohammad Didar (VA) of Tekhdari Khwazakhela are highly acknowledged. I can never forget the support and patience of Mr. Imran Ali (VA) CVH Harichand.

I wish to express sincere thanks to all my Lab fellows Tariq Zubair Avisi, Latafat Amin Khan, Rifat Gilani, Naushaba and Beenish Ishtiaq for their pleasant company. I convey my heartiest and sincerest acknowledgements to my tenacious friends Mohammad Karim, Mohammad Arif, Ghani Rehman, Amanullah, Nowsherwan, Adnan Shah and Dr Naeem-ud-Din Khatak for their help and encouragement.

I am cordially thankful to Dr Muhammad Saleem and Saeed Ahmad (PhD Scholar Biotechnology, Quaid-i-Azam University, Islamabad) for their cooperation in my research work.

My heartfelt gratitude is reserved for my parents (Noornama, Nisar Mahmood), brothers (Amir Zaman Khan, Badshah Khan, Wilayat Khan, Inayatur Rahman, Farmanullah) sister (Ruqia Nisar), uncle Sherin Taj and cousin Muhammad Saleem, for their amazing love and support not only during my research work and studies but also in my every step of my life.

In the last I convey my heartiest and sincerest acknowledgements to my wife Robina, son Ibadullah and daughter Sommayya whose suffering during my studies is irreparable, whereas my late son Mr Ibadur Rahman who will remain in my memory in the remaining of my life.

Momen Khan

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This study on physical and morphometric characteristics, productive and reproductive performance was carried out on Azikheli buffalos and bulls in Khwazakhela, District Swat, NWFP, Pakistan. Various physical characteristics studied included color patterns of the coat, forehead, eyelashes, eyes, horns, muzzle, forelegs, hind legs and hooves of Azikheli buffalos and bulls. Morphometric measurements included heart girth, body length, height at wither, height at hipbone, head region (face length, ear length and width), horn, neck, back, rump, legs, and tail. Productive performance studies included standard 305-day milk yield and daily milk yield. Parameters for reproductive performance were pubertal age, postpartum anestrus interval, conception efficiency, calving interval and dry period. The present study revealed that majority of Azikheli buffalos (62.04%) and bulls (61%) are brown in coat color, while a low percentage of cows and bulls are black, black and white but white was observed in only 4% of both sexes. They have completely white color forehead, white color eyelashes, blue shining eyes, black color horns, white muzzle, white color fore legs below knee joint, white color hind legs below hock joint and brownish color hooves with no sex differences among these color patterns. Azikheli buffalos have significantly higher heart girth size, longer horns, longer neck, and wider face at the level of eyes than bulls. On the other hand Azikheli buffalo have significantly longer bodies, longer ears, thick horns, thick neck and large hooves than buffalo. Tail of Azikheli buffalo and of bulls are above hock as cutting of switch is routine practice. Horns are flat laterally, directed backward and slightly upwards without twisting giving a sickle or semi-sickle appearance. Mean 305-day milk yield recorded in Azikheli buffalo was 2494.02±52.44 liters. Significant effect of parity was observed on mean 305-day milk yield with higher milk production in second ($P<0.001$) and third parity ($P<0.001$) compared to first parity. No significant effect of calving season on 305-day milk yield was observed. Mean daily milk yield recorded in Azikheli buffalo was 8.177±0.171 liters. Mean daily milk yield was significantly higher in second ($t_{(70)}=3.52$; $P<0.001$) and third ($t_{(70)} = 4.55$; $P<0.001$) parity compared to first parity.

There was no significant ($P>0.05$) difference in daily milk production among spring, summer, autumn and winter season. Mean pubertal age of Azikheli buffalos recorded was 1147.93±13.05 days and the highest percentage of buffalos (44.89%; n=202) was observed in pubertal age ranging from 811-1081 days with mean pubertal age of

1048.81±4.87 days. Mean postpartum estrus interval in Azikheli buffalo observed was 147.56±5.64 days. Highly significant (b= -0.026±0.0044; $F_{(1, 2)}$ = 30.59; p= 0.03) reduction in mean postpartum anestrus interval was observed as parity increases from first to fourth. Similarly significant (b= - 9.143±1.87; $F_{(1, 2)}$ = 23.77; P=0.0396) effect of season on postpartum anestrus interval was also observed with the longest postpartum anoestrus interval in autumn season and shortest in summer season. The percentage of Azikheli buffalo conceived after first service was 64.33 %. Mean calving interval observed in Azikheli buffalos was 489.16±5.82 days. Highly significant (b= -0.021±0.001; $F_{(1, 2)}$ =213.09; P=0.004) reduction in mean calving interval was noted as parity number advances from first to fourth. The effect of season on calving interval was statistically not significant. Mean dry period observed was 119.47±2.58 days. Highly significant (b= -0.049±0.0100; $F_{(1, 2)}$ = 24.56; P = 0.03) reduction in mean dry period was observed as parity increases from first to fourth. However, no significant effect of season on dry period was observed (P>0.05). Calf sex ratio observed in Azikheli buffalo was 100 ♀♀: 89 ♂♂. There was no significant effect of parity on calf sex ratio. Season significantly ($\chi 2_{(1)}$ = 3.985; P=0.045) affect calf sex ratio with more male birth in autumn compared to spring season. Mean birth weight of male calf observed in this study was 33.42±0.67 kg. Male birth weight in parity second was significantly higher than in first parity ($t_{(33)}$ = 2.26511; P=0.03) and third parity ($t_{(32)}$ = 3.2725; P=0.002). No significant ($F_{(3, 46)}$ =0.285456; P= 0.83) differences in male birth weight was found in calves born in different season of the year. Mean birth weight of female calf was 29.67±0.75 kg. No significant effect of parity ($F_{(2, 46)}$ =2.54; P= 0.08) and season ($F_{(3, 45)}$ =0.234732; P= 0.87) was observed on female calf birth weight. Male calves were highly significantly ($t_{(97)}$ =3.71; P= 0.0003) heavier than female calves at birth.

INTRODUCTION

Livestock sector contributes 53.2 percent of the agricultural value added and 11.4 percent to national GDP (Gross Domestic Product) during 2009-10 (Government of Pakistan, 2010). Livestock play a vital role in rural economy, 30-35 million people are engaged in livestock raising in rural areas (Government of Pakistan, 2008) deriving 30-40 percent of the household income from this sector (Government of Pakistan, 2007). Gross value addition of livestock increased to Rs.1287 billion in 2008-09 as compared to Rs. 1052 billion in 2007-08 showing an increase of 22.3 percent. The value of livestock is 6.1 percent more than the combined value of major and minor crops (Government of Pakistan, 2009). Pakistan is endowed with rich livestock genetic resources, well adapted to the local conditions. There are 15 breeds of cattle, 5 breeds of buffalo, 33 breeds of sheep and 36 breeds of goat (Government of Pakistan, 2006; Khan et al., 2007a; Khan et al., 2007b; Khan et al.,2008a: Khan et al., 2008b; Ali et al., 2009; Babar et al., 2009; Khan and Niamatullah, 2010). The population of cattle in Pakistan is 29.56 million, buffalo 27.33 million, sheep 26.49 million and goat 53.79 million (Government of Pakistan, 2006). There are 177.247 million buffalo head world wide in 50 countries, of which 171 million (97 %) are found in Asia, while 5.38 million (3 %) are found in rest of the world. Pakistan with 29.9 million population (14 %) is the second highest buffalo inhabiting country in the world after India which has the population of 98.7 million (56 %) of the total world buffalo (Chanthalakhana and Falvey, 1999; Sethi, 2009; Government of Pakistan, 2009; Khan and Niamatullah, 2010). Buffalo are the second largest (75 million tons) source of milk supply in the world (FAO, 2004).

Interestingly Pakistan is the second largest dairy buffalo country in the world (Khan and Niamatullah, 2010) and possesses the highest buffalo milk genetic potential in the world and they contribute 70% of the total milk produced in the country (Khan, 2009) and with annual increase of buffalo population at the rate of 3 percent, buffalo population in Pakistan is 29.9 million head and being the major source of national milk yield (62 %) is an enormous dairy genetic resource of Pakistan (Government of Pakistan, 2009). Similarly Pakistan is also second in Asia in terms of meat produced by buffalo which is evident from the fact that number of slaughtering buffalo increased from 2.18 million in 1996 to 3.34 million in 2006 showing a 53.2 percent increase during the specified period (Government of Pakistan, 2007). Buffalo breeds in Pakistan are Nili-Ravi and Kundi which are the finest dairy buffalo in the world

(Cockrill, 1974). The home tract of the Nili-Ravi buffalo includes Lahore, Sheikhupura, Faisalabad, Okara, Sahiwal, Pakpatten and Vehari districts of central Punjab; and Multan and parts of Bahawalpur and Bahawalnagar districts of southern Punjab. However, because of their well-recognized dairy qualities, these animals are now found all over the country (Khan et al., 2005). Kundi buffalo are found throughout Sindh, particularly on both sides of the Indus River from Kashmore in the north to Shah Bandar in the south on the coast of the Arabian Sea. They are also found in some parts of Balochistan province (Khan et al., 2005).

Indigenous breeds that have been evolved and adapted from the time immemorial and exist with their own genetic make up are disappearing by dilution and replacement (FAO/UNEP, 1992) as a result of new market demand, use of new breeding technology (FAO, 1992) changes in the socio-economic environments of a region (Dorji et al., 2009) and modern production techniques (FAO, 2010). Indigenous breed were considered as inferior to the exotic and cross-breed animals but with passage of time the performance of indigenous breed reported was equal to or even better than that of exotic, improved or crossbred animals (Kohler-Rollefson, 2001). In the production system of harsh environmental conditions, the performance of local indigenous breeds is well than exotic breed in term of productivity (Anderson, 2003; Ayalew et al., 2003), although the output is low but the inputs required is also low hence provide better financial returns to the farmer (Scarpa et al., 2003). Indigenous breeds are mainly kept in low-input-low-output production system (Scherf et al., 2005), are hardy, disease resistant, survive on little water, scanty and poor vegetation, have tasty meat and good adaptability to various environments where modern imported exotic breeds unable to exist (Dong Xuan, et al., 2006; Kohler-Rollefson, 2009; FAO, 2010).

Local indigenous breeds those adapted to harsh environment of developing countries have not yet been sufficiently characterized and in the case of their extinction the value lost to human kind is not known (Scherf et al., 2005). It is therefore, necessary first of all to evaluate local breeds for phenotype, special characteristics, performance, and performance potential and crossbred suitability especially in their home tracts and under existing management condition (Swaminathan, 1988; Zarate, 1996). Traditionally external or internal phenotypic characters have been adopted to ascribe a given animal to a breed (Bradley et al., 1993). Phenotypic and genetic characterization of populations, breeds and species is essential for the development of appropriate breeding strategies, sustainable use of the genetic diversity, genetic conservation and assessment of genetic variability (Loftus et al., 1994; Hassen et al., 2007) and thus the variations at molecular level are based on the phenotypic variations among breeds (Babar et al., 2009). Phenotypic as well as adaptive characteristics are important in identifying breed attributes for immediate use by farming communities (Zulu, 2008). The commonly used phenotypic characteristics are morphological (physical and morphometric), productive, reproductive performance, birth and adult body weight of the animals.

Physical and morphological characteristics:

Ranking of animal breeds in a population according to their levels of phylogenetic distribution is done on the basis of morphological characters (Gatesy and Arctander, 2000; Ndumu et al., 2008; Duguma et al., 2010) and morphological characters evaluate breeding goals (Zechner et al., 2001; Zechner et al., 2002; Curik et al., 2003; Pretorius et al., 2004; Dario et al., 2006). In traditional system in which breeding practices are not documented, it determines such goals retrospectively (Rege, 2001), indicating animal size and weight in a simple and less expensive way (Goe et al., 2001). Type and function of animals for beef or dairy purposes and their values as potential breeding stock is also assessed by morphological characters (Brotherstone and Hill, 1991; Fernandez et al., 1997; Luo et al., 1997; Alderson, 1999; Zechner et al., 2001). Colors of the body coat, horns, muzzle, hoof, orientation and/or shape of horn, ears are physical characteristics which provide an insight in the characterization of the animal.

Buffalo coat color

Phenotypic characterization provides a crude estimation of the average of the functional variants of genes carried by a given individual or population and provide base for evaluation of genetic characterization. The information provided through the characterization process helped, decisions making on priorities for the management and further development of animal genetic resource ensuring that these resources are conserved for the needs of present and future generations (FAO, 1992; FAO/UNEP, 1998; Yadav, 2005). In breed characterization importance is given to the traits like color and horns which are least affected by the environment (Mason, 1996) and are used as trademark of the breed (Adalsteinsson et al., 1995; Schmutz et al., 1995). Various coat colors of different breeds of buffalo have been reported in the literature. However, the Coat color of majority of buffalo is black, as in Murrah buffalo (Chavananikul et al., 1993), Nagpuri buffalo (Shrikhande et al., 1996; Sethi, 2003), Mehsana buffalo (Pundir et al., 2000) of India, Nili Ravi buffalo (Khan et al., 2005) and Kundi buffalo (Borghese, 2005; Khan et al., 2005) of Pakistan and Anatolian buffalo of Turkey (Soysal et al., 2007). Light brown, grey brown and black to brown color have also been found in Chinese buffalo (Wenpig, 1998), Lime buffalo breed of Nepal (Rasali, 1998a, b) and Manda buffalo of India (FAO, 2003). Color of Egyptian buffalo is blackish grey (Nigm, 1996; Moioli and Borghese, 2005) where as color of Bhadawari breed of India is copper (Kushwaha et al., 2007). Some buffalo have white marking on various parts of their body like face, legs and switch of tail such as Nagpuri buffalo (Shrikhande et al., 1996) and Nili Ravi buffalo (Khan et al., 2005).

Morphometric characteristics

Morphometric measurements have been used to evaluate the characteristics of the animal that may vary due to the influence of breed evolution, environment, nutrition, sex, age and physiological status and rearing system (Dia Palo et al., 2001; Campanile et al., 2003; Riva et al., 2004; Lazzaroni and Bigini, 2005). Morphometric measurements can be easily measured under field condition and are biologically related to cost traits (Gallo et al., 2001; CGRFA, 2007). Morphometric measurements have been suggested as more objective measures of body conformation of animal (Islam et al., 1991; Janssens and Vandepitte, 2004) which is an important component of breeding and selection decision both in dairy (Schneider et al., 2003) and beef animals (Doren et al., 1989; Arango et al., 2002) and could serve as a guideline in selection of high yielding females particularly in areas where performance records are not available (Jogi and Patel, 1990). The water buffalo of Asia has been classified on morphological and behavioral criteria into two types the River and Swamp buffalo (Lau et al., 1998). However, studies on buffalo with respect to body conformation, productive and reproductive potentialities are very limited, particularly in most local breeds which have been described as non-descript (Khan et al, 2007a; Patro et al., 2008).

Productive performance:

Milk production in buffalo is economically an important trait which contribute 12.5% of the total annual world milk production and provide milk to 50 countries of the world (Tonhati et al., 2008; Khan and Iqbal, 2009; Khan and Niamatullah, 2010). In Asia, 40% of milk (74.5 million tones) is obtained from buffalo (Tonhati et al., 2008; Khan and Iqbal, 2009). On the other hand, in Italy buffalo sustained a powerful dairy industry (Tonhati et al., 2008). In Pakistan 29.9 million buffalo provide 62 percent of milk in the country (Government of Pakistan, 2009). Estimation of milk yield is useful for dairy producers in making management and breeding decision and is essential for genetic evaluation (Ahmad and Sivarajasingam, 1998; Rehman et al., 2006; Quist et al., 2007). Any breed improvement program for dairy performance depends upon exploitation of the genetic variation in milk yield. Hence most of the dairy traits are influenced by genetic and environmental factors. Environmental factors of major importance are parity, season and year of calving. It is therefore necessary to find out the extent of all these factors to estimate the genetic variation among animals to be used to design effective breeding plans for improving ultimate genetic merits of buffalo for dairy production (Javed et al., 2009). Among the traits, 305 days milk production has the greatest influence on the dairy economy and should therefore be considered as the most important trait (Dahlin et al., 1998). Factors influencing milk production is both nature and nurture (Upadhyay et al., 2007; Afzal et al., 2007), age, year of calving, farm, sire, breed, calving season and parity (Mourad and Rashwan, 2001; Catillo et al., 2002; Dhar and Deshpandi, 1995; Yadav et al., 2003; Baharat et al., 2004; Tailer et al., 2006; Afzal et al., 2007; Mishra et al., 2008). Calving season and parity are the most important environmental factors affecting milk production in buffalo (Mourad et al., 1991; Mourad and Rashwan, 2001; Tomar et al., 2006; Afzal et al., 2007; Das et al., 2007; Nagasaku et al., 2007; Nagda et al., 2007; Khan et al., 2008a; Ahmad et al., 2009). Significant effect of parity on milk production was reported by Mourad et al (1991), Mourad and Rashwan (2001) in Egyptian buffalo and Afzal et al (2007) in Nili-Ravi buffalo. However Shafique and Usmani (1996) reported a non-significant effect of parity on milk production in Nili-Ravi buffalo. Similarly significant effect of season on milk production has been reported in Egyptian buffalo (Mourad and Rashwan, 2001), Nili-Ravi (Das et al., 2007; Afzal et al., 2007; Khan et al., 2008a), however Dutt and Yadav (1986) and

Ghaffar et al (1991) reported a non-significant effect of season on milk yield in Nili-Ravi buffalo of India and Pakistan respectively.

Reproductive performance:

Successful reproductive performance is a critical component of profitable dairy enterprise (Garcia-Ispierto et al., 2007) as it affects the amount of milk production per animal per day of herd life (Evans et al., 2006; Bishop and Pfeiffer, 2008). Increased herd longevity (Britt, 1985; Stevenson and call, 1988), availability of replacement stock (Esselmont, 1992) more selective culling and replacements is also associated with reproductive success. Reproductive performance influences the amount of milk produced per animal per day of herd life, breeding, rate of culling and rate of genetic improvement for the traits of economic importance (Evans et al., 2006; Chang et al., 2006). Reproductive performance is influenced by various factors like milk production (Melendez and Pinedo, 2007; Huang et al., 2008), parity (Mureda and Zeleke, 2007; Ansari-Lari and Abbasi, 2008; Soydan et al., 2009), season (Garcia-Ispierti et al., 2006; Soydan et al., 2009), nutrition (Ambrose et al., 2006) and diseases (Grohn and Rajal-Schultz, 2000). There are several indices like first service conception rate and calving interval that can be used to evaluate reproductive efficiency and fertility in dairy animal (Gonzalez-Stagnaro, 2001) and no single trait can adequately summarize reproductive performance (Kanuya et al., 2006). As far as fertility is concerned distribution of data are not always normally held and the traits are expressed differently during life and the traditional measures of fertility are used for assessing fertility (Weigel, 2004) as reliable physiological measures associated with inherent fertility status of dairy animal are not available. The reasons are of a practical nature e.g. multiple measurements per dairy animal during a certain time period are required, or the tests or analyses are too expensive to be used on a large scale. Methodically, fertility measures can be divided into two categories i.e. interval measures and fertility scores. Interval measures are days from calving to first service or heat (postpartum anestrus interval), days open and calving interval (Royal et al., 2000). Fertility scores include non-return to first service and conception at first service. Non-return to first service is determined by whether another service follows within pre-determined days of 56 or 90 days. Reproductive traits of major importance are pubertal age, postpartum anestrus interval, percentage of pregnant buffalo to various numbers of natural service, calving interval and dry period.

Pubertal age:

In dairy animal, puberty has been defined as the age at first standing estrus and is characterized by the first ovulation (Gonzalez-Paddilla et al., 1975; Rawling et al., 2003). The attainment of puberty is the fine adjusting of central and local endocrine balance and its relationship to the cellular events taking place in the organs of the reproductive tract (Presicci, 2007). Pubertal age is considered as an important determinant of reproductive efficiency and for optimum reproductive performance, an early attainment of puberty is of prime importance (Ali and Farooque, 1989; Tegegne et al., 1992). It is generally recognized that buffalo heifer have delayed attainment of puberty and the age at which riverine buffalo heifers attain puberty can be highly variable. Many factors influence age at puberty, such as breed, season, climate, nutrition and growth rate, body condition score and the period of the year at which the animal are born (Tegegne et al., 1992; Abeygunawardena et al., 1994; Rekwot, 2004; Terzano et al., 2007., De Rensis et al., 2008; De Rensis and Driancourt, 2008) male and female bio-stimulation (Rekwot et al., 2000). Raising heifers is the most expensive component of the dairy farm operations with better feeding and management pubertal age can be reduced to 2 years (Bhatti et al., 2007).

Postpartum anestrus interval:

The interval from calving to first estrus is known as postpartum estrus interval (Abeygunawardena and Dematawewa, 2004; Abdalla and Elsheikh, 2008). Prolong postpartum acyclicity and anestrus or subestrus is major sources of economic loss to buffalo dairying. To maintain a calving interval of 13-14 months in buffalo, these events must be accomplished by 60-80 days after calving with successful breeding with in 85-115 days. Hormonal changes during the peri-parturient period besides regulating lactogenesis and parturition also have their impact on postpartum reproductive activity (El-Wishy, 2007). Puerperal uterine soundness is essential for the early establishment of postpartum estrus cyclicity (Tiwari et al., 2004). Postpartum anestrus interval may be effected by several factors such as breed, nutritional plan, milk yield, suckling, uterine involution and season of calving

(Ahmad et al., 1981; Jainudeen et al., 1983; Usmnani et al., 1990; Borghese et al., 1993; Qureshi et al., 1999; Arya and Madan, 2001; Baruselli et al., 2001; Campo et al., 2002). As for as the effect of parity is concerned, a significant decrease of postpartum anestrus interval with increased parity order has been reported (Shah et al., 1989; Afifi et al., 1992; Mahdy et al., 2001). However, non-significant effect of parity was also noted by Kawthar et al (1985), Chaudhry et al (1988) and Suthar and Kavani (1992) in buffalo. The influence of season of calving on postpartum anestrus interval has been studied by various workers. Significant effect of season on postpartum anestrus interval has been reported in Kundi buffalo (Bughio et al., 2000) in Surti buffalo (Sule et al., 2001) and in Brazilian buffalo (Ribeiro et al., 2003). On the other hand Patel et al (1992), Qureshi et al (1999) and Mahdhy et al (2001) reported a non-significant effect on the trait in Mensoni buffalo, Nili-Ravi buffalo and Egyptian buffalo respectively.

Conception efficiency:

According to Fetrow et al (1990) conception efficiency can be measured by the percentage of animal conceived to first, second, third and greater than third service and the first service conception rate is most widely used in this regard. First service conception rate is an important index that measures the ability of the animal to become pregnant after first service and provides a useful estimate of the conception rate for a herd. It is the combined consequence of all events from fertilization to fetal development (Grimard et al., 2006). Various factors influencing conception rate in buffalo are breeding time (Samad et al., 2004; Paul and Parkash, 2005; SAH and Nakkao, 2006), body score condition (Qureshi et al., 2001), disease (Usmani and Mirza, 2000; Ingawal and Dhoble, 2004; Azawi et al., 2008), embryonic death (Samad et al., 2004; Campanil et al., 2007), suckling (Abeygunawardena et al., 1996; Perera and Abeygunawardena, 2000), Cyclic and non-cyclic ovarian condition (Neglia et al., 2003; De Rensis et al., 2004; Ali and Fahmy, 2007), Season (Qureshi, 2002; Samad et al., 2004; Zoheir et al., 2007; Manjunnatha et al., 2008), parity (Berber et al., 2002; Presicce et al., 2004; Thirunavukkarasu and Kathiravan, 2006) and inherent characteristic (Mourad, 1997; Drost, 2007).

Calving interval:

Calving interval in dairy animal is defined as the duration between two consecutive calving (Aurther et al., 1989; Qureshi et al., 1996; Sackey et al., 1999). An ideal calving interval of 12-14 months in buffalo is desirable where as a longer or shorter calving interval is unprofitable (Yadav et al., 2008). The Calving interval is one of the most important parameter to evaluate the productive and reproductive efficiency, economic value and number of calves by lifetime in a farm or in a population (Bettini, 1968; Singh and Lal, 1992; Colmenares et al., 2007). Buffalo have the inherent susceptibility to environmental stress, which causes anestrus and sub-estrus that are responsible for a prolonged calving interval resulting in great economic loss for buffalo dairy industry (Ingawale and Dhoble, 2004). Various factors affecting calving interval are season, parity and year of calving. Regarding the effect of season on calving interval, both significant and non-significant effect has been reported in literature. Colmenares et al., (2007), Hussain, (2007) and Yadav (2008) reported significant effect of season on calving interval in Venezuela buffalo, Murrah buffalo and Nili-Ravi buffalo respectively, whereas, in Murrah buffalo, Parkash et al (1989) and Kandasany et al (1993) reported a non-significant effect of season on calving interval. Parity has also been observed as a significant source of variation in calving interval in Murrah buffalo (Kandasamy et al., 1993; Chhikara et al., 1995). However, Siddique et al (1984) reported a non-significant effect of parity on calving interval in Mehsana buffalo.

Dry period:

Dry period is a non-lactating period incorporated between successive lactations and is vital in dairy buffalo for the recoupment and replacement of exhausted lacteal tissues (Yadav et al., 2008). It allows the mammary epithelial component to regress, proliferate and differentiate which in turn allows maximal milk production to occur during the subsequent lactation (Capuco et al., 1997; Annen et al., 2004). Dry period influences lifetime milk production and is a necessary management practice to maintain profitable milk production in dairy animal (Bachman and Schairer, 2003; Gruummer and Rastani, 2004). In dairy buffalo dry period have marked influence on replacement rate and cost of milk production (Kandasamy et al., 1993). Dry period in buffalo is influenced by various factors including genetic (Das et al., 2007), herd (Tekerli et al., 2001; Yadav et al., 2007; Yadav et al., 2008), age (Das et al., 2007), year (Das et al., 2005; Yadav et al., 2007; Yadav et al., 2008), parity (Zaman, 1996; Bharat et al., 2004; Das et al., 2005), season (Ahmad et al., 1998; Bharat et al., 2004; Das et al., 2005; Yadav et al., 2007; Yadav et al., 2008). Significant effect of parity on dry period was reported by Kandasamy et al (1993) in Murrah buffalo and Bharat et al (2004) in Surti and Mehsana buffalo. However, Das et al (2005) reported non-significant effect of parity on dry period in Swamp buffalo. Similarly significant effect of calving season was reported on dry period in Murrah buffalo (Yadav et al., 2007). However non-significant effect of calving season on dry period was also reported in Nili-Ravi buffalo in Pakistan (Tahir and Sial, 1976).

