

**ACTIVITIES PATTERN OF WILD WATER BUFFALO (*Bubalus arnee* Kerr, 1792) IN KOSHI TAPPU WILDLIFE RESERVE, NEPAL  
(A case study of Kusaha area)**



**NIRSING KUMAR RAI**

**T.U. REGISTRATION NO: 5-1-8-112-97**

**T.U. EXAMINATION ROLL NO: 6183**

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NEPAL**

**AUGUST 2013**



Phone No.: 01-4331896

**TRIBHUVAN UNIVERSITY**  
**CENTRAL DEPARTMENT OF ZOOLOGY**  
**Kirtipur, Kathmandu**  
**Nepal**

**Ref. No:**

**DECLARATION**

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institutions(s).

Date:08 August 2013

Nirsing Kumar Rai



Phone No.: 01-4331896

**TRIBHUVAN UNIVERSITY**  
**CENTRAL DEPARTMENT OF ZOOLOGY**  
**Kirtipur, Kathmandu**  
**Nepal**

Ref. No:

**RECOMMENDATIONS**

This is to recommend that the thesis entitled “**ACTIVITIES PATTERN OF WILD WATER BUFFALO (*Bubalus arnee* Kerr, 1792) IN KOSHI TAPPU WILDLIFE RESERVE, NEPAL (A case study of Kusaha area)**” has been carried out by **Mr. Nirsing Kumar Rai** for the partial fulfillment of **Master’s Degree** of Science in **Zoology with special paper of Ecology**. This is original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

Date: 31 August 2013

Dr. Mukesh Kumar Chalise  
Associate professor  
Central Department of Zoology  
Tribhuvan University  
Kirtipur, Kathmandu, Nepal



Phone No.: 01-4331896

**TRIBHUVAN UNIVERSITY**  
**CENTRAL DEPARTMENT OF ZOOLOGY**  
**Kirtipur, Kathmandu**  
**Nepal**

Ref. No:

**LETTER OF APPROVAL**

On the recommendation of supervisor **Dr. Mukesh Kumar Chalise** this thesis submitted by **Mr. Narsing Kumar Rai** entitled “**ACTIVITIES PATTERN OF WILD WATER BUFFALO (*Bubalus arnee* Kerr, 1792) IN KOSHI TAPPU WILDLIFE RESERVE, NEPAL (A case study of Kusaha area)**” is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for **Master’s Degree of Science in Zoology with special paper Ecology.**

Date: 19 September 2013

Prof. Dr. Ranjana Gupta  
Head of Department  
Central Department of Zoology  
Tribhuvan University  
Kirtipur, Kathmandu, Nepal



Phone No.: 01-4331896

**TRIBHUVAN UNIVERSITY**  
**CENTRAL DEPARTMENT OF ZOOLOGY**  
**Kirtipur, Kathmandu**  
**Nepal**

Ref. No:

**CERTIFICATE OF ACCEPTANCE**

This thesis work submitted by **Mr. Narsing Kumar Rai** entitled “**ACTIVITIES PATTERN OF WILD WATER BUFFALO (*Bubalus arnee* Kerr, 1792) IN KOSHI TAPPU WILDLIFE RESERVE, NEPAL (A case study of Kusaha area)**” has been accepted as a partial fulfillment for the requirements of **Master’s Degree of Science in Zoology** with special paper **Ecology**.

**EVALUATION COMMITTEE**

Supervisor  
Dr. Mukesh Kumar Chalise  
Central Department of Zoology  
Tribhuvan University  
Kirtipur, Kathmandu, Nepal

Head of Department  
Pro. Dr. Ranjana Gupta  
Central Department of Zoology  
Tribhuvan University  
Kirtipur, Kathmandu, Nepal

Pro. Dr. Bhaiya Khanal

Dr. Ramesh Kumar Shrestha

External Examiner

Internal Examiner

Date of Examination: 15 September 2013

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# CONTENTS

	Page No.
TITLE	I
DECLARATION	II
RECOMMENDATION	III
LETTER OF APPROVAL	IV
CERTIFICATE OF ACCEPTANCE	V
ACKNOWLEDGEMENT	VI-VII
CONTENTS	VIII
LIST OF TABLES	IX
LIST OF FIGURES	X
LIST OF MAP	XI
LIST OF ABBREVIATIONS	XII
ABSTRACT	1-8
1. INTRODUCTION	1-6
1.1 Background	2-3
1.1.1 History	3-4
1.1.2 Current distribution	4-5
1.1.3 Morphology	5-6
1.1.4 Ecology and behavior	7
1.2 Rational of the study	7-8
1.3 Research Hypothesis	8
1.4 Objectives of the study	8
1.5 Limitation of the study	9-10
2. LITERATURE REVIEW	11-22
3. METHODS AND MATERIALS	11-15
3.1 Study Area	11-13
3.1.1 Physical Parts	13-14
3.1.2 Faunal Diversity	14
3.1.3 Floral Diversity	14-15
3.1.4 Climate	15-22
3.2 Methods	15
3.2.1 Reconnaissance Survey	16
3.2.2 Discussion with people	16
3.2.3 Survey Techniques	16
3.2.3.1 <i>Random sampling technique</i>	16
3.2.3.2 <i>Scan sampling</i>	17
<i>i Major state activities</i>	18
<i>ii Short event activities</i>	18
3.3 Framing the study time pattern	19
3.4 Average activity pattern	19
3.5 Seasonal activity pattern	20
3.6 Shift wise activity pattern	20
3.7 Comparative study	21
3.7.1 Selection of herd	21

3.7.2 Average comparison	21
3.7.3 Seasonal comparison	22
3.8 Data analysis	22
3.8.1 t-test	22
3.9 Material used	22
4. RESULT	23-34
4.1 General diurnal activity pattern	23
4.1.1 Average diurnal activity pattern	23
4.1.2 Seasonal diurnal activity patter	24-27
4.1.3 Other activities	27-28
4.1.4 Shift wise activity pattern	28-30
4.2 Comparative Study	30-34
4.2.1 Average comparative study	30
4.2.2 Seasonal comparative study	31-34
5. DISCUSSION	35-43
5.1 General Study	35-39
5.1.1 Average diurnal activity pattern	35-37
5.1.2 Seasonal diurnal activity pattern	37-39
5.1.3 Other activities	39-40
5.2 Comparative study	40-43
5.2.1 General comparison	40-41
5.2.2 Seasonal comparison	41-43
6. CONCLUSION AND RECOMMENDATIONS	44-45
7. REFERENCES	46-51
8. APPENDICES	52-60
Appendix-I Tables	52-57
Appendix-II Photo plates	57-60



## LIST OF TABLES

<b>Table</b>	<b>Title of tables</b>	<b>Pages</b>
1	Population and age-sex category of Wild Water Buffalo in KTWR.	4
2	Preferred feeding plants by <i>Bubalus arnee</i> including agricultural Crops	6
3	List of local people discussed with about Wild Water Buffalo.	16
4	The whole number for the individuals selected randomly for scanning from the male band and mixed herd.	17
5	The scheduled pattern of studying herds for a season.	19

## LIST OF FIGURES

<b>Figure</b>	<b>Title of figures</b>	<b>Pages</b>
1	Average temperature (Tarahara station) and precipitation (Chatara station) related to the climate of the study area, KTWR.	15
2	The percentage of different activities of Wild Water Buffalo in KTWR.	23
3	The percentage chart of different activities of Wild Water Buffalo in Monsoon season.	24
4	The percentage chart of different activities of Wild Water Buffalo in Autumn season.	25
5	The percentage chart of different activities of Wild Water Buffalo in Winter season.	26
6	The percentage chart of different activities of Wild Water Buffalo in Spring season.	27
7	The bar graph showing different activities in different seasons.	27
8	Other activities in three different shifts.	28
9	Percentage of different activities in morning shift.	29
10	Percentage of different activities in day shift.	29
11	Percentage of different activities in evening shift.	30
12	Comparative activities in between male band and mixed herd.	31
13	Comparative activities in between male band and mixed herd of monsoon season.	32
14	Comparative activities in between male band and mixed herd of autumn season.	33
15	Comparative activities in between male band and mixed herd of winter season.	34
16	Comparative activities in between male band and mixed herd of spring season.	34

## LIST OF MAPS

Map	Title of Photographs	Page No.
1	Location and physical parts of KTWR in Nepal.	11
2	Study area of Kusaha KTWR.	12

## LIST OF ABBREVIATIONS

a.m.	Anti-meridian
BCN	Birds Conservation Nepal.
BZMP	Buffer Zones Management Plan.
CITES	The Convention on International Trade in Endangered species of wild fauna and flora.
DNPWC	Department of National Parks and Wildlife Conservation.
En	Endangered.
GEF	Global Environment Facility.
GoN	Government of Nepal.
GPS	Global Positioning System.
H <sub>1</sub>	First herd (here to male band).
H <sub>2</sub>	Second herd (here to mixed herd).
Ha	Hectare.
I <sub>(f)</sub>	The whole number for the individuals to be followed.
IUCN	International Union for Conservation of Nature
KTWR	Koshi Tappu Wildlife Reserve.
p.m.	Post-meridian.
PPP	Park People Project.
R	Random number generated by using a scientific calculator.
UNDP	United Nation.
UNDP	United Nations Development Program
VDC	Village Development Committee.
WMI	Woodlands Mountains Institute.
X	No study.

## ABSTRACT

This study was done on the diurnal activity patterns of two different herds of Wild Water Buffalo (*Bubalus arnee*) in Kusaha area of Koshi Tappu Wildlife Reserve; a flood plain of Koshi river. Four main activities as grazing, resting, standing and wallowing of diurnal patterns for four seasons were studied by scan sampling method in the year of 2011 and 2012. It was found that a herd of Wild Water Buffalo grazed by walking instead of single place for 50%, rested 27%, stood 13% and wallow 10% of observation of average diurnal period. So they are good browser.

Seasonally, it was found that they graze similar in average but comparatively more in winter season i.e. 57% of a day time. Their highest activities revealed for resting was in monsoon season 32%, standing was in winter season 20% and wallowing was in spring season 21% of day time but the least are for grazing in monsoon season 42%, resting in winter season 23%, standing in spring season 8% and wallowing in winter season 0% of a day time.

For the comparative study set hypothesis were, “four major activities patterns will be same in between male band and mixed herd” and tested as null hypothesis by using popular student test i.e. t-test. It had accepted only one activity is wallowing (p-value > 0.05). So there is no significant difference in wallowing pattern in between male band and mixed herd. But other activities like grazing (p-value < 0.05), resting (p-value < 0.05) and standing (p-value < 0.05) are significantly different between these male band and mixed herd of Wild Water Buffalo.

Generally male band was observed more resting (42% vs 12%) and more wallowing (12% vs 9%) than mixed herd. Similarly mixed herd was observed more grazing (62% vs 37%) and more standing (17% vs 9%) than male band in average diurnal time (11 hours and 30 minutes) of a day.

**Key Words:** Flood plains, Diurnal patterns, Browser, Scan sampling, t-test.

# 1 INTRODUCTION

## 1.1 Background

Wild Water Buffalo also known as Asian wild buffalo (*Bubalus arnee*) is a large ungulate, a member of the bovine subfamily and almost near ancestor or the close relative of the domestic water buffalo (Lau et al. 1998, Gentry et al. 2004). It is the second largest wild bovid where the largest one is Gaur (*Bos gaurus*). They are associated with wet grasslands, swamps and densely vegetated river valleys (Chalise 2008). Wild Water Buffaloes are still found in India, Nepal, Bhutan, Myanmar and Thailand. It is considered that wild Asian water Buffalo are extinct from Pakistan, Bangladesh, Laos and Viet Nam (Choudhary 2010). It is considered only the feral water buffaloes are found in northern Australia (Grubb 2005).

Wild Water Buffalo is listed as endangered (En) in IUCN red list since 1986 (IUCN. 2011) and CITES has kept under Appendix-III. Its number is considered to be less than 4,000 in the globe (Scherf 2000). From this data it can be assumed that the matured Wild Water Buffaloes may be less than 2,500 individuals. It is estimated that the decline of the number will be 20% within 14 years and if it continued then at least 50% will disappear within the last three generation i.e. 24 to 30 years. So the threat problems have been raised. The threats especially due to the hybridization with domestic water buffalo are being serious (Hedges et al. 2008). It was also claimed that the population found in Asia are feral buffalo (Nowak 1999).

Nepal government has protected the species and gazette Koshi Tappu Wildlife Reserve (KTWR) in 1976 A.D. mainly for their conservation. The last remnant population of Wild Water Buffalo is found in KTWR east Nepal. The reserve is the major flood plains of the snow fed Sapta Koshi River; a main tributary of Ganga river of India. This reserve has extended in three subtropical districts Sunsari, Udayapur and Saptari of Nepal. The population of Wild Water Buffalo had counted from 63 individuals in 1976 to 237 in 2011 (DNPWC 2011). The buffalo was found in largest herds of 87 and 99 individuals but some smaller herds of sub adult male and isolate male also prevailed (Khatri et al. 2012). The census held in 2004 had estimated that population of 159

individuals of wild buffalo, and a highly backcrossed, semi-feral population of 49 animals (Heinen and Kandel 2006, Chalise 2008).

The Wild Water Buffaloes are described as two types; Swamp and River (Cockrill 1977). It is classified on the basis of the morphological and behavioral characteristics of the buffaloes. The river Wild Water Buffaloes are found to be ranged from Indian subcontinent to west Balkans and Italy but the swamp Wild Water Buffaloes are found to be ranged from Assam, the south- East Asia to Yangtze valley of China to the east (Cockrill 1974). From the phylogenic study it has been pointed out that the Swamp water buffalo are originated from China and the river types of wild buffaloes are originated from India (Yang et al. 2008). China has huge variety of buffalo genetic resources where each region has different types of buffalo recorded and 16 local breeds of swamp buffalo has noted only in China (Borghese and Mazzi 2005).

