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Chapter 4 - RESULTS

BOURNEMOUTH UNIVERSITY

SCHOOL OF CONSERVATION SCIENCES

AN ASSESSMENT OF AVIAN AND OTHER SCAVENGING OF AN ANIMAL CARCASS AT KATERNIAGHAT WILDLIFE SANCTUARY, DISTRICT BAHRAICH, UTTAR PRADESH – INDIA, AND ITS FORENSIC IMPLICATIONS.

A DISSERTATION SUBMITTED AS PART OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN

FORENSIC ARCHAEOLOGY: CRIME SCENE AND INTERNATIONAL INVESTIGATIONS

By

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FEBRUARY 2006

CHAPTER 4 – RESULTS

4.0. Introduction

This chapter presents the results of the quality assessment for the literature review. It also presents the outcomes of the field observation at sites: A and B. A digital video format was produced for the observations at Site B and has been submitted with this dissertation and provides a visual representation of the field observational study carried out on the exposed buffalo carcass from 18th August 2005 to 24th August 2005. The presentation of these results, are in compliance with the aim and objectives of the research.

Quality assessment

A total of 38 articles was included in the literature review and each of the articles was allocated to a study type based on the research design as suggested by Whitworth (2003). The approach suggested by Whitworth (2003) is a variation based on models developed for standard clinical medicine (Mulrow 1987 and Droogan *et al.*, 1998), (see Appendix 8). Table 4.1 presents a concise report of the search articles based on their scientific ranking of the research design.

Table 4.1: Concise report of search articles based on their scientific ranking of the research design.

Study Type	No. of Articles
Controlled Experiments	4
Experiments	3
Prospective Studies	2
Retrospective Studies	2
Case Studies - Multiple	7
Case Studies – Single	3
Discussion	12
Religion	5
Total	**38**

Quality appraisal questions (see Appendix 4), were applied to each of the articles and their responses were given scores reflecting their value to research (see Appendix 9). Articles allocated under “discussion” and “religious” were not systematically appraised for quality. The papers were rated according to their scores and arbitrary thresholds. These were established by the author in a similar manner to those established by Whitworth (2003) for quality appraisal of the articles. They were:

> 80% = High

> 65% = Acceptable

> 50% = Of some value

< 50% = Poor

Table 4.2 presents the result of quality assessment based on the above standards.

Study Type	No. of Articles	Average Value	Level
Table 4.2: Result of Quality Assessment			
Controlled Experiments	4	87.50%	High
Experiments	3	76.67%	Acceptable
Prospective Studies	2	80%	High
Retrospective Studies	2	70%	Acceptable
Case Studies - Multiple	7	66.67%	Acceptable
Case Studies – Single	3	66.67%	Acceptable

In respect of the literature review, of the six study types of article accessed in the systematic search strategy, articles categorised as ‘controlled experiments’ (Komar *et al*., 1998a, Komar *et al*., 1998b, Turner *et al*., 1999 and Roen *et al*., 2005) and ‘prospective studies’ (Haynes 1983; Spennemann *et al*.,

1995 and Travaine *et al.*, 1998) were most useful and the other study types showed an acceptable level of value for the present study. Articles based upon case studies showed the lowest acceptable levels as they lacked uniformity and consistency that could be utilised for conducting scientific research. None of the articles assessed were directly relevant to an observational study of the type described here.

4.2. Assessment of actors observed at site A

During the two hour observation period from 0930 hours until 1130 hours on 18th August 2005 at Site A, eighteen White-backed Vultures were seen soaring in the sky at approximately 150 meters above the goat carcass and twelve were seen perched on the roost trees close-by. No actors, except for some flies, were observed approaching the carcass. Figure 4.1 shows the condition of the goat carcass after two hours of being exposed.



Figure 4.1: Condition of the goat carcass after two hours of being exposed

The experiment at this site had to be terminated at 1145 hours as explained chapter 3.9.1. All further results presented are pertinent to site B.

4.3. Assessment of actors observed at site B

Table 4.3 and Table 4.4 present an overview of the actors observed at site B and the type of recording undertaken, respectively, during the field experiment from 18th August 2005 until 24th August 2005.

The actors are divided into the three types of faunal scavengers as discussed earlier in the literature in sections 2.2, 2.3, 2.4 and 2.5. Each species is given a reference, as seen in Table 4.3, for

simplicity and will be used hereafter. The description of each species observed at the site can be found in Appendix 10. Graphical presentation of the table is seen in Figure 4.2.

Figure 4.3 presents the population of each species, i.e. maximum number of each species observed at the site at one time, during the seven day study period.

Actors	Species Common name	Reference	Species Scientific name	P	Q
Table 4.3: Summary of the actors and the maximum number of each species observed at the site, during the seven day study period.					
Avian	White-backed Vulture	WBV	*Pseudogyps bengalensis*	15	35
	Egyptian Vulture	EV	*Neophron percnopterus*	3	7
	Jungle Crow	JC	*Corvus macrorrhynchos*	15	74
Mammalian	Feral Dog	FD	*Canis familiaris*	2	3
	Common Fox	CF	*Vulpes vulpes*	2	3
Reptilian	Crocodile	C	*Crocodylus palustrius*	3	25
Total number approaches to the carcass by the various species					**147**
Key					
P = Maximum number of approaches by each species to the carcass at one time (species population at site)					
Q = Total number of approaches by each species to the carcass over the seven day study period.					

