A comparison between decomposition rates of buried and surface remains in a temperate region of South Africa

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Abstract

Several studies have been conducted on decomposition patterns and rates of surface remains, however, much less are known about this process for buried remains. Understanding the process of decomposition in buried remains is extremely important and aids in criminal investigations, especially when attempting to estimate the post mortem interval (PMI). The aim of this study was to compare the rates of decomposition between buried and surface remains. In order to compare these rates, twenty five pigs (*Sus scrofa*; 45-80 kg) were buried and excavated at different post mortem intervals (7 days, 14 days, 33 days, 92 days and 183 days). The observed total body scores were then compared to those of surface remains decomposing in the same region. Stages of decomposition were scored according to separate categories for different anatomical regions based on standardised methods. Variation in the degree of decomposition was considerable especially with the buried 7 day interval pigs that displayed variations in discolouration in the lower abdomen and trunk. At 14 and 33 days, buried pigs displayed features commonly associated with the early stages of decomposition, but with less variation. A state of advanced decomposition was reached where little change was observed in the next ±90-183 days after interment. Although the patterns of decomposition for buried and surface remains were very similar, the rates differed considerably. Based on the observations made in this study, a revised formula for the estimation of a PMI proposed pertaining to buried remains found at a depth of approximately 0.75m in the Central Highveld of South Africa.

KEYWORDS: Forensic anthropology, post mortem interval, decomposition, total body score, buried remains, decomposition rates, Accumulated Degree Days

1. Introduction

With the rising statistics of violent crime and death in South Africa (5% average increase over a period of 10 years (2004-2014); Crime Situation in South Africa 2014) the need for knowledge of decomposition in different settings is becoming increasingly important. Decomposition studies within a forensic context are often aimed at estimating the post mortem interval (PMI) (Beary and Lyman, 2012). The post mortem interval estimation remains a very complicated assessment due to the vast number of variables influencing the patterns and rate of decomposition (Pinheiro, 2006). While bodies decomposing on the soil surface may reach skeletonisation within weeks, buried remains may take months or even years under favourable conditions to reach the same stage (Mann *et al*., 1990; Gennard, 2012). To further complicate an accurate PMI estimation, decomposition rates of buried bodies decrease with burial depth due to lower in-soil temperatures, less insect activity and grave soil moisture content (Bachmann and Simmons, 2010). For this reason, developmental and succession data taking into consideration a great number of geographical regions and death scene scenarios are essential (Amendt *et al*., 2004).

According to Fiedler and Graw (2003), the rate of decomposition in both buried and surface remains depends mainly on three factors namely, (1) scavenger activity, (2) insect colonisation, and (3) temperature. Remains are usually protected from scavenger activity when buried at a depth of about a meter and/or deeper. Buried remains also reduce oviposition of insects as it can only be colonised by a minority of insects (Fiedler *et al*., 2003). Remains on the surface are vulnerable to scavengers, which normally leads to the destruction of soft tissue, gnawing on the bones and acceleration of the decomposition process (Mann *et al*., 1990). Even though stages of decomposition are very similar in some respects (Galloway *et al*., 1989; Megyesi *et al*., 2005, Comstock *et al*., 2014), it is important to note that decomposition stages will not always accurately describe the decomposition process, as decomposition occurs under varying conditions and many factors play a role in the patterns and tempo of decomposition. However, fewer variables are associated with in-soil decomposition than surface decomposition, as there is no access by scavengers, limited insect activity and reduced temperature fluctuations. Therefore one should potentially be able to get a narrower estimate than what is the case for surface remains. This study contributes to the understanding of decomposition stages of buried remains versus surface remains which may eventually contribute to more accurate PMI estimations.