The taxonomy of Wild Water Buffalo (*Bubalus arnee*) adopted by most authors (Gentry et al. 2004) is as follows:

<b>Kingdom:</b>	Animalia	<b>Sub-family:</b>	Bovinae
<b>Class:</b>	Mammalia	<b>Tribe:</b>	Bovini
<b>Order:</b>	Artiodactyla	<b>Genus:</b>	Bubalus
<b>Family:</b>	Bovidae	<b>Species:</b>	<i>Bubalus arnee</i> (Kerr,1792)
		<b>Local Name:</b>	Arna

### 1.1.1 History

The genus *Bubalus* was widely distributed in Europe and southern Asia during the Pleistocene age, but was later restricted to the Indian subcontinent and Southeast Asia (Mason 1974). Ancestors of the present buffalo *Bison laitefrons* were European herds grazer distributed in Europe around in 200,000 years ago, which was then connected with the Asia and America. Later due to the process of geographical evolution the land was submerged and separated from each other simultaneously, the species was also separated from the old location into these three Continents. *Bison laitefrons* considered that they were extinct before 120,000 years ago, but they leaved two new species as their new generations;

1. *Bison antiquus* in North America and mostly related with human beings. They got extinct 10,000 years ago.
2. *Bison occidentalis* is considered as today's buffalo. It has two races as *B. bison* also known as wood buffalo or mountain buffalo and *B. athabascae* in North America (Wilson and Strobeck 1999) .

Asian wild buffalo, no doubt are the ancestor family of the domesticated buffalo (Lau et al. 1998), which is being used as dairy and draught animals in Asia, a part of North America and Europe.

From the historical background, it can be said that the domestication of wild buffalo were started before 4,500 years. At that time wild buffaloes were considered ranging from the Mesopotamia to Indo China. The first domestication was in Zhejiang Province of China and somewhere in south of Yangtze River which started some 6000-7000 years ago. These are proved from different archeological evidences. The first domestication was done for wild buffalo (*Bubalus mephistopheles*) (Nowak 1999).

### **1.1.2 Current distribution**

The Asiatic Wild Water Buffalo (*Bubalus arnee*) is an endangered species restricted to South and South-east Asia. Currently wild buffaloes are distributed in eastern Nepal, India, Bhutan, Thailand, South Malaysia and Indonesia. In Nepal, the wild buffaloes were noted before 1960 in Royal Chitwan National Park. However, they were extinct locally from there probably due to diseases carried out by domesticated cattle or buffaloes (Seidensticker 1975, Chalise 2008). Currently, the one fragmented small population of Wild Water Buffalo (*Bubalus arnee*) is refuted in the eastern Nepal at Koshi Tappu Wildlife Reserve (Scherf 2000). The population trend of Wild Water Buffalo in Koshi Tappu area is in increasing order (Tab. 1) has indicated that small isolated populations may remain in the Koshi Tappu Wildlife Reserve. But due to the large number of domesticated buffalo invasion permanently in the reserve, there are high chances of genetic erosion of the Wild Water Buffalo. It has been already confirmed that around 20% of the Wild Water Buffaloes are not genetically pure (Flamand et al. 2003).



Table 1: Population and age sex category of Wild Water Buffalo in Koshi Tappu area.

Year	Adults		Calves		Total	Calves/cows
	Male	Female	2nd year	1st year		
1976	12	18	22	11	63	0.61
1987	32	29	14	16	91	0.55
1988	37	33	8	15	93	0.45
2000	56	53	17	19	145	0.36
2004	54	63	24	18	159	0.29
2009	55	119	22	23	219	0.19
2010	57	108	24	26	215	0.22
2011	66	117	15	39	237	0.33

Source: DNPWC. 2011. Arna (Asian Wild Buffalo) Census Report 2068

(Ashok Ram)

### 1.1.3 Morphology

Wild buffaloes are large and strongly built animal with 1.72 meter to 2.0 meter at shoulder height. They weigh 700 to 900 kilogram with 197.6 cm average length of both horns. Both sexes carry horns with heavy at the base and widely spreading up to 2m along the outer edges for female but in larger base and stouter for male, exceeding in size the horns of any other living bovid (Chalise 2008). A well and healthy buffalo may weigh to 800 to 1,200 kg and height of 2.4-3 m. They have wide long crescent shaped horn with pointed tip (IUCN 2011).

Their head to body length generally ranges from 240 cm to 300 cm with a tail length of 60 cm to 100 cm long and bears generally white bushy tip. Their skin color is ash gray to black. They have moderately long and coarse hair, sparsely arranged and directed forward from the haunches to the long and narrow head. There is presence of tuft of hair on the forehead, and the ears are comparatively small with pink or red skin and dirty white hair inside. The hooves are comparatively larger and broader than domesticated buffalo or other any bovid (Nowak 1999).

#### 1.1.4 Ecology and Behavior

Wild buffaloes are tied to the availability of water. Historically their preferred habitats were low laying alluvial grasslands, their surroundings, with riverine forests and some woodland (Lydekker and Dollman 1926, Prater 1971, Choudhary 1994). It apparently used small pools and marshes, in addition to permanently flowing rivers (Wharton 1957). Although the altitudinal range is not clear in Nepal for its occurrence but it is found at least up to 1000 m of elevation. So it shows that it depends on needs of level of land required rather than its altitudinal or low region land preference (Hedges et al. 2008).

As a social animal, bachelor male makes a herd may be of 10 individuals or remain as a solitaire. A herd of female is chased by only one dominant male also called alpha male. They may mix together during mating period. No serious fighting will occur among them (Chalise 2008). The herds of 15-20 individuals are common in KTWR, Nepal (Chalise 2008).

They are nocturnal though they spend mostly morning and evening hours lying up in dense cover. At midday, they wallow in fresh water or muddy water. Sometime in spring season, they wallow whole day. The wallowing is the process of thermoregulation because they could not bear hot climate due to their thickness and less sweat gland in skin (Sambraus and Spann 2005). During wallowing they keep their body under water or only keep nostrils out (Borghese and Mazzi 2005).

Maturity age, male attain at the age of 18 months and female attain puberty after the age of 3 years and is capable of regular production till 15 years. The male are capable in reproduction after 4 years of birth. Gestation Period may last up to 300 to 340 days or 10-11 months (Chalise 2008). A mother can give only one calf at once of birth in the interval of 2 years but twins are also possible. The breeding season is commonly within May – June. The early development is completed when weaning occurs at the age of 6-9 months. It has been recorded that the maximum age of wild buffalo is 25 years in wild and may reach 29 years in captivity (Nowak 1999).

They are herbivorous mainly grass grazer of alluvial grassland, raiding crops is the main cause of park people conflict. Little has been published on the diet of wild (or feral) Water Buffaloes. They are probably grazers by preference, feeding mainly on grasses when available, but they also feed on herbs, fruits, and bark as well as browse some trees and shrubs. Dubo (*Cynodon dactylon*), *Themeda quadrivalvis*, and *Coix* sp., all grasses are known to be eaten by wild buffaloes in India (Daniel and Grubh 1966).

They are also observed feeding on the sedge (*Cyperus corymbosus*). Dahmer (1978), Shrestha (1981) and Kushwaha (1986) provided a little information about the diet of Wild Water Buffalo in Nepal (Table 2). They also feed on crops including rice (*Oryza sps.*), sugar cane (*Saccharum sps*), and jute (*Corchorus sps*) etc. and sometimes cause considerable damage (Kushwaha 1986, Bauer 1987).

Table 2 Preferred feeding plants by *Bubalus arnee* including agricultural crops.

Scientific Name	Local Name	Preferences
<i>Cynodone dactylon</i>	Dubo	++++
<i>Imperata cylindrical</i>	Siru	++++
<i>Sccharum spontaneum</i>	Khar	++++
<i>Sccharum bengalensis</i>	Khari	+++
<i>Typha elephant</i>	Narkat	+++
<i>Themeda auradinaria</i>	Dhadi	+++
<i>Dalbergia sissoo</i>	Sisso	+
<i>Acacia catechu</i>	Khayer	+
<i>Bombyx ceiba</i>	Simal	+
<i>Ficus bengalensis</i>	Bar	+
<i>Eugenia jambolanta</i>	Jamun	+
<i>Oryza sativa</i>	Dhan	++++
<i>Triticum aestivum</i>	Ganhu	++++
<i>Zea mays</i>	Makai	++++
<i>Norenga drophyracorma</i>		+++

Note: The '+' represents the strength of their preference; source: Kherwar (1996)

## 1.2 Rationale of the study

There are many challenges for the conservation of Wild Water Buffalo. The genetic integrity of Wild Water Buffalo has become a big problem due to interbreeding with the domestic buffalo (Woodford 1979, Corbet and Hill 1992, Gee 1964, Maia 1970). Another problem is the loss of their natural habitat due to several reasons with degradation of (*Micania macrantha*) in KTWR (Heinen and Kandel 2006). Other problems are like Hunting (anthropogenic), flood (natural), diseases (zoonosis) etc. Acknowledging these problems study for the Wild Water Buffalo is very important.

Many studies have been made on Wild Water Buffalo (*Bubalus arnee*) from south Asian subcontinents. In Nepal also verity studies have already done on Wild Water Buffalo for example population viability (Heinen 1993a), anthropogenic impact (Kherwar 1996), phenotypic and behavioral differences from feral (Heinen 2002), genetic identification (Flamand et al. 2003) and population status (Dahmer 1978, Heinen and Singh 2001, DNPWC 2009, Ram 2010).

Though different studied have been made on the species but detail study on the behavior and activities patterns have not made yet. Only limited study has made on African Cape Buffalo (*Syncerus caffer*) from Africa continent (Ryan and Jordaan 2005). Being unknown about the behavior of a Wild Water Buffalo people of local area are still feeling a danger consciousness and take it as an angry beast of the park.

It is only one and last remnant population that makes it also very necessary to translocate them in other suitable habitat as well. For that important work different information on their activities and behavioral patterns are also necessary. Due to these reasons a detail study on the topic was initiated.

## 1.3 Research hypothesis:

- Seasonal changes affect the activities pattern of Wild Water Buffaloes.
- The type of herd by composition affects activities pattern of Wild Water Buffaloes.

#### **1.4 Objectives of the study**

The main objectives of the study were to assess the general behavioral pattern of Wild Water Buffalo (*Bubalus arnee*) in Koshi Tappu Wildlife Reserve, Sunsari. The specific objectives of the study were:

1. To estimate the average diurnal activities patterns of Wild Water Buffalo.
2. To determine the seasonal diurnal activities patterns of Wild Water Buffalo.
3. To compare the diurnal activities patterns in between two different herds by composition.

#### **1.5 Limitation of the study**

- Observation and generalization for different herds could not accomplish.
- Nocturnal activities could not assess.

## 2 LITERATURE REVIEW

### 2.1 Activities Pattern of Wild Water Buffalo

The Wild Water Buffaloes are the good grazer and found mainly engaged on surfing and feeding day or night because they are active in both periods at day and night. So they are both diurnal as well as nocturnal (Borghese and Mazzi 2005). The KTWR is the confusing home range of the Wild Water Buffalo because they frequently visit to sugarcane, wheat and maize fields (Kushwaha 1986).

Wild life does not understand the political and national boundary, they (large wild life as wild buffalo) need large area for their activities (Dhamer 1978). The genetic erosion is another main problem due to the interbreeding with feral and domesticated buffaloes. So the population of the Wild Water Buffalo in the reserve are not viable population (Heinen 1993a) so they need translocation ((Heinen and Shingh 2001). These mixed breeds seem equal number around the park and looks similar to wild species in shape size and behaviors (Chalise 2008)

The Wild Water Buffalo have thick skin layers generally six times thicker than other cattle and sweat gland has got reduced by one sixth so they cannot withstand hot so wallows mostly or rest in shady and cool places (Sambraus and Spannll 2005). They mostly wallowed in spring season by only keeping their nostril out for long time or whole day (Borghese and Mazzi 2005). Generally the Wild Water Buffalo grazes more in day time than the night time and they ruminates mostly in the either during wallowing or the during the laying down (Kassim and Baharin 1979).

The activities patterns of African Cape Buffalo have done in detail. Since it is also being near relatives of Wild Water Buffalo patterns can be compared. In the 24 hours of the activity time budget an African Cape Buffalo (*Syncerus caffer*) showed that they engaged 40% of a day for grazing i.e. nine hours and thirty six minutes. They rested 34% of a day which is equal to eight hour and ten minutes and found stand 11% of a day time which is equal to two hours and thirty eight minutes (Ryan and Jordaan 2005).

The population of wild buffalo is growing in comparison to before 12 years but, when population characteristic breeding structure and sources of mortality in KTWR were studied as physical nature of the reserve and known seasonal movement of buffalo suggested that the present population is not viable for several reasons. For example around 50% of the first year calves got swept away due to rainy flood; Wild Buffalo mostly raid the public crops so the reserve is not the all-time home range. Thousands of cattle and domesticated buffalo around the park wild buffalo of KTWR have high risk of diseases (Heinen 1993a).

There is a big challenge for conservationist because what we think as wild or pure *Bubalus arnee* are mostly feral one. This is due to the interbreeding of wild and domestic buffaloes. Similar reports of genetic integrity lost from Ruhana (Woodford 1979) Sri Lanka, Viet Nam and Lao PDR (Corbet and Hill 1992, Gee 1964, Maia 1970). In the other hand the invasive plant called Lahare Banmara also called Mizorame Lahara (especially by eastern local people who had visited Mizoram decades ago and back because they had story about such plant in Mizoram only that time) (*Mikania macrantha*) a vine also potentially has threaten wetlands in the south Asian range or Wild Water Buffalo habitat. Due to this reason also the Wild Water Buffaloes are in serious habitat threats (Heinen and Kandel 2006).