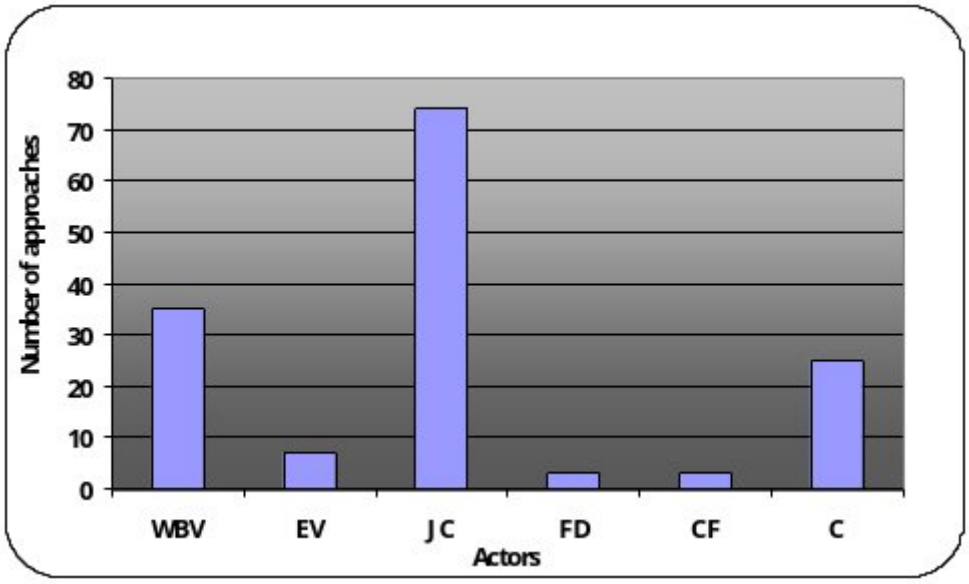
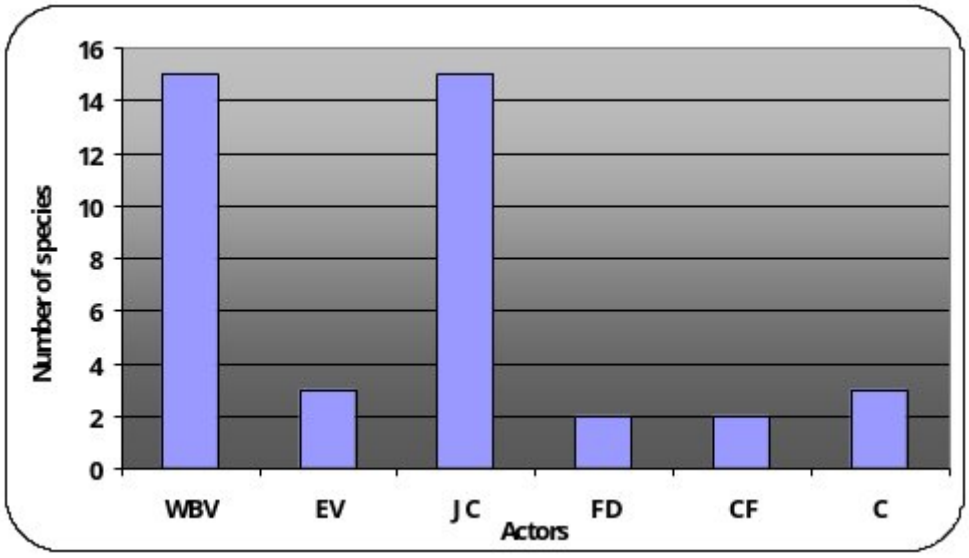


Figure 4.2: Actors and the total number of approaches by each species to the carcass, observed during the seven day period



As is evident in Table 4.3, the maximum number of approaches to the carcass was by Jungle crows, followed by the White-backed vultures, Crocodiles and Egyptian vultures respectively. The minimum numbers of approaches was by the Feral dogs and Common foxes. The total population of each species was between two and fifteen (see Table 4.3). Table 4.4 presents the overview of type of recording undertaken on each species of actors at site B.

Table 4.4: Summary of observation / recording

Avian	**WBV**	**Y**	**Y**	**Y**
Actors	**Species**	**Recording**		
		Documented	**Photographic**	**Video**
	EV	Y	Y	Y
	JC	Y	Y	Y
Mammalian	FD	Y	N	N
	CF	Y	N	N
Reptilian	C	Y	Y	Y

Key

Y – Recording was undertaken

N – Recording was not undertaken

4.4. Assessment of relative timing of scavenging by the actors

Assessment of relative timing of scavenging by actors is presented based on three factors: date; time; and decompositional stage. This is compared against the stages of decomposition in Table 4.7 and Figure 4.9. It was observed that the crocodiles approached the carcass with returning repeatedly until skeletonization. Each species of actors approached the carcass in the absence of the other species. This is discussed further in chapter 5.2.1.

4.4.1. Date factor

The daily record of the actors, i.e. number of each species and the type of species, approaching the carcass is presented in Table 4.5. A graphical presentation of the table is given in Figure 4.4.

Figure 4.5 and 4.6 shows the cumulative approach of all actors and their breakdown into separate types of species each day over the seven day study period respectively.

Date								Day	WBV	EV	JC	FD	CF	C	N	T
Table 4.5: Daily approaches by each species to the carcass during the seven day study period.																
18th August 2005	1	15	0	24	0	0	0	**39**	**2**							
19th August 2005	2	18	0	25	0	0	3	**46**	**3**							
20th August 2005	3	0	0	15	0	0	7	**22**	**2**							
21st August 2005	4	0	1	10	0	0	5	**16**	**3**							
22nd August 2005	5	2	3	0	2	3	3	**13**	**5**							
23rd August 2005	6	0	2	0	1	0	6	**9**	**3**							
24th August 2005	7	0	1	0	0	0	1	**2**	**2**							
P		**15**	**3**	**15**	**2**	**2**	**3**									

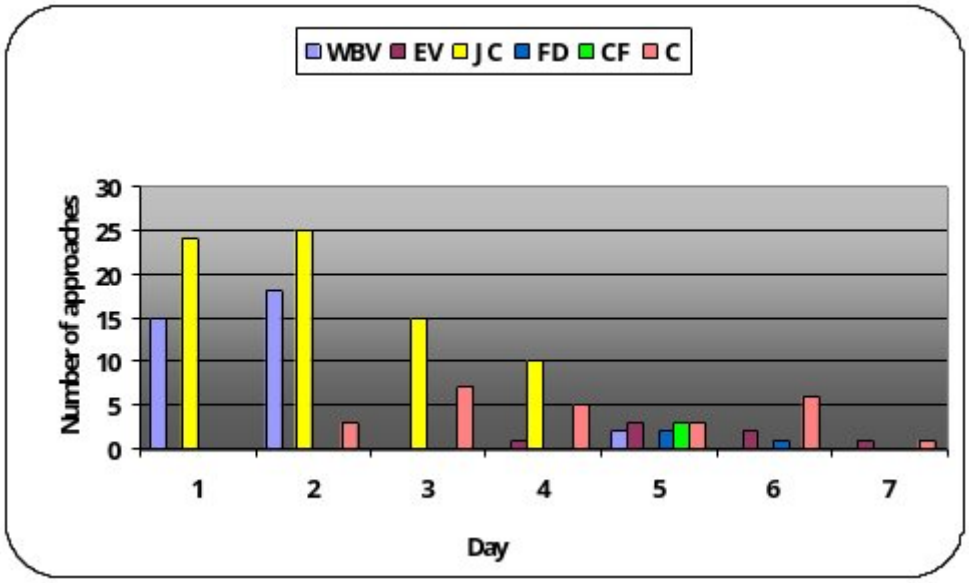
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P = Species population at site (also see column **P** of Table 4.3)