Researchers have been trying to establish standardised decomposition stages for decades. Standardising decomposition stages by making use of quantifiable methods, for example; Total Body Scores (TBS) and Accumulated Degree Days (ADD), data can be compared with similar studies, replicated and validated. A clear description of decomposition rates within specific geographical areas may assist investigators to estimate a more reliable PMI. In 2005, Megyesi *et al*. proposed a sequential ranking model in order for the decomposition scores to reflect the smaller sequential changes that took place, focusing specifically on the accumulative effect of temperature the remains were exposed to. ADD is the product of time and temperature between the lower and upper developmental thresholds needed for an organism to develop from one point to another in its life cycle for each day. Megyesi *et al*. (2005) concluded that over 80% of the variation in decomposition could be accounted for by the combination of ADD and elapsed time (Megyesi *et al*., 2005; Myburgh *et al*., 2013). One can therefore assume that ADD can also predict stages of decomposition (Adlam and Simmons, 2007). ADD would allow for the construction of taphonomic models for scoring decomposition rates which will enhance future studies on decomposition processes.

2. Materials and Methods

The study site for this research project is situated at the Forensic Anthropology Body Farm (FABF) on the Miertjie le Roux Experimental Farm belonging to the Faculty of Natural and Agricultural Sciences of the University of Pretoria, South Africa. The farm is located at Kaalfontein 513 JR, in the Cullinan District, Gauteng Province (25˚47’20.2”S; 28˚32’34.3”E), approximately 45 km east of Pretoria, Gauteng Province. This farm consists of a total of 560 hectares, situated on the central Highveld plateau of South Africa. This is a temperate region of the country with warm summer days and temperatures rarely below 0˚C. Rainfall mainly occurs during the spring and summer months of September to April (with an average 650 millimetres (mm) of rainfall per annum) and vegetation mostly consists of sour veldt grasslands.

For purposes of this study, *Sus scrofa*, or domestic pig carcasses was used as pigs are considered acceptable proxies for humans. Although differences in the decomposition pattern of *Sus scrofa* carcasses versus human cadavers can be expected, pig carcasses have been accepted as proxies for human bodies because they share many biological characteristics, such as comparable skin thickness, body size and the amount of body hair (Parsons, 2009; Taylor, 2011).

Pig carcasses (N=25) were donated from two local farmers and buried within 24 hours after natural death. According to these farmers, death is usually caused by E. coli (*Escherichia coli*) and Salmonellosis (*Salmonella choleraesuis)* infection. All pigs in this study had a weight range of between 45 and 80 kg. As it has been shown that smaller pigs decompose at a much faster rate than large pigs (Sutherland *et al*., 2013), no pigs smaller than 45kg were included. This weight range was also chosen as it resembles the average weight of an adult human. Five pigs were excavated for each predetermined time category from the date of burial. Each pig was allocated a number, and the date of placement (same as date of death), height, weight, length, sex and belly height were measured and recorded prior to placement in graves (Table 1).

Table 1: Summary of the date of death and excavation, sex, weight and metric dimensions of the pigs

Pig	Date of placement	Date of excavation	Sex	Weight (kg)	Length (cm)	Height (cm)	Width (cm)	Belly height (cm)
1	30/09/2014	31/03/2015	Male	80	114	57	22	38
3	30/09/2014	31/03/2015	Male	45	119	38	17	29
4	30/09/2014	31/03/2015	Male	45	108	39	20	28
6	30/09/2014	31/03/2015	Male	70	127	45	22	24
7	30/09/2014	31/03/2015	Male	73	130	52	19	26
15	09/10/2014	10/11/2014	Male	70	130	58	23	35
16	09/10/2014	10/11/2014	Male	80	132	53	21	24
17	09/10/2014	10/11/2014	Male	80	131	47	24	27
19	09/10/2014	10/11/2014	Male	65	125	46	19	24
20	09/10/2014	10/11/2014	Male	50	110	46	20	28
21	24/11/2014	08/12/2014	Male	80	135	57	25	37
22	24/11/2014	08/12/2014	Male	66	98	38	24	31
24	24/11/2014	08/12/2014	Male	60	108	35	18	29
25	24/11/2014	08/12/2014	Male	60	123	45	26	35
26	24/11/2014	08/12/2014	Male	58	114	41	23	35
28	19/03/2015	18/06/2015	Male	45	108	47	25	37
29	19/03/2015	18/06/2015	Male	60	137	49	26	32
30	19/03/2015	18/06/2015	Male	55	115	47	21	23
31	23/03/2015	22/06/2015	Female	70	118	47	24	27
32	23/03/2015	22/06/2015	Female	48	102	41	19	18
33	13/04/2015	20/04/2015	Male	80	125	47	24	28
34	13/04/2015	20/04/2015	Female	75	111	50	28	33
35	13/04/2015	20/04/2015	Female	76	127	42	25	29
36	13/04/2015	20/04/2015	Male	45	98	41	22	34
40	13/04/2015	20/04/2015	Female	64	108	44	23	32