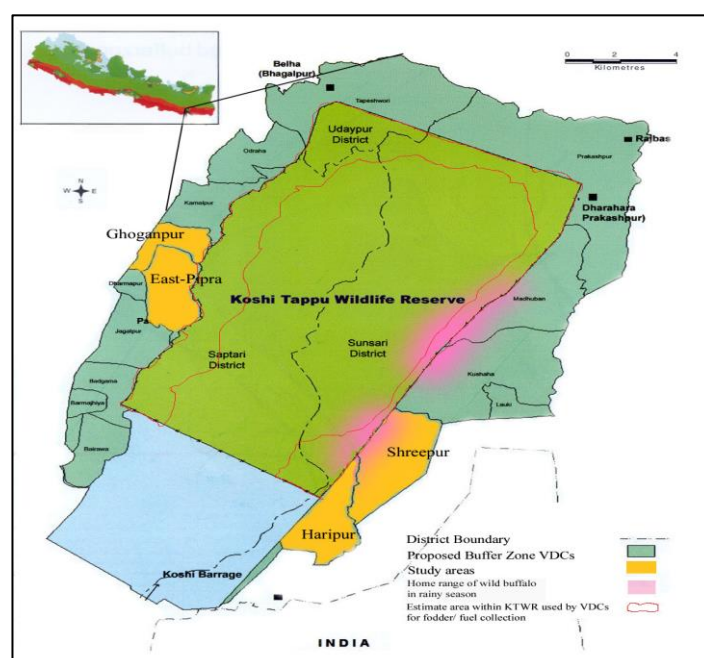
Acknowledging with the limited habitat, loss of genetic integrity of wild form, loss of habitat and different diseases from domestic cattle it is very important to study about the habitat preference, seasonal activity patterns and different survival threats. Such studies would shed light on different behavior and recommend sustainable conservation strategies for the endangered and only one strong hold population of Wild Water Buffalo in Koshi Tappu Wildlife Reserve.

### 3 MATERIALS AND METHODS

#### 3.1 Study area

##### 3.1.1 Physical parts

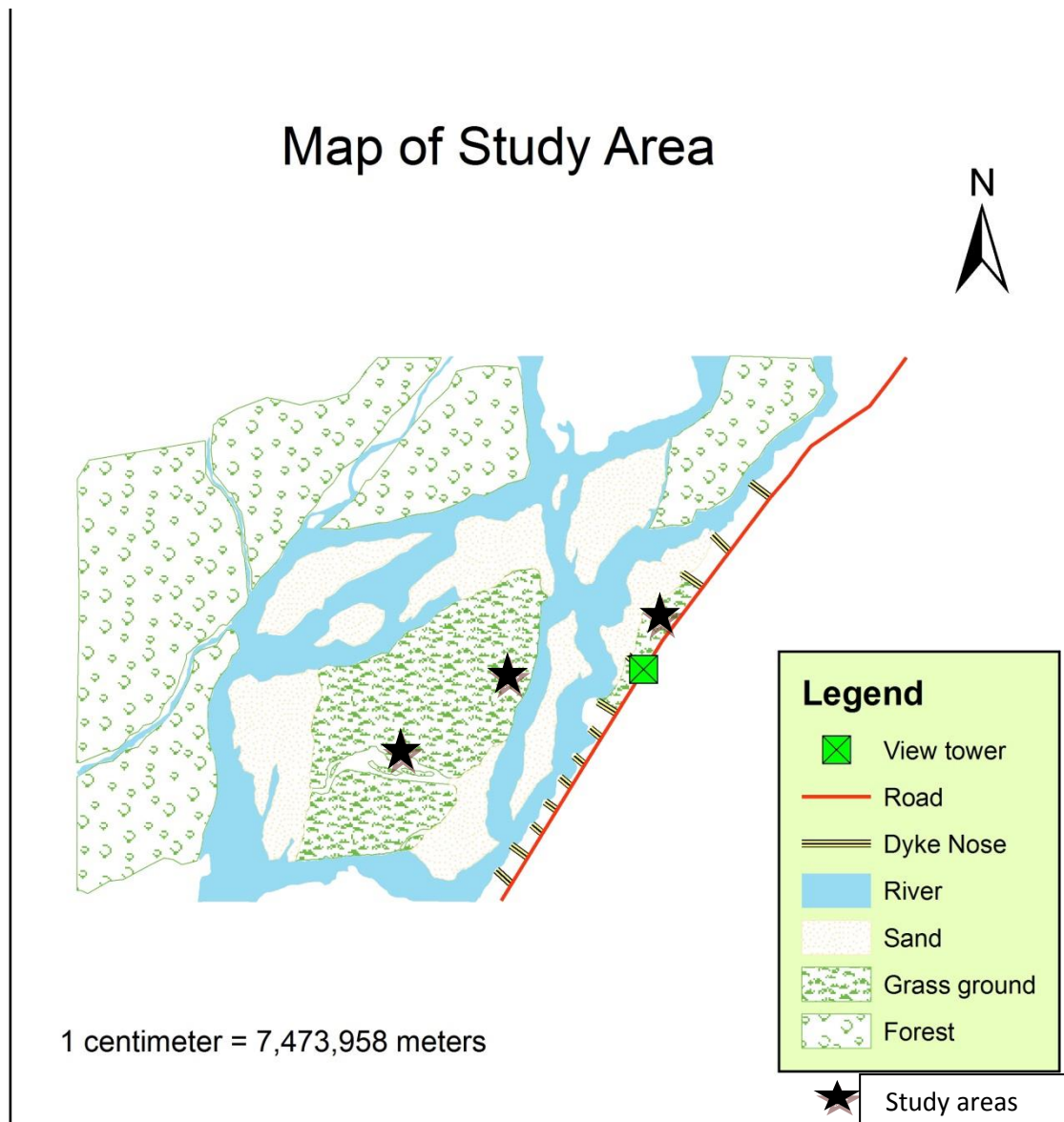
The study area of this research is Koshi Tappu Wildlife Reserve (KTWR), which is located at the south-eastern part of Nepal. It has occupied landmass of three districts named Sunsari, Saptari and Udayapur. It is one of the most contested protected areas of Nepal (Heinen and Mehta 2000) due to its poverty and high population. It is a small reserve, with an area of only 175 sq. km., while an additional 173 sq.km. as buffer zones including adjoining highly populated villages (Map 1). It is mainly characterized by extensive wetland habitats in the form of floodplains, oxbow lakes, and swamp forests. The terrestrial vegetation consists of grassland savannah as well as small areas of degraded forest (DNPWC 2002). Its prominent biological values, especially for Nepal's last remnant population of critically endangered Wild Water Buffalo (*Bubalus arnee*) contributed to its designation as a reserve area in 1976. Frequently human entry is restricted except once a year for the thatch grass harvest (Kharkhadai).



Map 1. Location and physical parts of Koshi Tappu Wildlife Reserve in Nepal.



The reserve is located in 26<sup>0</sup>33'-26<sup>0</sup>45'N and 86<sup>0</sup>54'-87<sup>0</sup>04'E in the flood plain of the Sapta Koshi river. It was established mainly to conserve the habitat for the remaining population of the Wild Buffalo (*Bubalus arnee*) in Nepal. Its habitat is designated as Ramsar site and was recognized in 1987. It is situated on the east and west bank of the Sapta Koshi River, the third most tributary of the Gangase river of India. It covers three surrounding districts as eastern and northern parts by Sunsari district and the north western part by Udayapur and south western parts by Saptari district of Nepal (Map 2).



Map 2 Study area of Kusaha, KTWR, Eastern Nepal.

The Koshi Tappu region is also characterized with a diverse population of high density of human beings. There are 340 settlements and 12,296 households with a population of 85,557 in the proposed buffer-zone which includes sixteen Village Development Committees (VDCs) in three districts (DNPWC 2002). The average population density is about 620 persons per square kilometer; which is extremely high compared to the national average population density of 157 persons per square kilometer (UNDP and GEF 2002). Furthermore, about 39% of households are either landless or owner of less than 0.05 ha (DNPWC 2002). The livelihoods of most of the economically active population in the buffer zone are derived from agriculture and natural resource use systems. From the establishment of KTWR, conflicts have arisen between the local communities and the utilization of the park's land and natural resources (Sah 1997). Studies have shown that the affected population is hostile to the park because of relatively serious crop depredation from wildlife (Adhikari 2000, Heinen 1993, Ghimire 2000, Kherwar 1996, WMI and IUCN 1994). In 1994, a Park People Program (PPP) was introduced in the KTWR and its five year Buffer Zone Management Plan (BZMP) was completed in 2002. However, there are reservations about how these new conservation policies will work, particularly the BZMP (Heinen and Mehta 2000, Sah 1997). It is yet to know in practice whether these management approaches can change people's attitudes towards Wild Water Buffaloes or not.

Nepalese government implemented the PPP (DNPWC 2002) with the financial and technical assistance from the United Nations Development Program in five Tarai PAs including KTWR. The objective of the PPP was to enhance the sustainability of the buffer zone communities by improving these socio-economic conditions and the natural resource base (DNPWC 2002).

### **3.1.2 Faunal Diversity**

Koshi Tappu is a home of total 486 different bird species including residents and migrants has been listed representing 61 birds families of the world (BCN 2008). It harbors about 31 species of mammals, 34 species of reptiles, 117 species of fishes, 11 species of amphibians, 77 species of butterflies and 21 species of insects (Bhandari 1992). Furthermore it is the home to threatened species as Gangetic Dolphin (*Platanista*

*gangetica*) (Shrestha 1993) and two species of crocodiles such as Mugger (*Crocodilus palustris*) and Ghariyal (*Gavialis gangeticus*) (Scott 1989).

### 3.1.3 Floral Diversity

The vegetation of the reserve is mainly characterized by mixed deciduous riverine forest. The vegetation includes mainly Khair (*Acacia catechu*), Sissoo (*Dalbergia sissoo*), Bayer (*Zizyphus sp.*) and tall Elephant Grass (*Saccharum spontaneum*) and Cat Tail (*Typha elephantia*) 400 ha i.e. 2.66% of total area of the reserve has occupied with *Dalbergia sissoo* dominated forest and 430.8 ha i.e. 2.87% of the reserve has covered with mixed deciduous riverine forest. 6,250 ha i.e. 41.6% of the total area is covered with Grassland and Savanna type of vegetation and 1,652 ha i.e. 10.98% of the total area is covered with swampy grassland. There are found 502 Angiosperm and 12 Gymnosperm so within this area there are noted 514 species of different plants (Sah 1997).

### 3.1.4 Climate

Commonly climate of Nepal has categorized in four seasons which are summer (June to September), autumn (September to November), winter (December to February) and spring (March to May). The climate of the Koshi Tappu Wildlife Reserve is of subtropical type. It has highly contrasting throughout the year. This is because of the seasonal changes in precipitation and temperature.

The summer or monsoon starts here at April to May and the June to September is the violent with extreme thunderstorms and lightening. This season might be problematic for calves because of the heavy flood in the Koshi River. Temperature is the highest in this season which may reach up to 33°C (Figure 1). The monsoon is followed by autumn which is characterized by clear sky and jovial period. This is optimum in mid of October. Winter is characterized with low temperature and may fall up to 9°C and spring is dry season with low precipitation and high temperature which may cross 33°C (Apendix I, Table XII)

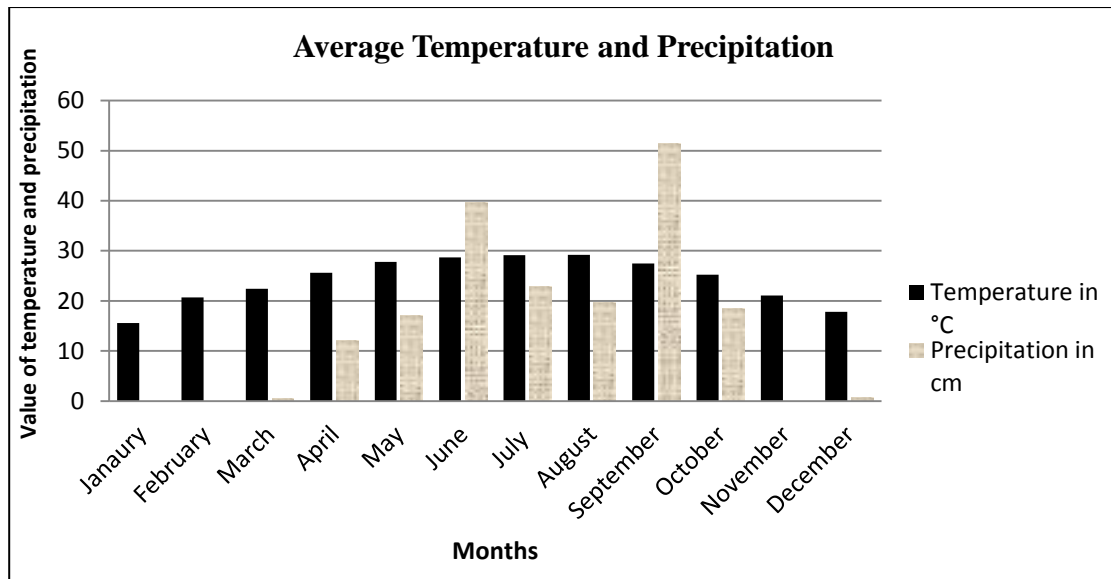


Fig. 1 Average temperature and precipitation of the Koshi River basin, eastern Nepal. Source: Climatological and Agro meteorological Records of Nepal 2006. Department of Hydrology and Meteorology.

### 3.2 Methods

#### 3.2.1 Reconnaissance survey

The initial survey was accomplished to locate the appropriate study area for the dissertation and accordingly to estimate and design the research. The preliminary survey had done for the four different sites of the possible continuous availability of the Wild Water Buffalo. These sites were Kusaha check post area, Madhuban area, Bhagalpur area of the Udayapur district and the Dakshini Duban area (southern inundate) area of Saptari district of eastern Nepal.

The survey was performed in five days by the help of assistance, a game scout to respective sites. Bhagalpur (Udayapur district) and the southern inundate area (Saptari District) were found highly anthropogenic disturbances. The main disturbance were of free buffaloes in thousands of numbers from southern inundate area (Dakshini Duban) and cattle again in thousands number from Bhagalpur side. The Madhuban site was found not consistence with the presence of herds of Wild Water Buffalo. Kushaha area; consistence and less disturbed herds of Wild Water Buffalo were noticed. Hence it was decided the site is best among other for detail study of this research.