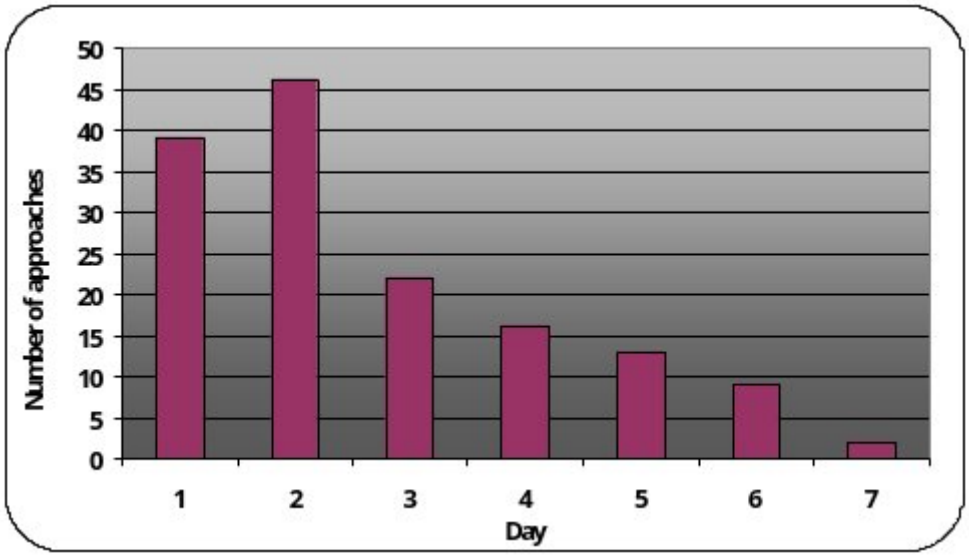
N = Total number of approaches by all the species

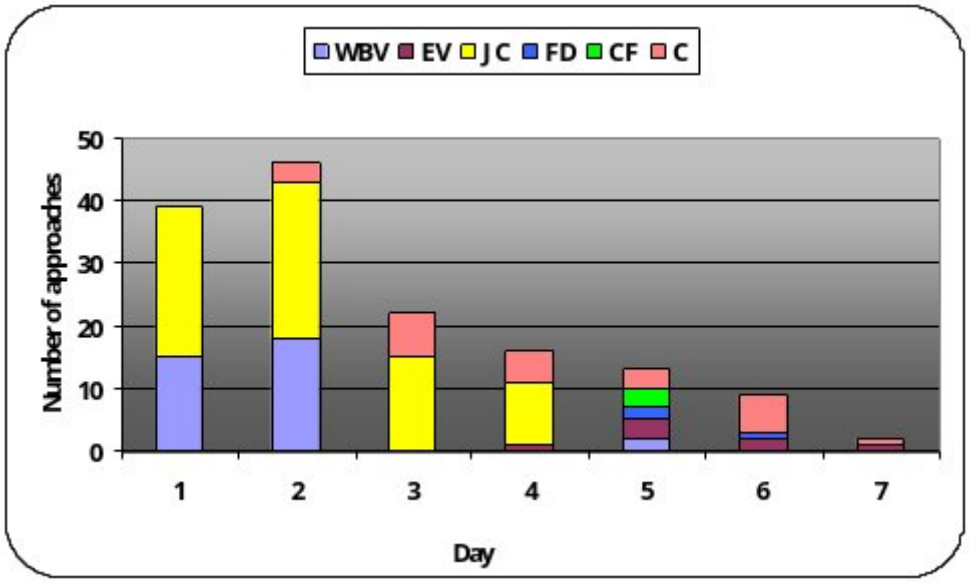
T = Total types of actors observed daily at the site

= Days with most (more than one) number of approaches



As apparent in Table 4.5, the White-backed Vultures scavenged early as did the Jungle Crows. Conversely the Crocodile showed little interest until day three, and the Egyptian Vulture also scavenged at this time.





The maximum types of species scavenged on day five, and the days when most number of approaches took place were day one and two, thereafter declining.

4.4.2. Time factor

The total number of observed approaches by the various actors to the carcass, at different times of the day, from 1000 hours to 1800 hours, each day of the study, is displayed in Table 4.6. The observation on day one was recorded from 1200 hours due to the availability of the carcass at that time. The last observation on day seven was carried out between 1100 hours and 1200 hours at that time the carcass had reached the dry remains stage of the decomposition process (see Appendix 12).

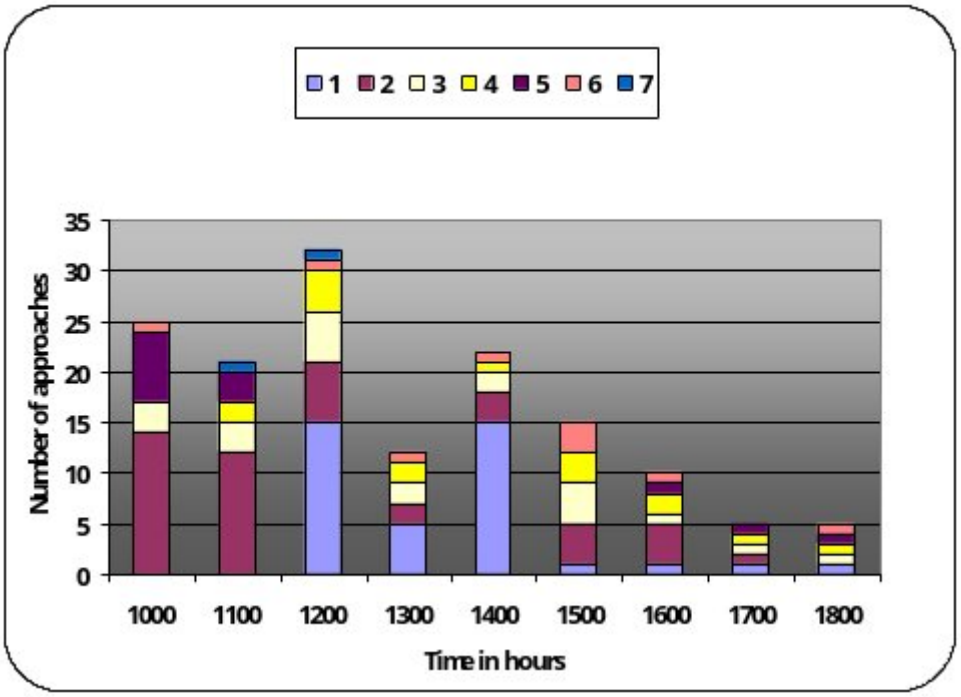
The number of approaches by individual actor at different times of the day can be found in Appendix 11. White-backed Vultures initiated the scavenging process, see Appendix 11. A graphical presentation of the number of approaches at different times of the day by the actors is seen in Figure 4.7.

Table 4.6: Total number of approaches at different times of the day by the actors over the seven day study period.