Shallow burial pits were dug by means of a back-actor to an average dimension of 2.25 m x 1.22 m with a depth of 0.75 m to simulate clandestine graves of buried victims (neither shallower than 0.4 m nor deeper than 0.9 m) (Manhein, 1997). The remains were placed in direct contact with soil. The pigs were not covered with additional objects (i.e., plastic) or clothed. Pigs were numbered and placed in sequence of arrival at the farm and observed *in situ*.

The decomposition rates for buried remains were observed at different time intervals (one week, two weeks, one month, three months and six months) over a period of 10 months

(September 2014 – June 2015). TBS was used to assess the rate of decomposition and the qualitative descriptions of the stages of decomposition were converted into quantitative scores. The allotted point values of each region were then added to determine the TBS which represents the overall stage of decomposition of each pig (from a minimum of three to a maximum of 35 points). An improved equation for ADD and a redefined scale range (from a minimum of zero to a maximum of 32 points) was suggested by Moffatt *et al*. (2016), however in order to compare results found in the Myburgh (2010) study on surface remains, the Megyesi *et al*. (2005) TBS scales was also used in this study.

ADD was calculated by adding together the daily average temperature for the duration of the data collection phase. This information was obtained from the closest South African National Weather Service Station, approximately 23 km south-east of the burial site, based in Bronkhorstspruit. The results in this study for buried remains were then compared to the study done by Myburgh (2010) on surface remains with respect to TBS relative to ADD. Both studies were conducted at the same research facility.

3. Results

As was expected, buried remains reached much lower TBS values compared to surface remains within similar periods (Table 2). Initially, the TBS of all pigs followed a sigmoidal curve during decomposition. During the early decomposition stages (a PMI of 6 to 7 days), decomposition followed a linear pattern for both groups. Buried remains reached an average TBS of 9.6 after 7 days of burial (Table 2) compared to surface remains that decomposed much faster reaching an average TBS of 13.8. TBS and decomposition rates began to vary drastically between buried and surface remains between 8 and 15 days as surface remains decomposed more rapidly. After a PMI of 14 days, buried remains had an average TBS of 13.4 (±3.8) compared to surface remains with a score of 22.6 (±8.8).

After rapid decomposition during the early phase, decomposition rates slowed considerably where little change was noted after 32 to 33 days PMI. Buried remains reached an average TBS of 17.4 and surface remains averaged 25.2. During advanced decomposition, the TBS did not increase much for either buried and surface remains, with TBS values of 20.4 and 22.2 observed after 92 days and 183 days, respectively. A similar plateau phase was observed with surface remains which reached an average TBS of 28.2 after 92 to 93 days and 29.8 after 162 to 175 days.