### 3.2.2 Discussion with public

Discussion programs were conducted in some important points with some local veteran of the reserve about the wild animals of the area. The discussion was made personally in their home or at field because of the problem to gather them in a place (Table 3). It had helped to concise the research design and selection of the study area. Discussion was focused on the availability of Wild Water Buffalo in different sites, some security matters and their percepts or attitudes on the animal and the reserve.

Table 3: List of the People discussed with about Wild Water Buffalo

S.N.	Name	Address
1	Arjun Karki	Shukrabare, Madhuban
2	Sharoj Mehata	Shripur-3
3	Shivlal Orau	Kusaha-8
4	Kedar Podar	Madhuban-8
5	Nandalal Orau	Kusaha-5
6	Bishu Mandal	Kusaha-4

### 3.2.3 The survey techniques

#### 3.2.3.1 Random sampling technique

The study was done over an individual of a group of Wild Water Buffalo. So the selection of that individual was done by random sampling. For that random selection technique, first each individuals of the herd to be scanned were numbered temporarily according to their position and total numbers were noted. With the help of a scientific calculator a random number was generated and multiplied by the total number of individuals of that group which determined a whole number (Table 4). The individual with that whole number was taken for the study.

$I_{(f)} = R \times N$ , Where

$I_{(f)}$ , stands for a whole number individual to be followed for scanning activities,

R, stands for a random number generated from a scientific calculator and

N, stands for total number of individuals in the herd to be studied.

Table 4: The whole numbers individuals selected randomly for the scanning.

Herd type→	Male band			Mixed herd		
Seasons ↓	R	N	I(f)	R	N	I(f)
Monsoon	0.318	9	3	0.688	12	8
	0.334	9	3	0.834	12	10
Autumn	0.196	8	2	0.473	13	6
	0.515	8	4	0.88	13	11
Winter	0.855	8	7	0.246	25	6
	0.676	8	5	0.677	25	17
Spring	0.554	8	4	0.573	17	10
	0.764	8	6	0.187	17	3

### 3.2.3.2 Scan sampling technique

It was described that the behavior or activities can be broadly divided into two categories they are state and events (Altmann 1974). Those activities which are continuous for long time duration or period then it is described as state behavior or major activities and in the opposite of those activities for instant and less than one minute are described as event behavior (Altmann 1974). The studies of the activities were grouped as major activities (state behavior) and minor as other activities (event behavior). In major activities included long term and consistence activities such as resting, grazing, standing and wallowing. In case of event activities short terms and not frequent activities were included such as defecating, defending, drinking, playing, licking and rubbing or brushing body parts against any objects etc.

Though the wild buffalo are both diurnal and nocturnal here only the diurnal activities were observed and recorded. This was due to lack of security at night time and lack of the aided instruments (e.g. infrared binocular) for the night observation. Here the direct observation was carried out and different activities were noted down in each minute time of the observation. The scanning was carried out with the help of binocular (7X35 times magnification). Some major activities were also snapped with digital camera (12.5 mega pixel and 10x, magnification power). The observation of the selected herd was tried for friendly and natural condition (slight habituation). For that the disturbed observations were rejected if the herd got disturbed by any anthropogenic activities and

even by observer. Hence the activities after disturbance and run away at least 100m far were totally rejected for that shift in this research (Altman 1974).

The behavioral generalization was done by the scan sampling method (Altman 1974). In this method the focal sample as a group or individual was under special observation and their different activities were noted down in equal interval of time. That helped to explore out the percentages of the different activities, time duration of specific activities and hence their preferred behavior. Here the detail activity sequences were noted by using wrist watch or mobile split timer for the duration of each activity sequence taking under an individual of a herd of Wild Water Buffalo. The observation was carried out for each minute on slightly habituated condition.

### **i. Major (State) activities**

Grazing: picking up grasses or other plants with mouth through slow and continuous walks.

Resting: sitting on knee, ruminating or sleeping by lying down on ground.

Standing: on feet, mostly ruminating or vigilance as alert by making chin up and horns parallel to body.

Wallow: rest in water as river, water hole, dipping either partial or whole body.

### **ii. Other (Event) activities**

Defecation: urination and defecation or either urination only or defecation only.

Drinking: drinking water from any water sources.

Play: pushing each other with head, horns and riding on back of own gender i.e. homo practice.

Rubbing: pushing and rubbing body on tree trunk or small tree twigs. Brushing horn base with small twigs and auto grooming with hind leg specially ear, eye etc.

Licking: licking each other or by cow for a calf or vice versa and sometime in close partner.

Defense: specially chasing other species or predator of calves by cow or bull.

### 3.3 Framing the study time pattern

The activity patterns were observed for twelve hours a day in three different shifts, which were; morning 6:00 to 10:00, day 10:01 to 14:00 and evening 14:01 to 18:00 in alternate days. This is to record all the diurnal activities for the projection of the general behaviors of the wild buffalo. But for winter season it became impossible due to late sun rise and early sun set as well as foggy weather at morning and evening time. So the study time was possible for only ten hours a day in three shifts as morning 7:00 am to 10:00 am, day 10:00 am to 14:00 and evening 14:01 to 17:00 in successive days.

The activity patterns were scanned in two shifts of a day. That was because of problem to stay and study for whole day by a single person being very difficult. The first day of observation was scheduled morning and evening for first herd; which was male herd in this study. The second day was for day and evening shifts for first and second, those were male band and mixed herd respectively. In the third day of the scan again morning and day for second herd; that was mixed herd in this study (Table 5).

Table 5: The scheduled pattern of studying herds for a season

Day ↓	Shift→	Morning	Day	Evening
	1 <sup>st</sup>	H <sub>1</sub>	X	H <sub>1</sub>
	2 <sup>nd</sup>	X	H <sub>1</sub>	H <sub>2</sub>
	3 <sup>rd</sup>	H <sub>2</sub>	H <sub>2</sub>	X

Note: H<sub>1</sub> stands for scanning first herd; H<sub>2</sub> stands for scanning second herd and X for no scanning.

### 3.4 Average diurnal activities patterns

The different activity time of each season was observed and noted for the two different herds; those were male band and mixed herd in this study. Obtained time data were summed for corresponding activities (Table 6) and converted into percentage. The obtained percentage of each activity of Wild Water Buffalo has been presented either in bar graph or pie chart so the patterns were made easy to understand.



### **3.5 Seasonal activity pattern**

The study was divided into four different seasons which were summer, autumn, winter and spring seasons (Appendix-1, Table 1). The different seasons were categorized as monsoon season Asar to Bhadra i.e. June to September, autumn season Asoj to Mangsir i.e. September to November, winter season in between Poush to Magh i.e. ; which was duration of end of December to February and spring season in between Falgun to Jestha i.e. March to May.

The study was performed for every season on the designed module (see Table 5). The obtained data has presented as bar graph and pie chart as required in percent base. All the seasonal activities were studied in the mean peak time of each season. But in case of monsoon season due to high disturbances of flood of the Koshi River; it was difficult to find the herds for the study. So the study was made in the month of Bhadra i.e. August. By then all other seasons were normal and found to locate them easily on the study area.

### **3.6 Shift wise diurnal activity pattern**

The study was done by dividing the day twelve hour into three different shifts as morning, day and evening (Appendix-I, Table III). The morning time was taken from 6:00 to 10:00 hours, the day time was taken from 10:01 to 14:00 hours and the evening was taken from 14:01 to 18:00 hours. But in case of winter season where the day time is short at that case the study time was shorten by one hour from both morning and evening time. That was because of the darkness and foggy climate in morning up to 7:00 am. Similarly the evening was also due to early sun set the dark raises from near 19:00 or even 18:00 hours so the observation was done from 7 am to 7 pm for the winter season.

The observation and records on the time activities were performed according to the module (see Table 5) as described before. The scanning were performed for the both herds male band and mixed herd for all four seasons and the average time duration of different activities were calculated by making sum of all corresponding time of

activities of the both herds and divided with two. So obtained average time duration were expressed as percentage for different diurnal activities of Wild Water Buffalo

### **3.7 Comparative study of diurnal activity pattern**

#### **3.7.1 Selection of herds**

From the reconnaissance study, there were mainly three types of herd male band, solitary male and mixed herd (Chalise 2008). The solitary male was a solitaire and the activities performed were not in group. So the activities of solitary male could not be considered as general. The male band was a group of only bachelor male of Wild Water Buffalo. They were found in the number of eight to twelve in my study period. But in case of the mixed herd; it was the largest and a complete herd by age sex and social activity. During the study period it was found that the herd number from 12 to 42.

Among the three types of herds of Wild Water Buffalo activities patterns were compared for mixed herd and male band. Selection of these two herds was because of their activities. That represented for a social group of a herd. But solitaire male could not represent for a herd activities. Another reason was their availability. The male band and mixed herd were always available but the solitaire male rarely observable in the study area of this research.

#### **3.7.2 Comparison of diurnal activity pattern**

In this study; the main four activities in between male band and mixed herd were compared. These activities were grazing, resting; wallowing and standing. The comparisons were performed only for the corresponding activities; for example grazing activity of male band was compared to the grazing activity of mixed herd and so on. The sum total of average time of activities was converted to percentages and was presented in bar graph for easy access or cursory comparison.

The significance test of the differences in activities pattern of male band and mixed herd of Wild Water Buffalo were tested with a statistical tool, called student's test popularly known as t-test. The tests were performed for each state activity which was described as major activities before.

### **3.7.3 Seasonal comparison on diurnal activity pattern**

The main four diurnal activities patterns i.e. state activities of a season were compared with activities of the remaining seasons. For that comparative study; the different activities of Wild Water Buffalo were observed for both male band and mixed herd (Appendix-I, Table 8 and Table 9). All the corresponding activities time durations were compared in bar graphs and pie graphs, which made easy to compare and understand the differences in activity patterns.

## **3.8 Data analysis**

### **3.8.1 t-test**

The students' test or t-test was performed for testing the mean significant difference in the different state or major activities between male band and mixed herd of the Wild Water Buffalo (Appendix-I, Table VII). The different hypotheses were set for testing the mean significance difference of four different major activities, which were;

- i.  $H_0$ : there is no significance difference in grazing time duration in between male band and mixed herd
- ii.  $H_0$ : there is no significance difference in resting activities in between male band and mixed herd.
- iii.  $H_0$ : there is no significance difference in standing activities in between male band and mixed herd.
- iv.  $H_0$ : there is no significance difference in wallowing activities in between male band and mixed herd.

## **3.9 Materials used**

For the study the following different materials were used:

Binocular, Still camera, Measuring tape, G.P.S., Stationaries, Scientific calculator etc.

## 4 RESULTS

### 4.1 General diurnal activities pattern

#### 4.1.1 Average diurnal activities pattern

Among the 186 hours of the field work in the Koshi Tappu Wildlife Reserve (KTWR); the detail study of behavior being in ocular contact was performed for 92 hours (Appendix-I, Table X). Through the whole year seasonal observation of the Wild Water Buffalo different activities patterns had been assessed. A herd of the buffalo was estimated to engage for grazing 50% of a day (Appendix-I, Table II). It means in average a *Bubalus arnee* spent 5 hours and 45 minutes time for grazing in each day. They were observed mostly grazing on the sandy ground with sprouting (*Sacchrum spontaneum*) thatch grass of the Kusaha study spots. The density of thatch grass in grazing area was recorded to 247 per square meter (Appendix-I, Table XI).

The second most time engaged by the animal was for resting which was recorded to 27% of a day. Mostly it was observed that herds were resting on sand near water sources. During resting almost all the time one or two individuals were found standing but rarely all members rested were recorded. That result revealed that a Wild Water Buffalo engaged three hours and six minutes of a day for resting. Similarly it was recorded that they were engaged s found to be 13% of a day time which was equal to one hour and 30 minutes. The wallowing was found 10% of a day time which was equal to one hour and nine minutes a day (Fig. 1)

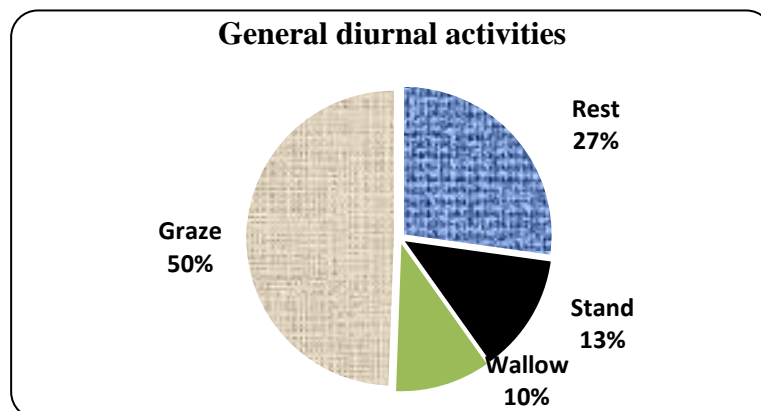


Fig. 1: The percentages of different activities Wild Water Buffalo in KTWR, Nepal.

## 4.1.2 Season wise diurnal activities of Wild Water Buffalo

### 4.1.2.1 Monsoon Season

The monsoon season lies in the months of Asar and Bhadra of Nepali calendar. This season represents by the heavy rain fall and flood in the research area, so this season also shows the different minor weather condition and in such different condition Wild Water Buffalo may shows different behavioral activities. Because of the heavy rain fall and flood of the Koshi River along Kusaha site; there was no Wild Water Buffalo in the mid time (Asar) of the monsoon season. So the studies for the herd were performed at the beginning of the Bhadra when continuous rain stopped. From the study it was found that mostly they spend time on grazing and resting 42% and 32% respectively. Instead of rainy season they also spent 15% of day time for wallow and 11% for standing (Fig.2).