Day	Time in Hours								
	1000	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**
1	X	X	15	5	15	1	1	1	1
2	14	12	6	2	3	4	4	1	0
3	3	3	5	2	2	4	1	1	1
4	0	2	4	2	1	3	2	1	1
5	7	3	0	0	0	0	1	1	1
6	1	0	1	1	1	3	1	0	1
7	0	1	1	X	X	X	X	X	X

Key

X represents no observations



It is clear from Figure 4.7 that maximum scavenging took place from morning until early afternoon, thereafter declining. As Table 4.6 indicates, there was considerable variation in approaches, particularly on day one and two, with some variations on all days. Possible reason for this is discussed in chapter 5.2 of this dissertation.

4.4.3. Decomposition

The date and time factor results were compared with the decomposition protocol, (see section 3.10.2). There were no observations undertaken during the fresh stage, (see section 3.9), of the carcass as it had already reached the bloat stage when the observations started at 1200 hours on 18th August 2005. At this point the approximate post-mortem interval was nineteen hours, (see Figure 4.8).

Table 4.7 shows the approach by the actors to the carcass at the various stages of decomposition including the insect activity. A graphical presentation is given in Figure 4.9.



Table 4.7: Approach by each species to the carcass at the various stages of decomposition including the insect activity

Day	Stages of decomposition	Species of actors						Insect activity
		WBV	EV	JC	FD	CF	C	
1	Bloat	15	0	24	0	0	0	Flies
2	Bloat	18	0	25	0	0	3	Maggots + Flies
3	Active decay	0	0	15	0	0	7	Maggots + Flies
4	Active decay	0	1	10	0	0	5	Maggots + Flies
5	Active decay	2	3	0	2	3	3	Maggots + Flies
6	Advanced decay	0	2	0	1	0	6	No insect activity
7	Dry Remains	0	1	0	0	0	1	No insect activity

Table 4.7 shows the time involved in the various stages of decomposition. There was no insect activity observed during the advanced and dry remains stage. Other than this, the data replicates that shown in Table 4.5. Table 4.8 shows the number of approaches by each species during the different stages of decomposition.

Table 4.8: Number of approaches by each species during the different stages of decomposition

Day	Stages of decomposition	Species of actors						
		WBV	EV	JC	FD	CF	C	Total
1 – 2	Bloat	33	0	49	0	0	3	**85**
3 – 5	Active decay	2	4	25	2	3	15	**51**
6	Advanced decay	0	2	0	1	0	6	**9**
7	Dry Remains	0	1	0	0	0	1	**2**

From Table 4.8, it can be clearly seen that the maximum number of approaches by the different species of actors was during the bloat and active stages. Interestingly, the White-backed Vulture was most interested during the bloat stage; the Jungle Crow during both bloat and active decay stage with the Crocodile most interested during the active and advanced decay stages.

Table 4.9 presents the number of approaches by the different types of actors observed, at various stages of decomposition.

Table 4.9: Number of approaches by the different types of actors observed, at various stages of decomposition

Day	Stages of decomposition	Type of actors		
		Avian	Mammalian	Reptilian
1 – 2	Bloat	82	0	3
3 – 5	Active decay	31	5	15
6	Advanced decay	2	1	6
7	Dry Remains	1	0	1

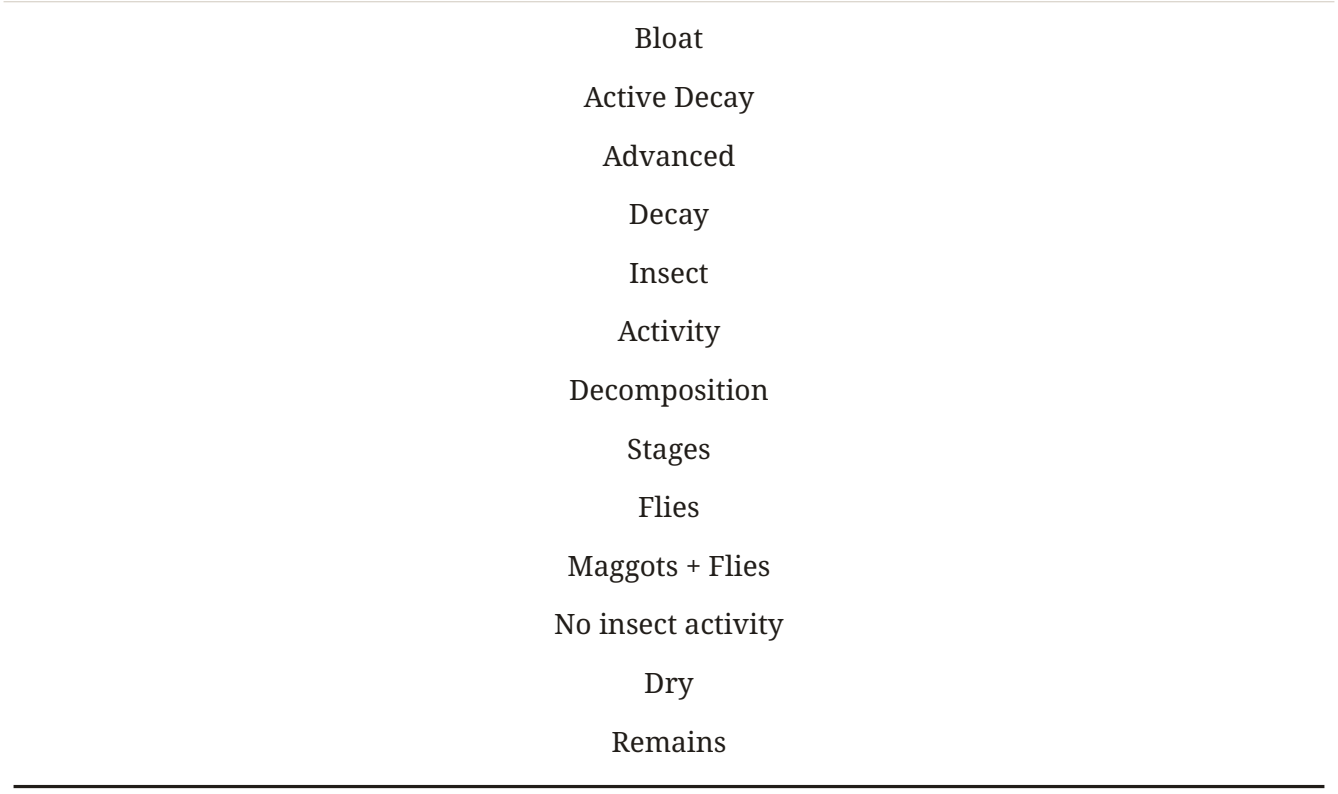


Figure 4.9: Illustration of daily approaches by the actors with reference to decomposition stages and insect activity.

It is apparent from Table 4.9 that the maximum number of avian species approached the carcass during the bloat stage and a reduced number in the active decay stage. The active decay stage witnessed all three types of actors declining in the later stages of decomposition. The insect activity was evident during the bloat and the active decay stages and disappearing in the later stages of decomposition. The reptilian species appeared on all days from day two to day six, showing more interest during the active decay stage followed by the advanced stage. Possible reasons are further discussed in chapter 5.3 of this dissertation.