Calf sex ratio:

To exploit the production potential of any species of the domestic animals, the basic information regarding different reproductive parameters such as ovarian activity, cornual implantation and sex ratio is of prime importance (Rind et al., 1987). Several attempts have been made for increasing the frequency of a desirable sex in animals with out much success. If frequency of a desirable sex is increased, then genetic gain can be maximized through increased intensity of selection (Jogi et al., 1998). Parity, season, month, year and sire vary non-significantly in buffalo calf sex ratio (Govindiah et al., 1985; Rao and Rao, 1996a; Jogi et al., 1998) and sex determination is controlled by genetic factors (Jogi et al., 1998).

Birth weight:

From economic point of view, birth weight in dairy animals is one of the most important factors as it is directly correlated with weight at maturity and can be used as a measure for effective selection. Birth weight is a measure of growth rate and is the first component which can be easily evaluated (Ahmad and Kumbhar, 1975; Dahama et al., 1990; Yadav et al., 2001; Das et al., 2004). Birth weight is influenced by breed (Malik and Ahmad, 1969), sex (Das et al., 2004), parity (Naqvi and Shaami, 1999) and season (Chantalakhana et al., 1984). Rao and Rao (1996b) and Naqvi and Shami (1999) reported significant effect of parity on calf birth weight in Murrah and Nili-Ravi buffalo respectively. Chantalakhana et al. (1984) reported significant effect of season on calf birth weight in Swamp buffalo, whereas, Zaman (1996); Singh et al (2003) and Das etal (2004) reported non-significant effect of season on calf birth weight in Swamp buffalo in Thailand, Swamp buffalo in Asam in India and Swamp buffalo of Assam in India respectively.

In Pakistan, mostly studied buffalo breeds are Nili-Ravi and Kundi and there is 37% of the buffalo population (10.13 million) which is non-descript (Khan et al., 2007b). Although these buffalo breed have been considered as non-descript, however, they are highly adapted to environmental condition of the area and have great potentials. Azikheli is a buffalo breed, in Swat, and acclimatized to the local conditions and is reared by farming communities. Only introductory information about the breed is available emphasizing the scientific characterization of the breed (Jabbar, 1987). It is an important indigenous animal genetic resource of the area and got its name from its original home tract called Azikheil, one of the several tributary valleys of river Swat. The broader home tract includes watershed of River Swat (District Swat) and River Panjkora (District Lower and Upper Dir), District Shangla, Bunair and Malakand agency. Pockets of the breed can also be found in District Mardan, Charsadda, Nowshera and Sawabi as a result of transhumant migration during winter season from upland pastures of District Swat and Dir. This breed needs characterization, description and improvement for sustainable future use in the adapted area. The present investigation is thus designed to study Azikheli buffalo breed with the following objectives:

1. To determine morphological and morphometric characteristics of Azikheli buffalo
2. To study reproductive performance of Azikheli buffalo under traditional management system.
3. To explore the productive traits of Azikheli buffalo under traditional management system.

MATERIALS AND METHODS

Study area.

Swat valley is situated at 34.4^{o} and 35 ^{o} North and 72 ^{o} and 74.6 ^{o} East, covers an area of 8220 square kilometers and elevation above mean sea level varies from 600 meters in the south to 6000 meters in the north; with a human population of 12,49,572, (Census, 1998). There are two main rainy seasons from the end of December to the end of April and from the end of July to mid September and the annual precipitation in Azikheil has a range of 1000-1750 mm/ year. July is the hottest and January is the coolest month of the year. The temperature is, however, not uniform and inversely varies with increasing elevation; however, it never goes above 38 C^{o} and bellow -10 C^{o}. The two main dry seasons are from the end of May to mid July and start of October to the end of November. Such an enormous spatial and temporal seasonal variation compels the residents to evolve a complex farming system and settlement pattern, based upon the provisions of relief and climate and labor requirements for obtaining a particular amount of output from a unit of natural resource base (Ur-Rahim and Viaro, 2002).

Khwazakhela valley (Azikheil) of Swat District was selected as the study area which is a central location in the original home tract of the Azikheli buffalo (Fig 1). This is one of the most fertile valley of Swat and lying at a distance of about 20 kilometers from Mingora, the head quarter of Swat district. Valley is almost 30 kilometer long and 20 kilometers wide. Major crops are wheat, rice and maize whereas; apple, fersimen (Dyospirus kaki) and shaftalo (Prunus persicum) are the main orchards. Different ethnic groups mostly occupy different ecological niches/units hence landowners are dominant in valley bottom, tenants on hill slopes and hilltops with cropping potentials and Gujar (settled livestock herders with cattle and buffalo herders; Ur-Rahim and Viaro, 2002) at hill slope and hill tops with grazing potentials. This stratification, however, is not strict/ water tight compartment and tenants and Gujars may be present in specific location in valley bottom and landowners at hill slope and hilltops. For this study the season was classified as autumn (September-October, temperature 24-26 C^{o}), winter: (November-February, temperature zero to minus eight C^{o}) spring (March-April, temperature 22-24 C^{o}), summer (May-August, temperature 21-38 C^{o} ; Urdu Tourists Guide).

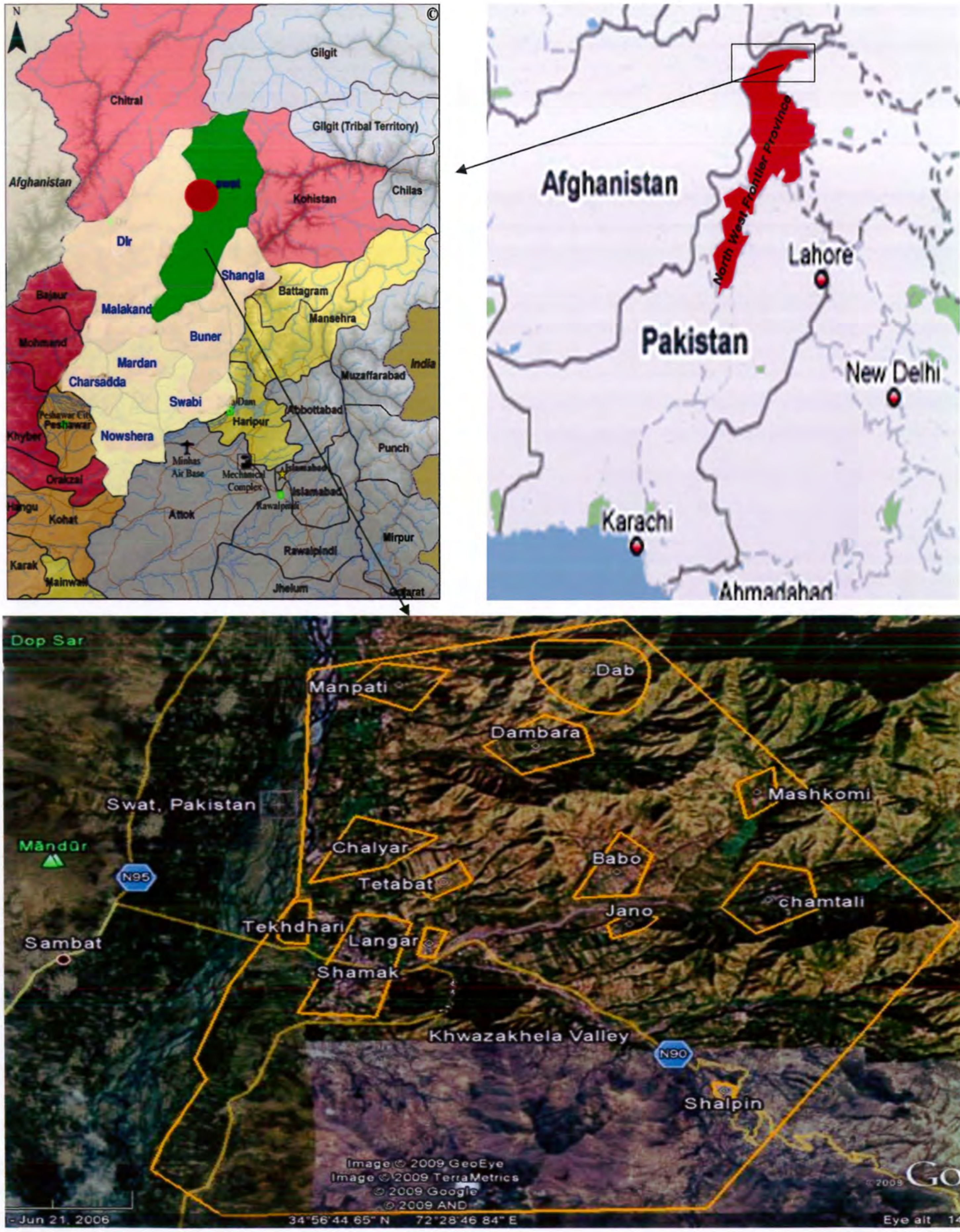


Fig. 1: Map of Khwazakhela District Swat, NWFP Pakistan. The encircled regions represents the sampling areas.

Identification of Azikheli buffalo breed:

Farmers who rear Azikheli buffalo since long and are well aware of the breed were identified in the study area through discussion with the officials of the Department of Livestock and Dairy Development District Swat. Meeting with farmers of Azikheli buffalo were conducted for identification of Azikheli buffalo breed. Salient features of the Azikheli buffalo known in the farmers communities were brown coat colors, short tail, blue colored shining eyes, with horns bent backward and upward without twisting which differentiate it from other breed of buffalo in the country.

Data collection on morphological and productive characteristics

Selection of Azikheli buffalo and bulls:

i. Azikheli buffalo cows: On the bases of parity thirty six Azikheli buffalo cows each from first, second and third parity (n=108) were randomly selected from Khwazakhela valley of District swat, NWFP during last month of pregnancy.

ii. Azikheli buffalo bulls: A total of 27 Azikheli buffalo bulls were also randomly selected from Khwazakhela valley of District Swat, NWFP for the morphological study including physical and morphometric characteristics.

Morphological characteristics:

Data on physical and morphometric characteristics was collected as per standard procedure of random sampling (FAO; 1986) from both Azikheli buffalo cows and buffalo bulls.

i. Physical characteristics: Physical characteristics like color of the coat; forehead, eyelashes, eyes, horn, muzzle, forelegs, hind legs and hooves on each animal were recorded.

ii. Morphometric characteristics: The following morphometric measurements (cm) were taken using measuring tape with animals standing on flat surface in normal position. In case of buffalo cows, measurements were taken within two to three months after parturition and adult bulls were also measured. The morphometric studies conducted were as follows which are also shown in Fig 2.

1. Heart girth, body length, height at wither and height at hipbone.

2. Head region: Measurements taken in head region were width of head between horns, width of head between eyes, ear length and width and face length.

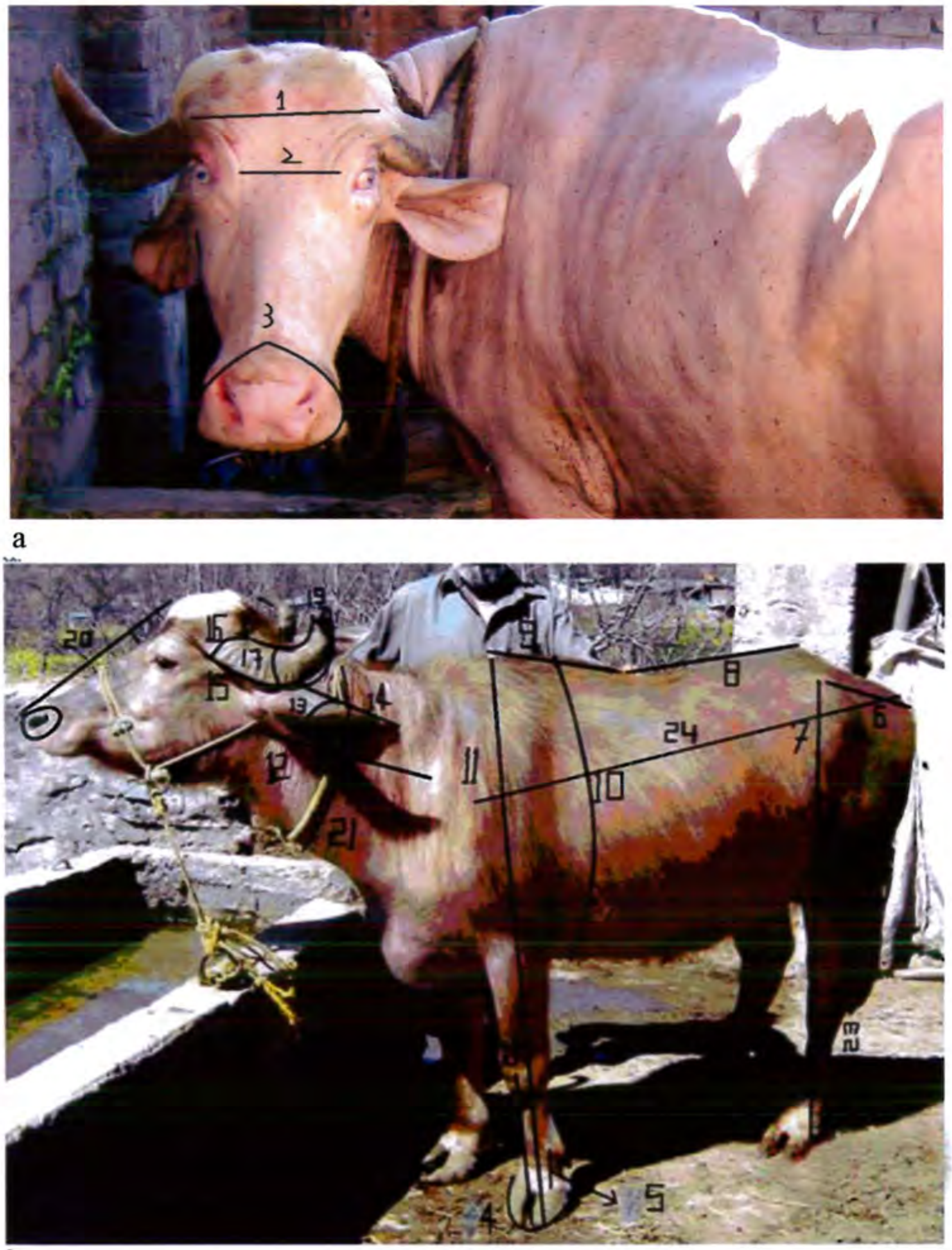
3. Horns: Measurements taken were length of horn at greater and small curvatures, circumference of horn base, mid and below tip

4. Neck: Measurements taken were neck length and circumference of neck at middle region

5. Back: Measurements taken were loin length (length from last rib to hipbone) and chine (length from wither to last rib).

6. Rump: Measurements taken were rump length (length from hipbone to pin bone) and width (distance between hipbone).

7. Legs: Measurements taken were height of the leg bellow knee and hock, height of pastern, hoof circumference and tail length.



a

b

Fig 2: Labelled diagram of Azikheli buffalo showing various body parts measured in this study **(a)** 1) width of head between horns 2) width of head between eyes 3) muzzle **(b)** 4) hoof circumference 5) pastern 6) rump length 7) hip height 8) loin length 9) chine 10) heart girth 11) height at wither 12) nick length 13) ear width 14) ear length 15) length of horn at greater curvature 16) horn base circumference 17) horn mid circumference 18) horn length at smaller curvature 19) horn circumference below tip 20) face length 21) nick circumference 22) height of fore leg below knee 23) height of hind leg below hock (24) body length.

Productive performance

On the bases of parity thirty six Azikheli buffalo cows each from first, second and third parity (n=108) were randomly selected from Khwazakhela valley of District swat, NWFP during last month of pregnancy. Selected lactating Azikheli buffalo cows were stall-fed and offered water twice daily morning and evening. Feeding components include wheat straw, rice straw, green fodders (barseem, shaftal (Trifolium alexendrianum) and barley), concentrates (cotton seed cakes, wheat brans) and weed thinning during spring season. In hot dry summer no green fodder is available while in autumn and winter hay is included in the feeding regime of the buffalo. They are housed either in small farms specially constructed in the farming land near the human settlement, separate rooms with a small paddock attached to human settlement and even inside the homes. In former case, the herd may be of a single farm family or comprises of 3-5 farm families. Herd was totally managed by male member of the family; however, females are only involved in preparation of concentrate (locally called Paira) for lactating buffalo cows in case where the housing is near to or inside the homes. Calves were fed two quarters of the udder during first month, one quarter during second and half quarter during third month of life. After third month, calf is only allowed to suckle the dam for milk let down. Calves are maintained in the vicinity of buffalo cows. Calves were used for birth weight and sex ratio in this study. Routine vaccination, deworming and other veterinary health care is practiced. Farmers were supported with incentives in the form of dewormer, mineral supplements and vaccination. The Azikheli buffalo cows were hand-milked twice a day; in the morning and evening. Calves were first allowed just to suck the teats as a stimulus for milk let down. Calves were then separated from buffalo and kept in the vicinity of milking place. Udder was washed and completely emptied and milk obtained was then measured in calibrated cylinder. Milk recording was carried out according to ICAR A4/2 method in which milk is recorded in the morning and evening on the same day at an interval of 4 weeks (ICAR, 2004). Milk was recorded from parturition till 305th day of lactation as the accepted standard length for a lactation record is 305 days (Sane et al., 1972; Mourad and Mohammed, 1995) with first record within first two weeks of parturition. Milk recording was carried out with the help of enumerators 4 in numbers. Morning and evening milk was added to obtain daily milk yield for individual buffalo. Methodology for projecting lactation records by estimating milk yield for the unknown part of lactation from last test day milk yield is presented by (Akram, 1997; Khan, 1997) the formula for 305-day milk yield estimation used was: Lactation milk yield = Known milk yield+ Estimated milk yield. Lactation milk yield is the estimated 305-day milk yield, known milk yield is milk yield recorded for the known lactation period and estimated milk yield is milk yield estimated for the unknown part of lactation length. The estimation of milk yield for the unknown part of lactation length is done from the information (milk yield) at the last recording i.e., the last test day, and the equations developed for such purpose for Nili-Ravi buffalo are given below.

$\hat{Y}_{305} = Y_t + [\alpha + \beta X_i]$ (305-DIM).

$\hat{Y}_{305}$= Predicted 305-day lactation milk yield

Y_t = Known milk yield or milk yield available to-date (up to the last test day)

α = Intercept for any lactation stage

β = Regression coefficient for any lactation stage

X_i = Milk yield (liters) on the last test day

DIM= days in milk

305-day milk production:

On the basis of parity thirty six Azikheli buffalo cows each from first, second and third parity (n=108) were randomly selected from Khwazakhela valley of District swat, NWFP during last month of pregnancy. Data were also grouped according to calving season and milk production of 108 buffalo was thus available for analysis with 08 buffalo calved in spring season, 64 in summer, 25 in autumn and 11 in winter season. Daily milk yield based on standard 305-day lactation period was also calculated.

Reproductive performance:

Data on reproductive performance were collected of Azikheli buffalo from farmers rearing Azikheli buffalo randomly selected through pre-designed tested questionnaires (annexure). Data were grouped according to parity and season for the study of both these effects. The low number of record for season effect was due to unavailability of information on calving season of the buffalo cows. Data collected for pubertal age was recorded on 450 buffalo cows. For postpartum estrus interval 483 buffalo cows were recorded for parity effect and 388 buffalo cows for season effect. Buffalo cows recorded for percentage of pregnant buffalo cows were 429 in number. Data on calving interval for parity effect was based on 303 buffalo cows and for season effect on 278 buffalo cows. Information on dry period was obtained from 445 buffalo cows for parity effect and 364 buffalo cows for season effect. The following reproductive traits were recorded.

i. Pubertal age: Pubertal age in Azikheli buffalo was taken as the age at first estrus based on bellowing and mucus discharge from vulva and pubertal age of 450 buffalo was available for analysis of the present study.

ii. Postpartum anoestrus interval: Postpartum anoestrus interval was considered as the interval from calving to first observed estrus. On parity basis mean postpartum anoestrus interval for the present study was recorded for 483 buffalo cows with 194 buffalo cows between first and second parity, 211 buffalo cows between second and third parity, 66 buffalo cows between third and fourth parity and 12 buffalo cows between fourth and fifth parity. Data was also grouped according to calving season and postpartum anoestrus interval of 365 buffalo cows was thus available for analysis with 73 buffalo cows calved in spring season, 233 in summer, 29 in autumn and 53 in winter season.

iii. Conception efficiency.

Conception efficiency of Azikheli buffalo cows was calculated as the number of Azikheli buffalo cows conceived to any number of service (first, second, third, fourth and more than fourth (fifth and sixth) divided by total number of buffalo cows provided with natural service × 100 (Fetrow et al., 1990) and was expressed as the percentage of Azikheli buffalo cows conceived after availing first, second, third, fourth and more than fourth (fifth and sixth) natural services. Data for 429 Azikheli buffalo cows was available for this trait.

iv. Calving interval.

Calving interval was taken as the interval between the last two successive calvings. On parity basis mean calving interval for the present study was calculated for 303 buffalo cows with 144 buffalo cows between first and second parity, 102 buffalo cows between second and third parity, 45 buffalo cows between third and fourth parity and 12 buffalo cows between fourth and fifth parity. Data was also grouped according to calving season and calving interval of 278 buffalo cows was thus available for analysis with 50 buffalo cows calved in spring season, 169 in summer, 23 in autumn and 36 in winter season.

v. Dry period. Dry period was taken as the non-lactating period between the last two successive calvings. On parity basis mean dry period for the present study was calculated for 445 buffalo cows with 183 buffalo cows between first and second parity, 190 buffalo cows between second and third parity, 60 buffalo cows between third and fourth parity and 12 buffalo cows between fourth and fifth parity. Data was also grouped according to calving season and calving interval of 364 buffalo cows was thus available for analysis with 66 buffalo cows calved in spring season, 223 in summer, 26 in autumn and 49 in winter season.

Calf sex ratio

Sex of 507 calves including 108 calves born to buffalo cows registered for milk yield recording and 399 calves recorded during farmer interview through questionnaire for reproductive performance were used to calculate calf sex ratio. On parity basis sex ratio for the present study was calculated for 507 buffalo calves with 209 buffalo calves between first and second parity, 198 buffalo calves between second and third parity, 89 buffalo calves between third and fourth parity and 11 buffalo calves between fourth and fifth parity. Data was also grouped according to calving season and calving interval of 507 buffalo calves was thus available for analysis with 83 buffalo calved in spring season, 304 in summer, 54 in autumn and 66 in winter season.

Birth weight

Calves born to buffalo registered for milk recording were weighed within 24 hours after birth with a portable balance. Weight was expressed in kilogram. Birth weight of 99 calves was available for analysis.

Male birth weight:

On parity basis male birth weight for the present study was calculated for 50 buffalo male calves with 16 buffalo male calves in first parity, 19 buffalo male calves in second parity, 15 buffalo male calves in third parity. Data was also grouped according to calving season and calving interval of 50 buffalo male calves was thus available for analysis with 3 buffalo male calves in spring season, 27 in summer, 12 in autumn and 8 in winter season.

Female birth weight:

On parity basis female birth weight for the present study was calculated for 49 buffalo female calves with 19 buffalo female calves in first parity, 14 buffalo female calves in second parity, 16 buffalo female calves in third parity. Data was also grouped according to calving season and calving interval of 49 buffalo female calves was thus available for analysis with 5 buffalo female calves in spring season, 31 in summer, 11 in autumn and 2 in winter season

Statistical analysis

Mean, standard error and Student's t-test were calculated for various comparisons. Chi-square test and analysis of variance was also performed using GraphPad Prism-5 (GraphPad Software, San Deigo, CA).

RESULTS

This study was carried out on 618 Azikheli buffalo and bulls. The recorded parameters were morphological characteristics, milk production and reproductive performance. Morphometric characteristics of 135 Azikheli buffalo and bulls were studied. Reproductive performance included pubertal age (n= 450), postpartum estrus interval (n= 483), percentage of Azikheli buffalo conceived after various number of natural services (n= 429), calving interval (n= 303) and dry period (n= 445).

Morphological characteristics:

Morphological characteristics included physical and morphometric characteristics. This study was carried out on 135 buffalo of which 108 were buffalo and 27 were buffalo bulls from Khwazakhela valley (Azikheil) of District Swat, NWFP, Pakistan.

Physical characteristics:

Physical characteristics studied were color patterns of the coat, forehead, eyelashes, eyes, horns, muzzle, forelegs, hind legs and hoof.

Color pattern:

Coat:

Four distinct coat colors were observed in Azikheli buffalo breed namely brown (Fig. 3 a, b), black (Fig. 4 a, b), black and white (Fig. 5 a, b) and pure white (Fig. 6 a, b) both in buffalo and bulls (Table 1). The prevailing higher percentage of coat color in buffalo was brown, followed by black and; black and white. Completely white coat color was noted only in 5 buffalo. Bull also follow the same coat color pattern as in buffalo with brown color, black and; black and white in 4% (n=1) in descending order of percentage. Completely white coat color was observed only in 4% (n=5) bulls. Sex differences for the prevalence of brown coat color ($\chi^2_{(2)}$ =0.07; P=0.96), black, ($\chi^2_{(2)}$ =0.65; P=0.72), black and white ($\chi^2_{(2)}$ =0.35; P=0.83) and white was statistically not significant ($\chi^2_{(2)}$ =2.40; P=0.30).

a.

b

Fig 3: Brown coat color (a) Azikheli buffalo cow (b) buffalo bull

a

b

Fig 4: black coat color (a) Azikheli buffalo cow (b) Azikheli buffalo bull

a

b

Fig 5: Black and white coat color (a) Azikheli buffalo cow (b) buffalo bull

a

b

Fig 6: White coat color (a) Azikheli buffalo cow (b) buffalo bull

Table 1: Coat color pattern of Azikheli buffalo and bull in Khwazakhela valley of District Swat, NWFP, Pakistan

Sex	Color pattern	No	%
Buffalo (108)	Brown	(67)	62.04
	Black	(24)	22.22
	Black and white	(12)	11.11
	White	(05)	04.63
Bulls (27)	Brown	(16)	61.00
	Black	(06)	22.00
	Black and white	(04)	13.00
	White	(01)	04.00

( ) = Number of buffalo / bull.