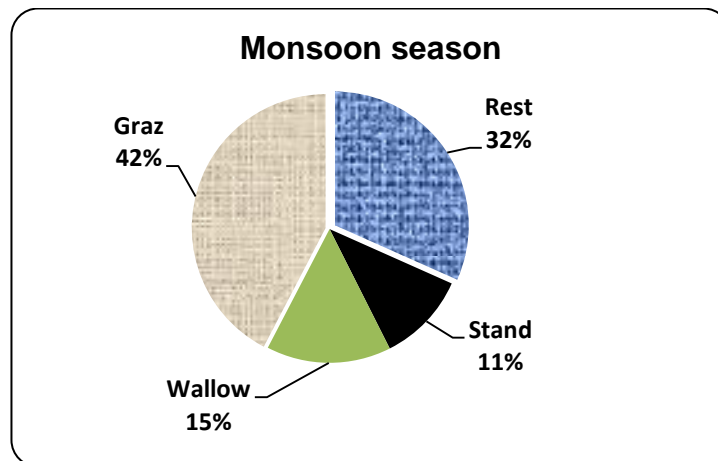


Fig.2: The percentages of different activities of Wild Water Buffalo in monsoon season.

### 4.1.2.2 Autumn Season

It is considered as the best season climatically and it lies in between Asoj to Mangsir. This season is climatically neither hot nor cold weather. In this season Koshi Tappu Wildlife Reserve was found just sprouting with *Sacrum spontanium* on the study area. From the study it was found that a herd of Wild Water Buffalo grazed about 54% of a

day time. That means about six hours and 13 minutes. The study had revealed that a herd rest for 28% of a day time which was equal to three hours and 13 minutes (Fig. 3). The standing activity was found 14% of a day time and it meant one hour and 37 minutes. The wallowing activity was found to four percent of a day in that autumn season. That was equal to 28 minutes each day.

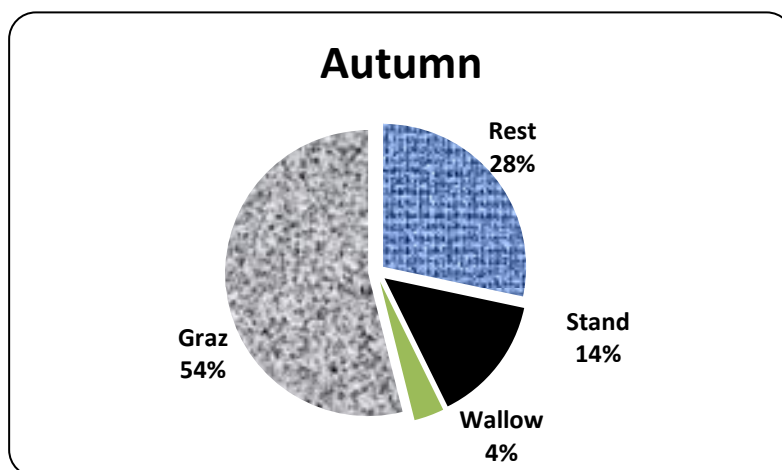


Fig. 3: The percentage of different activities of Wild Water Buffalo in autumn season.

#### 4.1.2.3 Winter Season

Winter is the cold season naturally where the climate becomes foggy and not as pleasant as autumn season. This season lies in between the months of the end of Mangsir and beginning of the Falgun. In this season the study had done in the month of Magh for the first and second week covering the coldest weather. From the study it was found that a herd of Wild Water Buffalo grazed 57% of a day time which was equivalent to six hours and 33 minutes of a day (Fig. 4). The grazing was mostly found on day shift of a day. After the grazing second most time spent was found on resting which 23% of a day time. It was equivalent to two hours and 39 minutes. The third more time spent was on standing which was found 20%. The 20% standing referred to two hours and 18 minutes time duration which was spent time for standing in a day. But in winter season no activity of wallowing was found

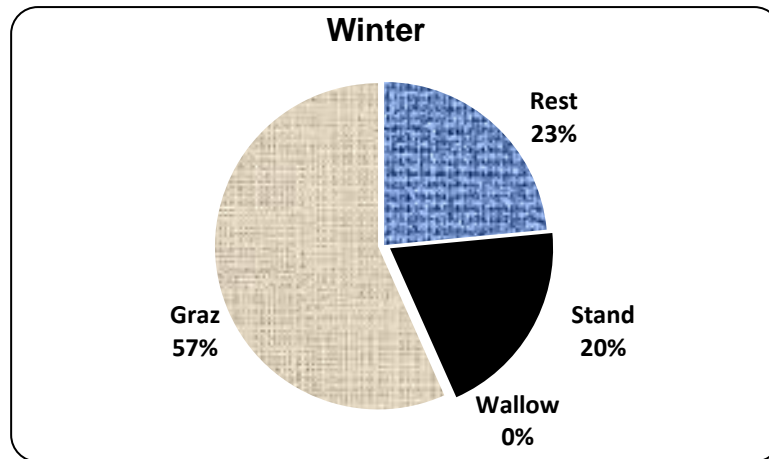


Fig. 4: The percentage of different activities of Wild Water Buffalo in winter season

#### 4.1.2.4 Spring Season

This spring season is different in KTWR than rest of the part of Nepal. The topology is mostly sandy banks of Sapta Koshi flood plain and influenced by the subtropical hot weather. Therefore this season is the worst season among all four seasons due to hot, dry and high blow of wind. The temperature was also high and intense. It was in between the months of end of Falgun and Zestha according to Nepali calendar. Scarcity of food level was high due to dryness of sand and shrinkage of water level in tributaries or trenches of river. It was found that they were grazing on the sandy and hot ground with small sprouting of *Sacchrum spontanium* most of the day time.

In that spring season, herds were found grazed for 46% of a day which was equivalent to five hours and 17 minutes of a day time (Fig. 5). The second most time spent was on the resting activity. It was found 25%, which was equivalent to two hours and 53 minutes of day time. The third was on wallowing around 21%; which was equal to two hours and 25 minutes. The standing was found around 55 minutes of day time which was equal to 8%.

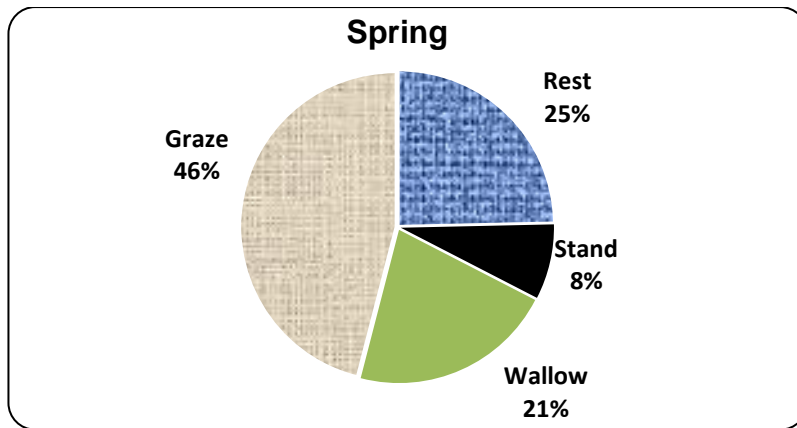


Fig.5: The percentage of different activities of Wild Water Buffalo in spring season

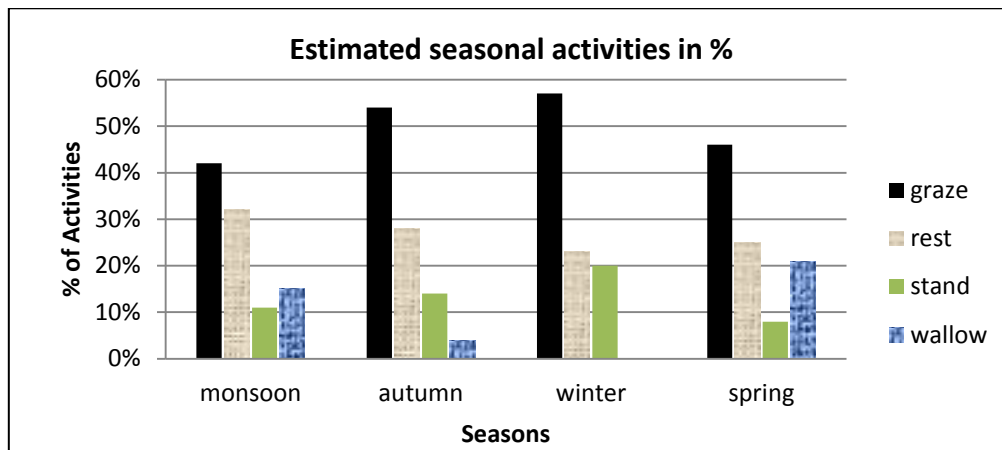


Fig.6: The different activities of Wild Water Buffalo during different seasons in KTWR

#### 4.1.3 Other Activities

Other activities which are short and event types were found more in day and evening time. The morning time, they showed the sincere either resting or grazing activities than day and evening. Drinking of water is mostly done in day time and less in evening time (Fig. 7). The evening time was seen mostly they with playful and enjoying the social gathering. They use the evening time for the defecation. From the study it also revealed that the evening time is risk from the small predators for their calves so found defending a golden jackal (*Canis aurious*) by chasing (Appendix-I, Table IV).



Sometimes between mother and calf a strange relation observed. A calf was observed irritating mother by trying to suck teats while mother was just avoiding by sitting down. Those events had remained for seven tries but finally calf leaved the mother while mother kept sitting for longer time. During those activities the cow never tried to chase or charge the calf instead just subtle try for avoiding its calf.

For scratching the body generally they used their hind leg to the ear or other frontal parts. But they were also frequently found pushing small twigs and branches of bush tree for scratching body. Especially they scratched or brushed the pit part of horn and head. They attached and pushed small woody twigs or branches of Gobre Sallo (*Pinus wallichiana*) bushy plant which were sparsely distributed near the Kusaha watch tower.

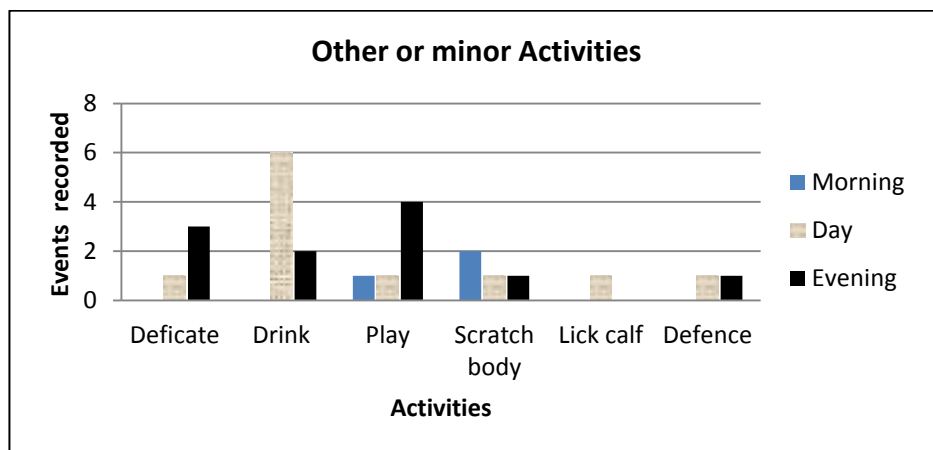


Fig.7: Other minor activities of Wild Water Buffalo in three different shifts in KTWR.

#### 4.1.4 Shift wise study of the activities

##### 4.1.4.1 Morning

In morning shift from 6:00 to 10:00 hours except winter which was from 7:00 to 10:00 hours; so the total average time duration of morning was three hours and 45 minutes of each morning. It was observed that a herd spent more time on rest which was 40% of morning that was equal to one hour and 30 minutes (Fig. 8). The second most time was found to spend for 39% of morning time which was equal to 1 hour and 28 minutes. During the morning shift a herd was found standing for 21% which was equal to 47

minutes of morning time. There were no any evidences were found for the wallowing in morning time (Appendix-I, Table III).

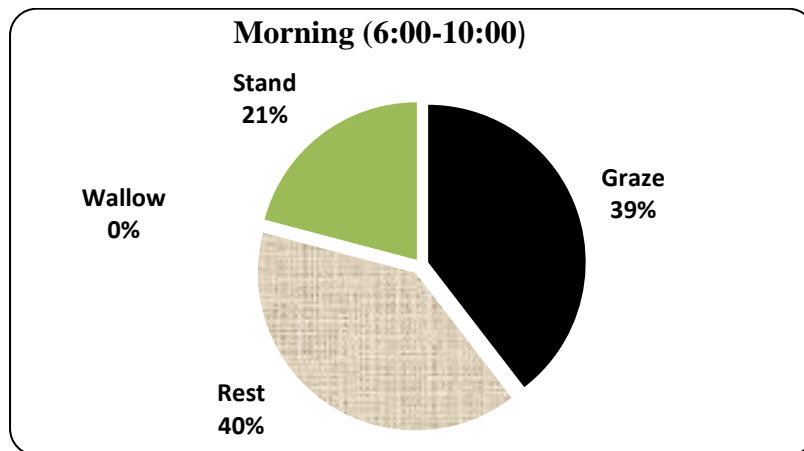


Fig. 8: Different activities in morning shift

#### 4.1.4.2 Day

Day shift was allocated from 10:01 to 14:00 hours of four hours period in a day. From the study of all seasonal data it revealed that a herd of Wild Water Buffalo mostly engaged on grazing. It was found that they spent 41% of day shift. Then they found spent 35% of day shift for resting. Around 13% that was equal to 31 minutes of day shift was found spent for standing activity by a herd of Wild Water Buffalo and 11% i.e. 26 minutes time was spent for wallowing (Appendix-I, Table III).