4.5. Anatomical sequence of scavenging

Scavenging occurred in the numerical sequences presented in Table 4.10. It has been assumed that the sequence is defined by the preferences of the actors to certain anatomical elements / parts and their accessibility. The target area, in the order of numerical sequence, can be compared to the detail shown in Figures 4.10 and 4.11.

Table 4.10: Preferences of the actors to certain anatomical elements / parts and the accessibility

Actors	Preferred part of the carcass	Target Area
WBV	1. Eyes 2. Nose 3. Intestines were pulled out 4. Soft tissue of facial area, 5. Rumen and stomach contents	2, 3, 14*, 30
EV	1. Soft tissue of belly area 2. Rumen and stomach contents	13, 14*
JC	1. Mouth 2. Soft tissue of facial area 3. Anus 4. Tail 5. Coccygeal vertebra 6. Rumen and stomach contents	4, 30, 23, 21, 24, 14*
FD	1. Flesh from the limbs 2. Lumbar vertebra	6, 7, 20, 22, 27
CF	1. Flesh from the limbs	6, 7, 20, 22
C	1. Intestines 2. Abdominal cavity 3. Ribs, scapula 4. Soft tissue of belly area 5. Flesh from fore limbs 6. Rumen and stomach contents 7. Flesh from hind limbs	14*, 12, 13, 5, 6, 7, 20, 22

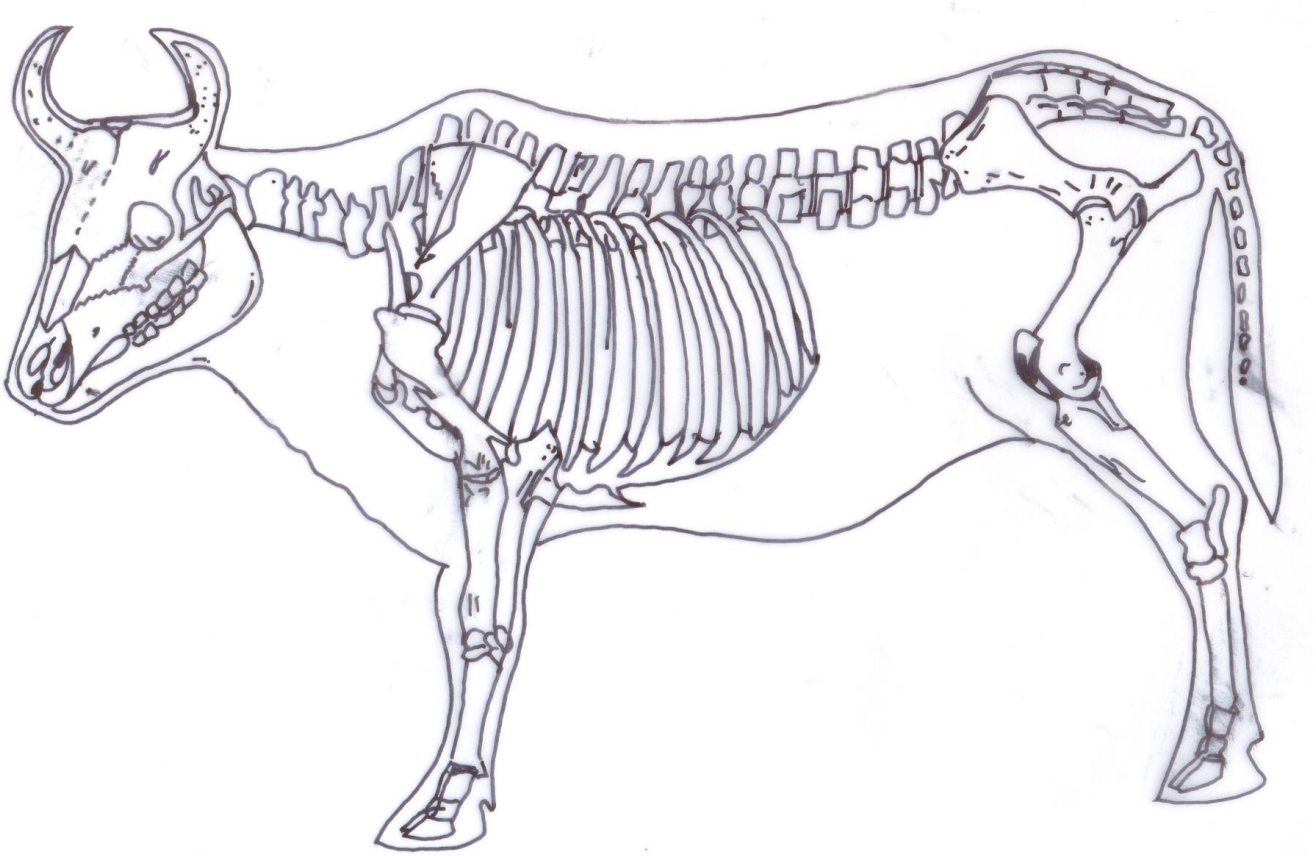


Table 4.8 shows the White-backed Vultures began the scavenging process (i.e. by accessing the carcass first, see Appendix 11 and Table 4.6), and also in practical terms by accessing the most readily available part of the carcass.