Table 2: Summary of PMI and TBS scores of buried and surface remains (*estimates)

Buried Remains					Surface Remains				
Pig number	Sex	Kgs	PMI / TBS	Avg TBS	Pig number[#]	Sex	Kgs	PMI / TBS	Avg TBS
33	M	80	7/10		7	M	38	7/9	
34	F	75	7/11		8	M	68	7/8	
35	F	76	7/8	9.6	9	M	80	7/21	13.8
36	M	45	7/9		12	M	85	7/17	
40	F	64	7/10		28	M	91	6/14	
21	M	80	14/13		20	M	65*	15/23	
22	M	66	14/14		23	F	75*	15/21	
24	M	60	14/13	13.4	24	F	75*	15/23	22.6
25	M	60	14/13		25	M	85*	15/21	
26	M	58	14/14		26	M	68	15/25	
15	M	70	33/16		10	M	80*	32/25	
16	M	80	33/20		11	F	59	33/23	
17	M	80	33/16	17.4	14	M	74	32/21	25.2
19	M	65	33/16		21	M	65*	32/26	
20	M	50	33/20		22	M	70*	32/31	
28	M	45	92/20		13	F	80*	92/24	
29	M	60	92/22		15	M	80*	93/29	
30	M	55	92/21	20.4	16	M	65*	93/31	28.2
31	F	70	92/20		17	M	75*	92/29	
32	F	48	92/19		18	F	65*	92/28	
1	M	80	183/21		1	M	82	175/31	
3	M	45	183/21		2	F	75	169/32	
4	M	45	183/23	22.2	4	F	55	168/30	29.8
6	M	70	183/25		5	F	63	163/25	
7	M	73	183/21		6	F	83	162/31	

[#] From the Myburgh *et al.* (2010) study

A comparison of TBS vs. PMI or ADD for both buried and surface remains shows a non-linear relationship (Figures 1 and 2). In both groups, decomposition rates followed a curvilinear pattern indicating rapid decomposition during early decomposition where after the rate of decomposition slowed down during the later stages.

The averaged TBS values for surface remains are higher than buried remains within the complete timeframe, and are also much more spread, emphasising the higher degree of variation seen in surface remains. After two weeks (313.1 ADD) there was a noticeable difference between the groups (an averaged 9.8 score difference) after which decomposition slowed down to reach the plateau phase (between 665 ADD and 3860.6 ADD). TBS differences remain, on average, 7.7 between buried and surface remains during the plateau phase. Throughout the study period TBS remained higher for surface remains. The greater rate of decomposition for surface remains may be due to exposure to insects and higher temperatures where in contrast, buried remains were protected from these elements by their burial depth and the moist soil surrounding the remains.

Table 3: PMI estimation for buried vs surface remains in the Central Highveld region of South Africa

Buried Remains				Surface Remains			
Estimated PMI	Estimated ADD (daily avg 23°C)	Estimated TBS (days)	Description of remains	Estimated PMI	Estimated ADD (daily avg 23°C)	Estimated TBS (days)	Description of remains
4 - 9 days	90 - 200	8 - 11	Bloating Purging of fluids Skin slippage	4 - 9 days	90 - 200	11 - 17	Insect activity Bloating Discolouration Drying of extremities
10 – 18 days	250 - 450	9 - 15	Sagging of trunk Discolouration	10 – 18 days	250 - 450	18 - 24	Purging of fluids Bone exposure Insect activity
24 – 40 days	550 - 900	14 - 19	Bloating Adipocere Insect infestation	24 – 40 days	500 - 1000	23 - 26	Bone exposure Insect activity
56 – 100 days	1300 - 2300	17 - 22	Dark discolouration Strong putrid smell Adipocere Partial skeletonisation Collapsed trunk	56 – 100 days	1800 - 2600	25 - 29	Desiccated tissue Grease on bone Mummification
152 days +	3500 +	20 - 35	Black skin interface Adipocere Skeletonisation of the head	152 days +	3300 +	28 - 35	Dry bone Mummification

Table 3 shows an estimation for calculating a PMI from the TBS of burials based on the observations made in this study. The estimation would, however, pertain to adult remains with a weight range between 45-80 kgs (Table 1). Also, the estimations will only be applicable for remains found at approximately the same depth (0.75 m) in the Central Highveld region of South Africa with similar environmental factors as it is not yet known if the process of decomposition would be different in other regions within South Africa.