Color of the forehead:

Forehead color was white in this breed (Fig.7 a), however, white spotted forehead (Fig.7 b) and white color of forehead extended to nose bridge (Fig.7 c) was also noted (Table 2). Based on coat color and color of forehead, buffalo are locally termed as "Sara Chargai"means brown coat color with completely white forehead and are considered the most preferred. The other is "Sara Tikai" referred to brown coat color with white spot on forehead. The term "Tora Chargai" is used for buffalo with black coat color and white forehead. Tora Tikai is the buffalo with black coat color and white spot on forehead.

Out of 108 Azikheli buffalo, the forehead of 61% (n=66) buffalo was completely white; forehead of 30% (n=32) buffalo was with white spot and 9% (n=10) was with white color forehead extended to nose bridge. Among 27 bulls, the forehead of 55.56% (n=15) bulls was completely white, forehead of 29% (n=8) bulls was with white spot and 14.81% (n=4) bulls were with white color forehead extended to nose bridge (Table.3.2). Sex differences for the prevalence of completely white color ($\chi^2_{(2)}$ =0.41; P=0.81), white spotted ($\chi^2_{(2)}$ =1.01; P=0.05) and white color forehead extended to nose bridge ($\chi^2_{(2)}$ =0.058; P=0.97) was not statistically different.

Color of eyelashes:

Various colours of eyelashes observed in Azikheli buffalo and bulls were white (Fig. 8 a), black (Fig. 8 b), brown (Fig. 8 c) and reddish with black tinge (Fig. 8 d). Out of 108 buffalo, eyelash color of 50% (n=54) buffalo was white; 28% (n=30) was with black eyelash color; 17% (n=19) buffalo were with brown and 4.63% b (n=5) buffalo were reddish with black tinge. Among 27 bulls, eyelash color of 44.44% (n=12) bulls was white; 29.63% (n=8) were black; 22.22% (n=6) were brown and 3.70% b (n=1) were reddish with black tinge (Table.3.2). Sex of Azikheli buffalo has no significant effect on the prevalence of white color ($\chi^2_{(2)}$ =0.43; P=0.81), black ($\chi^2_{(2)}$ =0.27; P=0.87), brown ($\chi^2_{(2)}$ =0.17; p=0.92) and reddish with black tinge ($\chi^2_{(2)\ 2}$ =1.2; p=0.55) of eyelashes in Khwazakhela valley, of District Swat, NWFP.

Shape and color of eyes:

Eyes are oval shaped and are located beneath the origin of the horn from forehead. Blue (Fig. 9 a) shinning eyes were mostly observed however black color (Fig. 9 b) eyes were also noted. Out 0f 108 Azikheli buffalo, the eyes of 80% (n=86) buffalo were blue shining and that of 20% (n=22) were black in color. Among 27 bulls, the eyes of 76% (n=21) bulls were blue shining and that of 24% (n=6) were black in color (Table. 2). Sex differences for the prevalence of blue shining eye color ($\chi^2_{(2)}$ =0.35; P=0.84) and black color was not significant ($\chi^2_{(2)}$=1.21; P=0.54).


a. b.

c.

Fig.7: Spotting pattern of forehead of Azikheli buffalo (a) completely white (b) white spotted (c) white spotted extended to nose bridge.

a b c. d

Fig, 8: Colors of the eyelashes of Azikheli buffalo (a) white (b) black (c) brown (d) reddish with black tinge

a b.

Fig 9: Eye colors of Azikheli buffalo (a) blue shining (b) black

Table 2: Color pattern of the forehead, eyelashes and eyes in Azikheli buffalo and bull in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Colors	No	%
Buffalo (108)	Forehead	Completely white	(66)	61.00
		White spotted	(32)	30.00
		White color forehead extended to nose bridge	(10)	09.00
	Eyelashes	White	(54)	50.00
		Black	(30)	28.00
		brown	(19)	17.00
		Reddish and black tinge	(05)	04.63
	Eyes	Blue shinning	(86)	80.00
		Black	(22)	20.00
Bulls (27)	Forehead	Completely white	(15)	55.56
		White spotted	(08)	29.63
		WCF extended nose bridge	(04)	14.81
	Eyelashes	White	(12)	44.44
		Black	(08)	29.63
		brown	(06)	22.22
		Reddish and black tinge	(01)	03.70
	Eyes	Blue shinning	(21)	76.00
		Black	(06)	24.00

( ) = Number of buffalo / bull.

Shape and color of horns:

Horns are flat laterally and directed backward and slightly upward without twisting. Upward turning is variable and gives a sickle or semi sickle appearance to the horn. Mostly color of the horns observed in this breed was black (Fig. 10 b) however brown (Fig. 10 a), brown with black tip (Fig.10 c) and black with brown tip (Fig. 10 d) were also noted (Table 3). Out of 108 buffalo, horn color of 34% (n=37) buffalo was completely brown, 52% (n=56) buffalo were with black color horn, 9% (n=10) buffalo were brown with black tip horn and 4.63% (n=5) buffalo were black with brown tip horns.

Among 27 bulls, horn color of 29.63% (n=8) of bulls was completely brown, 51.85% (n=14) bulls were with black color horn, 11.11% (n=3) bulls had brown color horn with black tip and 7.41% (n=2) bulls possessed black horn with brown tip (Table 3). Sex of buffalo was not a significant source of variation for the prevalence of completely brown color ($\chi^2_{(2)}$ =0.10; P=0.95), black ($\chi^2_{(2)}$ =0.02; P=0.99), brown with black tip ($\chi^2_{(2)}$ =0.04; P=0.98) and black with brown tip ($\chi^2_{(2)}$ =1.28; p=0.53) horn color pattern.

Color of muzzle:

Mostly color of muzzle was white (Fig. 11 a) in this breed, however, black (Fig. 11 b), black and white (Fig. 11 c) and light black pigmented to whitish pigmented were also noted. Out of 108 buffalo, muzzle color of 55% (n=60) buffalo was white, 16% (n=17) buffalo were with black muzzle, 15% (n=16) buffalo were with black and white color muzzle and 14% (n=15) buffalo were with light black pigmented to whitish pigmented color of muzzle. Among 27 bulls, muzzle color of 51.85% (n=14) bulls was white, 18.51% (n=5) bulls were with black color muzzle, and 41.81% (n=4) bulls were with black and white color muzzle and 14.81% (n=4) bulls were with light black pigmented to whitish pigmented color of muzzle (Table 3). Sex differences for the distribution of white color ($\chi^2_{(2)}$ =0.09; P=0.95), black ($\chi^2_{(2)}$ =0.04; P=0.98), black and white ($\chi^2_{(2)\ 2}$ =0.95; P=0.62) and light black pigmented to whitish pigmented was not significant ($\chi^2_{(2)}$ =0.43; P=0.80).

a. b. c. d.

Fig 10: Colors of the horns of Azikheli buffalo (a) completely brown (b) black (c) brown with black tip (d) black with brown tip

a. b.

c.

Fig 11: Colors of the muzzle of Azikheli buffalo (a) white (b) black (c) black and white

Table 3: Color pattern of horns and muzzle in Azikheli buffalo and bull in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Colors	No	%
Buffalo (108)	Horns	Completely brown	(37)	34.00
		Black	(56)	52.00
		Brown with black tips	(10)	09.00
		Black with brown tips	(05)	04.63
	Muzzle	White	(60)	55.00
		Black	(17)	16.00
		Black and white	(16)	15.00
		Light black pigmented to whitish pigmented	(15)	14.00
Bulls (27)	Horns	Completely brown	(08)	29.63
		Black	(14)	51.85
		Brown with black tips	(03)	11.11
		Black with brown tips	(02)	07.41
	Muzzle	White	(14)	51.85
		Black	(05)	18.51
		Black and white	(04)	41.81
		Light black pigmented to whitish pigmented	(04)	14.81

( ) = Number of buffalo / bull

Shape and color of forelegs:

Legs are strong and well built. Front legs are almost straight, whereas, hind legs have medium angularity. Mostly forelegs were white bellow knee (Fig. 12 a) in this breed however completely white forelegs (Fig. 12 b) and black and white forelegs (Fig. 12 c) were also noted (Table 4). Out of 108 buffalo, forelegs of 75% (n=81) buffalo was white bellow knee, 10% (n=11) buffalo were with completely white forelegs and 15% (n=16) buffalo were with black and white forelegs. Among 27 bulls, forelegs of 70.37% (n=19) bulls was white bellow knee, 7.41% (n=2) bulls were with completely white forelegs and 22.22% (n=6) bulls were with black and white forelegs (Table 4). No significant effect of buffalo sex was observed on the prevalence of white color below knee ($\chi^2_{(2)}$ =0.13; P=0.93), completely white color of foreleg ($\chi^2_{(2)}$ =1.09; P=0.58) and black and white color of foreleg ($\chi^2_{(2)}$ =0.99; P=0.61).

Color of hind legs:

Mostly hind legs were white bellow hock (Fig. 13 a) in this breed. However, completely white hind leg (Fig. 13 b) and black and white (Fig.13 c) hind legs were also noted. Out of 108 buffalo, hind legs of 66% (n=71) buffalo was white bellow hock, 15% (n=516) buffalo were with completely white color hind legs and 19% (n=21) buffalo were with black and white color hind legs. Among 27 bulls, hind legs of 59.26% (n=16) bulls was white bellow hock, 18.52% (n=5) bulls were with completely white color hind legs and 22.22% (n=6) bulls were with black and white color hind legs (Table 4). Sex differences for the prevalence of white color bellow hock ($\chi^2_{(2)}$ =0.09; P=0.98), completely white ($\chi^2_{(2)}$ =0.26; P=0.87) and black and white ($\chi^2_{(2)}$ =0.41; P=0.81) was not significantly different

Color of hoof:

Color of hoof observed were mostly brown in this breed (Fig. 14 a) however black (Fig. 14 b) and brown with black striation (Fig. 14 c) were also noted. Out of 108 buffalos, hoof of 60.19% (n=65) buffalo was brown, 37.04% (n=4) buffalo were with black hoof and 2.77% (n=3) buffalo were brown with black striation hoof. Among 27 bulls, hoof of 55.55% (n=15) bulls was brown, 40.74% (n=11) bulls were with black hoof and 3.70% (n=1) bulls were brown with black striation hoof (Table 4). Sex of the buffalo was not a significant source of variation in the distribution of brownish color

($\chi^2_{(2)}$ =0.21; P=0.89), black ($\chi^2_{(2)}$ =0.33; P=0.85) and brown with black striation ($\chi^2_{(2)}$ =4.00; P=0.13).color of hoof in Azikheli buffalo breed in Khwazakhela valley, District Swat.

a

b.

c

Fig 12: Colors of the foreleg of the Azikheli buffalo (a) white bellow knee (b) completely white (c) black and white

a

b

c

Fig13: Colors of the hind leg of Azikheli buffalo (a) white bellow hock(b) completely white (c) black and white

Fig 14: Colors of the hoof of Azikheli buffalo (a) brownish (b) black (c) brownish with black striation

Table 4: Color pattern of hoof, fore legs and hind legs in Azikheli buffalo and bull in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Colors	No	%
Buffalo (108)	Forelegs	White below knee	(81)	75.00
		Completely white	(11)	10.00
		Black and white	(16)	15.00
	Hind legs	White below hock	(71)	66.00
		Completely white	(16)	15.00
		Black and white	(21)	19.00
	Hoof	Brown	(65)	60.19
		Black	(40)	37.04
		Brown with black striation	(03)	02.77
Bulls (27)	Forelegs	White below knee	(19)	70.37
		Completely white	(02)	07.41
		Black and white	(06)	22.22
	Hind legs	White below hock	(16)	59.26
		Completely white	(05)	18.52
		Black and white	(06)	22.22
	Hoof	Brown	(15)	55.55
		Black	(11)	40.74
		Brown with black striation	(01)	03.70

( ) = Number of buffalo/ bull

Morphometric characteristics:

This study was conducted on 135 buffalo out of which 108 were buffalo and 27 were buffalo bulls. Morphometric measurements taken were heart girth, body length, height at wither, height at hipbone, head, horn, neck, back, rump, legs, and tail.

Heart girth, body length, height at withers (from hoof to shoulder girdle) and height at hipbone:

Mean heart girths, body length, height at withers and height at hip bone of Azikheli buffalo and bulls is shown in Table 5. Azikheli buffalo have significantly ($t_{(133)} = 4.36$; $P<0.001$) larger heart girth size than buffalo bull. Azikheli buffalo were also taller at wither than bulls, however, the difference is statistically not significant ($t_{(133)} = 1.108$; $P>0.05$). On the other hand, Azikheli buffalo bulls have significantly ($t_{(133)} = 3.28$; $P< 0.001$) long body than buffalo. Azikheli buffalo bulls were also taller at hip bone than buffalo but the difference was statistically not significant ($t_{(133)} = 0.75$; $P > 0.05$).

Table 5: Measurements (cm) of heart girth, body length, height at withers and height at hip bone of Azikheli buffalo and bulls in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Mean	Range
Buffalo (108)	Heart girth	191.36±1.26	149.86-223.52
	Body length	140.39±0.94	114.30-167.64
	Height at wither	131.35±0.57	119.38-147.32
	Height at hip bone	123.41±0.41	111.76-137.16
Bulls (27)	Heart girth	177.68±3.76 ^{a***}	136.25-205.74
	Body length	147.89±2.60 ^{a***}	117.58-164.25
	Height at wither	130.01±0.78	118.11-134.69
	Height at hip bone	124.08±0.67	116.84-129.56

Mean±SE

a = Azilkheli buffalo vs bulls

P<0.001 ***

Head region:

Measurements of head region like width of head between horns, width of head between eyes, ear length and width, and face length are presented in Table 6. Azikheli buffalo have wider head region between horns and between eyes than bulls. However, the difference for the former was statistically not significant, whereas for the later it was significant ($t_{(133)} = 3.28$; $P<0.001$). Compared to buffalo, bulls have longer and wider ears and long face than buffalo, but the difference for these measurements was also statistically not significant.

Table 6: Measurements (cm) of head region of Azikheli buffalo and bulls in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Mean	Range
Buffalo (108)	Width of head between horns	22.74±0.27	17.78-30.48
	Width of head between eyes	20.37±0.13	17.15-22.86
	Ear length	21.39±0.18	17.78-30.48
	Ear width	16.46±0.12	15.24-20.32
	Face length	52.45±0.2	45.72-63.50
Bulls (27)	Width of head between horns	22.15±0.47	20.16-30.48
	Width of head between eyes	19.43±0.32 [a***]	17.18-23.54
	Ear length	22.80±0.23	20.32-24.86
	Ear width	16.86±0.21	15.24-19.05
	Face length	52.67±0.55	47.42-58.42

Mean±SE

a = Azilkheli buffalo vs bull

P<0.001 ***

Horns:

Mean length of the horn along the grater and smaller curvature and circumference at base, mid region and below the tip of Azikheli buffalo and buffalo bull is presented in Table 7. Azikheli buffalo have significantly longer horn (both along greater curvature; $t_{(133)} = 3.13$; $P<0.001$ and smaller curvature; $t_{(133)} = 3.53$; $P<0.001$) than Azikheli bulls. However, Azikheli bulls have significantly ($t_{(133)} = 5.13$; $P<0.001$) thicker horns at base than Azikheli buffalo. Horn circumference at mid region and tip was not significantly different in both sexes.

Table 7: Measurements (cm) of horns of Azikheli buffalo and bulls in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Mean	Range
Buffalo (108)	Horn greater curvature	42.52±1.02	24.13-68.58
	Horn smaller curvature	27.55±0.82	15.24-45.72
	Horn base circumference	22.60±0.22	17.78-27.94
	Horn mid region circumference	20.13±0.22	13.97-25.40
	Horn below tip circumference	7.63±0.13	05.08-12.70
Bulls (27)	Horn greater curvature	35.7±1.36 ^{a***}	24.13-50.80
	Horn smaller curvature	21.62±0.68 ^{a***}	13.97-27.94
	Horn base circumference	25.12±0.41 ^{a***}	21.45-30.48
	Horn mid region circumference	20.83±0.31	16.51-23.46
	Horn below tip circumference	7.13±0.21	05.08-08.89

Mean±SE

a = Azilkheli vs bull

$P<0.001^{***}$

Neck region:

Neck length and circumference of Azikheli buffalo and bulls is shown in Table 8. Azikheli buffalo have significantly ($t_{(133)} = 2.57$; $P < 0.05$) longer but narrow neck ($t_{(133)} = 5.09$; $P<0.001$) than Azikheli buffalo bulls.

Table 8: Measurements (cm) of neck region of Azikheli buffalo and bulls in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Mean	Range
Buffalo	Neck length	42.57±0.37	35.36-53.34
(108)	Neck circumference	89.60±0.61	73.66-101.6
Bulls	Neck length	40.50±0.57 [a*]	34.58-45.72
(27)	Neck circumference	97.32±1.81 [a***]	71.12-114.3

Mean±SE

a = Azilkheli buffalo vs bull

P<0.05 *

P<0.001 ***

Back region:

Measurement of the back region like chine length and loin length are shown in Table 9. Azikheli buffalo bull have longer chine than buffalo, whereas, loin was longer in buffalo compared to bulls. However, there was no significant difference in chine and loin length between both sexes.

Table 9: Measurements (cm) of back region of Azikheli buffalo and bulls in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Mean	Range
Buffalo	Loin length	35.97±0.36	25.40-43.18
(108)	Chine	45.95±0.54	35.56-66.04
Bulls	Loin length	34.55±0.55	28.45-43.18
(27)	Chine	46.76±0.80	38.10-55.88

Mean±SE

Rump region:

Mean rump length and rump width of Azikheli buffalo and bulls is presented in Table 10. Azikheli buffalo have shorter but wider rump than bulls but the difference for both measurements was statistically non-significant between buffalo and bulls.

Table 10: Measurements (cm) of rump of Azikheli buffalo and bulls in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Mean	Range
Buffalo	Rump length	41.45±0.31	33.02-48.26
(108)	Rump width	51.03±0.37	41.91-58.42
Bulls	Rump length	42.03±0.39	38.10-45.72
(27)	Rump width	50.43±0.59	44.45-55.88

Mean±SE

Legs region:

Height below knee, height below hock, height of pastern and hoof circumference of Azikheli buffalo and bulls is shown in Table 11. Azikheli bulls had longer front leg bellow knee joint and hind leg bellow hock joint compared to buffalo but the difference was statistically not significant for both measurements. Pastern height was more in buffalo than bulls but the gender difference for the measurement was not significant. On the other hand Azikheli bulls have significantly ($t_{(133)} = 2.5$; $P<0.05$) greater hoof circumference compared to buffalo. Azikheli buffalo have longer tail than bulls, but the difference was statistically not significant ($t_{(133)} = 1.80$; $P>0.05$).

Table 11: Measurements (cm) of Legs in Azikheli buffalo and bulls in Khwazakhela valley of District Swat, NWFP, Pakistan.

Sex	Variables	Mean	Range
	Height of the leg below knee	30.34±0.25	25.40-41.91
	Height of the leg below hock	46.27±0.32	40.64-53.34
Buffalo	Height of the pastern	5.92±0.11	02.54-70.62
(108)	Hoof circumference	51.26±0.38	40.64-58.42
	Tail length	71.39±1.04	55.88-101.6
	Height of the leg below knee	31.34±0.43	27.25-35.56
	Height of the leg below hock	47.51±0.38	43.18-50.80
Bulls	Height of the pastern	5.65±0.14	05.04-07.62
(27)	Hoof circumference	53.53±1.00 [a*]	45.72-76.20
	Tail length	67.38±1.58	53.34-76.46

Mean±SE

a = Azilkheli buffalo vs bull
P<0.05 *

Productive performance:

Standard 305-day milk yield and daily milk yield based on standard 305-day lactation length was recorded.

Standard 305-day milk yield:

Overall sample:

Standard 305-day milk yield was recorded in 108 Azikheli buffalo. The overall mean 305-day milk yield observed was 2494.02±52.44 liters (range: from 1293.23-4166 liters) (Table 12).

Milk yield based on parity:

Mean standard 305-day milk yield of 108 buffalo according to parity is presented in Table 12. The lowest mean standard 305 day milk yield was observed in the first parity while highest in third parity. Mean standard 305-day milk yield increased highly significantly in second ($t_{(70)}$ =3.52; P<0.001) and third parity ($t_{(70)}$ = 4.55; P<0.001) compared to first parity. However, the differences in mean standard 305-day milk yield in second and third parity was statistically not-significant ($t_{(70)}$ = 1.53; P=0.13).

Milk yield based on seasonal variation:

Mean standard 305-day milk yield of 108 buffalo according to season is shown in Table 12. The highest mean 305-day milk yield observed was in summer season and the lowest in winter season. One-way analysis of variances shows no significant differences in mean standard 305 days milk yield, among spring, summer, autumn and winter season $F_{(3, 104)}$=1.59; P>0.05) Table 13.

Table 12: Standard 305-day milk yield (liters) of Azikheli buffalo in first, second and third parity, and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

	Mean milk production (liters)		
Source	Mean	Range	Number
Overall	2494.02±52.44	1293.23-4166.00	108
Parity			
First	2182.24±77.16	1293.23-3452.34	36
Second	2557.71±73.57 a***	1846.85-3946.48	36
Third	2742.13±95.91 a***	1384.05-4166.00	36
Season			
Autumn	2362.30±101.35	1384.05-3167.78	25
Winter	2316.41±117.97	1736.16-2953.85	11
Spring	2405.93±146.34	1879.26-2924.89	08
Summer	2587.02±72.99	1293.23-4166	64

Mean±SE

a= parity first vs second and third

b= parity second vs third

P<0.001 ***

Table 13: One-way analysis of variance showing differences in mean 305-day milk yield of Azikheli buffalo calved in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Source	df	SS	MS	F	P
Between season	3	1396333	465444.2	1.59	0.19
Within season	104	30378347	292099.5		
Total	107	31774680			

Daily milk yield:

Overall sample:

Daily milk yield was recorded in 108 Azikheli buffalo. The overall mean daily milk yield observed was 8.18±0.17 liters (range: from 4.24-13.66 liters) (Table 14).

Milk production based on parity:

Mean daily milk yield of 108 buffalo according to parity is shown in Table 14. The lowest mean daily milk yield was observed in first parity while highest in third parity. Mean daily milk yield increased highly significantly in second ($t_{(70)}$ =3.52; P<0.001) and third ($t_{(70)}$ = 4.55; P<0.001) parity compared to first parity. However the differences in mean daily milk yield in second and third parity was statistically not-significant ($t_{(70)}$ = 1.53; P=0.13).

Milk production based on seasonal variation:

Mean daily milk yield of 108 buffalo according to season is presented in Table 14. The highest mean daily milk yield was observed in summer season and lowest in winter season. One-way analysis of variances showed no significant differences in mean daily milk yield among spring, summer, autumn and winter season $F_{(3, 104)}$ = 01.59; P>0.05) Table 15.

Table 14: Daily milk (liter) production of Azikheli buffalo in first, second and third parity, and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

	Mean milk production (liters)		
Source	Mean	Range	Number
Overall	8.18±0.17	4.24-13.66	108
Parity			
First	7.15±0.25	4.24-11.32	36
Second	8.38±0.24	6.05-12.94	36
Third	8.99±0.31	4.54-13.66	36
Season			
Autumn	7.74±0.33	4.54-10.39	25
Winter	7.59±0.39	5.69-9.68	11
Spring	7.89±0.48	6.16-9.59	08
Summer	8.48±0.23	4.24-13.66	64

Mean±SE

a= parity first vs second and third

b= parity second vs third

P<0.001 ***

Table 15: One way analysis of variance showing differences in mean daily milk yield of Azikheli buffalo calved in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Source	df	SS	MS	F	P
Between season	3	15.01029	5.0034	1.59	0.19
With in season	104	326.5611	3.14001		
Total	107	341.5711			

Reproductive performance:

Reproductive traits studied were pubertal age, postpartum anoestrus interval, conception efficiency, calving interval and dry period.

Pubertal age:

Mean pubertal age of Azikheli buffalo observed in this study was 1147.93±13.05 days, ranging from 540-1800 days. Pubertal age was divided into five groups with an interval of 270 days (Table 16). The lowest percentage of buffalo reached pubertal at an early age ranging from 540-810 days. The highest percentage (44.89%; n=202) of buffalo reached pubertal age ranging from 811-1081 days with mean of 1048.81±4.87 days. Those buffalo who take larger time to reach pubertal age were very small in number. The minimum and maximum age at maturity recorded in this study was 540 days and 1800 days respectively. Mean pubertal age in this buffalo ranged from 704.57±7.41 days to 1788.46±7.99 days (Table 16).

Table 16: Pubertal age (days) of Azikheli buffalo in Khwazakhela valley of District Swat, NWFP, Pakistan.

Pubertal age in Azikheli buffalo (days)			
Range	Mean	Number	Percentage
540-810	704.75±7.41	61	13.56
811-1081	1048.81±4.87	202	44.89
1082-1352	1191.17±7.93	68	15.11
1353-1623	1443.23±2.53	93	20.67
1624-1894	1788.46±7.99	26	05.78

Postpartum anoestrus interval:

Overall sample:

Postpartum anoestrus interval of 483 buffalo was recorded. The overall mean postpartum anoestrus interval was 147.56± 5.64 days which ranged between 10-570 days. Postpartum anoestrus interval was divided into seven groups with an interval of ninety days. Longest mean postpartum anoestrus interval (560.00±5.00 days) was noted in postpartum anoestrus interval ranging from 546-636 days. Highest percentage of buffalo (50.10 %, n= 242) with mean postpartum anoestrus interval (51.80±1.76) days was observed in postpartum anoestrus interval ranging from 10-90 days (Table 17).

In relation to parity:

Mean postpartum anoestrus interval according to parity is presented in Table 18. The highest mean postpartum anoestrus interval was observed in the first parity (167.03±9.19 days) ranging between 10-555 days. The mean postpartum anoestrus interval declined in the second, third and fourth parity. The lowest mean postpartum anoestrus interval (57.97±15.77 days) was in the fourth parity. Regression analysis of variances shows highly significant (b= -0.03±0.004; $F_{(1, 2)}$ = 30.59; P= 0.03; Table 19) reduction in mean postpartum anoestrus interval as parity number increases from first to fourth.