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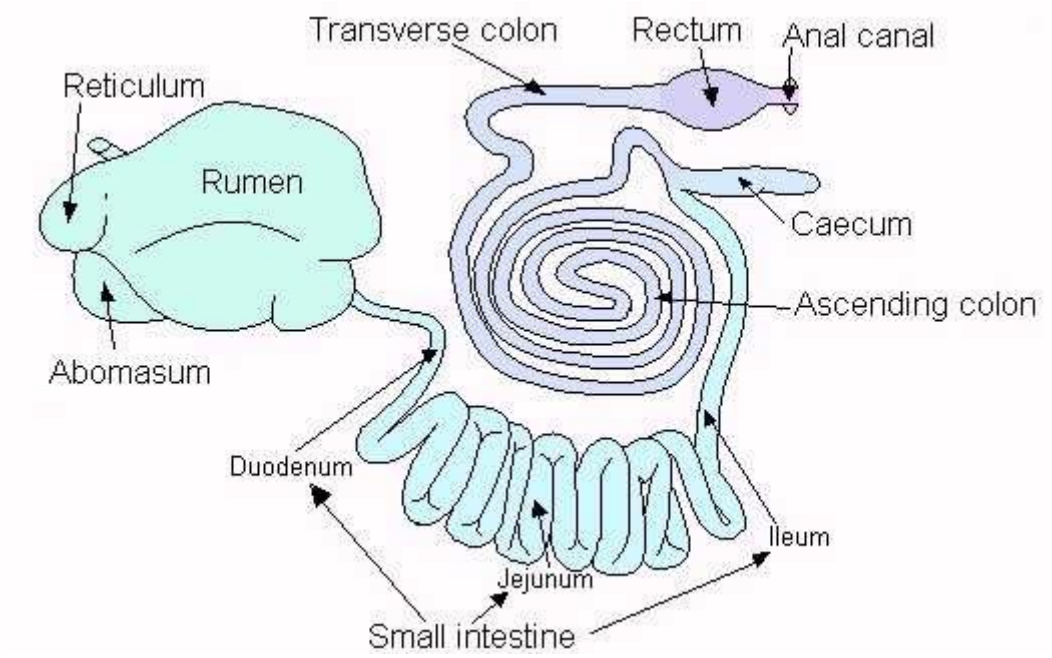
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Key					
1	Skull	11	Sternum	21	Tail
2	Eyes	12	Rib	22	Femur
3	Nose	13	Belly	23	Anus
4	Mouth	14*	* Abdominal cavity	24	Coccygeal vertebra
5	Scapula	15	Third Phalanx	25	Innominates
6	Humerus	16	Second Phalanx	26	Sacrum
7	Radius and Ulna	17	First Phalanx	27	Lumbar vertebra
8	Carpals	18	Metatarsal	28	Thoracic vertebra
9	Metacarpal	19	Tarsal	29	Cervical vertebra
10	Hoof	20	Tibia and Fibula	30	Soft tissue of Facial area

* Abdominal cavity – see figure 4.9.

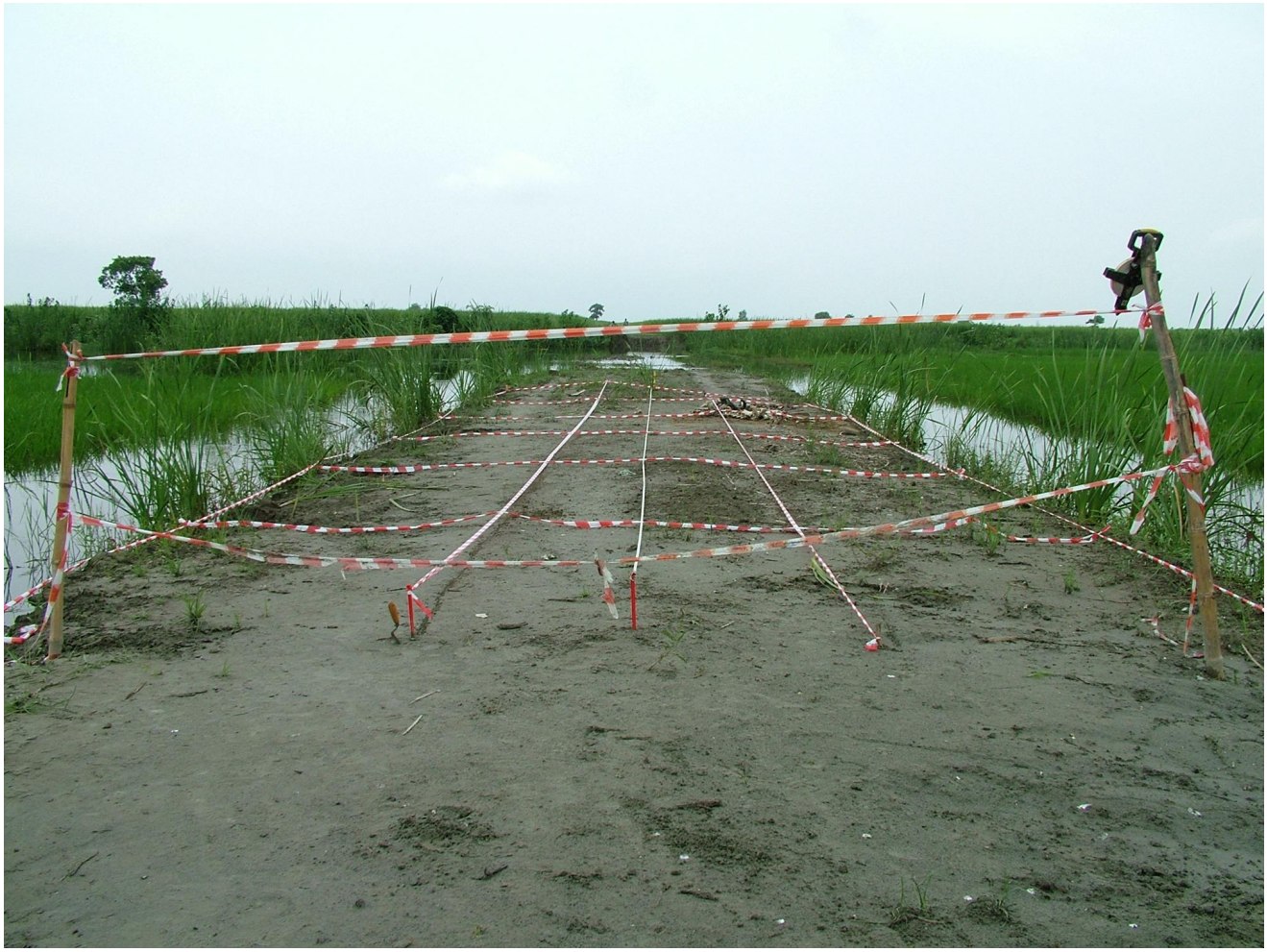
Figure 4.10: Lateral view of the skeleton of a buffalo (adapted from Ghosh, 1994).



4.6. Scatter pattern

As described earlier in the 3.9.1, 2 metres x 3 metres grids were established in the cordoned area, (see Figure 4.12).

Table 4.11 shows the approximate distance of the scatter, as observed during the seven day study period, caused by each actor within the study area of site B, i.e. 6 metres x 18 metres. All measurements were taken using offsets from the NW - NE baseline. The initial position of the carcass lied between five metres to ten metres from the NW corner. Figure 4.13 shows the relative scatter pattern of remains by the seventh day of the study period and the days it occurred.



3 metres

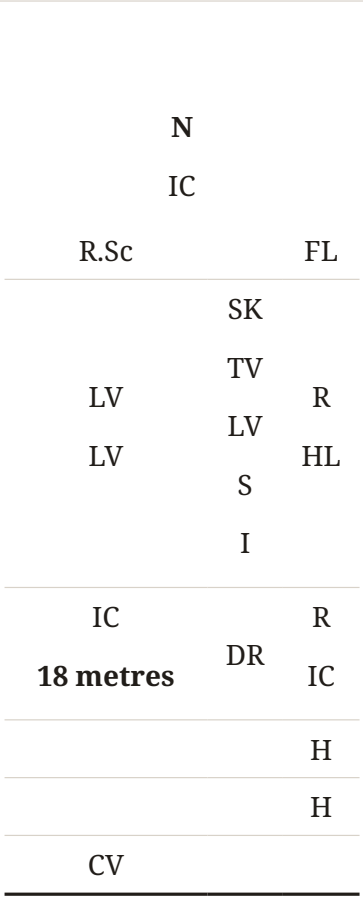
2 metres

Figure 4.12: Showing grids within the cordoned area.