When insects or insect activity are visible on buried remains, it is suggested that the estimated PMI be shortened as insects might accelerate the rate of decomposition due to the consumption of soft tissue. On the other hand, adipocere formation on remains should suggest a longer PMI estimation as adipocere can delay the rate of decomposition on remains.

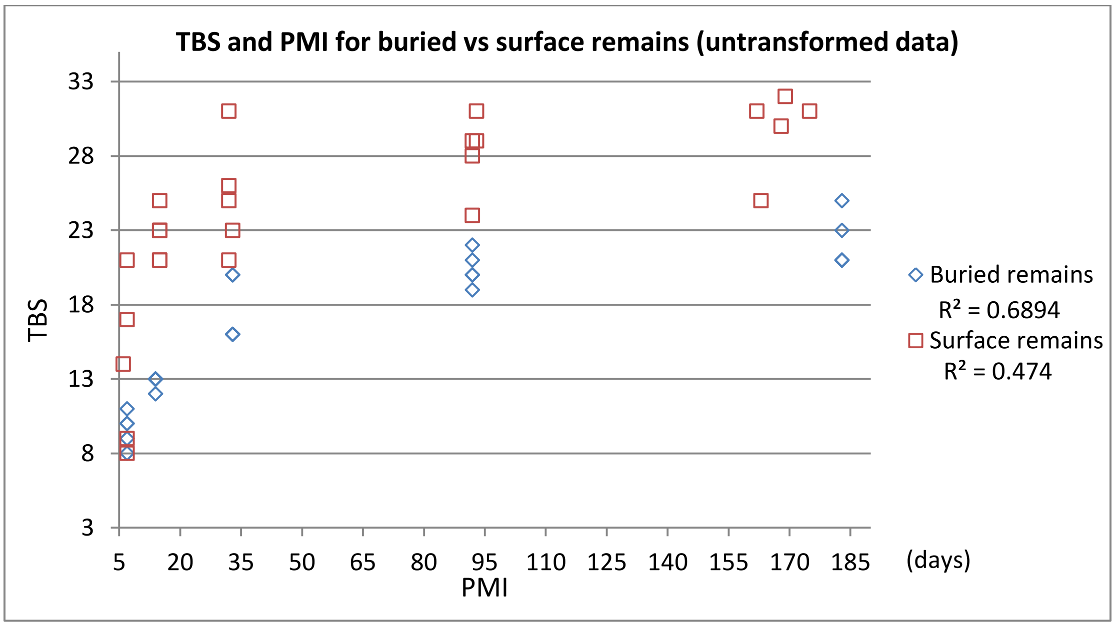

Figure 1: TBS vs. PMI for buried (N=25) and surface (N=25) remains with similar PMI's

In the untransformed data for TBS of buried remains, PMI accounted for 68% of the variability in decomposition, while PMI accounted for 47% of the variability for surface remains (Figure 1). This TBS and PMI are much better correlated for buried as opposed to surface remains. When plotting TBS vs. ADD, the r-value increases for surface remains to 49% and declines for buried remains to 61% (Figure 2). Although PMI is of course always the constant factor, and the value that we attempt to determine either by means of TBS or by means of ADD. In this instance, ADD reflects the amount of temperature (degree days), whereas PMI reflects the passage of time.