In relation to season:

Mean postpartum anoestrus interval of 388 buffalo according to season is shown in Table 18. The lowest mean postpartum anoestrus interval was observed in summer season and the highest postpartum anoestrus interval was in autumn season. Regression analysis of variance shows highly significant (b= - 9.14±1.87; $F_{(1, 2)}$ = 23.77; P=0.04) decline in postpartum anoestrus interval in relation to seasons.

Table 17: Postpartum anoestrus interval of Azikheli buffalo in Khwazakhela Valley of District Swat, NWFP, Pakistan.

	Postpartum anoestrus interval (days)		
Range (days)	Mean	Number	Percentage
Up to 90	51.80±1.76	242	50.10
91-181	153.46±02.49	117	24.22
182-272	225.75±03.03	40	8.28
273-363	358.71±00.95	70	14.49
364-454 +	474.64±17.34	14	02.90

Mean±SE

Table 18: Postpartum anestrous interval of Azikheli buffalo in first, second, third and fourth parity and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

	Postpartum estrus interval (days)			
Source	Mean	Range	Number	Percentage
Overall	147.56±5.64	10-570	483	-
Parity				
First	167.03±9.19	10-555	194	40.17
Second	143.82±8.36	20-570	211	43.69
Third	118.60±14.51	20-540	66	13.66
Fourth	57.97±15.77	20-210	12	0 2.48
Season				
Autumn	169.85±23.03	20-450	29	07.47
Winter	161.62±17.39	20-465	53	13.66
Spring	157.76±15.03	20-570	73	18.81
Summer	140.66±08.21	10-555	233	60.05

Table 19: Regression analysis of variance showing differences in mean postpartum estrus interval of Azikheli buffalo in first, second, third and fourth parity in Khwazakhela valley of District Swat, NWFP, Pakistan.

b= -0.03±0.004

Source	df	SS	MS	F	P
Regression	1	4.693	4.693	30.59	0.03
Residual	2	0.306	0.153		
Total	3	5			

Conception efficiency:

Conception efficiency based on percentage of Azikheli buffalo conceived after availing first, second, third, fourth and more than fourth natural (fifth and sixth) services is shown in Table 20. The highest percentage of Azikheli buffalo conceived was after first service whereas buffalo who conceived after three services were only 5.83 percent. Regression analysis of variance shows no significant differences in these percentage reductions of pregnant buffalo from first to fourth and above services (b= -0.01±0.003, $F_{(1,2)}$ = 9.31; P= 0.09) (Table 21).

Table 20: Number and percentage of Azikheli buffalo conceived after various number of natural services in Khwazakhela valley of District Swat, NWFP, Pakistan.

Percentage of pregnant buffalo								
1st service		2nd service		3rd service		4th and more than 4th (5th and 6th) service		
No.	%	No.	%	No.	%	No.	%	No.*
276	64.33	105	24.47	23	5.36	25	5.83	429

* Total number of pregnant buffalo conceived

Table 21: Regression analysis of variance showing differences in percentage of pregnant Azikheli buffalo after first, second, third, fourth and above services in Khwazakhela valley of District Swat, NWFP, Pakistan.

b= -0.00986±0.00323

Sources	df	SS	MS	F	P
Regression	1	4.11	4.11	9.31	0.09
Residual	2	0.88	0.44		
Total	3	5			

Calving interval:

Overall sample:

Calving interval was recorded in 303 Azikheli buffalo. The overall mean calving interval was 489.16±5.82 days which ranged between 345-750 days. Calving interval was divided into five groups with an interval of ninety days. Highest percentage of buffalo (35.31 %; n=107) with mean calving interval of 396.16±2.18 days was observed in calving interval ranging from 340-430 days (Table 22). Highest mean calving interval was in range between 704-794 and the lowest was in the range between 340-430 days.

In relation to parity:

Mean calving interval of buffalo according to parity is presented in Table 23. The longest mean calving interval was observed in the first parity (508.63±8.31 days) and the lowest mean calving interval (414.58±15.49 days) was in fourth parity. Regression analysis of variances showed highly significant (b= -0.02±0.001; $F_{(1, 2)}$ =213.09; P=0.004; Table 24) reduction in mean calving interval as parity increases from first to fourth

In relation to season:

Mean calving interval of 278 buffalo according to season is shown in Table 23. The longest mean calving interval was observed in buffalo calving in autumn season (526.96±21.06 days) and the lowest mean calving interval (482.7±13.89 days) in buffalo calving in spring season. Regression analysis of variance shows that decline in calving interval in summer season is not significant from zero (b= -13.07±6.09; $F_{(1, 2)}$ = 4.61; P=0.16; Table 25).

Fig 14: Colors of the hoof of Azikheli buffalo (a) brownish (b) black (c) brownish with black striation

Table 22: Calving interval of Azikheli buffalo in Khwazakhela valley of District Swat, NWFP, Pakistan.

Calving interval (days)			
Range	Mean	Number	Percentage
340-430	396.16±2.18	107	35.31
431-521	471.73±2.38	106	34.98
522-612	545.83±2.96	42	13.86
613-703	677.5±2.01	40	13.20
704-794	727.5±4.91	8	02.64

Mean±SE

Table 23: Calving interval of Azikheli buffalo in first, second, third and fourth parity and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Mean calving interval (days)			
Parity	Mean	Range	Number
First	508.63±08.31	360-720	144
Second	484.26±10.30	345-750	102
Third	457.88±13.90	345-750	45
Fourth	414.58±15.49	360-520	12
Season			
Autumn	526.96±21.06	390-720	23
Winter	492.36±17.79	360-720	36
Spring	483.00±13.86	345-705	50
Summer	486.51±07.76	345-750	169

Table 24: Regression analysis of variance showing differences in mean calving interval in first, second, third and fourth parity of Azikheli buffalo in Khwazakhela valley of District Swat, NWFP, Pakistan.

b= -0.021±0.001

Source	df	SS	MS	F	P
Regression	1	4.9535	4.9535	213.09	0.005
Residual	2	0.0464	0.0232		
Total	3	5			

Table 25: Regression analysis of variance showing differences in mean calving interval of Azikheli buffalo calved in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, pakistan.

b= -13.07±6.09

Source	df	SS	MS	F	P
Regression	1	854.25	854.25	4.61	0.16
Residual	2	370.74	185.37		
Total	3	1224.99			

Dry period:

Overall sample:

Dry period was recorded in 445 Azikheli buffalo. The overall mean dry period was 119.74±2.58 day ranging from 10-255 days. Ranges for dry period, their mean and percentage are given in Table 3.31. Dry period was divided into nine groups with an interval of thirty days. Highest percentage of buffalo (25.84 %; n=115) was observed in dry period ranging from 93-123 days with mean of 105.66±0.28 days (Table 26). Minimum dry period was 10 days and maximum dry period was 255 days.

In relation to parity:

Mean dry period of buffalo according to parity is presented in Table 27. The longest (126.72±4.15 days) mean dry period was observed in the first parity and the shortest mean dry period (72.5±10.15 days) in fourth parity. Regression analysis of variance showed highly significant (b= -0.05±0.01; $F_{(1, 2)} = 24.56$; p = 0.03; Table 28) reduction in mean dry period as parity number increased from first to fourth

In relation to season:

Mean dry period of 364 buffalo according to season is shown in Table 27. The longest mean dry period was observed in spring season (128.94±7.36 days) and the lowest mean dry period in autumn season (107.31±9.58 day). Analysis of variances showed no significant differences in mean dry period of buffalo calving in spring, summer, autumn and winter season ($F_{(3, 360)} = 0.94$; $P>0.05$; Table 29).

Table 26: Dry period (days) of Azikheli buffalo in Khwazakhela valley of District Swat, NWFP, Pakistan.

Dry period (days)			
Range	Mean	Number	Percentage
Up to 30	24.41±1.97	16	03.6
31-61	50.00±1.02	52	11.69
62-92	78.85±0.76	74	16.63
93-123	105.66±0.28	115	25.84
124-154	135.83±0.40	72	16.18
155-185	165.94±0.52	49	11.01
186-216	195.32±0.46	34	07.64
217-247	225	22	04.94
248-278	255	11	02.47

Table 27: Dry period (days) of Azikheli buffalo in first, second, third and fourth parity, and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Dry period (days)			
Parity	Mean	Range	Number
First	126.72±4.15	15-255	183
Second	122.27±3.86	10-255	190
Third	99.83±6.10	20-225	60
Fourth	72.5±10.15	20-135	12
Season			
Autumn	107.31±9.58	15-255	26
Winter	121.23±8.42	10-255	49
Spring	128.94±7.36	20-255	66
Summer	120.90±3.72	15-255	223

Mean±SE

Table 28: Regression analysis of variance showing differences in mean dry period of Azikheli buffalo in first, second, third and fourth parity of in Khwazakhela valley of District Swat, NWFP, Pakistan.

b= -0.05±0.01

Source	df	SS	MS	F	P
Regression	1	4.6236	4.6236	24.57	0.03
Residual	2	0.3763	0.1881		
Total	3	5			

Table 29: One-way analysis of variance showing differences in mean dry period of Azikheli buffalo calved in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Source	df	SS	MS	F	P
Between seasons	3	8972.8341	2990.945	0.94	0.42
With in seasons	360	1143525.107	3176.459		
Total	363	1152497.941			

Sex ratio:

Overall sample:

The overall sex ratio of male and female calves of Azikheli buffalo recorded were 100 ♀♀ :89 ♂♂ (Table 30). The differences between the two sexes is not significant ($\chi^2_{(1)}$ = 1.66; P ≈ 0.20).

In relation to parity:

Table 30 shows sex ratio of male and female calves of Azikheli buffalo according to parity. Increase in male birth observed was in first parity (100 ♀♀ :94 ♂♂) and the lowest male birth observed was in fourth parity (100 ♀♀ :57 ♂♂). The differences in number of male and females born in first, second, third and fourth parity were statistically not significant.

In relation to season:

Table 30. shows sex ratio of male and female calves of Azikheli buffalo according to season. Sex ratio of male and female calves in spring season observed was 100 ♀♀:60 ♂♂ and in autumn sex ratio of male and female calves observed was 100 ♀♀: 145 ♂♂. There was highly significant ($\chi^2_{(1)}$ = 3.98; P=0.04) increase in male births in autumn compared to spring season.

Table 30: Sex ratio of Azikheli buffalo calves in first, second, third and fourth parity, and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Parity	Number of male calves	Number of female calves	Sex ratio	$\chi^2_{(1)}$	P
Overall	239	268	100 ♀♀ :89 ♂♂	1.66	≈ 0.20
First	101	108	100 ♀♀ :94 ♂♂	0.24	> 0.50
Second	91	107	100 ♀♀ :85 ♂♂	1.30	> 0.20
Third	43	46	100 ♀♀ :93 ♂♂	0.10	> 0.50
Fourth	4	7	100 ♀♀ :57 ♂♂	0.82	> 0.20
Season					
Autumn	32	22	100 ♀♀: 145 ♂♂	1.86	> 0.05
Winter	33	33	100 ♀♀: 100 ♂♂	-	
Spring	31	52	100 ♀♀: 60 ♂♂ [a*]	5.32	< 0.05
Summer	141	163	100 ♀♀: 87♂♂	1.58	>0.20

a =Autumn vs Winter, Spring, Summer

b = Winter vs Spring, Summer

c = Spring vs Summer

$P< 0.05$ [*]

Calf birth weight:

Male calf:

Overall sample:

The over all mean birth weight of male calf was 33.42±0.67 kg which ranged between 20-41 kg (Table 31.).

In relation to parity:

Table 32. showed mean calf birth weight of male Azikheli buffalo according to parity. Highest birth weight (35.89±0.90 kg) was observed in second parity and the lowest birth weight (31.33±1.07 kg) in third parity. One way analysis of variances showed highly significant ($F_{(2, 47)}$ =5.09; P= 0.01; Table 33) difference in male calf birth weight among the three parities. Male birth weight in parity two was significantly higher than parity first ($t_{(33)}$ = 2.26; P=0.03; Table 32) and third ($t_{(32)}$ = 3.27; P=0.002; Table 32). There were no significant differences in male birth weight of parity first and third ($t_{(29)}$ = 0.66; P=0.51; Table 32).

In relation to season:

Table 32 showed calf birth weight of male according to season. Highest birth weight (33.83±1.48 kg; n=12) ranging between 26-41 kg was observed in autumn season. One-way analysis of variances showed no significant differences in male calf birth weight among different seasons ($F_{(3, 46)}$ =0.28; P= 0.83; Table 34).

Female calf:

Overall sample:

The over all mean birth weight of female calf was 29.67±0.75 kg which ranged between 19-40 kg (Table 31.).

In relation to parity:

Table 35 showed mean calf birth weight of female Azikheli buffalo according to parity. Highest mean birth weight (30.38±1.33 kg) was observed in third parity and the lowest birth weight (27.68±1.42 Kg) in first parity. One-way analysis of variances showed no significant ($F_{(2, 46)}$ =2.54; P= 0.09; Table 36) differences in female calf birth weight among first, second and third parity

In relation to season:

Table 35 showed calf birth weight of female according to season. Highest birth weight (32.00 kg; n=2) was observed in winter season. One-way analysis of variances showed no significant ($F_{(3, 45)}$ =0.23; P= 0.87; Table 37) differences in female calf birth weight among different seasons.

Effect of calf sex on birth weight:

Mean birth weight of male calf observed was 33.42±0.67 kg and mean female calf birth weight was 29.67±0.75 kg (Table 31). Male calves were significantly ($t_{(97)}$ = 3.71; P<0.001; Table 31) heavier than female calves at birth.

Table 31: Mean birth weight of male and female calves (Kg) in Azikheli buffalo in Khwazakhela valley of District Swat, NWFP, Pakistan.

Mean birth weight (kg) of male and female calf			
Sex	Mean	Range	Number
Male	33.42±0.67	20-41	50
Female	29.67±0.75 ^{a***}	19-40	49
Overall	31.56±0.54	19-41	99

Mean±SE

a= male calf vs female calf

P<0.001 ***

Table 32: Mean calf birth weight of male calves in Azikheli buffalo in first, second and third parity, and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

	Mean birth weight (kg) of male calves		
Source	Mean	Range	Number
Parity			
First	32.44±1.27	20-38	16
Second	35.89±0.90 [a*]	28-41	19
Third	31.33±1.07 [b**]	20-37	15
Season			
Autumn	33.83±1.48	26-41	*12*
Winter	32.5±2.24	20-39	8
Spring	31.67±1.85	28-34	3
Summer	33.70±0.84	20-41	*27*

Mean±SE

a = parity first vs parity second and third

b= parity second vs third

Table 33: One-way analysis of variance showed differences in mean birth weight of male calf in first, second and third parity of Azikheli buffalo of Khwazakhela valley of District Swat, NWFP, Pakistan.

Source of Variation	df	SS	MS	F	P
Between Parity	2	197.1197	98.55985	5.09	0.01
With in Parity	47	909.0603	19.34171		
Total	49	1106.18			

Table 34: One-way analysis of variance showed differences in mean birth weight of male calf in spring, summer, autumn and winter season of Azikheli buffalo of Khwazakhela valley of District Swat, NWFP, Pakistan.

Source of Variation	df	SS	MS	F	P
Between Season	3	20.21704	6.739012	0.28	0.83
With in Season	46	1085.963	23.60789		
Total	49	1106.18			

Table 35: Mean birth weight of female calf born in first, second and third parity, and in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Mean calf birth weight (kg) of female calves			
Source	Mean	Range	Number
Parity			
First	27.68±1.42	19-36	19
Second	31.57±1.36	20-40	14
Third	30.38±1.33	20-39	16
Season			
Autumn	30.27±1.33	20-36	11
Winter	32±0.00	32	2
Spring	30±1.30	26-34	5
Summer	29.26±1.08	19-40	31

Table 36: One-way analysis of variance showed differences in mean birth weight of female Azikheli buffalo calf in first, second and third parity of Azikheli buffalo of Khwazakhela valley of District Swat, NWFP, Pakistan.

Source of Variation	df	SS	MS	F	P
Between Parity	2	133.4917	66.74584	2.54	0.09
With in Parity	46	1207.284	26.2453		
Total	48	1340.776			

Table 37: One-way analysis of variance showing differences in mean birth weight of female Azikheli buffalo calf born in spring, summer, autumn and winter season in Khwazakhela valley of District Swat, NWFP, Pakistan.

Source of Variation	df	SS	MS	F	P
Between Season	3	20.65821	6.886069	0.23	0.87
With in Season	45	1320.117	29.33594		
Total	48	1340.776			

Statistical analyses were applied to analyze the data. Different tests of significance were applied to ascertain significant or non significant differences among variables under study. Where needed Chi-square test of significance, t-test, analysis of variance and regression analysis of variance were applied. Morphological features were studied because of the reason that they constitute the information regarding the identification of this breed. Unless we identify any breed the description about it shall be of no importance. Since Azikheli buffalo is a non descript breed it was essential to describe the details of its morphological traits. Gender differences have also been analyzed. The analysis showed that Azikheli buffalo have significantly higher heart girth, longer horns longer neck and wider face than bulls. But the bulls compared to buffalo have longer bodies, longer ears, thick horns, thick neck and large hoofs.

Among productive features there was significant effect of parity on increase in mean 305-day milk production particularly in the 2^{nd} parity and 3^{rd} parity. Highly significant reduction in mean postpartum anestrous interval was seen with increasing parity. Postpartum anestrous interval was longest in autumn season and shorter in summer season.

Mean calving interval reduced significantly with the advance in parity. Dry period also reduced significantly with the increasing parity. Sex ratio showed male calves were born less in number than the buffalo.

DISCUSSION

Azikheli buffalo is an indigenous breed of District Swat, NWFP. Very meager information is available on phenotypic as well productive and reproductive characteristics of this breed. The present study was conducted to investigate the physical and morphometric characteristics, productive and reproductive performance of Azikheli buffalo in District Swat, NWFP. Physical characteristics include color of the coat, eyelashes, muzzle, hooves and legs, whereas morphometric measurements of different body parts were taken. Productive performance included standard 305-day milk yield and calf birth weight. Reproductive traits included pubertal age, postpartum anestrus interval, conception efficiency, calving interval and dry period.

Coat color of domestic animals is an important characteristic used to distinguish breeds. Globally buffalo represents a variety of coat colors. Most of the riverine buffalo are black to ashy grey (Maqsood, 1980; Chavaninkul et al., 1993; Ligda, 1998; Mishra et al., 2002; Soysal et al., 2007) whereas skin color of swamp buffalo ranges from grey to completely black with a very few white in color (Maqsood, 1980; Chang and Huang, 2003). Dark coat color makes buffalo heat intolerant, rendered the animal to stay near the swamp (Chang and Huang, 2003). The dominant brown coat color of Azikheli buffalo thus seems an adaptation to the mountainous environment and genetic in origin (Maqsood, 1980) because swamp facilities are not available to buffalo in Swat.

The present study on Azikheli buffalo and buffalo bulls in District Swat revealed that majority of Azikheli buffalo and buffalo bulls are brown in coat color (Table.1) with no sex differences in these color. Azikheli buffalo have high percentage (62.04 %) of brown coat color compared to very low percentage (8 %) among other Pakistani buffalo (Maqsood, 1980) and Nagpuri buffalo of India (8 %; Kolt and Sadekar, 1996) where the dominant coat color is black. It was observed that majority of Azikheli buffalo and buffalo bulls have black color horns (52 % in buffalo and 51.85 % in bulls) with no sex differences. The color of the horns in other buffalo breeds of Pakistan like Nili-Ravi and Kundi is also black (Maqsood, 1980). It was observed that majority of Azikheli buffalo and bulls have completely white color forehead (61 % in buffalo and 55.56 % in bulls), white color eyelashes (50 % in buffalo and 44.44 % in bulls; Table.2), white muzzle (55 % in buffalo and 51.85 % in bulls; Table.3) and white color fore legs below knee joint (75 % in buffalo and 70.37 % bulls). The present study revealed that on the basis of the color pattern of the coat and other body parts, Azikheli buffalo are locally termed as "Sra Chargai" (brown coat color with completely white forehead) and is preferred to "Sara Tikai" (brown coat color with white spot on forehead), "Tora Chargai" (black coat color and white forehead) and Tora Tikai (black coat color and white spot on fore head). These local terminologies regarding the morphological description not only facilitate selection criteria but also denote the cultural association of the farming community to the breed. White marking on forehead, face, muzzle, legs, tail and wall eyes (eyes with a whitish iris) have also been reported in Nili-Ravi buffalo hence called Panch Kalyani due to the possession of these five white markings (Maqsood 1980; Vij and Tantia, 2005). Chavananikul et al (1993), Patil and Ulmek (2002) Vij and Tantia (2005) and Sukla et al (2006) also reported various local terminologies for various colors marking in various buffalo like chevrons (white color ring) in Murrah buffalo, panchaguni in Pandharpuri buffalo and kanthi in Bhadawari buffalo respectively.

It was observed that majority of Azikheli buffalo and bulls had white colored fore legs below knee joint (75 % in buffalo and 70.37 % bulls), and hind legs below hock joint (66 % in buffalo and 59.26 % bulls; Table.4). Hooves of brownish color (60.19 % in buffalo and 55.55 % bulls; Table.4) with no sex differences for these color patterns. Maqsood (1980) reported that legs are white or of grey color from hoof to above the knee (stocking) in Swamp buffalo and in Nili-Ravi buffalo legs have white marking on lower part of legs. Roth and Myers (2004) reported that in water buffalo legs are white up to the knees. Sukla et al (2006) observed that color of legs is like wheat straw in Bhadawari buffalo and there is white marking on legs of the Mehsana buffalo. Soysal et al (2007) reported white marks on the lower part of legs and black hooves in Anatolian water buffalo. On the other hand, Kolte and Sadekar (1996) reported higher percentage of buffalo with black color of legs (90 %) but legs were with white patches (10 %) in Nagpuri buffalo. Different authors have observed different color patterns of legs in different buffalo breeds making them distinct from one another. These morphological differences may used as identification mark for various breeds of buffalo.

Morphometric measurements are used to evaluate the characteristics of the animal and they vary due to the influence of breed evolution, environment, nutrition, sex, age, physiological status, rearing system and related to cost traits (Dia Palo, 2001; Campanil et al., 2003; Riva et al., 2004; Lazzaroni and Bigini, 2005; CGRFA, 2007). Morphometric measurement is the measurement of body conformation of animal (Janssens and Vandepitte, 2004; Janseens et al., 2004) which is an important component of breeding and selection decision (Schneider et al., 2003) and could serve as a guideline in selection of high yielding females particularly in areas where performance records are not available (Jogi and Patel, 1990). Azikheli buffalo have significantly higher heart girth size, longer horns, longer neck and wider face at the level of eyes than bulls (Table.5-8). On the other hand Azikheli bulls, compared to Azikheli buffalo, have significantly longer bodies, longer ears, thick horns, thick neck and large hooves (Table.5-8 and Table.11). The values for body length and height at hipbone of Azikheli bulls were higher than buffalo whereas, height at wither was higher in buffalo than bulls (Table.5). Soysal et al (2007) also reported higher values for body length and height at hipbone in Anatolian bull. Tail in Azikheli buffalo is above hock as cutting point of switch, is routine practice. In Nili-Ravi buffalo tail is long extending bellow hock and had a white switch compared to that in Azikheli buffalo (Vij and Tantia, 2005). Azikheli buffalo had smaller heart girth size (191.36±1.26 cm) than Nili-Ravi buffalo (215-225 cm; Khan et al., 1982; Ranjhan and Pathak, 1993; Moioli and Borghese, 2005) whereas height at wither of Azikheli buffalo (131.35±0.57 cm) falls within the range of Nili-Ravi buffalo (125-135 cm Khan et al., 1982; Ranjhan and Pathak, 1993; Moioli and Borghese, 2005). However Nili-Ravi buffalo are longer (145-149 cm; Khan et al., 1982; Ranjhan and Pathak, 1993; Moioli and Borghese, 2005) than Azikheli buffalo (140.39±0.94). On the other hand Azikheli bull has smaller heart girth, smaller at wither and have shorter body than Nili-Ravi bulls (225-226 cm; 135-137 cm; 159-165 cm; Khan et al., 1982; Ranjhan and Pathak, 1993; Moioli and Borghese, 2005). There is low heart girth in Azikheli buffalo compared to that in kundi buffalo (205 cm; Khan et al., 1982; Moioli and Borghese, 2005), but are taller at wither height (112-125 cm; Khan et al., 1982; Moioli and Borghese, 2005) and have longer body (137 cm; Khan et al., 1982; Moioli and Borghese, 2005) than kundi buffalo. Bulls of Azikheli buffalo breed have smaller heart girth size than Kundi bulls (217 cm; Khan et al., 1982; Moioli and Borghese, 2005). However, height at wither and body length of Azikheli buffalo approximate that of the Kundi bull (Khan et al., 1982; Moioli and Borghese, 2005). Pandharpuri buffalo have comparable heart girth size (192.79 cm; Patil et al., 1998) and height at wither (132.92 cm; Patil et al., 1998) to that of Azikheli but the later is longer than the former (130.02 cm; Patil et al., 1998). Gaddi buffalo have also comparable values to that of Azikheli buffalo with respect to heart girth, height at wither and body length (194.98±1.8, 131.3±1.1 cm; 141.2±1.63 cm; Kumar and Raj, 2007). Nagpuri buffalo had smaller heart girth, height at wither and body length than that of Azikheli buffalo (172.61±4.12 cm; 121.41±2.34 cm; 128.00±3.70 cm; Shrikhande et al., 1996). There was no significant difference in face length between Azikheli buffalo and bull. Ranjhan and Pathak (1993) also reported no difference in face length in Nili-Ravi buffalo (58 cm) and bull (58 cm). Rump length and rump width in both sexes were not significantly different in Azikheli breed. Ranjhan and Pathak (1993) also reported the same values for mean rump length (45 cm each for buffalo and bull) and rump width without marked variation (61.2 cm for buffalo and 62 cm for bull) in both sexes of Murrah buffalo. However Terzano et al (2007) reported that in Romania buffalo heifers rump length was significantly different in intensive feeding (34.5% mais silage, 31% hay, 13.8% maize meal, 10.9% Soya been and 9.8% wheat flour on DM basis (14% crude protein and 0.88 MFU/kg DM) as compared to pasture system (45±12% grass, 12±9% legume, 29±11% composite and 14±15% other species (0.49±0.11 MFU/kg DM, 14.6±6.0% crude protein and 22.8±3.4% crude fiber).