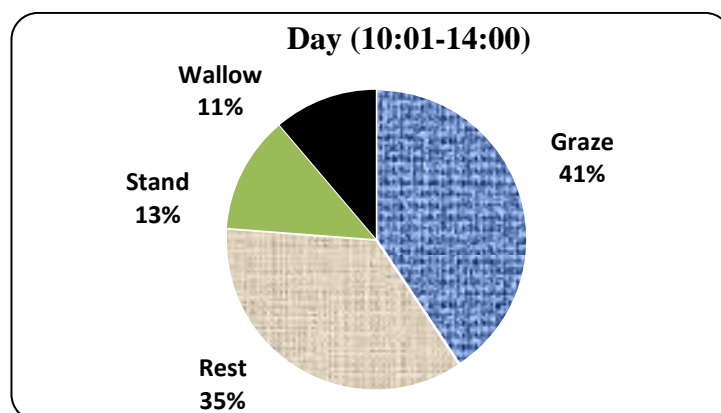


Fig. 9 Major activities of Wild Water Buffalo in day shift in KTWR.

#### 4.1.4.3 Evening

The evening shift was taken from 14:01 to 18:00 hours but in the winter season being the sun set soon as the study had taken only up to five pm. So the average time of study for evening for a day was equal to three hours 45 minutes. All together the study of this shift was done for 30 hours from all seasons. After the study and calculation it revealed that most of the time was spent for grazing; which was found to 69% i.e. two hours and 35 minutes of an evening shift (Fig. 10). The grazing was followed by wallowing; which was found 20%. It was equal to 45 minutes of each evening time of a day. In comparison to morning and day shifts rest was found less in evening shift; that was only 6% or 14 minutes and the standing also found less; only five percent or 11 minutes (Appendix-I, Table III).

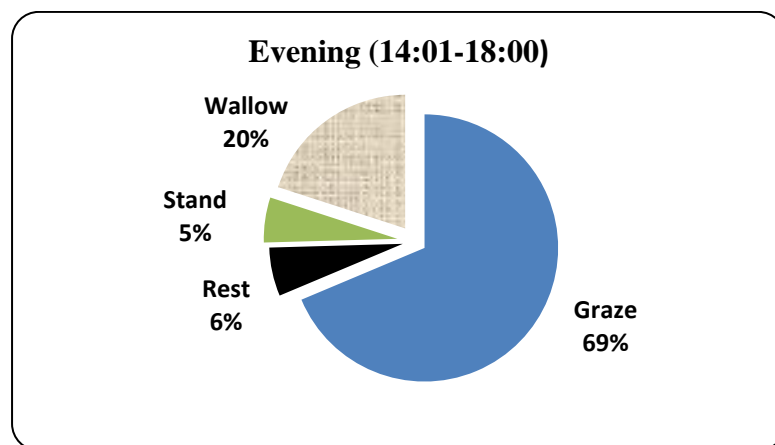


Fig.10 Different activities of Wild Water Buffalo in evening shift at KTWR.

## 4.2 Comparative study

### 4.2.1 General comparison

The overall seasonal study revealed that a male band showed diurnal activities mostly spent on rest; which was equal to 42% of a day time than a mixed herd which had spent only 12% (Fig. 11). But in the case of mixed herd they had spent more time of a day in grazing which was 62% of a day time in comparison to a male band which had only 37%. Again a male band had spent more time on wallowing 12% than the mixed herd

9% and male band had spent time only 9% on standing which was less than the mixed herd had spent 17% for standing.

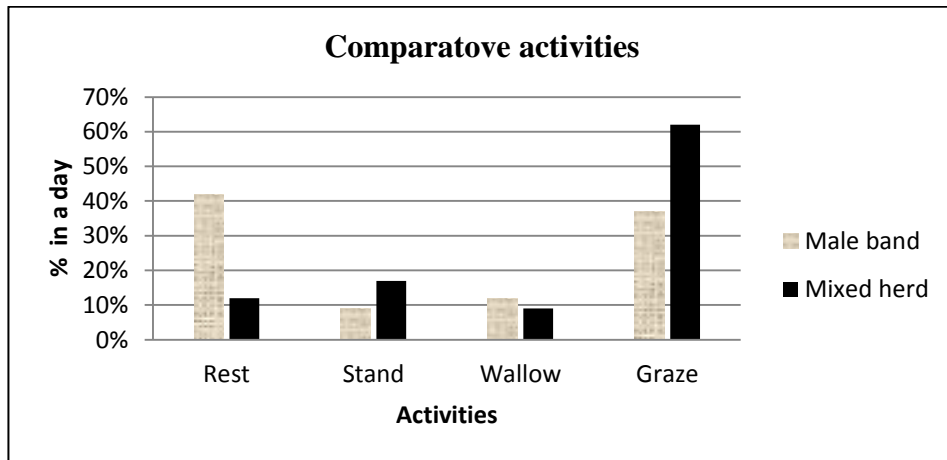


Fig.11: Comparative activities between male band and mixed herd of Wild Water Buffalo in KTWR.

Since the differences were found in the diurnal activities in between male band and mixed herd; the significance in the difference were tested by the help of t-test. From the t-test, for the grazing activity calculated was  $t=3.8997 > \text{tabulated value } t_{0.05(6)} = 1.943$  (p-value  $< 0.05$ ). Hence the null hypothesis was rejected or the difference in grazing pattern was significance at five percent of level of significance. For the resting activity calculated  $t= 4.5058 > \text{tabulated value } t_{0.05(6)} = 1.943$  (p-value  $< 0.05$ ) and so the resting activity of male band and mixed herd were significantly difference. For the standing activity calculated  $t= 2.4677 > \text{tabulated value } t_{0.05(6)} = 1.943$  (p-value  $< 0.05$ ) also rejected the null hypothesis which meant the standing activity of these herds were not of same mean and significantly different from each other. But the wallowing activity was found similar in pattern in between the male band and the mixed herd of the study because the calculated  $t= 0.3045 < \text{tabulated value } t_{0.05(6)} = 1.943$  (p-value  $> 0.05$ ) (Appendix-I, Table VII).

#### 4.2.2 Seasonal comparison

From this detail study of the Wild Water Buffalo in the slight habituate state it was figured out some drastic difference in diurnal activities pattern. The comparative study

were performed in between homogenous group of the animal (male herd) called male band and heterogeneous group of the animal called mixed herd. The comparative observations were performed for four different seasons which were different weather conditions.

#### 4.2.2.1 Monsoon season

The male band was observed comparatively less grazed (30%) than that of the mixed herd (54%) in monsoon season (see Fig. 12). In the other hand male band found rested more (47%) of the day time in monsoon season than the mixed herd (17%). From these two results the grazing activity and the resting activity, it could be said that there were the complimentary relationship between the grazing and resting activities. The result had revealed that the male band wallows (17%) more than the mixed herd (14%). But in case of the standing activity; mixed herd found stood more (15%) than the male band (6%).

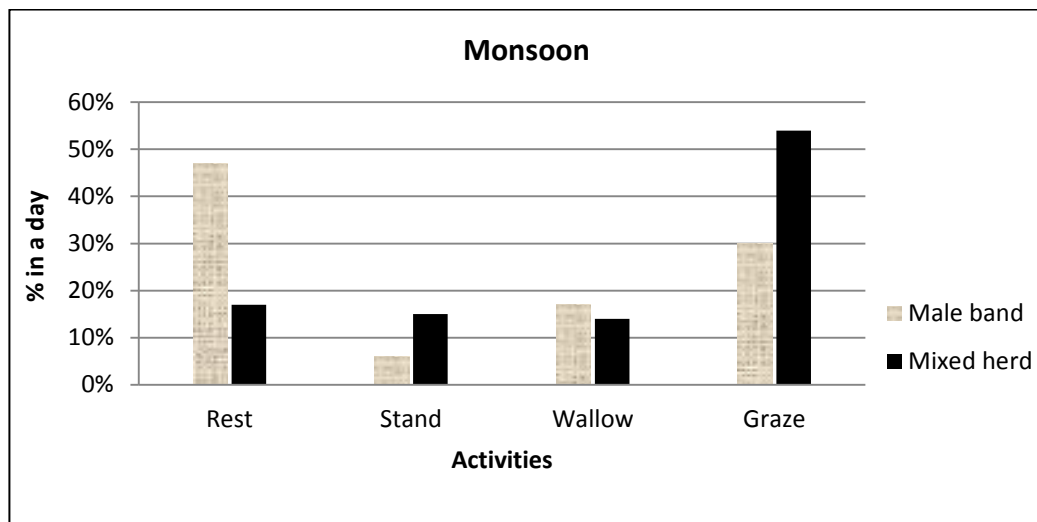


Fig.12: Comparative activities between male band and mixed herd during monsoon season.

#### 4.2.2.2 Autumn season

In autumn season the male band again observed spent the diurnal time more for resting and wallow activities but the mixed herd was observed more active in grazing and

standing activities. It was observed that male band spent 40% of diurnal time for the resting in the autumn season but the mixed herd found only 17% (Fig. 13). The male band was found to wallow 7% of a diurnal time in the autumn season but in case of the mixed herd found to nil for the activity in this autumn season. The mixed herd had spent more time for grazing (68% of a diurnal time) than that of male band (40%). It was always observed that the mixed herd stood more than male band. In this season also mixed herd observed more standing (15%) than that of male band (13%).

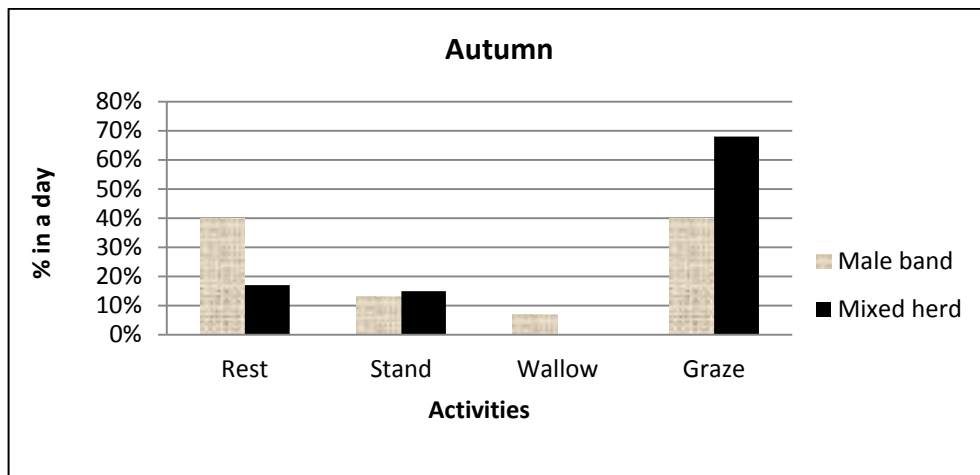


Fig.13: Comparative activities between male band and mixed herd during autumn season.

#### 4.2.2.3 Winter season

This season also shared the same patterns. The male band rested more than the mixed herd. The male band was found rested 32% of the day time but in case of the mixed herd they were recorded engaged on resting only 15% (Fig. 14) of the diurnal time. The grazing activity was observed not so much difference in the winter season. The grazing pattern was observed not so much contrast in this season as in other season as both types of herds were found engaged more for grazing in that season. Like the male band was recorded engaged on grazing for 54% and the mixed herd was recorded 60% of a day time. Being the winter season the climate remained cold with low temperature up to 8°C (see Table XII) and so the wallowing activity were recorded nil from both types of the herds during the day time.

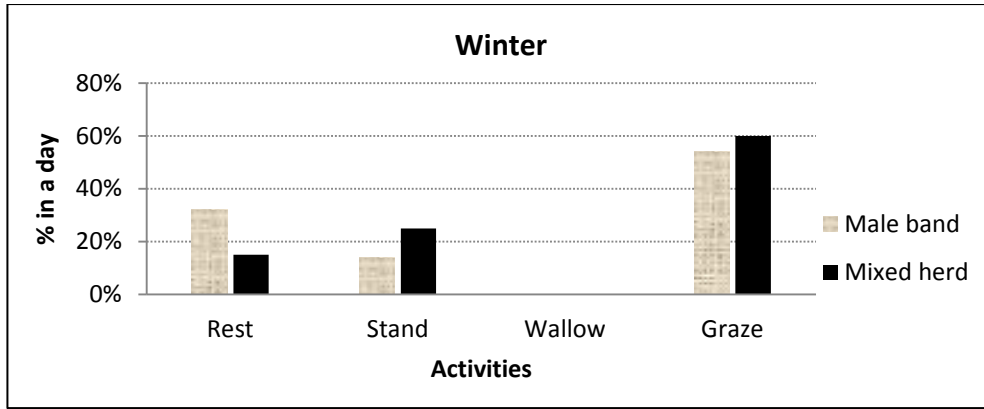


Fig.14: Comparative activities between male band and mixed herd in winter season.

#### 4.2.2.4 Spring season

The diurnal activities in the spring season was found that the male band rested with 49% of a day time but in case of the mixed herd was noted no resting. The grazing was found more in case of the mixed herd (Fig. 15). About 66% of a day time for mixed herd was found to graze. The grazing pattern of the mixed herd was normal but in case of male band only with 26% which was less than other seasons. Wallowing was found quite equal in both male band and mixed herd; the male band had wallowed for 21% of a day time in average of 11.5 hours budgets and the mixed herd was found wallowed for 22%. The standing activity pattern was found as usual. In this season also, the mixed herd found stood more than the male band. The mixed herd had stood for 12% but the male band was found stood only four percent of a day time of 11.5 hours duration (Appendix-I, Table VIII and IX).