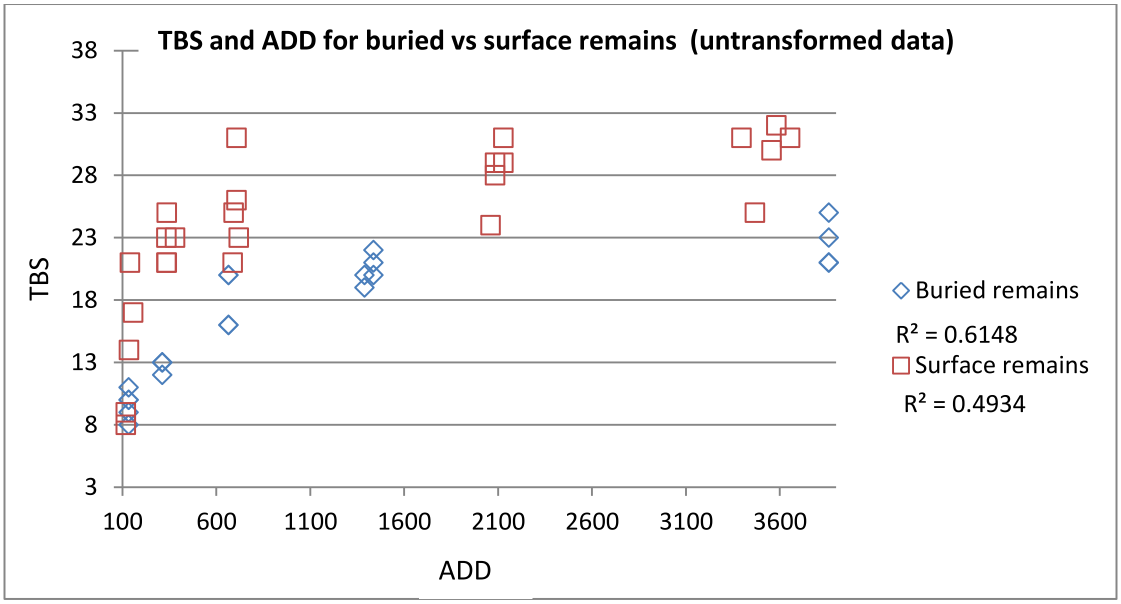

Figure 2: TBS vs. ADD for buried (N=25) and surface (N=25) remains with similar PMI's

Therefore, in this case, it was attempted to assess what contributes most to the observed decomposition changes; temperature or simply elapsed time. As the correlation between TBS vs. PMI and TBS vs. ADD was not too different for buried remains, data was log-transformed to determine the relationship between TBS vs. PMI and ADD respectively. By log-transformation, a more linear curve was produced which provided a better indication of the relationship between TBS and PMI and allowed the use of Random-Effects Maximum Likelihood Regression. Log transformations produced improvements in the r-squared value for TBS (Figures 3 and 4). The r-squared value increased from 0.6894 (Figure 1) to 0.8805 (Figure 3) for buried remains and from 0.474 (Figure 1) to 0.5705 (Figure 3) for surface remains. Therefore, the log-transformed data for TBS against PMI for buried remains has a strong correlation of 88% indicating that the variability in decomposition is more distinct for surface remains (57%).