Similarly there was no significant difference in the height of fore-legs below knees, height of the hind legs below hock and height of pastern in both sexes. Ranjhan and Pathak (1993) also reported mean height of legs below knee in Murrah buffalo was 21.6 cm and it was 24.6 cm for Murrah bull with out mentioning any statistical analysis.

On the basis of horns buffalo are also divided into two groups. One group consists of the horns which are closed and set close to head and are down swept: e.g Murrah, Nili-Ravi, Mehsana, Jaffarabadi and Sambalpur and the other group consists of the horns which are sickle shaped and un-swept: e.g Bhadawari, Kalahandi, Kanara, Nagpuri, Tarai and Toda (Singh and Barwal; 2010). The Azikheli buffalo breed falls in the second group of horn shape. Horns are flat laterally, directed backward and slightly upwards without twisting. Upwards turning is variable and gives a sickle or semi-sickle appearance to the horn in the breed under study. It is similar to Surti breed

(Moioli and Borghese, 2005). It is different from that of Nili-Ravi and Kundi in which the horn are short and twisted/ curled (Moioli and Borghese, 2005). Size of the horn of Azikheli buffalo observed in this study is smaller than Nagpuri (50-65 cm; Shrikhande et al., 1996; Moioli and Borghese, 2005), Gauli (51.82±3.28 cm; Kolt and Sadekar, 1996) and Chilika (49±0.2 cm, Patro et al., 2008), but longer than Nili-Ravi (Sukla et al., 2006) and Kundi (Moioli and Borghese, 2005). Horns of Azikheli buffalo were significantly longer than bull whereas, bulls have significantly thicker horn base circumference than buffalo. Soyal et al (2007) reported longer and thicker horn in female Anatolian buffalo. However, Roth (2004) in Asian buffalo reported smaller horn in female buffalo as compared to that of bull. This study and reported information on morphometry, like leg color patterns, makes different buffalo breeds distinct from each other, perhaps this may also be used as a good identification mark.

Milk production is an economically important trait in buffalo (Tonhati et al., 2008; Sethi, 2009). Estimation of milk yield is useful for dairy producers in making management and breeding decision and is essential for genetic evaluation (Ahmad and Sivarajasingam, 1998; Rehman et al., 2006; Quist et al., 2007). The overall mean 305-day milk yield recorded in Azikheli buffalo in the present study (2494.02±52.44 liters) was comparable to that of Nili-Ravi (2486.02±11.03 liters; Babar et al., 1998). However, in Nili-Ravi buffalo, Shafiq and Usmani (1996) reported lower milk yield (2193.4±23.4 liters) than Azikheli buffalo. Similarly mean 305-day milk yield in Azikheli buffalo was higher compared to Egyptian buffalo (1078±36-2015 kg; Mohamed et al., 1983; El-Kaschab et al., 1987), Mehsana (1983.56±18.48 kg; Singh et al., 1996), Surti buffalo (1043±23 kg; Jahageerdar et al., 1997), Anatolian buffalo (894.17±19.55 kg; Tekerli et al., 2001), Nili-Ravi buffalo in NWFP (1755±15.2-2175±18.78 kg, Hamid et al., 2003) and Brazili buffalo (1495.08±617.12 kg; Tonhati et al., 2008). These differences in mean 305-day milk may be due to feeding, management and environmental factors (Shafique and Usmani, 1996; Babar et al., 1998; Tekerli et al., 2001).

In the present study, a significant effect of parity was observed on mean 305-day milk yield with significantly low milk yield during first parity as compared to 2^{nd} ($P<0.001$) and third parity ($P<0.001$). Significant effect of parity on 305-day milk yield have also been reported in Anatolian buffalo in Turkey with significantly lower

305-day milk yield in first parity (Tekerli et al., 2001) and in Nili-Ravi buffalo in Pakistan with significantly highest 305-day milk yield in second parity as compared to seventh parity (Babar et al., 1998). According to Tekerli et al (2001) the persistency and calving interval were higher in the first lactations. The higher persistency may be caused by the relatively lower peak yield resulting in flatter lactation curve in the primiparous cows. These cows were additionally tend to have more negative energy balance postpartum than do multiparous cows and may fail to show estrous until the energy balance is more favorable as in cattle. Contrary to this Shafique and Usmani (1996) reported a non-significant effect of parity on mean 305-day milk yield in Nili-Ravi buffalo in Pakistan.

No significant effect of calving season on milk production was observed in the present study. Similar results have also been reported in Nili-Ravi buffalo in Pakistan (Shafique and Usmani, 1996; Babar et al., 1998), India (Singh and Yadav, 1987), Egyptian buffalo (Alim, 1979) and Surti buffalo (Jahageerdar et al., 1997). Variations in 305-day milk yield during different seasons may be due to environmental factors along with difference in fodder availability in various seasons (Shafique and Usmani 1996; Khan et al., 1991; Tekerli et al., 2001). As Azikheli buffalo are reared in sheds which protect them from seasonal stress and are provided with fodder and concentrates, thus minimizing the climatic and feed shortage stress. This be the reason for non-significant effect of season on 305-day milk yield in Azikheli buffalo. Jahageerdar et al. (1997) were also of the opinion that proper feeding and management can help to overcome any adverse effect of season on the productivity of buffalo. Contrary to the present study, Khan et al. (1991) reported significant effect of season on milk yield in Nili-Ravi buffalo with more milk yield in winter calvers compared to autumn calvers. Similarly, Singh et al. (1996) reported that Mehsana buffalo of India calved during summer season and yielded highest, than those calved during autumn season.

The overall daily milk yield recorded in Azikheli buffalo was 8.18±0.17 liters. This was comparable to milk yield (8.0 kg) reported in Murrah buffalo in India (Singh et al., 2002) and Nili-Ravi buffalo (8.19 liters) under village conditions in Pakistan (Gill et al., 1983). Higher values for daily milk yield than the present study have been reported in Nili-Ravi buffalo (9.78 liters; Khan et al., 2008c; 10.5±0.27 liters; Hamid et al., 2003), Kundi buffalo (8.92 kg; khan, 1994), Murrah buffalo (10.92±0.608 kg; Mishra et al., 2008), and Italian buffalo (8.73 kg; Catillo et al., 2002). Daily milk yield of Azikheli buffalo was higher (8.18±0.17 liters) as compared to Nili-Ravi buffalo (6 liters; Nematu llah, 2001; 5 liters; Khan et al.,2008), Kundi buffalo (4.46 kg; Khan, 1994; 6.8 liters; Haq, 2000), Bhadawari (2.79±0.23 kg; Misra et al., 2008), Surti buffalo (9.4 liters; Rakshe, 2003; 3.75±0.17 kg; Misra et al., 2008), Mehsana (6.07±0.15 kg; Misra et al., 2008), Iranian buffalo (5.6±1.17 liters; Moghaddam and Mamoei, 2004) and Iraqi buffalo (4.9 kg; Juma et al., 1992). Differences in daily milk yield may be due to differences in breed of the buffalo, climate, nutrition and management that affect the productive performance of buffalo (Thomas, 2004; Misra et al., 2008).

In this study, the significant effect of parity on daily milk yield was observed. Mean daily milk yield increased highly significantly in the second parity ($t_{(70)} = 3.52$; $P<0.001$) and third parity ($t_{(70)} = 4.55$; $P<0.001$) compared to first parity. Similarly peak value in Swamp buffalo was recorded in second and third parity as compared to first parity (Zaman et al., 2003).The effect of parity on mean daily milk yield in Bhadawari buffalo was significant up to fourth parity and thereafter it decreased (Sachan et al., 2005). In Murrah buffalo the effect of parity on mean daily peak yield was significant in parity fourth (Gajbhiye and Tripathi, 1988). According to Shrivastava et al (1998), increase in milk yield with increase in parity may be due to more physiological growth of body and udder, better stabilization of hormonal system over the calving and the selection of animals for better productivity. The same reasons may be valid for significant effect of parity on 305-day milk yield observed in Azikheli buffalo in the current study. Non-significant ($P>0.05$) difference of calving season on daily milk production was observed in the present study between spring, summer, autumn and winter season. Non-significant effect of season on daily milk yield has also been reported in Murrah buffalo (Parkash et al., 1990), Surti buffalo (Jahageerdar et al., 1997) and Bhadawari buffalo (Sachan et al., 2005). On the other hand, Catillo et al (2002) reported a significant effect of season on milk yield in Italian buffalo and Gajbhiye and Tripathi, (1988) in Murrah buffalo.

Data on reproductive performance including pubertal age, postpartum anestrus interval, conception efficiency, calving interval and dry period were collected from farmers through questionnaire and these questionnaire based results obtained are discussed in the following paragraphs.

Pubertal age of animal is an important determinant of reproductive efficiency and early attainment of puberty is necessary for optimum reproductive performance (Ali and Farooque, 1989; Tegegne et a., 1992). It provides the availability of replacement stock (Esslemont, 1992) which creates opportunities for more selective culling and allows the herd to sell replacements (Evans et al., 2006; Chang et al., 2006). Mean pubertal age of Azikheli buffalo recorded in this study was 1147.93±13.05 days and highest percentage of buffalo (44.89%) was observed in pubertal age ranging from 811-1081 days with mean pubertal age of 1048.81±4.87 days (Table.16). It is evident from this study that Azikheli buffalo attain puberty at later age as compared to Mediterranean buffalo (603.7 days; Borghese et al., 1994), Swamp buffalo (720 days; Tuyen, 2003), Asian Buffalo (720 days; Jesser et al., 2008), Nili-Ravi buffalo (1110 days; Bashir, 2006; 1020 days; Rehman, 2006; 1044±171 days; Akhtar et al., 2007) and Indian buffalo (1080 days; Ingawale and Dhoble, 2004). Late pubertal age in buffalo has been attributed to poor nutrition (Akhtar et al., 2007; Rafiq et al., 2008) and poor management (Barkawi et al., 1989; Hogberg and Lind, 2009). Individual selection of buffalo and better nutrition can reduce pubertal age in buffalo (Nanda et al., 2003; Dash et al., 2005). Longer pubertal age than the present study has been reported in Gaddi buffalo (1368 days; Kumar and Raj, 2007) and Bangladeshi buffalo (1411.58±43.01 days, Alam and Ghosh, 1993).

Prolonged postpartum anestrus interval is a major source of economic loss to buffalo breeders (Anwar et al., 2003; El-Wishy, 2007a), hence, early return to ovarian cyclic activity is a prerequisite for high reproductive efficiency (Honparkhe et al., 2008). To maintain a calving interval of 13-14 months in buffalo, resumption of anestrus postpartum must be accomplished by 60-80 days with successful breeding within 85-115 days (El-Wishy, 2007a and b). The overall mean postpartum anestorus interval in Azikheli buffalo observed was 147.56±5.64 days in this study. Long postpartum anestrus interval than the present study was reported in Nili-Ravi buffalo in Pakistan (183.42±2.37 days, Rehman et al., 1991; 176.73±2.71, Hussain et al., 1993), Indian Murrah buffalo (178 days; Porwal et al., 1981) and Bangladeshi buffalo (179.32±10.31 days, Alam and Gosh, 1993). But other had reported lower values for postpartum anestrus interval than the present study in Nili-Ravi buffalo (124±14.58 days, Chaudhry et al., 1989; 52.22±4.12 days, Chaudhry et al., 1990; 69.03±6.03 days, Qureshi et al; 1998), Surti buffalo in India (126 days, Rao et al., 1973), Sri Lankan Murrah buffalo (133±91 days, Mohamed and Jayaruban, 1991), Anatolian buffalo (15-82 days, Ucar et al., 2004) and Egyptian buffalo (18-65 days, Barkawi et al., 1986).

Post partum anestrus interval observed in this study was ranging from 10-570 days (mean: 147.56±5.64 days). A wide range of 11-526 days (Chaudhry et al., 1988b), 21-749 days (Rehman et al., 1991), 30-750 days (Jost, 1979) and 21-915 days (Zafar, 1983), has been reported for post partum anestrus interval in Nili-Ravi buffalo in Pakistan. It was observed in the present study that 50.10% of Azikheli buffalo showed estrus up to 90 days postpartum. Ahmad et al (1981) reported 49 % of Nili-Ravi buffalo showing estrous up to 90 days post partum. However, in Egyptian buffalo (34 %, Youssef et al., 1988) and Indian Murrah buffalo (45 %, Shrivastava and Kharche, 1986) lower percentages of buffalo were observed to show estrus up to 90 days post partum than the present study. In this investigation, 24.22 % of Azikheli buffalo were observed to show estrus from 91-181 days post partum. In the literature it has been reported that 24% of the Egyptian buffalo (Youssef et al., 1988), 55% of the Indian Murrah buffalo (Shrivastava and Kharche, 1986) and 20% of the Nili-Ravi (Ahmad et al., 1981) exhibit estrus which ranges from 91-150 days post partum. This wide variation in post partum anestrus interval might be the effect of limited suckling and non-suckling practices, inadequate estrus detection or failure to detect estrus and nutrition (Jainudeen et al., 1983; Fonseca et al., 1983'; Dachir et al.., 1984; Usmani et al., 1985; Qureshi et al., 1998; Gupta et al., 2008).

Highly significant (P=0.02) reduction in mean postpartum anestrus interval was observed in the present study as parity increased from first to fourth. Significant effect of parity was also reported in Nili-Ravi buffalo with long postpartum anestrus interval in parities first and second as compared to other subsequent parities (Chaudhry et al., 1988b). Shah et al (1989) reported that postpartum anestrus interval is significantly shorter in higher parity than the first parity in Nili-Ravi buffalo. In Egyptian buffalo, it was also reported that postpartum anestrus interval significantly decreases with increased parity order (Ali and El-Sheikh, 1983; Afifi et al., 1992; Mahdy et al., 2001). It has been reported that with increasing parity order, postpartum uterine involution occurs sooner resulting into short postpartum anoestrus interval (Peiris et al., 1982; Jainudeen et al., 1983). The same reason may be valid for Azikheli buffalo observed in this study that postpartum anoestrus interval significantly reduced with advancing parity number. Contrary to the present study, non-significant effect of parity on post partum estrus was reported in Nili-Ravi buffalo (Usmani, 1983; Chaudhry et al., 1989), Mehsana buffalo (Suthar and Kavani, 1992), Egyptian buffalo (Kawthar et al., 1985) and Murrah buffalo (Porwal et al., 1981).

Significant (P=0.03) effect of season on postpartum anestrus interval was observed in the present study with the longest postpartum anoestrus interval in autumn season and shortest in summer season. Significant effect of season on postpartum anoestrus interval have also been reported in various buffalo breeds form Pakistan and other countries. In Pakistan, Chaudhry et al. (1988b) reported significantly longest postpartum anestrus interval in winter season than autumn season in Nili-Ravi buffalo, whereas, Qureshi et al. (1998) in Nili-Ravi buffalo reported significantly longer postpartum anoestrus interval in buffalo calved in the low breeding season (February-July) than normal breeding season (August-January). Bughio et al. (2000) also reported shorter postpartum anestrus interval during autumn season in Kundi buffalo. Significantly longer postpartum anestrus was reported for hot season calvers as compared to cold season calvers in Egyptian buffalo (Khattab et al., 1995; Barkawi et al., 1996). In Cuba, Campo et al. (2002) reported significantly longer postpartum anestrus interval in the rainy than in the dry season calvers in river buffalo. Ribeiro et al. (2003) reported significantly shorter postpartum anestrus interval in buffalo calved during peak rainy season (January to March) than buffalo calved during December in Brazili buffalo. These differences in post partum anestrus interval might be due to differences in the environment, management and breed of buffalo (Chaudhry et al., 1989). According to Mohammed and Jayaruban (1991) variation in climatic condition have direct effect on the physiological functions of the animal and indirectly affect the availability of required nutrients (Mohammed and Jayaruban, 1991). Sometime the anestrus interval is prolonged due to sudden climatic variation such as fall in temperature, exposure to cold wind, heavy rain associated with low temperature or hot weather without any possibility of bathing or sheltering from the sun (Zicarelli, 1997). Apart from breeding season mating is an other reason for the prolonged anestrus (Zicarelli, 1997). The long postpartum anoestrus interval in Azikheli buffalo calved in Autumn season might be due to the reason that autumn calvers immediately entered winter season which is the coldest of all the seasons in the study area (Ur-Rahim and Viaro, 2002) and there is also fodder shortage as compared to other seasons. Shah et al. (1989) also reported low frequency of estrus in buffalo during winter season (November, December and January) in Swat and attribute it to the fodder shortage during the winter season in the area. However non-significant effect of season has also reported in Nili-Ravi buffalo under farm condition in Pakistan (Chaudhry et al., 1989; Chaudhry et al., 1990) and Egyptian buffalo (El-Wardani, 1990; Mahdy et al., 2001).

In the present study the percentage of Azikheli buffalo conceived after first service was higher (64.33 %), whereas, low percentage of buffalo conceived after first service in buffalo of Bangladesh (50.88 %; Alam and Ghosh, 1993), Murrah buffalo of India (40 %; Hogberg and Lind, 2003; 35 %, Khan, 2009), buffalo in Sri Lanka (45 %, Perara and Abeygunawadena, 2000) and Nili-Ravi buffalo of Pakistan (47 %, Khan. 2009; 53.4 %, Usmani and Mirza, 2000), Egyptian buffalo (55 %; Khan, 2009) and in other various buffalo (56.8 %; Barnabe, 1994; 48.3 %; Baruselli, 1994; 38.1 % to 55.5 %; Riveiro et al., 1994). However, highest percentage of pregnant buffalo to first service was reported in indigenous buffalo of Sri Lanka (77 %: Perera et al., 1987). Jainudeen (1986) also reported that the first service conception rate varied from 50 % to 75 % in water buffalo. According to Shah et al (1989) the ideal value for the percentage of buffalo conceived after first services is 50 %. In the present study the observed percentage of pregnant buffalo after first services is 64.33 % which is above the ideal value. It was observed in the present study that Azikheli buffalo conceived after second service was 24.47 %. Alam and Ghosh (1993) also reported 24.56% of Bangladeshi buffalo conceived after availing second service. Azikheli buffalo conceived after availing third (5.36%) and fourth and more than fourth services (5.83%) were lower than reported for Bangaldshi buffalo which were 12.28% for third and 12.28% for fourth service (Alam and Ghosh, 1993).

Calving interval is one of the most important parameter to evaluate the productive and reproductive efficiency, economic value and number of calves by lifetime in a farm and / or in a population (Bettini, 1968; Singh et al., 1992; Colmenares et al., 2007).

An ideal calving interval is considered to be of 12 to 14 months whereas a longer or shorter calving interval than the ideal is unprofitable (Yadav et al., 2008). The overall mean calving interval observed in Azikheli buffalo in this study was 489.16±5.82 days. Close value of calving interval to the present study has been reported in Murrah buffalo (481±13 day; Gurnani et al., 1976; 492 days; Agrawal et al., 1987), Nepali buffalo (486 days; Shrestha and Yazman, 1988) and Marathwada buffalo (496.251±5.94 days; Patange et al., 2004). However short calving interval than the present study was reported in Nili-Ravi buffalo of Pakistan (420 days; Yasin and Wahid, 1952), Anatolian buffalo in Turkey (441.97±7.93 days; Tekerli et al., 2001), Surti buffalo in India (461.68±8.429 days; Jain and Tailor, 1994), crossbred of Jafarabadi, Murrah and Mediterranean buffalo in Brazil (409±105 days; Nascimento et al., 2007), Romanian buffalo (437 days; Paraschivescu et al., 2007), Murrah, Mediterranean and Carabao buffalo, of Brazil (446.7±10.4 days; Lamberson et al., 2007) and buffalo in Venezuela (473.9±3.0 days; Colmenares et al., 2007). Longer calving interval than the present study was also reported in Nili-Ravi buffalo in Pakistan (522.72±2.66 days; Rehman et al., 1988; 517.29 days; Shah et al., 1989; 508.06±2.76 days; Chaudhry et al., 1990), Murrah buffalo in India (560±38.85 days; Narasimharao and Sreemannarayana, 1994), Bhadawari buffalo (524 days; Singh et al., 1993), Nagpuri buffalo (510 days; Shrikhande et al., 1998), Swamp buffalo in Indonesia (540-630 days; Suryanto et al., 2002), Azerbaijan buffalo in Iran (510±30 days; Karimi et al., 2007) and Bangladeshi buffalo (544.04±17.57 days, Alam and Gosh, 1993).

In this study highly significant (P=0.004) reduction in mean calving interval was noted as parity number advances from first to fourth. Significant effect of parity on calving interval was also reported in Nili-Ravi buffalo that first and second calving intervals were significantly longer as compared to the calving intervals in later parities (Chaudhry et al., 1990). Shah et al (1989) reported that calving interval is significantly shorter in higher parity than in the first parity. Lundstrom et al (1982) also reported that calving interval was significantly longer between the first and second calving than subsequently. In Surti buffalo the effect of parity reported was significant with long calving interval in first parity than later parity (Jain and Tailor, 1994). The long calving interval in Azikheli buffalo in first parity compared to other parities might be due to the lactation stress and longer open period required by buffalo which have still not reached mature size (Gurnani et al., 1976). The selection of buffalo with better reproductive efficiency might be another reason for short calving interval in Azikheli buffalo as Usmani and Mirza (2000) were of the opinion that farmer selection or retaining of the buffalo with better reproductive efficiency could be a reason for short calving interval in subsequent parities as compared to first parity. However, in Mehsana buffalo Siddique et al (1984) reported a non-significant effect of parity on calving interval.

Non-significant effect of season on calving interval was observed in this study. Similar results regarding the effect of season on calving interval have also been reported in Nili-Ravi buffalo (Tayyib and Qureshi, 1967), Murrah buffalo (Parkash et al., 1989; Kandasamy et al., 1993) and Egyptian buffalo (Farrage et al., 1982). However, season of calving was reported to significantly affect calving interval in Nili-Ravi (Chaudhry et al., 1990; Shah; 2007; Hyder et al., 2007), Murrah buffalo (Gogoi et al., 1984; Lamberson et al., 2007), Surti buffalo (Jain and Tailor, 1994), Anatolian buffalo (Tekerli et al., 2001) and buffalo in Venezuela (Bello, 2003; Colmenares et al., 2007).

Dry period is one of the important factors that influence lifetime milk production and has been established as a necessary management practice to maintain profitable milk production in dairy animal (Bachman and Schairer, 2003; Gruummer and Rastani, 2004). In dairy buffalo dry period has marked influence on cost of milk production and replacement rate (kandasamy et al., 1993).

Mean dry period observed in this study was 119.47±2.58 days. A comparable dry period of 115±15 days has been reported in Azerbaijan buffalo (Karimi et al., 2007). Longer dry period than the present investigation has been reported in Nili-Ravi buffalo (216.07±16.62 days; Khan et al., 1990; 131 days; Moioli and Borghese, 2005), Kundi buffalo (335 days; Dhanani et al., 1983), Murrah buffalo (144±26 days ; Moioli and Borghese, 2005; 174.06±9.50 days ; Yadav et al., 2007), Pandharpuri buffalo (140.00±10.57 days; Patil et al., 1998; 189.54±2.09 days; Baglane et al., 2005), Kalahandi buffalo (218.59±3.97 days; Dash et al., 2005), Marathawada buffalo (174.17±5.77 days; Patange et al., 2004) and Chilika buffalo (192±20 days; Patro et al., 2008).

In this study significant effect of parity was noted on dry period with highly significant reduction in mean dry period as parity increases (P=0.03). Significant effect of parity on dry period was also reported by Kanaujia et al (1975) in Indian buffalo that dry period was longest in first parity and there was significant reduction in dry period in later parities. In Surti buffalo, Bharat et al (2004) observed that dry period was longer in early parity and reduce significantly up to fifth parity and increased again in later parities. Variation in dry period could be attributed to yielding capability of the buffalo, in higher yielding buffalo the dry period will be short (Hamid et al., 2003). As the first parity buffalo seem to have poor lactation yield, therefore, the dry period may be longer as compared to second and later parities. Increased dry period causes increased calving interval, which in turn reduces the calf crops. Optimizing dry period to 45-60 days, depends on reproductive management (Kanaujia and Balaine, 1975). Selection, feeding schedule and managemental practices favor the trait of short dry period in buffalo (Yadav et al., 2007). However, Das et al (2005) reported non-significant effect of parity on dry period in Swamp buffalo.

No significant effect of season on dry period was observed in this study (P>0.05). Non-significant effect of calving season on dry period was also reported in Nili-Ravi buffalo in Pakistan (Tahir and Sial, 1976). However significant effect of calving season was reported on dry period in Murrah buffalo (Yadav et al., 2007).

To exploit the production potential of any species of the domestic animals, the basic information regarding different reproductive parameters such as ovarian activity, cornual implantation and sex ratio is of prime importance (Rind et al., 1987). Several attempts have been made for increasing the frequency of a desirable sex in animals with out much success. If frequency of a desirable sex is increased, then genetic gain can be maximized through increased intensity of selection (Jogi et al., 1998). The overall calf sex ratio observed in Azikheli buffalo in this study was 100 ♀♀: 89 ♂♂. Male to female calf ratio has been reported as 52.28: 47.55 in Nili-Ravi buffalo (Malik and Ahmad, 1969) and 48.3: 51.7 (Rao and Rao, 1996a) and 50: 50 (Jogi et al., 1998) in Murrah buffalo. In this study non-significant (P>0.05) effect of parity on calf sex ratio was observed. Similar results were also reported by Rao and Rao (1996a) and Jogi et al (1998). There was highly significant (P=0.045) increase in male birth in autumn compared to spring season in the present study. However, a non-significant influence of season on sex ratio has been reported in Murrah buffalo (Rao and Rao, 1996a; Jogi et al (1998). No extrinsic factors (month, season, year of calving and lactation number) either during the prenatal or postnatal life of an animal was found to influence the sex ratio and sex determination is controlled by genetic factors only (Jogi et al., 1998). However, certain sires produced higher number of female calves. Hence by selecting certain sires, greater number of females can be obtained (Jogi et al., 1998). Similar finding have been reported by Mishra et al (1980), Pander et al (1985) in goat and Jogi and Johar (1991) in Pigs.