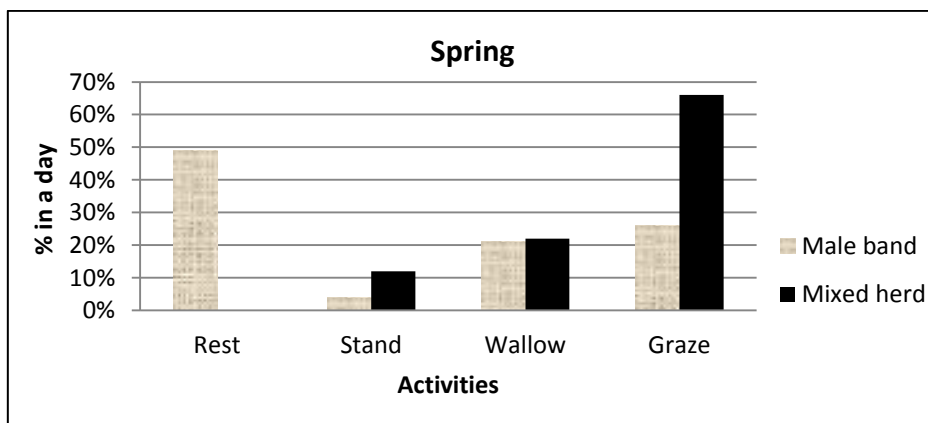


Fig.15: Comparative activities between male band and mixed herd in spring season.

## 5 DISCUSSION

### 5.1.1 Average diurnal activities pattern

There are bibliographies on the Wild Water Buffalo for different subjects but references on activities pattern are very few. The relative of the Wild Water Buffalo is considered for African Cape Buffalo (*Syncerus caffer*). It is less for diurnal because it grazes only 37.5% at day time and graze comparatively more at night time 44.5% (Ryan and Jordaan 2005) but in case of 24 hour cycle of a day they graze 40% (Winterbach and Bothma 1998). The diurnal grazing of African Buffalo again found 37.5%, which is 4 hours and 30 minutes of diurnal time (Grimsdell and Field 1976). But in this study Wild Water Buffalo were found grazing for 50% of diurnal time which is equal to five hours and 45 minutes of 11 hours and thirty minutes time budgets of diurnal time in average. This is more than African Cape Buffalo. This suggests that the diurnal grazing time has difference in average 12.5% to 18% more in Wild Water Buffalo. This may be due to difference in food availability because they are both big grazer bovine and good browser of food. From the sampling the mostly grazing ground found the density of sapling thatch grass (*Sacchrum spontaneum*) was 247 per square meter. The buffalo were never noticed grazing by standing in same place instead continuous slow walk and random direction. This suggests that the animal is dwelling grazer or browser of food for better diet towards most sprouting and open areas.

Generally Wild Water Buffaloes were found grazing followed by resting in the same way that an African Cape Buffalo also spend 74% of a day of 24 hours' time cycle for grazing and resting but only 34% time spend for resting (Winterbatch and Bothma 1998). But in the same species rest was also noted as 25.9% of a day time from South Africa (Ryan and Jordaan 2005). This difference in the resting pattern may be due to difference in the habitat and ecological conditions. During the resting time mostly African Buffalo ruminates (Kasim 1996). In this study it was found 27% of a day time was spent for rest which was equivalent to 3 hours and 6 minutes of a day. This is 7% less than of an African Cape Buffalo. Similar pattern of ruminating was found in both African Buffalo and Asian Wild Water Buffalo because almost all resting period was found ruminating except sleep which was recorded rare in Wild Water Buffalo.



Standing has been defined as the head up and ruminating condition of the animal (Ryan and Jordaan 2005) in case of Africa Cape Buffalo from Krugger National Park, South Africa. They also recorded that a herd of African Buffalo stands for 28.8% of diurnal time which is approximately equal to 3 hours and 30 minutes of each day. In the same species it was recorded that only 11% of a day of 24 hours cycle only paid for the standing from the Willem Pretorious Game Reserve, South Africa. From this study it revealed that a herd of Wild Water Buffalo stands for 13% of the diurnal time. This is equal to 1 hour and 30 minutes each day. From this it is seen that diurnal standing was highly difference in between the Cape Buffalo and Water Buffalo but in average for a whole day it is in more or less same pattern for this behavior.

Vigilance was also noted in case of Wild Water Buffalo during standing (Ryan and Jordaan 2005). This is if they scared or perceived some danger evidence of any kinds for example sounds, human, predator etc. This activity performed with the chin up and horns parallel with shoulder and ears facing front.

Wallowing activity specially performed for the maintenance of the body temperature. However there is no wallowing activity recorded from African Cape Buffalo. There is some reasons for the wallowing has been studied for Swamp Buffalo. A Swamp Buffalo wallows more at mid-day due to ambient temperature (Kassim and Baharin 1979). This is a practice of thermoregulation of body temperature in natural way because they are unable to dissipate heat from sweating (Hafez et al. 1954). Hence similarly in case of Wild Water Buffalo also found wallowing only in hot seasons except winter season. They found wallowing 10% in average of a day but excluding the winter if we calculate then the wallowing be 13.31% of a day time. The wallowing was found only in the still water or slow current water at the side of the river but never noticed on the middle and high current water in the middle of the river. It was found wallowed in mud hole in monsoon season only. This may be due to the nuisance of the flies and intense hot near Sisso (*Dalbergia sisso*) forest of the study area.

In case of Cape Buffalo the drinking takes place predominantly early afternoon in between 13:00 to 15:00 once a day but some time at any time of day and no drinking activity in night (Winterbach and Bothma 1998). Drinking water was found mostly at late of day and early of evening time. But it had been estimated mostly twice a day a

Wild Water Buffalo drinks rather once as in Cape Buffalo but this is similar to the at least once Cape Buffalo drinks a day (Mloszewski 1983). Mostly the drinking activity was recorded before resting or wallowing after grazing. The water might be necessary for ruminating grass.

Defecation had been found generally at the evening time and few in day but rarely found in the morning period. It was also recorded that Wild Water Buffalo played to each other. Mostly it was recorded that they prefer to play at evening period to morning and day. Evening time playful might be due to big bowel after grazing morning and day period. Sometimes there is conflict between cow and calf to acquire the milk and cows use to chase calf too. This may be the weaning practices of a cow for a calf or may be due to ill condition of the cow.

Scratching or rubbing their body against small bushes, twigs and by own hind leg for front part were noted. There was not found any pattern for scratching body so it had noted from all shifts. But relevantly it had noted morning shift was common. There was a very technical brushing (Gerhard and Rene 2010) the pit part of horns with a hard twig or small trees were also noted.

Licking to calves and other nearby individual was commonly especially observed to own calves. That was noted mainly in spring season because that time calves were still with cows. This reveals the parental care in the Wild Water Buffalo and it might also in between the close siblings or partner.

In Koshi Tappu Wildlife Reserve there was no record of any big predators such as tiger, leopard but golden jackal (*Canis aurious*) in many. These jackals mainly attack the buffalo's calves at late evening and cows defending by chasing to them.

### **5.1.2 Seasonal diurnal activities pattern**

The changes in activities with seasonal changes were found in the study of Cape Buffalo in the Willium Pretorious Game Reserve (Sinclayer 1977, Grimsdell and Field 1976) due to the changes in different environmental parameters. The grazing gets more in the day time in the winter season than day and at night they mostly keep busy for resting and ruminating (Winterbatch and Bothma 1998). Just in support of this Cape

Buffalo graze more at night than day (Grimsdell and Field 1976). Comparatively, the winter season was recorded the peak of grazing i.e. 57% with respect to day time duration afterward is the autumn season i.e. 54%. This reveals the similarity in grazing activity with Cape Buffalo as they rest and ruminate more at night and graze more in day (Winterbatch and Bothma 1998). But they found spend more time in autumn season six hours and 29 minutes in 12 hours of study in the same way five hours 42 minutes in winter. The pattern found to be near to African buffalo (*Syncerus caffer*) grazing budget of five hours 45 minutes according to Ryan and Jordan (2005). It was found that they were highly disturbed in monsoon season due to heavy flood. During heavy flood the herds could not be seen on the study area i.e. near Kusaha post. They were confined near forest dominated with Sisoo (*Dalbergia sisoo*) and Khair (*Acacia catechu*). In other seasons they were found generally near to the post. Especially in dry spring they depend on only small sprouting thatch grass (*Sacchrum spontanium*) at early flooded areas of the Koshi river banks. Density of the grass was found 247 (Table XI) in the grazing ground. Winter season was found most crossed towards the cultivated field in the evening and night time. They prepared themselves around five o'clock to cross the river towards the Kushaha post and finally to the field after seven and eight of evening.

According to Winterbatch and Bothma (1998) buffalo rest more at day and graze more at night period. This is the same case as of Cape Buffalo which rest mostly in the monsoon season (32%) of the day time. It was near to 23% of this study (Appendix-I, Table IX). The resting generally started early in the morning shift and till evening. It was found that in case of monsoon season due to either rain or hot weather they preferred resting rather grazing. But in case of winter season and due to the short day light and less disturbances of flies they were engaged mostly on grazing rather resting.

The study had estimated that winter and autumn seasons are the peak of the standing. It was 20% and 14% in autumn season out of 10 hours' time budgets in winter and 12 hours of time budgets in autumn. In these seasons Wild Water Buffalo were found least wallowing and standing more instead of wallowing. Generally, autumn and winter being their calves bearing period they spent more time for vigilance of enemy because standing actually is for ruminating and vigilance for safety aspects of that herd (Ryan and Jordaan 2005). In case of African Cape Buffalo (*Syncerus caffer*) the vigilance and ruminating i.e. standing was found to be 15% of diurnal time; which is approximately

similar to the Wild Water Buffalo (*Bubalus arnee*) with 13% of the diurnal time (Appendix-I, Table II).

The least standing activity was recorded in spring and monsoon with 8% and 11% respectively. These were due to being hot weather and mostly they went wallowing instead of standing. In monsoon season they were found rested or wallowed more instead of standing may be due to the nuisance of flies.

From this study it revealed that the standing and wallowing activities are found complementary to each other because if Wild Water Buffalo stand more then they wallow less; was recorded and vice versa (Appendix-I, Table IX). Wallowing were found to the peak in dry season of spring 21% of a day time i.e. two hours 31 minutes and 15% in monsoon season. The wallowing activity generally started late of day and evening shifts that was in between 13:00 to 18:00 hours of a day. The wallowing activity was either to get rid of nuisance of insects or to relieve from hot climate. In monsoon season there were found more density of insects which pierced the Wild Water Buffalo so they tried to get rid of these flies by dipping whole body in water hole or river. They found frequently whole body dipped in water up to three minutes of breathe holding inside water. Mostly they were found just keeping nostril above water and  $\frac{1}{4}$  i.e. a quarter part of body above water but some time they used to plunge their mouth parts repeatedly to remove cattle flies from their front parts. The wallowing activity found to ground level i.e. nil at winter season while rarely at autumn season.

### **5.1.3 Other activities**

Drinking was found to be more in day time, mostly before the midday and after midday. That estimation was similar to African Cape Buffalo (*Syncerus caffer*) that drinks two times a day time (Ryan and Jordaan 2005) which is a near relative of the Wild Water Buffalo. It was also noticed that the buffalo drank under the period of resting, standing or wallowing. During these times they mostly ruminate so it can be concluded that they usually drank before ruminating. The interesting behavior found frequently was that the urination and defecation mostly followed by drinking. It seemed that they generally keep trying to maintain their body fluid. A cape African buffalo drinks once a day

(Synclair 1977). But the evidence of this study an Asian Wild Water Buffalo generally drinks twice a day.

Defecation mainly had noticed at day and evening period. Generally the activity had recorded before drinking or wallowing. The defecation performed with raised tail base and little humped up and body with back posture but some time it was also noted that they defecated during walking condition and such defecated fecal were loose type as they got diarrhoea.

It was also noted that a Wild Water Buffalo were playful. That activities mostly seen in standing condition as they acted as striking their horns and head, one near partner pushes with head to back and belly region and the peculiar way was found the mounting practice in between two immature male. A calf following to cow and try to steal out milk just greedily was also some of the noticeable behavior in Wild Water Buffalo.

Scratching body against bushes of Gobre Sallo (*Pinus wallichiana*) were mostly seen in monsoon and spring seasons. Sometime it was also found that they brush their horns base pit and head with small but woody branches of bushes or trees. That was also recorded in African Cape Buffalo (Gerhard and Rene 2010). They also scratched their head with hind leg as auto groom. Licking calf by cow as a parental care was also observed. They also found defending their calf by chasing golden jackal if they are around.

### **4.3 Comparative study**

#### **5.2.1 General comparison of diurnal activities**

In this study; comparatively male band were found to less grazer and more rested or relaxed than a mixed herd. From this study it was found that the male band grazed with 37% of the diurnal time but mixed herd was found with 62% of the day time but in contrast the male band was found rested with 42% and a mixed herd was found rested only with 12%. This study clearly and substantially claimed that a mix herd had higher responsibility so they had less rest and more grazing than a male band which was just opposite. From the year of study it was revealed that in average a male band graze four hours and 15 minutes but a mixed herd nearly double seven hours and eight minutes.

From the result it had more dietary concern for mixed herd because they had calves with lactating cows. So they had to spend more time in surfing better diet. Another cause might be that they had no large territorial for grazing due to security reason, so they had a challenge to maintained balanced diet within limited source area. Hardly the mixed herd found crossed for the crop raiding.

There is big difference in age and sex composition between male band and mixed herd. A male band generally consists of around ten bachelor males which are strong and well defending. But in case of mixed herd there are cows, calves and few sub adults male which are not so well strong and defending. A mixed herd has more responsibility than a male band for feeding and caring calves. So the mixed herd was found spend more vigilance than resting but in case of male band less vigilance and more resting. So the male band was found resting (42%) more than three times to a mixed herds (12%). Mostly bachelor male groups used to visit crops frequently at night so due to bulk of feeding, they mostly rest to ruminate.

In case of wallowing also male band 12% which was equal to one hour 23 minutes per day but in case of mixed herd only 9% of diurnal time which was equal to one hour two minutes.

Standing was found more in mixed herd for vigilance and ruminating (Ryan and Jordaan 2005) than male band. A mixed herd was found 17% of a day time which was equal to one hour 57 minutes per day time but in case of male band it was found nine percent of a day time equal to one hour and two minutes. This data also matched to the result made before by Ryan and Jordaan (2005) for African buffalo.