Table 4 (continued)

Table 4.11: Scatter pattern by each actor by the seventh day of the study and the day it occurred

Actors	Parts scattered and their distances from the carcass	Day occurred
WBV	No parts were scattered	-
EV	No parts were scattered	-
JC	Coccygeal bone was scattered to a distance of **seventeen metres** SE	Day 3
FD	Right scapula was scattered to a distance of **five metres** SW	Day 5 – Day 6
	Lumbar vertebra was scattered to a distance of **three and a half metres** SW	Day 5 – Day 6
	Lumbar vertebra was scattered to a distance of **four and a half metres** SW	Day 5 – Day 6
CF	Left femur was not recovered	-
C	Ribs were scattered to a distance of **one metre to two metres** NE of the carcass	Day 3 – Day 7
	Hooves were scattered to a distance of **five metres** SE of the carcass	Day 6 – Day 7



Key	
IC	Irrigation Canal
R.Sc	Right Scapula
LV	Lumbar vertebra
FL	Fore Leg (Both)
SK	Skull
R	Ribs
TV	Thoracic vertebra
S	Sacrum
I	Innominates
HL	Hind Leg (Right only)
DR	Dried rumen
CV	Coccygeal vertebra
	Shaded areas indicate primary deposition position
	Trajectories of dispersal are marked by arrows
	Area of dispersal of ribs
	Area of dried rumen
	Border of the irrigation canal

Figure 4.13: Relative scatter pattern of the remains by the seventh day of the study period. (Not to scale)

As can be seen in Table 4.11, no scattering of skeletal elements occurred prior to day three. This coincides with the onset of active decay stage, (see Table 4.7). It is also prior to the approach of Egyptian Vultures, Feral Dogs and Common Foxes. This is further discussed in chapter 5.4 of this dissertation.

4.7. Presence of Trauma

External examination of the Asian Water Buffalo carcass on day one did not show any presence of trauma. However, an anomaly was present in the superficial tissues and located above the vertebra at the level of the forelimbs, see Figure 4.14. It could not be identified.



Figure 4.14: Arrow indicates anomaly

Interestingly, this lesion was not utilised by the species as an access point to soft tissue through the hide. This may be explained by the close proximity to the vertebral column which is not overlain by muscle (see Figure 4.10, key 28). Limitations precluded extensive study of skeletal elements. Further work is required to do a full analysis of skeletal elements retrieved from site (i.e. Sacrum, scapula and two ribs).

4.8. Weather

All climatological data was obtained from the Girija Barrage Flood control Unit situated at ten kilometres SE from the site which was of similar environmental conditions. Independent weather (temperature, humidity and rainfall represented by blue lines in Figures 4.15, 4.16 and 4.17 respectively) data is compared with the daily cumulative approach (represented by pink column bars in Figures 4.15, Figure 4.16 and Figure 4.17) (see also Table 4.5), by all the actors on the carcass during the seven day study period.

4.8.1. Temperature

Table 4.12 shows the daily recorded temperature at 0600 hours, 1200 hours and 1800 hours, the daily average temperatures and the total number of visits by all the actors during the seven days of the study period. A graphical representation of the comparison of the daily average temperature and the daily cumulative approach by all the actors during the seven day period is shown in Figure 4.15.

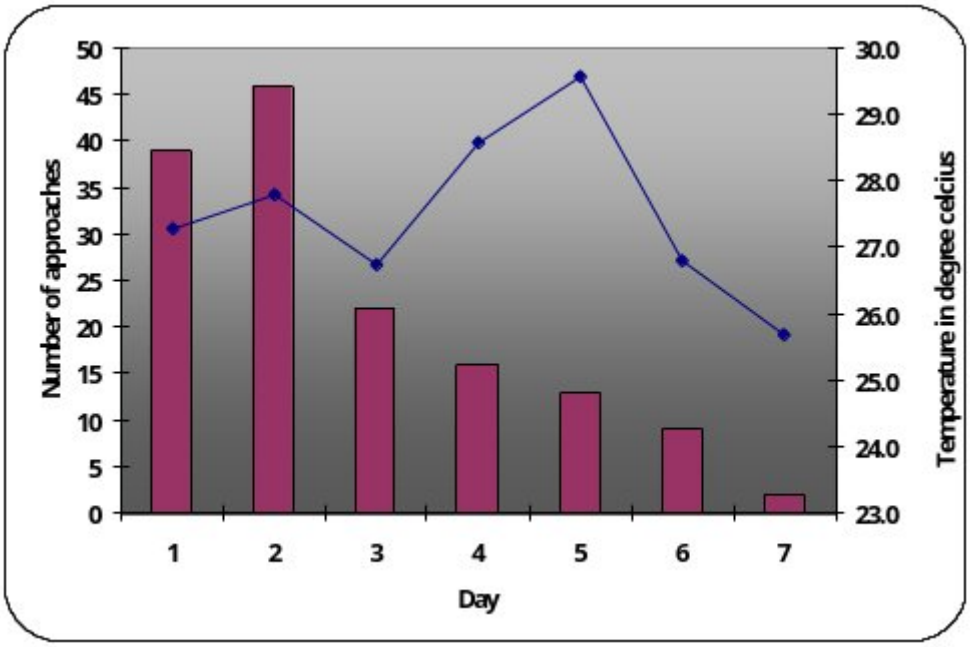
Table 4.12: Daily temperature and average daily temperature in Celsius during the seven day study.

Date	Day	Daily Temperature in Celsius				N
		Average	0600 hours	1200 hours	1800 hours	
18th August 2005	1	27.3	21.1	32.3	28.4	39
19th August 2005	2	27.8	25.6	31.6	26.2	46
20th August 2005	3	26.7	22.0	31.4	26.8	22
21st August 2005	4	28.6	25.3	31.2	29.2	16
22nd August 2005	5	29.6	26.1	32.6	30.0	13
23rd August 2005	6	26.8	23.2	31.1	26.1	9
24th August 2005	7	24.7	20.2	29.1	24.9	2

Key

N = Total number of approaches by all the actors during the seven day study period.

The temperature fluctuations are clearly seen in Table 4.12 being hot during the early afternoon and comparatively cooler in the mornings and evenings.