Body weight gives an indication of growth rate which has definite economic and genetic importance which reflecting the overall interaction of genotype with all environmental factors under which it is expressed (Jogi and Lakhani, 1996). The overall mean birth weight of male calf observed in this study was 33.42±0.67 kg. Ahmed et al (1988) reported male calf birth weight as 32.24±2.16 kg in Nili-Ravi buffalo. Lower male calf birth weight than the present study has been reported in Murrah buffalo (30.96 kg) by Jogi and Lakhani (1996). However, Hill (1990) reported higher male birth weight (39.8±6.0 kg) in Egyptian buffalo and Uslu (1970) in Anatolian buffalo (34.3±1.20 kg). Variation in birth weight appears to be primarily genetic in nature (Ahmad eal., 1983; Chantalakhana et al., 1985; Sabrani et al., 1994).

The effect of parity on male calf birth weight was highly significant (P=0.009) in this study. Male birth weight in second parity was significantly higher than first parity (P=0.03) and third parity (P=0.002) and there was no significant (P=0.51) differences in male birth weight of parity first and third. Significant effect of parity ($P<0.05$) on male calf birth weight was also reported in Murrah buffalo by Rao and Rao (1996b) where male birth weight was more in parity 2-6 (32.76-33.66 kg) than first parity (30.92 kg). Basu et al (1976) also reported significant effect of parity on birth weight with calves of heifers lighter by 3 kg than others. This increase in birth weight with advancing parity number might be due to increased vascularization of the uterus during first pregnancy (Khong et al., 2003) and greater blood volume expansion during second pregnancy (Campbell and MacGillivary, 1984) thus facilitating relatively greater fetal growth in the subsequent pregnancies.

No significant (P=0.83) differences in male birth weight was found in calves born in different season of the year in this study. Non-significant effect of season on birth weight was also observed in Swamp buffalo (Zaman, 1996; Das et al., 2004). Singh et al (2003) also reported a non-significant effect of season on birth weight in riverine buffalo calves. In Murrah buffalo a non-significant effect of season was reported by Rao and Rao, (1996b). However, Chantalakhana et al (1984) reported a significant effect of season on birth weight in Swamp buffalo of Thailand.

The over all mean birth weight of female calf was 29.67±0.75 kg in this study. Mean female birth weight reported in Murrah buffalo was 30.09 kg (Jogi and Lakhani, 1996) and Anatolian buffalo was 22.1-31.6 kg (Uslu, 1970). In Egyptian buffalo higher female birth weight (36.8±5.8 Kg) was reported than the present study (Hill, 1990). No significant effect (P=0.08) of parity and season (P=0.87) was observed on female calf birth weight in this study.

Male calves were highly significantly (P<0.001) heavier than female calves at birth in Azikheli buffalo observed in this study. Zaman, (1996) and Das et al (2004) also reported significantly heaver birth weight of male calves than female calves. Higher male birth weight might be due to the effect of breed, sex, hormonal influence and maternal effect as male calves grow faster than female calves in uterus (De Zegher et al., 1999; Bhattacharya et al., 1999; Loos et al., 2001). On the other hand, Singh et al (2003) reported a non-significant effect of calf sex on birth weight in buffalo. Azikheli buffalo features studied here have been discussed in relation to other buffalo breeds in Pakistan and from other countries. It is concluded that Azikheli buffalo shows some parameters which are better than in other buffalo breeds particularly from Pakistan. There is one Pakistani breed, Nili Ravi buffalo, which has been described in detail for productive and reproductive characteristics. Compared to Nili Ravi buffalo from N.W.F.P , Egyptian buffalo, Mehsana and Surti buffalo from India Azikheli buffalo showed high milk yield. Calving season had no effect on milk yield in Azikheli buffalo but it did have effect in the case of Nili Ravi buffalo where more milk yield was in winter calvers than in autumn calvers.. Overall milk yield in Azikheli buffalo was comparable to that in Nili Ravi buffalo and Murrah buffalo from India.

Parity had significant effect on milk production particularly in the second and third parity than in Indian Murrah buffalo and Surti buffalo. Late pubertal age was observed in Azikheli buffalo than in Nili Ravi buffalo and Indian buffalo from plains. In the breed under study the late puberty could be due to harsh cold conditions.

Post partum anestrus interval is an important factor for breeders. The shorter the interval the better it is from economic point of view. Azikheli buffalo showed shorter postpartum anestrus interval compared to Nili Ravi buffalo and Indian Murrah buffalo and Bangaladeshi buffalo. Azikheli buffalo breeders are at advantage because of this factor that these buffalo can conceive earlier than other breeds.

Another important factor is conception of cow after first service or not. In the case of Azikheli buffalo majority of buffalo conceived after first service but lower in percentage conception after first service was seen in Nili Ravi buffalo and Egyptian buffalo.

Calving interval is another important economic factor. It is regarded that an ideal calving interval is between 12 to 14 months. Azikheli buffalo's calving interval falls within this range. This also goes to the benefit of the breeders.

Dry period has significance for the breeders. A shorter dry period goes to their advantage. This is what was seen in Azikheli buffalo which showed shorter dry period compared to Nili Ravi buffalo, Kundi buffalo, Murrah buffalo.

From breeder's point of view the above parameters are important and have economic significance too.

CONCLUSION

1. The dominant coat color of Azikheli buffalo and bulls was brown. However, black, black and white, and white coat colors were also observed.

2. Azikheli buffalo had large body size (heart girth) than bull whereas bulls had longer body (body length) than Azikheli buffalo.

3. Azikheli buffalo produced 2494.02±52.44 liters of milk in standard 305-day lactation period, whereas, daily milk yield based on 305-day lactation period was 8.18±0.17 liters.

4. Azikheli buffalo attain puberty at the age of 1147.93±13.05 days, ranging from 540 to 1800 days. The mean postpartum anestrus interval was 147.56±5.64 days, ranging from 10 to 570 days. Conception efficiency based on first service was 64.33%. Calving interval of Azikheli buffalo (489.16 ±5.82 days) was longer than the recommended value (365 to 420 days).

5. The overall sex ratio was 100♀♀:89♂♂ in Azikheli buffalo.

6. Significant effect of parity was observed on 305-day milk yield and daily milk yield with significantly higher milk yield in third and second parity as compared to first parity. Parity also significantly affect postpartum anestrus, calving interval and dry period and these traits are decreasing as the parity number increased from first to fourth. Male birth weight was significantly higher in parity second as compared to parity first and parity third.

7. The significant effect of season was observed on postpartum anestrus interval with significantly short postpartum anestrus interval during summer season than autumn. Calf sex ratio was also significantly affected by season with significantly more male births in autumn as compared to spring season.

8. Male calves were highly significantly ($P<0.001$) heavier than female calves at birth.

SUGGESTIONS FOR FUTURE STUDIES

1. In the current study, traditional measures of fertility like postpartum anoestrus interval, conception efficiency and calving interval have been investigated. Physiological parameters of fertility such as the commencement of luteal activity postpartum, ovulation time, lifespan of corpus luteum, pattern of estrus cyclicity and maintenance of pregnancy, assessed by milk progesterone levels, are necessary to be investigated to obtain information on the inherent capability of Azikheli buffalo cow to resume ovarian cyclicity postpartum which are useful for selecting buffalo for improved fertility.

2. There is need to investigate the causes of late pubertal age, long postpartum anoestrus interval, long calving interval and long dry period and to devise strategies to optimize these reproductive performances.

3. Studies should be conducted on the existing management; feeding and breeding system to find out the weaknesses and to introduce a systematic management system to optimize the productivity of Azikheli buffalo breed.

4. The high milk producing Azikheli buffalo cows should be bred with Azikheli buffalo bulls from high milk producing dams to find out the transmitting capabilities of milk yield traits in the next generations.

5. Comparative evaluation of productive and reproductive performance of Azikheli buffalo cows and crossbred buffalo cows should be conducted with more emphasis on the cost of production so that the breed of choice can be ranked and promoted in specific environment.

6. Based on the results of the present study the breeders can be suggested to modify the existing management system and breeding programme. There are some features like late pubertal age, long calving interval, high milk producing buffalo cows. In general, in farms no attention is paid to the breeding system that mostly inbreeding is followed at farms. The farmers can be advised that they should establish Lines for buffaloes with High Milk Production and these should be mated with bulls coming from high milk producing buffalo cows. Within Lines mating should be avoided but between Lines mating should be encouraged. This way more genetic variations shall be inherited by the future

offspring. Similarly, buffalo cows with early pubertal age and short calving interval can be selected for producing future buffalo cows where they could inherit early pubertal age and short calving intervals through selection programming. It is just possible buffalo cows could be identified with combination of factors possessing simultaneously both high milk production and early pubertal age. These will be very useful buffalo cows transmitting simultaneously both economically important factors. Although this is a long term selection programme but will improve milk production in the coming future. Through this selection programme early pubertal age and short calving interval can be attained. Better environments in terms of healthy food should be provided, their living conditions be improved in terms of sanitary condition. Good environmental conditions shall lead to better expression of genes. In other animals particularly in poultry, in America, I.M.Lerner (1958, 1968) had improved egg production per hen, meat quantity and acceleration in growth rate. This he achieved through selection programme.

REFERENCES

Abdalla MY, and Elsheikh AS (2008). Postpartum interval of Darfurian Cows: Influences of breed, BCS, parity and season. African J Agri Res. 3 (7): 499-504.

Abeygunawardena H, and Dematawewa CMB (2004). Pre-pubertal and postpartum anestrus in tropical Zebu cattle. Anim Reprod Sci. 83: 373-387.

Abeygunawardena H, Kuruwita VY, and Perera BMAO (1996). Effects of different suckling regimes on postpartum fertility of buffalo cows and growth rates and mortality of calves. In: Role of the Buffalo in Rural Development in Asia. NARESA press, Colombo, Sri Lanka. pp. 321-336

Adalsteinsson S, Bjarnadottir S, Vage DI, and Jonmundsson JV (1995). Brown coat color in Icelandic cattle produced by loci Extenssion and Agouti: J Hered. 86: 395-398.

Afifi EA, Khalil MH, Bedeir LH, and Zeidan SM (1992). Genetic analysis of reproductive traits in Egyptian buffaloes Egypt. J Anim Prod. 29: 139-154.

Afzal M, and Naqvi, AN (2003-2004). Livestock resources of Pakistan: Present status and future trends. Science Vision. 9: 185-198.

Afzal M, Anwar M, and Mirza MA (2007). Some factors affecting milk yield and lactation length in Nili-Ravi buffaloes. Pak Vet J. 27 (3): 113-117.

Agrawal SS, Patel RK, and Sharma KNS (1987). Intercalving period in Murrah buffaloes. Indian J Dairy Sci. 40: 200-204.

Ahmad M, Azhar MS, and Aziz MM, (2009). Performance of buffalo population using test day milk yield in progeny testing program areas of district Gujranwala. J Anim Pl Sci. 19: 10-12.

Ahmad MD, and Kumbhar MI (1975). Genetic and environmental factors affecting the birth weight of calves in Tharparker cattle. Pak J Agri Sci. 12(3): 118-124.

Ahmad N, Chaudhry RA, and Ahmad W (1983). Postpartum estrus interval in Nili-Ravi buffaloes in Pakistan. Egypt J Anim Prod. 23: 27-32.

Ahmad N, Chaudhry RA, and Khan BB, (1981). Effect of month and season of calving on the length of subsequent calving interval in Nili-Ravi buffaloes. Anim. Reprod Sci. 3: 301-306.

Ahmad S, and Sivarajasingam S (1998). Analysis on the productive and reproductive traits in cows. Proceedings of the 6th World Congress on Genetics Applied to livestock production, Vol. 23-28, Armidale NSW 2351, Australia, (11-16 January).

Ahmed N, Ahmad M, Anzar M, Khan LH, and Arslan M (1988). Morphology of reproductive organs and related endocrine glands in newborn male buffaloes. Pak Vet J 8 (4): 159-163

Akhtar T, Lodhi LA, Khanum SA, Rashad MA, and Hussain M (2007). Improving reproductive efficiency in an artificial insemination programme through early non-pregnancy diagnosis, management and training. IAEA.-TECDOC-1533, Animal production and health section, joint FAO-IAEA division, international atomic energy agency Wagramer Strasse 5 post office box-100, A-1400 Vienna, Austria, pp: 103-112.

Akram M (1997). Genetics and environmental aspects of diurnal variation in milk yield of buffaloes. M. Sc. Thesis, Department of Animal Breeding and Genetics, University of Agriculture, Faisalabad.

Alam MGS, and Ghosh A (1993). Reproductive patterns of rural buffaloes (Bubalus bubalis) in Bangladesh. Buffalo Bulletin 12 (3): 66-69.

Alderson GLH, (1999). The development of a system of linear measurements to provide an assessment of type and function of beef cattle. Animal Genetic Resources Information 25: 45-56.

Ali A, and Fahmy S (2007). Ovarian dynamics and milk progesterone concentrations in cycling and non-cycling buffalo-cows (Bubalus bubalis) during Ovsynch program. Theriogenology 68; 23–28

Ali CS, and Farooqe MA (1989). Puberty of Sahiwal heifers. Pak Vet J 9 (4): 170-172.

Ali MA, and El-Sheikh AS (1983). Postpartum ovulation in a herd of Egyptian buffaloes. Indian J Anim Sci. 53: 485-487.

Ali S, Babar ME, Akhtar P, Ahmad A, Rahman M, Sultan JI, and Shaheen HL (2009). Genetic divergence and relationship among five buffalo breed of Pakistan using a random amplified polymorphic DNA (RAPD) analysis. Pak J Zool (Suppl.9): 303-308.

Alim KA, (1979). The productive performance of Egyptian buffaloes in a dairy herd. Asian Buffalo Association 47: 601.

Ambrose D J, Kastelic J P, Corbett R, Pitney P A, Petit H V, Small J A, and Zalkovic P (2006). Lower Pregnancy Losses in Lactating Dairy Cows Fed a diet enriched in α – Linolenic Acid. J Dairy Sci. 89: 3066-3074.

Annen EL, Collier RJ, McGuire MA, Vicini JL, Ballam JM, and Lormore MJ (2004). Effect of modified dry period lengths and bovine somatotropin on yield and composition of milk from dairy cows. J Dairy Sci. 87: 3746-3761.

Ansari-Lari M. and Abbasi S (2008). Study of reproductive performance and related factors in four dairy herds in Fars province (Southern Iran) by Cox proportional-hazard model. Preventive Veterinary Medicine 85: 158-165.

Anwar M, Ullah N, Mehmood A, and Andrabi SMH (2003). Postpartum anoestrus in Nili-Ravi buffaloes maintained under rural and peri-urban management . Pak Vet J. 23 (3): 114-117.

Arango JA, and Vleck LDV (2002). Size of beef Cows: early ideas, new developments. Genet and Mol Res. 1 (1): 51-63.

Arthur GH, Noakes DE, and Person H (1989). Veterinary reproduction and obstetrics, 6th edition, (Bailliere-Tindall, London). pp 344-442

Arya J S and Madan M (2001). Postpartum reproductive cyclicity based on ovarian steroids in suckled and weaned buffaloes. Buffalo J. 17: 361-369.

Ayalew W, King J, Bruns E, and Rischkowsky B (2003). Economic evaluation of smallholder subsistence livestock production: lessons from an Ethiopian goat development program. Ecological Economics 45: 473-485.

Azawi OI, Omran SN, and Hadad JJ (2008). A Study on postpartum metritis in Iraqi buffalo cows: bacterial causes and treatment. Reprod Dom Anim. 43: 556–565.

Babar MI, Husssain T, Nadeem A, Jabeen R, and Javed M (2009). Genetic Characterization of Azikheli Buffalo Breed of Pakistan Using Micro-satellites DNA Markers. Pa. J Zool. (Suppl. 9): 361-366.

Babar, M.E, Ahmad T, and Zia-Ul-Hasan (1998). Environmental factors affecting 305-day milk yield and total milk yield in Nili-Ravi buffalo. Pak J Agri Sci. 35: 70-73

Bachman KC, and Schairer ML (2003). Invited Review: Bovine studies on optimal lengths of dry periods. J Dairy Sci. 86: 3027-3037.

Baglane BB, Ambulkar DR, Ali SZ, and Gote N R (2005). Productive performance of Purnathadi buffaloes. Indian Vet J. 82: 83-84.

Barkawi AH, Khattab RM, Mokhless EM, and El-Wardani MA (1996). Patterns of ovarian activity influencing calving interval of Egyptian buffaloes in relation to season of calving. Bulgarian J Agric Sci. 2: 49-53

Barkawi AH, Mokhless EM, and Bedeir LH (1989). Environmental factors affecting age at puberty in Egyptian buffaloes. Buffalo J. 1: 71-78

Barkawi AH, Shafie MM, Mekawy Y, and Aboul-Ela MB (1986). Buffalo J. 2: 117-124

Barnabe VH (1994). Artificial insemination using two different diluents. Buffalo J. (supl) 2: 83-86.

Baruselli PS, Barnabe VH, Barnabe RC, Visintin JA, and Molero-Fihlo JR (1994). Artificial insemination in buffalo. In: Actas del IV Congreso Mundial de Criadores de Bufalos, Sao Paulo, Brazil. 111: 649-651.

Baruselli PS, Barnabe VH, Barnabe RC, Visintin JA, Molero-Filho, and Porto R (2001). Effect of body condition score at calving on postpartum reproductive performance in buffalo. Buffalo J. 17, 53-656.

Basher M.K (2006). Genetic and phenotypic aspects of some performance traits of Nili-Ravi buffaloes in Pakistan. PhD Thesis, University of Agricultur, Faisalabad, Pakistan.

Basu SB, Sharma PA, and Nagercenkar R (1976). Annual Report of NDRI for 1975. pp. 139-141.

Bello R (2003). Factores no genetics que afectan el intervalo entre partosy peso al destete en un rebano de bufalos (Bubalus bubalis) en el estado Guarico. Thesis Ing. Agr. Mencion Zootecnia. Facultad de Agronomia, Universidad Central de Venezuela. pp 40.

Berber RCdeA, Madureira EdH, and Baruselli PS. (2002). Comparison of two ovsynch protocols (GnRH versus LH) for fixed time insemination in buffalo (Bubalus bubalis). Theriogenology 57: 1421-1430.

Bettini TM (1968). Element di Demografia, CNR, Produzione Animale, Arti grafiche Palomba, Torre del Greco (NA), Italy

Bharat NK, Thapan PC, and Gahlot GC (2004). Production and reproduction performance of light breed of buffaloes. Indian J Anim Sci. 74 (5): 527-529.

Bhattacharya TK, Kumar P, and Patil VK (1999). Sex ratio in a herd of Tharparker cattle. Indian Vet J. 76: 942-943.

Bhatti SA, Sarwar M, Khan MS, and Hussain MI (2007). Reproducing the age at first calving through nutritional manipulations in dairy buffaloes and Cows: A review. Pak Vet J. 27 (1): 42-47.

Bishop H, and Pfeiffer D (2008). Factors effecting reproductive performance in Rwandan cattle. Trop Anim Health Prod. 40: 181-184.

Borghese A (2005). Buffalo production and research. Food agriculture Organization of the Uninted Nation, Rome.

Borghese A, Barile VL, Terzano GM,, Annicchiarico G, Debenedetti A, and Malfatti A (1993). Anestrus length in Italian buffalo cows. In: Prospects of Buffalo Production in the Mediterranean and Middle East, Note I. Cairo, Egypt. pp. 389-392.

Borghese A, Terzano GM, Barile VL, and Parneagiani A (1994). IV World Buffalo Congress, SAO Paulo-Brazil (June).

Bradley DG, Maschugh DE, Meghen C, Loftus RT, Sharp DM, and Cunningham E P (1993). Genetic Characterization of indigenous cattle breeds: first results and implications for genetic improvement. FAO Anim Prod Health Paper. 110:37-44.

Britt J H (1985). Enhanced reproduction and its economic implications. J Dairy Sci. 68: 1585-1592.

Brotherstone S, and Hill WG (1991). Dairy herd life in relation to linear type traits and production 1: phenotypic and genetic analysis in pedigree type classified herds. Animal Production (UK). 53: 279-287.

Bughio S, Shahani AK, Mirani AH, Moriani AA, Oad FC, and Bughio ZA (2000). Seasonal Trend of Calving and Subsequent Service Period in Buffaloes. Pak J Biolo Sci. 3 (12): 2169-2170

Campanile G, Di Palo, R; De Rosa, C; Peretti, V; Amante, L; Ciotola, F. and Coletta, A. (2003). Preliminary results on Mediterranean Italian Buffalo morfometry. Proc.XV ASPA Cong. 337-339.

Campbell DM, and MacGillivary I (1984). The importance of plasma volume expansion and nutrition in twin pregnancy. Acta Geneticae Medicae et Gemellologiae (Roma). 33: 19-24.

Campo E, Alonso JC, Hincapie JJ, GarciaL, Faure O, and Fernandez O (2002). Seasonal influence on uterine involution and postpartum ovarian activity in river buffaloes. Bubalus babalis 8. 59-63.

Capuco AV, Akers RM, and Smith JJ (1997). Mammary growth in Holstein cows during the dry period: Quantification of nucleic acids and histology. J Dairy Sci. 80: 477-487

Catillo G, Macciotta NPP, Caretta A, and Cappio-Borlino (2002). Effects of age and calving season on lactation curves of milk production traits in Italian water buffaloes. American Dairy Science Association. 85: 1298-1306.

Census (1998). http:// www.census.gov.pk

CGRFA (Commission on Genetic Resources for Food and Agriculture) 2007. The state of the world's animal genetic resources for food and agriculture final version (Item 3.1(c) of the Draft Provisional Agenda). 11th Regular Session, Rome, (11-15 June).

Chang HL, and Huang YC (2003) (eds.). The relationship between indigenous animals and humans in APEC region. The Chinese Society of Animal Science, Taiwan. pp.186.

Chang YM, Andersen-Ranberg M, Herinstad B, Gianola D, and Klemetsdal G (2006). Bivariate Analysis of Number of Services to conception and Days Open in Norwegian Red Using a Censored Threshhold-Liner Model. J Dairy Sci. 89: 772-778.

Chantala Khana C, and Flavey L (1999). Smallholder dairying in the tropic, ILRI (International Livestock Research Institute), Nairobi, Kenya. pp 462.

Chanthalakhana C, Bunyavejchewin CP, and Veerasit P (1984). Effect of seasonal fluctuation and parturition on body weight of Swamp buffalo. Buffalo Bulletin. 3: 3-7.

Chanthalakhana C, Bunyayejchewin P, Faarungsarng S, and Veerasit P (1985). Growth pattern of Thai Swamp buffalo. Buffalo Bulletin. 4: 55-56

Chaudhry MA, Ahmad M, and Chaudhry RA (1989). Postpartum ovarian functions and oestrus interval in Nili-Ravi buffaloes. Pak Vet J. 9 (4): 155-158.

Chaudhry MA, Ahmad M, and Khan NU (1988a). Postpartum oestrus behavior in Nili-Ravi buffaloes. Pak J Agric Res. 9 (2): 241-245.

Chaudhry MA, Chohan MH, and Pasha TN (1990). Uterine involution and postpartum oestrus in primiparous Nili-Ravi buffaloes. Pak J Agric Res. 11 (3): 183-190.

Chaudhry MA, Pasha TN, and Iqbal J (1988b). Factors influencing the length of postpartum oestrus in Nili-Ravi buffaloes (Bubalus bubalis). Pak Vet J. 8:105-11.

Chavananikul V, Chantaraprateep P, Sanghuayprai N, and Buarak B (1993). Phenotypes of F2 crossbreds between riverine and Thai Swamp buffaloes. Buffalo Bulletin. 12 (3): 51-54.

Chhikara SK, Singh N, Dhaka SS, and Yadav RS (1995). Effect of certain factors on calving interval of Murrah buffaloes. J Dairying Food Home Sci. 14(1): 29-32.

Cockrill WR (1974). The Husbadry and Health of the Domestic Buffalo. Food and Agricultural Organization of the United Nation, Rome (Italy).

Colmenares O, Bello R, Herrera P, Birbe B, and Martinez N (2007). Non-genettic factors affecting calving interval and weaning weight in a buffalo herd located in well drained savannas, Guarico state, Venezuela. ITAL. J Anim Sci. 6 (Suppl. 2): 1354-1356

Curik I, Zechner P, Solkner J, Achmann R, Bodo I, Dovc P, Kavar T, Marti E, and Brem G (2003). Inbreeding, Microsatellite Heterozygosity , and Morphological Traits in Lipizzan Horses. J. Heredity : 94 (2): 125-132.

Dachirs S, Blake RW, and Harms PG (1984). Ovarian activity of Holstein and Jersey cows of diverse transmitting abilities for milk. J Dairy Sci. 67: 1776-1782.

Dahama RS, Malik PS, and Singh B (1990). Genetic analysis of birth weight in buffaloes. Indian Vet J. 67: 934-938

Dahlin A, Khan UN, Zafar AH, Saleem M, Chaudhry MA, and Philipsson J (1998). Genetic and environmental causes of variation in milk production traits of Sahiwal cattle in Pakistan. Anim Sci. 66: 307-318.

Dario C, Carnicella D, Dario M. and Bufano G (2006). Morphological evolution and heritability estimates for some biometric traits in the Murgese horse breed. Genetic Mol Res. 5 (2): 309-314.

Das A, Das D, Goswami R N, and Bhuyan D (2007). Persistencey of milk yield and its correlation with certain economic traits in Swamp buffaloes of Assam. Buffalo Bulletin. 26 (2): 36-39.

Das A, Das D, Goswami R N, Das G C, and Bhuyan D (2005). Performance of Swamp buffaloes of Assam in respect of some economically important traits of reproduction under farm condition. Buffalo bulletin. 24 (2): 25-27

Das A, Das D, Goswami RN, and Bhuyan D (2004). Growth performance of Swamp buffaloes of assam from birth to 12 months of age. Buffalo Bulletin. 23 (4): 84-89.

Das A, Das D, Goswami RN, Das GC, and Bhuyan D (2005). Performance of Swmp buffaloes of Assam in respect of some economically important traits of reproduction under farm condition. Buffalo Bulletin. 24 (2): 25-27.

Dash SK, Patro BN, and Rao PK (2005). Genetic analysis of Kalahandi buffaloes of Orissa. Indian Vet J. 82: 158-160.

De Rensis F, and Driancourt MA (2008). The control of ovarian activity in dairy buffalo (Bubalus bubalis): a review. Reprod Manag Bulletin. 4 (6). Department of Animal health, university of pharma, via del Taglio 8, 43100 pharma, Italy.