### **5.2.2 Seasonal comparison of diurnal activity pattern.**

From this study it was found that the mixed herd (Heterogeneous herd) always engaged more in grazing than male band (Homogenous herd) for all seasons. The difference in grazing pattern of mixed herd and male band was found highly significant ( $P < 0.05$ ). Mainly in hot and dry spring season the highest difference in the grazing pattern were observed. It was found 40% more mixed herd engaged for grazing than the male band.

This evidence may be due to several reasons. The most probable reason is that mixed herd have infants in this season and being lactating period they need more nutrition so they browse more time. Another reason may be due to hot and dry season the area is in scarcity of food so they have to rely on sprouting thatch grass rather raiding crops as male band. The second more high difference found in autumn season by 28% more in mixed herd than male band. Since the autumn season is the near harvesting time for crops and good for raiding to Wild Water Buffalo. A male band is more secure for crossing the dyke and invades the crop of people than a mixed herd. So the male band found less day grazing than mixed herd. Winter is short day and extreme cold at night time. They generally rest in very cold time so be active at day time. Due to this reason both were found mostly engaged for grazing, male band (54%) and mixed herd (60%). So the least difference (6%) was observed or grazing pattern was similar in this cold season for male band and mixed herd.

The difference in resting pattern for male band and mixed herd is highly significance ( $P < 0.05$ ). This was mainly due to the difference in age and sex composition. The spring season was in peak for the difference where male band rest with 49% but mixed herd no record was made. This high difference for this season might be due to presence of infant with mixed herd but with less food availability. The big challenge for maintaining good diet and caring for infants remain in front of mixed herd so they engaged more for grazing and standing or vigilance rather resting. In case of male band all bachelor males were defensive and easily can cross the dyke for crop raiding and spent more time for grazing and standing or vigilance for defending as in mixed herd. The monsoon and autumn seasons provide more rest for the mixed herd (17%) of a day. Food availability is also good in these seasons.

The standing activity pattern which has explained as vigilance with eye or olfactory and ruminating by Ryan and Jordaan (2005) in African Cape Buffalo, was also found significantly different from the male band to the mixed herd ( $P < 0.05$ ) in Wild Water Buffalo. Generally mixed herd was found standing more than a male herd. This can be simply reasoned with reference to vigilance necessity is more for mixed herd than male band. The maximum difference (11%) was observed in winter season. That is 11% more in mixed herd than male band. It means a mixed herd stands more by 1 hour 6 minutes than a male band. In the monsoon season by 9% more in mixed herd again i.e.

by one hour but least difference was in autumn season by 2% i.e. by 14 minutes. The difference seemed happened due to male band rested more time in monsoon season than autumn season. Autumn season comparatively provided more rest for both herds.

The wallowing activity was not found significantly differing ( $P > 0.05$ ) from male band to the mixed herd. It revealed that the wallowing is the common interest for both the herds so it did not affect the compositional differences or other like safety and security aspects. They differ maximum by seven percent only in both the monsoon and autumn seasons which were equal to 50 minutes but were almost same in spring season which differed by 1% more in mixed herd which equals to seven minutes.



## 6 CONCLUSION AND RECOMMENDATIONS

This study presents the estimation and comparative study of activities pattern of Wild Water Buffalo in Koshi Tappu Wildlife Reserve with reference of Kusaha a buffer zone of the reserve having no large predators. The reserve is highly affected with monsoon flood, fire in dry season and evergreen domesticated cattle. A normal herd of Wild Water Buffalo (*Bubllus arnee*) graze about five hours and forty five minutes every day of 11 hour 30 minutes time budget so they are a dwelling grazer which mostly spent their time on surfing diet. From the comparative study of activity patterns of mixed herd and male band are different significantly for grazing, resting and standing but were found similar for wallowing.

From the point of activeness i.e. grazing and standing is summed for active and resting and wallowing summed up for non-active or rest then a herd of Wild Water Buffalo remains active around 62% of a day time i.e. seven hours and eight minutes in eleven and half hours in diurnal time budgets.

Among the three different types of herds found according to members' composition like male band, mixed herd and single or solitaire-male, there are significant differences in between male band and mixed herd in three different major activities pattern. These activities are grazing, resting and standing but the pattern of wallowing is same in both herds where the solitaire-male was kept unstudied. Here in KTWR a mixed herd spent more time in grazing or surfing balance diet and less rest in comparison to a male band.

On the basis of this study and observation some points have been recommended here for the livelihood and sustainable conservation of Wild Water Buffalo in KTWR.

1. The thatch harvesting (Kharkhadai) should be in managed way and wild lives be made friendly under the supervision of specialist.
2. The yearly setting forest fire in KTWR must be discouraged.
3. NTFP local collectors at the early morning make trouble for the Wild Water Buffaloes and collectors both because that time is for returning to across river from dyke or crop field.

4. There is highly encroachment of domesticated buffaloes from southern inundate area and other cattle from Vagalpur (North West) part of the KTWR this must be managed.
5. The heavy sound of music and the overflow of irritating visitors found to be problem to the animal so the picnic near Kushaha post must be restricted.
6. Most of the night invasions of the poacher were found to the northern and western Udayapur as well as Saptari districts; so security post should manage as soon as possible.

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## 8 APPENDICES

### Appendix-I (Tables)

Table I The observed time duration for different activities of male band and mixed herd for four different seasons in the field data sheet form.

Table I.I Scanned sampling data of male band and mixed herd for their duration of different activities of monsoon season

MONSOON SEASON								
Morning			Day			Evening		
Activities	Time Interval	Duration	Activities	Time Interval	Duration	Activities	Time Interval	Duration
Rest	6:00-10:00	240	Rest	10:00-11:35	95	Graze	14:00-15-43	103
			Stand	11:35-11:50	15	Stand	15:43-16:15	32
			Wallow	11:50-13:49	119	Graze	16:15-18:00	105
			Graze	13:49-14:00	11			
Male band above					Mixed herd down			
Graze	6:00-6:45	45	Graze	10:00-11:30	90	Graze	14:00-16:25	145
Stand	6:45-8:09	84	Rest	11:30-13:31	121	Stand	16:25-16:49	24
Graze	8:09-10:00	111	Stand	13:31-13:33	2	Wallow	16:49-18:00	71
			Wallow	13:33-14:00	27			

Table I.II Scanned sampling data of male band and mixed herd for their duration of different activities of autumn season.

AUTUMN								
Morning			Day			Evening		
Activities	Time Interval	Duration	Activities	Time Interval	Duration	Activities	Time Interval	Duration
Rest	6:00-7:10	70	Rest	10:00-11:25	85	Rest	14:00-14:31	31
Stand	7:10-8:20	70	Stand	11:25-11_51	26	Graze	14:31-18:00	209
Rest	8:20-10:00	100	Wallow	11:51-12:40	49			
			Graze	12:40-14:00	80			
Male band above					Mixed herd down			
Stand	6:00-7:27	87	Graze	10:00-11:30	90	Graze	14:00-16:25	145
Graze	7:27-10:00	153	Rest	11:30-13:32	122	Stand	16:25-16:49	24
			Graze	13:32-14:00	28	Graze	16:49-18:00	71

Table I.III Scanned sampling data of male band and mixed herd for their duration of different activities of winter season

WINTER								
Morning			Day			Evening		
Activities	Time Interval	Duration	Activities	Time Interval	Duration	Activities	Time Interval	Duration
Rest	7:00-8:57	117	Graze	10:00-12:35	155	Rest	14:00-15:15	75
Graze	8:57-10:00	63	Stand	12:35-14:00	85	Graze	15:15-17:00	105
Male band down			Mixed herd down					
Stand	7:00-9:15	135	Graze	10:00-12:18	138	Graze	14:00-16:12	132
Graze	9:15-10:00	45	Rest	12:18-13:48	90	Stand	16:12-16:30	18
			Graze	13:48-14:00	12	Graze	16:30-17:00	30

Table I.IV Scanned sampling data of male band and mixed herd for their duration of different activities of spring season.

SPRING SEASON								
Morning			Day			Evening		
Activities	Time Interval	Duration	Activities	Time Interval	Duration	Activities	Time Interval	Duration
Rest	6:00-9:05	185	Graze	10:00-10:45	45	Graze	14:00-14:15	15
Graze	9:05-10:00	55	Rest	10:45-13:35	170	Wallow	14:15-16:46	151
			Stand	13:35-14:00	25	Graze	16:46-18:00	74
Male band above			Mixed herd down					
Graze	6:00-10:00	240	Graze	10:00-11:08	68	Graze	14:00-14:35	35
			Stand	11:08-12:37	89	Wallow	14:35-16:53	138
			Graze	12:37-13:40	63	Graze	16:53-18:00	67
			Wallow	13:40-14:00	20			

Table II Average activities duration and their percentages of Wild Water Buffalo.

Activities	Both	average	Percentage
Rest	1501	750.5	27%
Stand	716	358	13%
Wallow	575	287.5	10%
Graze	2728	1364	50%

Table III Showing time duration in minutes of four main activities for a herd of a whole year in shift wise.

Shifts	Morning	Day	Evening	Total time
Graze	712	780	1236	2728
Rest	712	683	106	1501
Stand	376	242	98	716
Wallow	0	215	360	575
Total time	1800	1920	1800	5520

Table IV Other activities recorded from four seasons

Shifts	Morning	Day	Evening
Defecate	0	1	3
Drink	0	6	2
Play	1	1	4
Scratch body	2	1	1
Lick calf	0	1	0
Defense	0	1	1

Table V Showing time duration in minutes for different activities of four seasons of a herd.

Activities	Graze	Rest	Stand	Wallow	Total
Monsoon	305	228	78.5	108.5	720
Autumn	388	204	103.5	24.5	720
Winter	340	141	119	0	600
Spring	331	177.5	57	154.5	720
Total	1364	750.5	358	287.5	2760

Table VI Showing percentage of different activities for four seasons of a herd.

Activities	Graze	Rest	Stand	Wallow
Monsoon	42%	32%	11%	15%
Autumn	54%	28%	14%	4%
Winter	57%	23%	20%	0%
Spring	46%	25%	8%	21%

Table VII Values of t-test for significance of difference in pattern of diurnal activity of Wild Water Buffalo.

Activity	t-value	D.f.	p-value	A	Remark
Graze	-3.8997	6	0.007993	0.05	Significance
Rest	4.5058	6	0.004636	0.05	Significance
Stand	-2.4677	6	0.05029	0.1	Significance
Wallow	0.3045	6	0.7712	0.5	Not significance

Table VIII Comparative data on diurnal activities of Wild Water Buffalo for different seasons in between male band and mixed herd.

Activities	Monsoon		Autumn		Winter		Spring		Total
	Male	Mixed	Male	Mixed	Male	Mixed	Male	mixed	
Rest	335	121	286	122	192	90	355	0	1501
Stand	47	110	96	111	85	153	25	89	716
Wallow	119	98	49	0	0	0	151	158	575
Graze	219	391	289	487	323	357	189	473	2728
Total	720	720	720	600	600	720	720	720	5520

Table IX Comparative seasonal diurnal activities of Wild Water Buffalo in percentage in between male band and mixed herd.

Activities	Monsoon		Autumn		Winter		Spring	
	Male	Mixed	Male	Mixed	Male	mixed	Male	mixed
Rest	47%	17%	40%	17%	32%	15%	49%	0%
Stand	6%	15%	13%	15%	14%	25%	4%	12%
Wallow	17%	14%	7%	0%	0%	0%	21%	22%
Graze	30%	54%	40%	68%	54%	60%	26%	66%

Table X The time budget of the field study in detail

Time	Reconnaissance survey	Monsoon	Autumn	Winter	Spring	Total
Time in days	4	3	3	3	3	16 Day
Time in hours	48	36	36	30	36	186 hrs.
Actual contact time	0	24	24	20	24	92hrs

Table XI The density of *Sacchrum spontaneum* in the sandy ground of the study area.

Q.N.	Plant species	Total count	Average density =988/4 =247 per square meter
1	<i>Sacchrum spontaneum</i>	220	
2	<i>Sacchrum spontaneum</i>	367	
3	<i>Sacchrum spontaneum</i>	166	
4	<i>Sacchrum spontaneum</i>	235	
Total count of the <i>Sacchrum spontaneum</i> in 4 quadrates		988	

Table XII Temperature and precipitation record of 2006 from Tarahara and Chatara stations respectively.

Month	Temperature			Precipitation
	Maximum	Minimum	Average	
January	22.5	8.7	15.6	0
February	27.6	13.7	20.7	0
March	31.2	13.5	22.4	4.7
April	32.2	18.9	25.6	120.5
May	32.5	23.1	27.8	170.5
June	32.5	24.8	28.7	396.6
July	32.4	25.8	29.1	229.4
August	32.7	25.7	29.2	196.1
September	30.9	24	27.5	514.3
October	31.4	19	25.2	184.3
November	27.5	14.7	21.1	0
December	25	10.5	17.8	6.3

## Appendix-II (Photo Plates)



1. The initial field visit with supervisor and wildlife experts



2. The study area (Kusaha post and next side of the Koshi river)



3. The largest mixed herd (counted 42 individuals) seen in the field area at last of April.



4. Solitary male in alert



5. A fraction of male band, two vigilance and two graze position inside thatch grass (*Saachrum spontanium*) field



6. A mud hole made by Wild buffalo.



7. Playing a pair of male after rest with gentle pushing head



8. A male band in the study area after rest



9. Resting male band in the monsoon season After heavy rain and flood.



10. Sapling thatch grass (*Saachrum spontanium*) of spring season.



11. Khayer (*Acacia catechu*) after separating Economic log. Near Bhagalpur.



12. Burnt eggs with nest of francolin after Forest fire inside the KTWR.





13. A mixed herd resting on sand near the River



14. Grazing a male band in the study area



15. A single pile of fresh dung of Wild water Buffalo (*Bubalus arnee*)



16. Encroachment of domesticated cattle in the KTRW



17. Locals collecting cattle dung inside the western part of reserve



18. Burnt remain of Hog deer (*Hyelaphus porcinus*) After setting forest fire inside the reserve.