It is evident from Table 4.12 and Figure 4.15, that the highest temperature was observed on day five; this coincides with the day when the maximum types of species were observed at site, (see Table 4.5). Possible reasons are discussed in chapter 5.5 of this dissertation.

4.8.2. Humidity

Table 4.13 shows the daily recorded humidity at 0600 hours, 1200 hours and 1800 hours and the daily average humidity during the seven day study period.

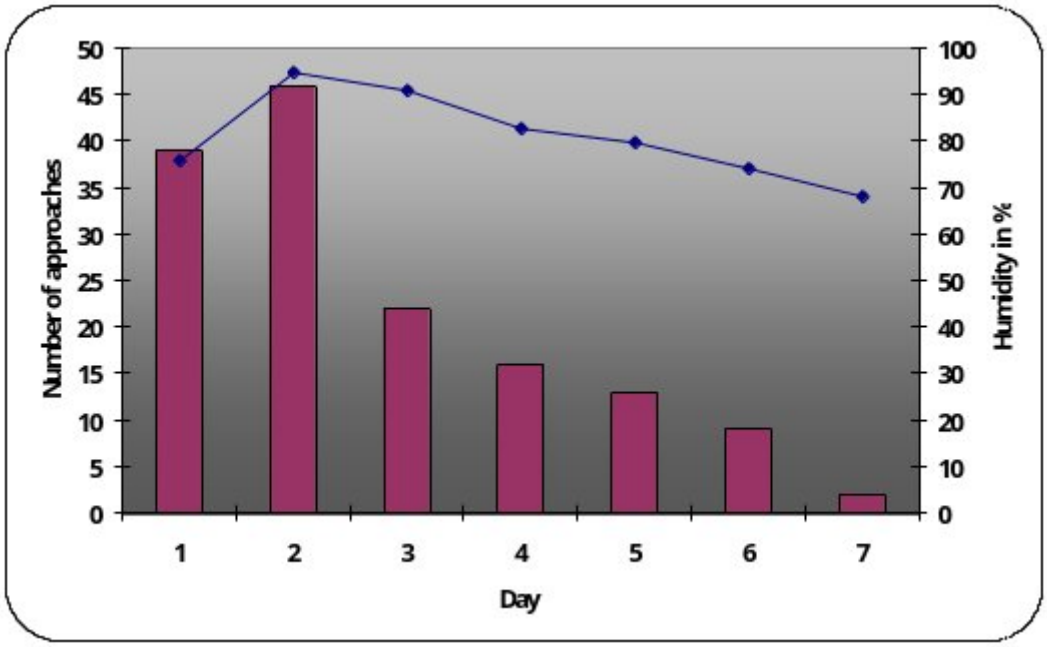
A graphical presentation of the comparison of the daily average humidity and the daily cumulative approach, (see Table 4.13), by all the actors during the seven day period is shown in Figure 4.16.

Table 4.13: Daily humidity recorded at 0700 hours, 1200 hours and 2000 hours, average daily figures and the total number of approaches by the actors

Date	Day	Humidity in Percent				N
		Average	0600 hours	1200 hours	1800 hours	
18th August 2005	1	76.0	77	77	74	39
19th August 2005	2	94.7	95	97	92	46
20th August 2005	3	91.0	93	95	85	22
21st August 2005	4	82.7	88	90	70	16
22nd August 2005	5	79.7	81	89	69	13
23rd August 2005	6	74.0	77	80	65	9
24th August 2005	7	68.0	70	73	61	2

Key

N = Total Number of approaches by all the actors during the seven day study period.



As seen in Table 4.13, day two shows the maximum humidity and a declining thereafter. This coincides with the maximum number of approaches by all the actors, (see Table 4.5). Between days two and three there is a large decrease in number of approaches by the actors and this decrease appears to continue at the same rate as the decline in humidity, (see Figure 4.16). Further reasons are discussed in chapter 5.5 of this dissertation.

4.8.3. Rainfall

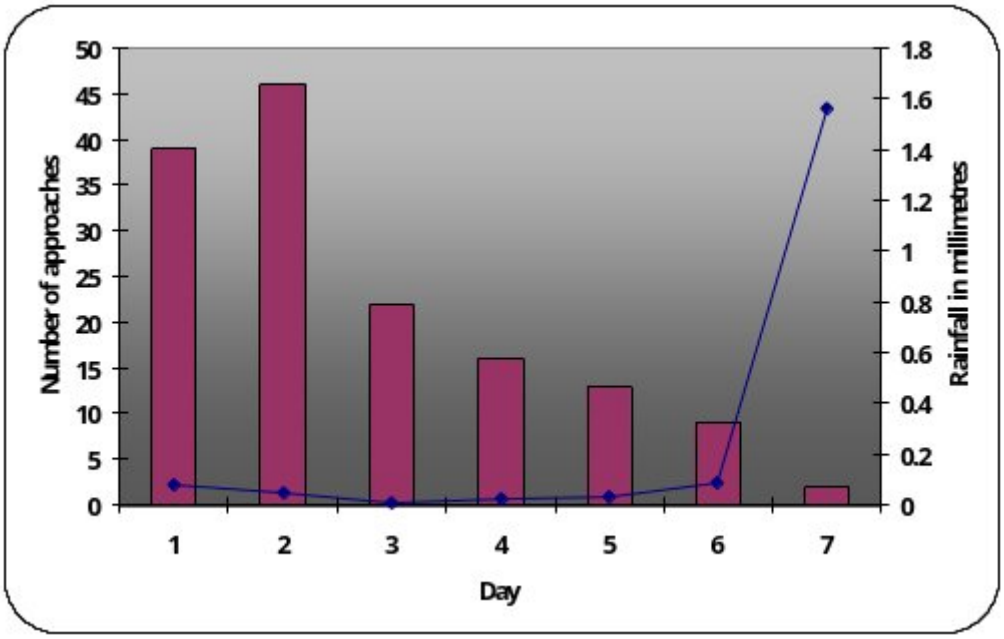
Table 4.14 shows the daily recorded rainfall at 0800 hours during the seven day study period. A graphical representation of the comparison of daily rainfall and the daily cumulative approach by all the actors during the seven day period is shown in Figure 4.17.

Table 4.14 : Daily recorded rainfall in mm during the seven day study period

Date	Day	Rainfall in mm	N
18th August 2005	1	.08	39
19th August 2005	2	.05	46
20th August 2005	3	.01	22
21st August 2005	4	.02	16
22nd August 2005	5	.03	13
23rd August 2005	6	.09	9
24th August 2005	7	1.56	2

Key

N = Total Number of approaches by all the actors during the seven day study period.



As seen in Table 4.14 the maximum rainfall was on day seven and was minimal during day one to day six of the study period. There appear to be a negative correlation between the approach by the actors and the maximum and minimal rainfall. Further reasons are discussed in chapter 5.5 of this dissertation.

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Back to the thesis page