De Rensis F, Nguyen BX, and Techakumphu M (2008). The control of reproduction in female swamp buffalo (Bubalus bubalis): a review. Reprod Manag Bulletin. 5 (7): Department of Animal health, university of pharma, via del Taglio 8, 43100 pharma, Italy.

De Rensis F, Ronci G, Guarneri P, Nguyenc BX, Presicced GA, Huszeniczae G, Scaramuzzi and RJ (2004). Conception rate after fixed time insemination following ovsynch protocol with and without progesterone supplementation in cyclic and non-cyclic Mediterranean Italian buffaloes (Bubalus bubalis). Theriogenology. 63:1824–1831

De Zegher F, Devlieger H, and Eeckels R (1999). Fetal growth: boys before girls. Hormone Research. 51: 258-259.

Dguma G, Mirkena T, Haile A, Iniguez L, Okeyo AM, Tibbo M, Rischkowsky B, Solkner J, and Wurzinger M (2010). Participatory approaches to investigate breeding objectives of livestock keepers. Livestock Research for Rural Development 22 (4): 1-13

Dhanani J, Khangharani S, Zia-ud-din, and Baloch MA (1983). A preliminary study on the performance of Kundi buffalo. Proceedings of the seminar on "Buffalo production in Pakistan" held at Lahore, Pakistan (16-17, November).

Dhar YM, and Deshpandi KS (1995). Genetic studies on lactation milk and lactation length in Murrah buffaloes. Indian J Dairy Sci. 48: 164-166.

Dia Palo R, Peretti V, De Rosa C, Campanile G, and Barbieri V (2001). Computerized image analysis in type trait evaluation of the Mediterranean dairy buffalo (Bubalus bubalis). Proc. XIV ASPA Cong. 225-227.

Dong Xuan DT, Szalay I, Su VV, Tie HV, and Dang Vang N (2006). Animal genetic resources and traditional farming in Vietnam. AGRI. 38: 1-17.

Doren PE, Baker J F, Long C R, Cartwright (1989). Estimating Parameters of Growth Curves of Bulls. J Anim Sci. 67: 1432-1445.

Dorji T, Tshering L, and Rai DB (2009). Conservation of the last Himalayan cattle breed of Bhutan, South Asia; Pro Poor Livestock Policy Programme; A joint initiative of NDDB and FAO, NDDB house (6th floor) PB 4906, Safdarjang enclave, Newdlhi-110029, India. www.sapplpp.org

Drost M (2007). Advanced reproductive technology in the water buffalo. Theriogenology. 68 : 450–453.

Dutt G, and Yadav MC (1986). Effects of various management factors on milk yield and dry period in Nili buffaloes. Indian J Anim Sci. 56: 1168.

El-Kaschab S, El-Danasory MS, and Omar S (1987). Studies on some reproductive and productive traits of buffaloes in Egypt. Asian Buffalo Association. 55: 5009.

El-Wardani MA (1990). Heat detection in Egyptian buffaloes with particular reference to postpartum period. M.V.Sc, Cario University.

El-Wishy (2007 b). The postpartum buffalo: 1. Endocrinological changes and uterine involution. Anim Reprod Sci. 97: 201-215.

El-Wishy AB (2007a). The postpartum buffalo II. Acyclicty and anestrous review. Anim Reprod Sci. 97: 216-236.

Esselmont RJ (1992). Measuring dairy herd fertility. Vet Rec. 131. 209-212.

Evans RD, Dillon P, Buckley F, Berry DP, Wallace M, Ducrocq V, and Garrick DJ (2006). Trends in milk production, calving rate and survival of cows in 14 Irish dairy herds as a result of the introgression of Holstein-Friesian genes. Anim Sci. 82: 423-433.

FAO (1986). Animal genetic resources data banks. 2. Descriptor lists for cattle, buffalo, pigs, sheep and goats. FAO Animal Production and Health Paper 59/2, Food and Agriculture Organization of the United Nations, Rome.

FAO (1992). The management of global animal genetic resources. Proceedings of FAO Expert Consultation Rome, Italy, April 1992, (Hoges J. edr)

FAO (2003). www.FAO.org/DAD.IS

FAO (2004). http://appsfao.org/accessed 20 December 2004.

FAO (2010). LPP, LIFE Network, IUCN-WISP, and FAO (2010). Adding value to livestock diversity-Marketing to promote local breeds. FAO- Animal Production and Health Paper. No. 168. Rome.

FAO/UNEP (1992). In Situ Conservation of Livestock and Poultry. (Edited: Henson E L), M-22, ISSN 92-5-103143-6; Food and Agricultural Organization of the United Nation Rome.

FAO/UNEP (1998). Primary guidelines for development of national farm animal genetic resources management plans. Rome.

Farrage FH, Elshinnawy MM, Aziz MMA, and El-Eryian MN (1982). Effect of farm, parity, year of calving and season of calving on lactation length, calving interval, dry period and service period of Egyptian buffaloes. Proceedings of the 6th International

Conference of animal and poultry production held at University of Zagazig, Egypt. (21-23 September).

Fernandez G, Baro JA, de la Fuente FL, and San Primitivo F (1997). Genetic parameters for linear under traits of dairy ewes. J Dairy Sci. 80: 601-605.

Fetrow J, McClary D, Harman R, Butcher K, Weaver L, Studer E, Ehrlich J, Etherington W, Guterbock W, Klingborg D, Reneau J, and Williamson N (1990). Calculating selected reproductive indices: recommendations of the American Association of Bovine Practitioners. J Dairy Sci. 73: 78-90.

Fonseca FA, Britt JH, MacDaniel BT, Wilk JC, and Rakes AH (1983). Reproductive traits in Holsteins and Jerseys. Effects of age, milk and clinical abnormalities on involution of cervix and uterus, ovulation, oestrus cycles, detection of oestrus, conception rates and days open. J Dairy Sci. 66: 1128-1147.

Gajbhiye PU, and Tripathi VN (1988). Factors affecting daily peak yield and days to attain peak yield in Murrah buffaloes. Abstract- II World Buffalo Congress: pp. 147

Gallo I, Carnier P, Cassandro M, Dal Zotto R, and Bittante G (2001). Test-Day genetic analysis of condition score and heart girth in Holstein Friesian cows. J Dairy Sci. 84: 2321-2326.

Garcia-Ispierto I, Lopez-Gatius F, Bech-Sabat G, santolaria P, Yaniz JL, Nogareda C, De Rensis F, and LopeziBejar M (2007). Climate factors affecting conception rate of high producing dairy cows in northeastern Spain. Theriogenology. 67 : 1379-1385.

Garcıa-Ispierto I, Lopez-Gatius F, Bech-Sabat, G, Santolaria P, Yaniz JL, Nogareda, C, De Rensis, F, and Lopez-Bejar M (2007). Climate factors affecting conception rate of high producing dairy cows in northeastern Spain. Theriogenology. 67: 1379–1385.

Garcia-Ispierto I, Lopez-Gatius F, Santolaria P, Yaniz J L, Nogareda C, Lopez-Bejar M, and De rensis F (2006). Relationship between heat stress during the peri-implantation period and early fetal loss in dairy cattle. Theriogenology. 65: 799-807.

Gatesy J, and Arctander P (2000). Hidden morphological support for the phylogenetic placement of Pseudoryx ngetinheusis with bovine bovids: a combined analysis of gross anatomical evidence and DNA sequences from five genes. Systematic Biology. 49 (3): 515-538.

Ghaffar A, Khan MI, Mirza MA, and Pirzada WH (1991). Effect of year and calving season on some traits of economic importance in Nili-Ravi buffaloes. Pak J Agric Res. 12 (3): 217-221.

Gill RA, Farooq U, Faiz IA, and Ahmed Z (1983). Perspectives of livestock development in Pakistan. A study of socio-economic determinants of milk production with special reference to rainfed areas. Pak Vet J. 3 (2): 93-98.

Goe MR, Alldredge JR, and Light D (2001). Use of heart girth to predict body weight of working oxen in the Ethiopian highlands. Livest Prod Sci. 69 (2): 187-195. 187-195.

Gogoi PK, Johar KS, and Singh A (1984). Effect of genetic and non-genetic factors on calving intervals in Murrah buffaloes. Indian Vet Med J. 8: 107-111.

Gonzalez-paddilla E, Wiltbank E, and Niswender GD (1975). The interrelationship between pituitary, hypothalamic and ovarian hormones. J Anim Sci. 40: 1091-1104.

Gonzalez-Stagnaro C (2001). Parameters, calculus e indices aplicados a la evaluacion de la eficiencia reproductivea. In: Gonzalez-Stagnaro C (ed), Reproduccion Bovina, (Fundacion GIRARZ, Ediciones Astro Data S.A., Maracaibo-Venezuela) pp. 203-247.

Government of Pakistan (2006). Livestock Census, 2006. Agricultural Census Organization, Statistic Division, Government of Pakistan, Lahore.

Government of Pakistan (2007). Economic Survey of Pakistan, 2006-2007. Finance Division, Government of Pakistan, Islamabad.

Government of Pakistan (2008). Economic Survey of Pakistan, 2007-2008. Finance Division, Government of Pakistan, Islamabad.

Government of Pakistan (2009). Economic Survey of Pakistan, 2008-2009 Finance Division, Government of Pakistan, Islamabad

Government of Pakistan (2010). Economic Survey of Pakistan, 2009-2010. Finance Division, Government of Pakistan, Islamabad.

Govindiah MG, Seenappa K, and Rai AV (1985). Effect of month and year of calving on sex ratio in Surti buffaloes . Livestock Advisor. 5: 19-22.

Grimard JA, Freret S, Chevallier A, Pinto A, Ponsart C, and Humbolt P (2006). Genetic and environmental factors influencing first service conception rate and late embryonic/foetal mortality in low fertility dairy herds. Anim Reprod Sci. 91: 31-44.

Grohn YT, and Rajala-Schltz PJ (2000). Epidemiology of reproductive performance in dairy cows. Anim Reprod Sci. 61: 605-614.

Grummer RR, and Rastani RR (2004). Why reevaluate dry period length? J Dairy Sci. 87 (E. Suppl.): E 77-E 85.

Gupta J, Laxmi a, singh OV, and Ashtosh (2008). A comparative study on evaluation of three synchronization protocols at field level in both cattle and buffaloes. Livestock Research for Rural Development 20(11): 35-39

Gurnani M, Nagarcenkar R, and Gupta SK (1976). Performance in different lactations and repeatability of economic characters in Murrah buffaloes. Indian J Dairy Sci. 29: 117-120.

Hamid SK, Farooq M, Mian MA, Syed M, and Jamal S (2003). Milk production performance and inter-relationship among traits of economic importance in buffaloes maintained at commercial dairy farms. Livestock Research for Rural Development 15 (10): 103-109.

Haq A (2000). Dairy Farming. Livestock Production and Research Institute (LPRI) Bahadarnagar, Okara, Pakistan.

Hassen F, Bekele E, Ayalew W, and dessie T (2007). Genetic variability of five indigenous Ethiopian cattle breeds using RAPD markers. African J Biotech. 6 (19): 2274-2279.

Hill DH (1990). The cattle and buffalo of Africa. Outlook on Agriculture. 19 (3): 189-199.

Hogberg MS, and Lind O (2003). Buffalo milk production (chapter 2). In: Reproduction and Breeding. www.milkproduction.com buffalo milk production – chapter2: Reproduction and breeding.

Honparkhe M, Singh J, Dadarwal D, Dhaliwal GS, and Kumar A (2008). Estrus induction and fertility rates in response to exogenous hormonal administration in postpartum anoestrus and subestrus bovines and buffaloes. J Vet Med Sci. 70 (12): 1327-1331.

Huang C, Tsuruta S, Bertrand JK, Misztal I, Lawlor TJ, and Clay J S (2008). Environmental effects on conception rates of Holsteins in New York and Georgia. (2008). J Dairy Sci. 91: 818-825.

Hussain J, Khan MA, Mohiuddin G, Khan BB, and Shafiqu M (1993). Repeatability estimates of some reproductive traits in Nili-Ravi buffaloes. Pak J Agri Sci. 30 (4): 355-357

Hussain Z (2007). Seasonal variation in breeding and calving patterns of Nili-Ravi buffaloes in Azad Kashmir, Pakistan. Buffalo Bulletin. 26 (4): 127-130.

Hyder AU, Khan MS, Aslam M, Rehman MS, and Bajwa IR (2007). Milk yield and season of calving in buffaloes and cattle in Pakistan. Italian J Anim Sci. 6 (Suppl. 2): 1347-1350.

ICAR (International Committee for Animal Recording) 2004. Introduction (Recording milk and milk constituents) and Section 2 (ICAR rules, standards and guidelines for dairy production recording). http:// www.icar.org.

Ingawale MV, and Dhoble RL (2004). Buffalo reproduction in India: an overview. Buffalo Bulletin. 23 (1). 4-9.

Ingawale MV, and Dhoble RL (2004). Buffalo reproduction in India: An overview. Buffalo Bulletin. 23 (1): 4-9.

Islam MR, Saadullah M, Howlidaer AR. and Huq MA (1991). Estimation of live weight and dressed carcass weight from different body measurements in goats. Indian J Anim Sci. 61 (40): 460-461.

Jabbar G (1987). Live weight of Azikheli buffalo at different age groups. J Anim Health Prod. 7: 128-133.

Jahageerdar S, Govindaiah MG, and Jayashankar MR (1997). Genetic studies on first lactation performance of Surti buffaloes. Buffalo Bulletin. 16 (3): 51-55.

Jain LS, and Tailor SP (1994). Inheritance of reproduction traits in Surti buffaloes. Indian Vet. J: 684-688.

Jainudeen MR (1986). Reproduction in the water buffalo. In: Current Therapy in Theriogenology. 2nd Edn. (D. A Morrow, W. B. Saunders Co. Philadelphia), pp 443-449.

Jainudeen MR, Bongso TA, and Tan HS (1983). Postpartum ovarian activity and uterine involution in the suckled Swamp buffalo (Bubalus bubalis). Anim Reprod Sci. 5: 181-190.

Janssens S, and Vandepitte (2004). Genetic parameters for body measurements and linear type traits in Belgain bleu de mairie, Suffolk and texel sheep. Small Ruminant Research. 54 (1)13-24.

Javed K, Babar ME, Shafiq M, and Ali A (2009). Environmental Sources of Variation for Milk Yield in Nili-Ravi Buffaloes. Pak J Zool. (Suppl.9) 79-83

Javid R, and Ahmad M (1969). Heritability estimate of age at first calving and calving interval in Nili-Ravi buffaloes. Research studies, Vol.1, West Pakistan Agriculture University, Lyllpur, Pakistan.

Jesser P, Markula A, and Csurhes S (2008). Water buffalo (Bubalus bubalis): In Pest animal risk assessment; Department of Primary Industries and Fisheries, Queensland GPO Box 46, Brisbane Qld 4001.

Jogi RVK, and Patil UG (1990). Various body measurements and their correlation with milk yield and fat percentage. Studies in Surti buffaloes. Buffalo Bulletin. 9 (2): 35-38.

Jogi S, and Johar KS (1991). Sex ratio in common Indian pigs and its crosses with large white Yorkshire pigs. Indian J Anim Res. 25(2): 99-100.

Jogi S, and Lakhani GP (1996). Study of body weights, rate of gain and mortality percentage in murrah buffalo calves. Buffalo Bulletin. 15 (3): 51-54.

Jogi S, Lakhani GP. and Kahlon BS (1998). Effect of month, season, year of birth and lactation number on sex ratio in Murrah buffaloes. Buffalo Bulletin. 17 (2): 37-40.

Jost NP (1979). Livestock production and marketing survey, Punjab. Draft report, Directorate of Livestock Production, Education and Artificial Insemination (AI) Services, Lahore, Pakistan. pp 17-20.

Juma KH, Baghdasar GA, and Said SI (1992). Iraqi buffaloes. II. some factors affecting total milk yield. Buffalo Bulletin. 11 (2): 27-29.

Kanaujia AS, Balaine DS, and Rathi SS (1975). Effect of some environmental and physiological factors on reproduction and production traits in Indian buffaloes. Haryana Agri Univ J Res. 5: 178-187.

Kandasamy N, Lagaiathan VU, and Krishnan AR (1993). Non-genetic factors affecting calving interval and dry period of Murrah buffaloes. Buffalo Bulletin. 12 (3): 63-65.

Kanuya NL, Kessy BM, Bittegeko SBP, Modoe NSY,And Aboud AAO (2000). Suboptional reproductive performance of dairy cattle kept in smallholder herds in a rural area of northern Tanzania. Prev Vet Med. 45: 183-192.

Kanuya NL, Matiko MK, Kessy BM, Mgongo FO, Ropstand E, and Reksen O (2006). A study on reproductive performance and related factors of Zebu cows in pastoral herd in a semi-arid area of Tanzania. Theriogenology. 65:1859-1874.

Karimi H, ahpeakar HA, eamattollahi A, Anvari R, Moradinia AF, and Niksan K (2007). The Study of Important Factor on Reproduction of Azerbaijan Buffalo (Bubalus bubalis). J Anim Vet Adva 6(11): 1296-1297.

Kawthar AM, Youssif RH, and Khattab AS (1985). Individual factors affecting the interval between calving and first service in Egyptian buffaloes. Egypt J Anim Prod. 25: 319-327.

Khan BB, Younas M, and Hanjra SH (1982). Breeds and types of livestock in Pakistan. Department of Livestock Management, University of Agriculture Faisalabad, Pakistan.

Khan BB, Younas M, Riaz M, and Yaqoob M (2005). Breeds of Livestock in Pakistan. Third Edition. Department of Livestock Management, University of Agriculture Faisalabad, Pakistan.

Khan HU, Raziq A, Khan MI, Mehtabuddin, And Khan SB (2008). Productive performance of buffaloes in Peshawar under farm conditions. ARPN J Agri Biol Sci. 3; 1-7

Khan MA (2009). Buffalo the animal of future. 1st, (Edi). Published by Idara Matbuaat-e-Sulemani.

Khan MA, Ahmad MD, Abdullah M, and Ali S (1990). Effect of age at first calving of some performance traits in Nili-ravi buffaloes. Vet J. 10 (1): 25-27.

Khan MA, and Niamatullah M (2010). Buffalo versus cattle? let us close this controversy and concentrate on improving the productivity of buffalo. Proceedings of the 9th World Buffalo Congress Argentina, pp: 1043-1045.

Khan MA, Ghaffar A, Tufail M, and Shafique M (1991). Correction factors for the standardization of lactation milk yield in Nili-Ravi buffaloes. Sarhad J Agric. 7 (1): 21-25.

Khan MS (1997). Predicting lactation milk yield from last day yield in buffaloes. Buffalo Bulletin.16 (4): 78-80.

Khan MS, Ahmad N, and Khan MA (2007a). Genetic resources and diversity in dairy buffaloes of Pakistan. Pak Vet J. 27 (4): 201-207.

Khan MS, Khan MA, Ahmad S, and Mahmood S (2007b). Genetic resources and diversity in Pakistani sheep. International J Agri Biol 9 (6): 941-44.

Khan MS, Khan MA, and Mahmood S (2008b) Genetic resources and diversity in Pakistani goats. . International J Agri Biol. 10 (2): 227-31.

Khan MS, Rehman Z, Khan MA, and Ahmad S (2008a) Genetic resources and diversity in Pakistani cattle. Pak Vet J. 28 (20): 95-102.

Khan UN (1994). Critical review on buffalo research and development activities in Pakistan-past experience and future strategies. Proceedings of 1st Asian Buffalo Association-congress. Khon, Kaen, Thailand (January 17-21). pp. 49-56.

Khan, B.B. and Iqbal, A. (2009). The water buffalo: An underutilized source of milk and meat: A review. Pak J Zool. (Suppl. 9): 517-521.

Khattab RM, El-Wardani MA, Enaam MM, and Barkawi AH (1995). Patterns of ovarian activity influencing calving interval of Egyptian buffaloes in relation to season of calving. J Agric Sci. Mansoura Univ. (Egypt) 20: 4331-4335

Khong TY, Adema ED, and Erwich JJ (2003). On an anatomical basis for the increase in birth weight in second and subsequent born children. Placenta. 24: 348-353.

Kohler-Rollefson I (2001). Intellectual property rights regime necessary for traditional livestock raisers. Indigenous Knowledge Development Monitor. 9 (1): 12-15.

Kohler-Rollefson I, Rathore HS, and Mathias E (2009). Local breeds, livelihood and livestock keepers' rights in South Asia. Trop Anim Health Prod 41: 1061-1070.

Kolte AY, and Sadekar RD (1996). Phenotypic characters of Gauli Strain of Nagpuri (Berari) buffaloes. Indian Vet J. 73: 1094-1096.

Kumar PP, and Raj TM (2007). Gaddi Buffalo: An Indigenous Breed of Far-west Nepal. Ital. J Anim Sci. 6 (Suppl. 2): 1230-1233.

Kushwaha BP, Kundu SS, Kumar A, Maity SB, and Singh S (2007). Status of Badawari breed of buffalo in its breeding tract and its conservation. Indian J Anim Sci. 77 (12): 1293-1297.

Lamberson WR, Ramos AA, Mahado CHM, Jorge AM, Ferraz Filho PB, DeFreitas JA, and De Souza JC (2007). Parturition intervals and distributions of parturitions by months of buffalo in southern and south-eastern Brazil. Italian J Anim Sci. 6 (Suppl. 2): 593-596.

Lau CH, Drinkwater RD, Yusoff K, Tan SG, Hetzel DJS, and Barker JSF (1998). Genetic diversity of Asian water buffalo (Bubalus bubalis): mitochondrial DNA D-loop and cytochrome b sequence variation. Animal genetics. 29: 253-264.

Lazzaroni C, and Bigini D (2005). Influence of rearing system on body measurements in piemontese young bulls. Italian j Anim Sci. 4 (Suppl. 2): 287.

Ligda DJ (1998). The water buffalo http://www.candiancontent.net/en/jd/go?url=http://ww2.netnitco.net/users/djlida/waterbuf.htm. Accessed on July 1st, 2005.

Loftus T, Machugh DE, Bradley DG, Sharp PM, and Cunningham P (1994). Evidence for two independent domestication of cattle. Proc. National Acad. Sci., USA. 91:2757-2761.

Loos RJ, Derom C, Eeckels R, Derom R, and Vlietinck R (2001). Length of gestation and birth weight in dizygotic twins. Lancet. 358: 560-561.

Lundstrom k, Abeygunawardena H, De Silva LNA, and Perera MMAO (1982). Environmental influence on calving interval and estimates of its repeatability in the Murrah buffalo in Sri Lanka. Anim Reprod Sci. 5: 99-109.

Luo MF, Wiggans GR, and Hubbard SM (1997). Variance component estimation and multitrait genetic evaluation for type traits of dairy goats. J Dairy Sci. 80: 594-600.

Mahdy AE, El-Shafie OM, and Rigalaty HA (2001). Relative importance of some factors affecting performance traits in a herd of Egyptian buffaloes. Alex J Agric Res. 46: 1-18.

Malik KH, and Ahmad M (1969). Heritability estimate of birth weight in Nili-Ravi buffalo calves. Project No-20 ABG. Research studies Vol.1: Long summaries based on the thesis of post-graduate students, West Pakistan Agricultural University Lyallpur.

Manjunatha BM, Ravindra JP, Gupta PSP, Devaraj M, and Nandi S (2008). Oocyte Recovery by Ovum Pick Up and Embryo Production in River Bu□aloes (Bubalus bubalis). Reprod Dom Anim. 43: 477–480

Maqsood M (1980). Development of Asian Buffaloes "Breeds and Types" J Anim Sci. Pakistan. II (3-4): 60-64.

Mason IL (1996). A world dictionary of livestock breeds types and varieties. Technical Commission No. 8 (revised) of the Commonwealth Bureau of Animal Genetics, Edinburgh, Scotland.

Maurad KA (1997). Buffaloes in Egypt. Buffalo Bulletin. 16 (4): 81-85.

Melendez P, and Pinedo P (2007). The association between reproductive perform-

acne and milk yield in Chilean Holstein cattle. J Dairy Sci. 90: 184-192.

Mishra A, Pankaj PK, and Prakash BS (2008). Lactogenic effects of growth hormone in post-partum lactating riverine buffaloes (Bubalus bubalis). Buffalo Bulletin. 27 (2): 196-201.

Mishra K, Neopane SP, and Kandel R (2002). Performance study of Gaddi buffalo in the far-western region of Nepal. Proceedings of the 5th National Workshop on "Livestock and Fishries Research" held at Kathmandu, Nepal (July 10-11). pp 111-114.

Mishra RK, Gourd D, Arora CL (1980). A note on the variation in secondary sex ratio in Sirohi and its half-breds with Beetal goats. Indian J Dairy Sci. 33: 147-152.

Misra SS, Sharma A, Bhattacharya TK, Kumar P, and Roy SS (2008). Association of breed and polymorphism of αS1- And αS2-Casen genes with milk quality and daily milk and constituent yield traits of buffaloes (Bubalus bubalis). Buffalo Bulletin. 27 (4): 294-301

Moghaddam AAI, and Mamoei M2 (2004). A survey on some of the reproductive and reproductive traits of the buffalo in Iran. 23rd World Buiatrics, Quebec City, Canada, (July 11-16).

Mohamed AR, and Jayaruban MG (1991). Reproductive performance and body weight Changes of the lankan and Murrah Buffalo in Sri Lanka. Buffalo and goats in Asia: genetic diversity and its application; proceeding of a seminar Kuala Lumpur, Malaysia, 10-14 February, 1991.

Mohamed M, Mourad KA, and Khattab AS (1993). Genetic relationship of age and weight at first calving with first lactation milk yield in Egyptian buffaloes. Buffalo Bulletin.12 (2): 56-59

Moioli B, and Borghese A (2005). Buffalo Breeds and Management Systems: Chapter III: In: Buffalo Production and Research". (Borghese A, edr). FAO Regional Office for Europe, REU Technical Series 67, the state of art of the research, development, products and market of buffalo species in the world.

Mourad K, Mohamme MM, and Khatab AS (1991). Genetic parameters for milk production traits in a closed herd of Egyptian buffaloes. Egypt J Anim Production. 28: 11-20.

Mourad KA (1997). Buffaloes in Egypt. Buffalo Bulletin. 16 (4): 81-85.

Mourad KA, and Mohamed MM (1995). Genetic and phenotypic aspects of milk yield traits and reproductive performance of Egyptian buffaloes. Egyp J Anim Prod 32: 125-137.

Mourad M, and Rashwan (2001). Milk production of buffaloes and causes of calf mortality under a semi-intensive production system in Egypt. Revue Elev Med Vet Pays Trop. 54 (2): 139-145.

Mureda E, and Zeleke ZM (2007). Reproductive performance of crossbred dairy cows in eastern Lowlands of Ethiopia. (2007). Livestock Research for Rural development 19 (11): 123-128.

Nagasaku EM, Toledo LM, Baruselli PS, and Carvalho NAT (2007). Effects of the season and number of calving on buffaloes milk production. Ital J Anim Sci. 6 (Suppl. 2): 1287-1289.

Nagda RK, Jain IS, and Tailor SP (2007). Effect of non-genetic factors on performance of Surti buffaloes. Indian J Anim Sci. 77 (3): 273-274.

Nanda AS, Brar PS, and Pradhakar S (2003). Enhancing reproduction reproductive performance in dairy buffaloes: major constraints and achievements. Reproduction (Suppl). 61: 27-36.

Naqvi A, and Shami SA (1999). Factors affecting birth weight in Nili-Ravi buffalo calves. Pak Vet J. 19 (3): 89-93.

Narasimharao A V. and Sreemannaryana O. (1994). Milk production efficiency as influenced by month and season of calving in Murrah buffaloes in Andhra Pradesh. Indian Vet J. 71: 341-344

Nascimento VA, Dias M, and Machado TMM (2007). Reproductive and productive performance of water buffaloes in central plateau of Brazil. Ital J Anim Sci. 6 (Suppl. 2): 640-642.

Ndumu DB, Baumung R, Wurzinger M, Drucker AG, Okeyo AM, Semambo D, and Solkner J (2008). Performance and fitness versus phenotypic appearance in the African Ankole Longhorn cattle: a novel approach to identify selection criteria for indigenous breeds. Livestock Science. 113: 234-242.

Neglia G, Gasparrini B, Di Palo R, De Rosa C, Zicareli L, and Campanil G (2003). Comparison of pregnancy rates with two estrus synchronization protocol in Italian Mediterranean Buffalo cows. Theriogenology. 60: 125-133

Nemat-ullah (2001). Recorded reproductive problems in buffalo and cattle in around Islamabad. Proceedings part III. Regional training workshop on reproductive disorders of buffaloes, National Agricultural Research Council (NARC), Islamabad, Pakistan (23-24 July). pp 182-185.

Nigam AA (1996). Characterization of Egyptian buffalo. Proceedings of International Symposium on Buffalo Resources and Production system, Giza, Egypt (17th October).

Pander BL, Kanaujia AS, and Balaine DS (1985). Factors affecting secondary sex ratio in goats. A note. Indian J Anim Prod Manag. 1(3): 131-132.

Parashivescu M, Nicolate I, Bota A, and Grigore F (2007). Hidden resources of buffalo productivity. Bulleti USAMV-CN. 63-64.

Parkash A, Tripathi VN, and Tomer SS (1989). Genetic analysis of reproductive traits of Murrah buffaloes. Ind J Dairy Sci. 42 (3): 426-430.

Patange DD, Rajguru DN, Kulkarrni AN, and Kalyankar SD (2004). Studies on some productive and reproductive traits of Marathwada buffaloes. Indian Vet J. 81 (1): 86-87.

Patel KK, Ninan J, Sulthar BN, and Kavani FS (1992). Factors affecting fertile postpartum estrus in Mensoni buffaloes. Cheiron. 21: 39-43

Patil SS, Kale AM, and Awati AA (1998). Pandharpuri buffaloes for better persistency. Buffalo Bulletin. 17 (3): 65-66.

Patil VP, and Ulmek BR (2002). Phenotypic characteristics of Pandharpuri buffaloes. Indian J Dairy Sci. 55 (1): 58-59.

Patro BN, Mishra PK, and Rao PK (2008). Chilika buffaloes in Orissa: a unique germplasm. File://F\My-Buff-4.12.8\Morphometry.htm.

Paul V, and Prakash BS (2005). Efficacy of the Ovsynch protocol for synchronization of ovulation and fixed-time artificial insemination in Murrah buffaloes (Bubalus bubalis). Theriogenology. 64:1049–1060

Peiris GS, Muhammad AR, and Abeygunawaradena H (1982). Studies on postpartum involution of the uterus in the buffalo. Proceedings of the workshop on "Water buffalo Research in Sri Lanka". Swedish Agency for Research Cooperation with Developing Countries, Stockholm". Report R-3. pp 126-130.

Perera BMAO, and Abeygunawardena H (2000). Use of nuclear techniques for improving livestock production and health in Sri Lanka. A review of studies conducted and strategies for technology transfer. Trop Agri Res Ext. 3(1): 1-13.

Perera BMAO, de Silva LNA, Kuruwita VY, and Karunaratne AM (1987). Postpartum Ovarian Activity, Uterine Involution and Fertility in Indigenous Buffaloes at a Selected Village Location in Sri Lanka. Anim Reprod Sci. 14: 115-127

Porwal ML, Singh MP, and Karandikar GW (1981). Studies on reproductive performance of Murrah buffaloes. Indian Vet J. 58: 295-299.

Prakash A, Tomar SS, Tripathi VN, Singh KP (1990). Inheritance of milk yield per day in Murrah buffaloes. Indian J Anim Genet Breeding 12(2): 6-7

Presicci GA (2007). Reproduction in the Water Buffalo. Reprod Dom Anim. 42 (Suppl. 2): 24-32.

Presiccea GA, Senatore EM, Bella A, De Santis G, Barile VL, De Mauro GJ, Terzano GM, Stecco R, and Parmeggiani A (2004). Ovarian follicular dynamics and hormonal profiles in heifer and mixed-parity Mediterranean Italian buffaloes (Bubalus bubalis) following an estrus synchronization protocol. Theriogenology. 61: 1343–1355.

Pretorius SM, Marle-Koster EV, and Mostert BE (2004). Description of the Friesian Horse population of South Africa and Namibia. S African J Anim Sci. 34 (3): 149-157.

Pundir RK, Sahana G, Navani NK, Jain PK, Singh DV, Kumar S, and Dave AS (2000). Characterization of Mehsana Buffaloes in India. AGRI. 28: 53-62.

Quist MA, LeBlance SJ, Hand KJ, Lazenby D, Miglior F, and Kelton DF (2007). Agreement of Predicted 305-Day Milk Yield Relative to Actual 305-day Milk Weight yields. J Dairy Sci. 90: 4684-4692.

Qureshi MS, Habib G, Samad HA, Siddiqui MM, Ahmad N, and Syed M (2001). Reproduction-nutrition relationship in dairy buffaloes. I. effect of intake of protein, energy and blood metabolites levels. Asian-Aust J Anim Sci. 15: 330-339.

Qureshi MS, Habib G, Samad HA, Siddiqui MM, Ahmad N, and Syed M (2002). Reproduction-nutrition relationship in dairy buffaloes. I. Effect of intake of protein, energy and blood metabolites levels. Asian-Aust J Anim Sci. 15 (3): 330-339.

Qureshi MS, Safi GM, Dhanani J, and Kaka I (1999). Reproductive performance of dairy buffaloes in northern hilly areas of Pakistan. Buffalo J. 15: 391-396.

Qureshi MS, Samad HA, Ahmad N, Habib G, Anjum AD, and Siddiqui MM (1998). Reproductive performance of dairy buffaloes under peri-urban commercial farming in NWFP, Pakistan. Pak Vet J. 18(4): 197-202.

Qureshi ZI, Magray TW, Lodhi LA, and Muhammad G (1996). Service period and calving interval as indices of reproductive performance of cows under field conditions. Pak Vet J. 16 (3): 128-130.

Rafiq M, Chaudhry MA, and Jabbar MA (2008). Effect of level of concentrate supplementation on growth rate and age at maturity in growing buffalo heifers. Pak Vet J. 28 (1): 37-39.

Rakshe PT (2003). Effect of age at first calving and subsequent period of breeding on the performance of buffaloes from the college of Agriculture Pune (MS), India. Buffalo Bulletin. 22 (1): 7-11.

Ranjhan SK, and Pathak NN (1993). Text book on buffalo production (Third edition). Vikas Publishing House Pvt LTD, 576, Masjid Road, Jangpura, New Delhi-110014.

Rao AVN, and Rao HRM (1996a). Calving pattern in Murrah buffaloes in relation to time of the day and season of the year. Indian Vet J. 73: 1195.

Rao AVN, and Rao HRM (1996b). Effect of some non-genetic factors on growth rate of Murrah male calves . Indian Vet J. 73: 1193-1194.

Rao BRC, Patel VG, and Tehman SS (1973). Seasonal trend in reproductive behavior of Surti buffaloes service period, postpartum oestrus interval. Ind. Vet J. 50: 413-417.

Rasali DP, Joshi HD, Patel RK, and Harding AH (1998 b). Phenotypic clusters and karyotypes of indigenous buffaloes in the western hills of Nepal. Lumle Agricultural Research Centre- Technical paper, 98/2: 24.

Rasali DP, Joshi HD, Shrestha H, and Gantam DC (1998 a). Assessment of the infertility situation in cows and buffaloes in the western hills of Nepal. Lumle Agricultural Research Centre working paper, 98/40: 16.

Rawling NC, Evans, ACO, Honramooz A, and Bartlewski PM (2003). Antral follicle growth and endocrine changes in prepubertal cattle, sheep and goats. Anim Reprod Sci. 78: 259-270.

Rege JEO (2001). Defining livestock breeds in the context of community-based management of farm animal genetic resources. In: Proceedings of a Workshop on Community-based management of Animal Genetic Resources- A Tool for Rural Development and Food Security, Mbabane, Swaziland, (FAO, Rome). 27-35.

Rehman A, Khan MA, and Ahmad M (1988). Studies on Nili-Ravi buffaloes in Pakistan. 2. Effect of year and season of calving on service period and calving interval. Pak J Agri Sci. 25 (3) 169.

Rehman A, Tahir M, Khan MA, and Anwar M (1991). Studies on Nili-Ravi buffaloes in Pakistan IV. Effect of year and season of calving on postpartum oestrus interval. Pak Vet J. 11 (1): 17-20.

Rehman SU, Ahmad M, and Shafiq M (2006). Comparative performance of Sahiwal cows at the livestock experiment station Bahadurnagar, Okara vs Patadar's herd. Pak Vet J. 26 (4): 179-183.

Rehman ZU (2006). Inter-herd performance and genetic evaluation of Sahiwal cattle in Pakistan. PhD thesis. University of Agriculture Faisalabad, Pakistan.

Rekwot PI (2004). Effects of feeding Maiz Stover and Cottonseed Cake on Onset of Puberty in Bunaji (Bos indicus) Heifers. Trop Anim Health Prod. 36: 637-644.

Rekwot PI, Ogwn D, Oyedipe EO, and Sekoni VO (2000). Effects of bull exposure and body growth on onset of puberty in Bunaji and Friesian × Bunaji heifers. Reprod Nutr Dev. 40: 359-367.

Ribeiro HFL, Vale WG, Anfrade de VJ, and Marques Jr AP (2003). Environmental effect on the ovarian postpartum activity in the buffaloes raised in low Amazon region, Brazil Buffalo J. 19: 311-321

Rind R, Dhanani J, Samo MU, Unar AM, and Khangharani S (1987). Sex ratio, corneal implantation and ovarian activity in pregnant buffaloes (Bos Bubalis). Pak Vet J. 7 (1): 24-25.

Riva J, Rizzai R, Marelli S. and Cavalchinni L G. (2004). Body measurements in Bergamasca sheep. Small Ruminant Research. 55: 221-227.

Riveiro HFL, Lau HD, Silva AOA, Sousa JS, and Vale WG (1994). Preliminary report on artificial insemination in buffaloes of the Amazon region through imported semen. In: Anales del IV Congreso Mundial de Criadores de Bufalos, sao Paulo, Brazil. 111: 593.

Roth J, and Mayers P (2004). Bubalus bubalis, Animal Diversity Web, viewed 4 July 2005;http://animaldiversity.ummz.umich.edu/site/accounts/information/bubalus_bubalis.html

Royal M, Mann GE, and Flint APF (2000). Strategies for reversing the trend towards subfertility in dairy cattle. The Veterinary Journal. 160: 53–60

Sabrani M, Diwyanto K, and Winugroho M (1994). A critical review of buffalo research and development activities in Indonesia. Past performance and future strategies. Proceedings of 1st Asian Buffalo Association Congress, Thailand, (January 17-21). pp 78-89.

Sachan CB, Kushwaha BP, Kundu SS, and Singh NP (2005). Inheritance of milk yield per day in Bhadawari buffaloes. Indian J Anim Sci. 75 (6): 685-687.

Sackey AK, Okaiyeto SO, Ate IU, Dangana D, and Allam L (1999). Calving interval of some indigenous breeds of cattle in Northern Nigera. Israel J Vet Med. 54 (2).

Sah SK, and Nakkao T (2006). Characteristics of repeat breeding buffaloes in Nepal. J Rep Dev. 52: 335-341.

Samad HA, Ahmad N, Bengmen, Rehman NU, and Ahmad I (2004). Use of milk progesterone assay for monitoring oestrus and early pregnancy in nili-ravi buffaloes. Pak Vet J 24 (3): 121-124.

Sane DD, Khanna RS, Bajpai LD, and Bhat PN (1972). Studies on Murrah buffalo (Bubalus bubalis). II: Genetic analysis of milk yield and peak yield. Indian J Anim Prod. 3: 61-65.

Scarpa R, Drucker A, Anderson S, Ferraes-Ehuan N, Gomez V, Risoparoin C, and Rubio-Leonel O (2003). Valuing animal genetic resources in peasant economies. The case of the Box Keken creole pig in Yuctan. Ecol Economics. 45: 427-443.

Scherf B, Rischkowsky B, and Hoffmann I (2005). Status of animal genetic resources: time for action? International Workshop on" Options and Strategies for the Conservation of Farm Animal genetic Resources" AGROPOLIS' Montpellier, France (7-10 November).

Schmutz SM, Marquess FL, Berryere TG, and Moker J (1995). DNA marker-assisted selection of the polled condition in Charolais cattle. Mamm Genome. 6: 710-713.

Schneider MdeP, Durr JW, Cue RI, and Monardes HG (2003). Impact of type traits on functional herd life of quebec Holsteins assessed by survival analysis. J Dairy Sci. 86: 4083-4089.

Sethi RK (2003). Buffalo breeds of India. Proceedings of the 4th Asian Buffalo Congress, New Delhi, India (25-28 February).

Sethi RK (2009). Genetic improvement of buffaloes for milk production. Pak J Zool. (Suppl. 9): 559-569.

Shafiq P, and Usmani RH (1996). Reproductive performance and milk production of Nili-Ravi buffaloes maintained under barani (Rain fed) area of Punjab. Pak Vet J. 16 (4): 168-171.

Shah NH, Willemse AH, Van de Weil DFM, and Engel B (1989). Influence of season and parity on several reproductive parameters in Nili-Ravi buffaloes in Pakistan. Anim Reprod Sci. 21: 177-190.

Shah SNH (2007). Prolonged Calving Interval in the Nili-Ravi buffalo. Ital J. Anim Sci. 6 (suppl. 2): 694-696.

Shah SNH, Willemse AH, Wiel VD, and Engel B (1989). Influence of season and parity on several reproductive parameters in Nili-Ravi buffaloes in Pakistan. Anim Reprod Sci. 21: 177-190.

Shrestha NP, and Yazman JA (1988). Performance of Murrah and Murrah-cross buffalo at the Lampathan livestock farm, Nepal. Proceeding II-World Buffalo Congress Vol. (1) Abstract.

Shrikhande GB, Kolte AY, and Kolte BR (1996). Phenotypic characters of Nagpuri (Berari) buffaloes. Indian Vet J. 73: 1198-119.

Shrikhande GB, Kolte AY, and Vhora SC (1998). Intercalving period (ICP) in Nagpuri buffaloes. Indian Vet J. 75: 608-611.

Shrivastava AK, Singh CSP, and Verma SK (1998). Effect of non-genetic factors on production traits in buffaloes of un-organized farming system. Indian Vet J. 75: 228-230.

Shrivastave HK, and Kharche KG (1996). Studies on the incidence of normal and abnormal cycling, postpartum estrus interval, frequency of estrus and calvings in buffaloes. Livestock Advisor. 11: 23-26.

Siddique GM, Rajane KR, and Pande MB (1984). Effect of year and parity on some of reproductive traits in Mehsana buffaloes. Livestock advisor 9: 23-25.

Sigh M, Ludri RS, and Nair S (2002). Milk production and reproductive performance of Murrah buffaloes (Bubalus bubalis) hormonally induced into lactation. Indian J Dairy Sci. 5(1): 30-35.

Singh B, and Lal K (1992). Effect of season and breed on certain reproductive traits in buffaloes under village condition. Indian J Anim Res. 26: 15-19

Singh CV, and Barwal RS (2010). Buffalo Breeding Research and Improvement Strategies in India. Proceedings of the 9th World Buffalo Congress Argentina, pp 1024-1031.

Singh CV, and Yadav MC (1987). Non-genetic variation in part lacttion and 300 day milk yield of Nili-Ravi buffaloes. Indian J Anim Sci. 57: 100-105

Singh DV, Tripathi VN, Pathak BL, and Dave AS (1996). Factors influencing 305-day first lactation milk yield in Mehsana buffaloes. Indian Vet J. 73: 584-586.

Singh M, Gulati HK, and Yadav RS (2003). Growth performance of buffalo calves under organized farm management conditions. Proceedings of 4th Asian Buffalo Association Congress, New Delhi, Vol. II pp. 192.

Singh RV, Pundir RK, Nivsarkar AE, Saha R, and Singh CD (1993). Proc. Nt. Seinar on Animal Genetic Research and their conservation, NBAGR. Karnal.

Soydan E, Ocak N, and Onder H (2009). Conception of Jersey cattle in Turkey. Trop Anim Health Prod. 41: 623-628.

Soysal MI, Tuna YT, Gurcan EK, Ozkan E, Kok S, Castellano N, Cobanoglu O, and Barone CMA (2007). Anatolian water buffaloes husbandry in Turkey: Preliminary results on somatic characterization. Ital J Anim Sci. 6 (Suppl. 2): 1302-1307.

Stevenson JS, and Call EP (1988). Reproductive disorders in the peri-parturient dairy cow. J Dairy Sci. 2572-2583.

Sukla S, Yadav BR, and Bhattacharya TK (2006). Characterization of Indian Riverine Buffaloes by Microsatellite Markers. Asian-Aust J Anim Sci. 19 (11): 1556-1560.

Sule SR, Taparia AL, Jain LS, and Tailor SP (2001). Reproductive status of Surti buffaloes maintained under sub-humid conditions of Rajasthan. Indian Vet J. 78: 1049-1051

Suryanto B, Arifin M, and Rianto E (2002). Potential of swamp buffalo development in central Java, Indonesia. Buffalo Bulletin. 21 (1): 3-9.

Suthar BN, and Kavani FS (1992). Occurrence and nature of postpartum estrus in Mehsani buffaloes. Indian J Anim Reprod. 13: 161-164.

Swaminathan MS (1988). Conservation of animal genetic resources. Proceeding II-World Buffalo Congress Vol. 2 part I: 375-386 (Decermber, 1988).

Tahir M, and Sial MA (1976). Effect of calving season on lactation length and dry period in Nili-Ravi buffaloes. Pak J Agri Sci. XIII (2): 241-244.

Tailer SP, Kothari MS, and Nagda RK (2006). Genetic studies of first lactation traits in Surti buffaloes. Compendium of National Symposium on Buffalo for Rural Upliftment and Annual Convention of Indian Society for Buffalo Development. (May, 27-30) Mumbai. pp 31.

Tayyib M, and Qureshi AW (1967). Some environmental influences on calving interval of cows and buffaloes. Pak J Agric Sci. 4: 27-32.

Tegegne A, Entwistle KW, and Mukasa-Mugerwa E (1992). Effects of dry season nutritional supplementation on growth, onset of puberty and subsequent fertility in Boran and Boran × Friesian heifer in Ethiopia. Theriogenology. 37: 1017-1027.

Tekerli M, Kucukkebabci M, Akalin NH, and Kocak S (2001). Effects of environmental factors on some milk production traits, persistency and calving interval of Anatolian buffaloes. Livestock Prod Sci. 68: 275-281

Terzano GM, Neglia G, Maschio M, Barile VL, Razzano M, Martiniello P, Cannone I, and Borghese A. (2007). Effect of intensive or extensive systems on buffalo heifers performances: onset of puberty and ovarian size. Ital J Anim Sci. 6 (Suppl. 2): 1273-1276.

Thirunavukkarasu M, and Kathiravan G (2006). Predcting the probability of conception in artificial inseminated bovines- A logistic regression analysis. J Anim Vet Adv. 5 (6): 525-527.

Thomas CS (2004). Milking management of dairy buffaloes. PhD Thesis, Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Tiwari RP, Jogi S, and Sahu SK (2004). Effect of prostaglandin administration after calving in buffaloes on postpartum reproductive performance. Buffalo Bulletin 23: (3): 78-83

Tomar AKS, Pandy HN, Bisht GS, and Joshi HC (2006). Milk production in Murrah buffaloes and factors affecting in northern India. Compendium of National Symposium on Buffalo for Rural Upliftment and Annual Convention of Indain Society for Buffalo Development (May, 27-30), Mumbai. pp 20-21.

Tonhati H, Ceron-Munoz MF, de Oliveira JA, Faro LE, Lima AL F, and de Albuquerque LG (2008). Test-day milk yield as a selection criterion for dairy buffaloes (Bubalus bubalis artiodactyla, Bovidae). Genetic Mol Biol. 31 (3): 674-679.

Tuyen DK (2003). The role of Swamp buffalo in agricultural production of small farm holders. Buffalo Bulletin. 22 (4): 91-95.

Ucar M, Kucukkebabci M, Gundogan M, Uguz C, and Saban E (2004). Reproductive performance of Anatolian water buffaloes during postpartum period. Indian Vet J. 81: 784-786.

Upadhyay RC, Singh SV, and Kumar A (2007). Impact of Climate Chalange on Milk Production of Murrah buffaloes. Ital J Anim Sci. 6 (Suppl. 2): 1329-1332.

Ur-Rahim, I, and Viaro A (2002). Swat: An Afghan society in Pakistan. Urbanization and change in a tribal environment. City Press, 316, Madina City Mall, Abdullah Haroon Road, Saddar, Karachi 74400.

Urdu Tourists Guide. http://www.swatvalley.com/swat/utg/mausam.shtml

Uslu NT (1970). Buyume Doneminde Bulunan Mandalarin Protein ve Nisasta Degeri Ihtiyaclari Uzerinde Calismalar. Yem Bitkileri Deneme ve Uretme Ist. Yayin No. 5 Afyon.

Usmani RH (1983). Postpartum changes in reproductive organs and oestrus activity. M. Sc. Thesis. West Vargina University Morgantouem.

Usmani RH, and Mirza MA (2000). Influence of parity and month of peak calving season postpartum estrus activity and fertility of Nili-Ravi buffaloes. Pak J Biol Sci. 3(12): 2179-2181.

Usmani RH, Daily RA, and Inskeep EK (1990). Effects of limited suckling and varying prepartum nutrition on postpartum reproductive traits of milked buffaloes. J Dairy Sci. 73: 1564-1570.

Usmani RH, Lewis GS, and Naz N (1987). Factors Affecting Length of Gestation and Birth Weight of Nili-Ravi Buffaloes. Anim Reprod Sci. 14: 195-203

Usmani RH, Ullah N, and Shah SK (1985). A note on the effect of suckling stimulus on uterine involution, postpartum ovarian activity and fertility in Nili_Ravi buffaloes. Anim Prod. 41: 119-122.

Vij PK, and Tantia MS (2005). Status of Nili-Ravi buffaloes in India. AGRI. 37: 75-81

Weigel K A (2004). Imroving the reproductive efficiency of dairy cattle through genetic selection. J Dairy Sci. 87 (E Suppl): E86-E92.

Annexure

Questionnaire:

No.________________________Interviewer_______________________________

Village______________________________Date___________________________

Herd composition of Azikheli buffalo

Type	Number
Azikheli buffalo cows	
Heifers	
Female calves	
Male calves	
Bulls	

Pubertal age of Azikheli buffalo cows/heifers

Type	No. of Buffalo cow/heifer	Pubertal age (months)
Azikheli buffalo cows	Buffalo cow No.1	
	Buffalo cow No.2	
	Buffalo cow No.3	
	Buffalo cow No.4	
	Buffalo cow No. 5	
Heifers	Heifer No. 1	
	Heifer No. 2	
	Heifer No. 3	
	Heifer No. 4	

Parity number, calving season and calf sex of Azikheli buffalo cows

Azikheli buffalo cows	Parity No.	Calving season	Sex of the calf
Buffalo cow No.1			
Buffalo cow No.2			
Buffalo cow No.3			
Buffalo cow No.4			
Buffalo cow No. 5			

Postpartum anoestrus interval of Azikheli buffalo cows (months)

Azikheli buffalo cows	Postpartum anoestrus interval (months)
Buffalo cow No.1	
Buffalo cow No.2	
Buffalo cow No.3	
Buffalo cow No.4	
Buffalo cow No. 5	

Conception efficiency of Azikheli buffalo cows

	Number of natural services provided							
Azikheli buffalo cows	1^{st}	2^{nd}	3^{rd}	4th	5th	6th	7th	8th
Buffalo cow No.1								
Buffalo cow No.2								
Buffalo cow No.3								
Buffalo cow No.4								
Buffalo cow No. 5								

Calving interval of Azikheli buffalo cows (months)

	First parity	Second parity	Third parity	Fourth parity
Azikheli buffalo cows				
Buffalo cow No.1				
Buffalo cow No.2				
Buffalo cow No.3				
Buffalo cow No.4				
Buffalo cow No. 5				

Dry period of Azikheli buffalo cows (months)

	First parity	Second parity	Third parity	Fourth parity
Azikheli buffalo cows				
Buffalo cow No.1				
Buffalo cow No.2				
Buffalo cow No.3				
Buffalo cow No.4				
Buffalo cow No. 5				