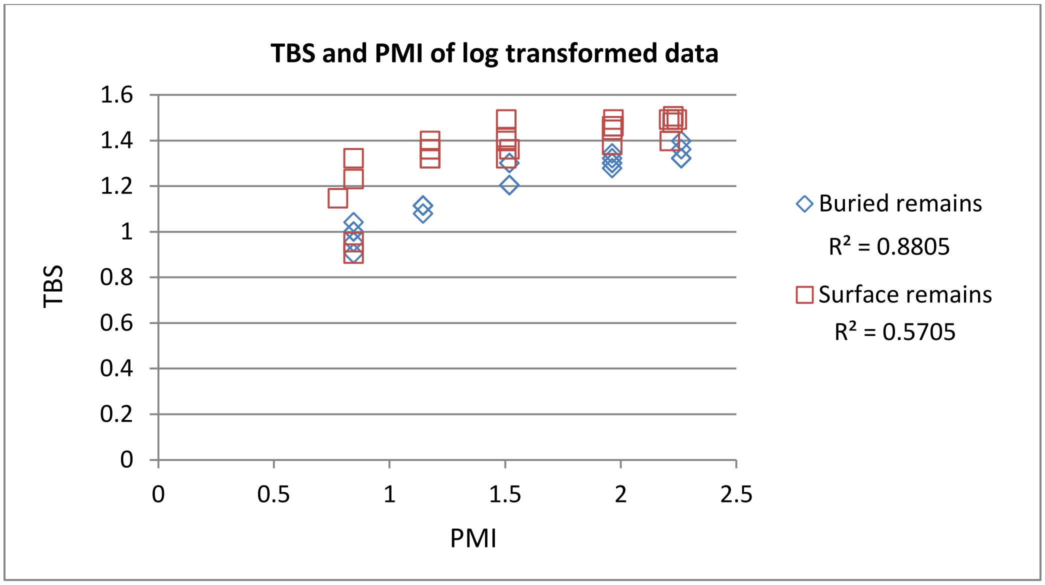

Figure 3: LogTBS vs. PMI for all pigs indicating the regression relationship

TBS was also plotted against ADD (Figure 4) and log-transformed. When ADD and TBS data were logged (Figures 2 and 4), the r-squared value increased from 0.6148 (Figure 2) to 0.8717 (Figure 4) for buried remains and from 0.4934 (Figure 2) to 0.6218 (Figure 4) for surface remains. In this study, the log transformed r-squared values remained very similar for buried remains (88% for PMI and 87% for ADD), irrespective of the use of PMI and/or ADD (1% difference). The log transformed r-squared value increase from 57% (PMI) to 62% (ADD) for surface remains, indicating a 5% stronger correlation. ADD is therefore a better descriptor of decomposition for surface remains, whereas for buried remains PMI (lapsed time) is more closely correlated with TBS.

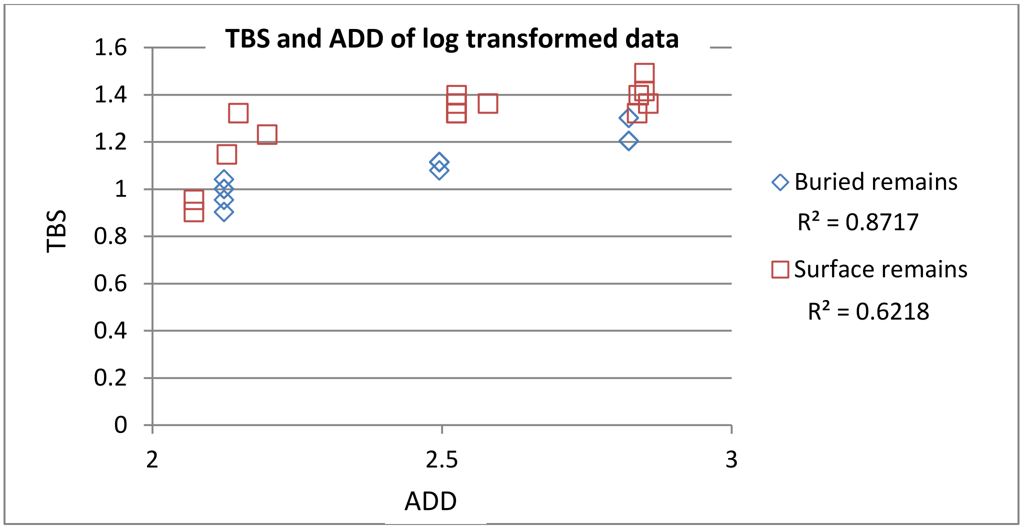

Figure 4: LogTBS vs. ADD for all pigs indicating the regression relationship

4. Discussion

It would be valuable to observe the rate of decomposition when remains are buried and excavated with similar PMIs, in different seasons to compare seasonal fluctuations if applicable. With this study no difference in the rate of decay which could be ascribed to (in soil) season fluctuations was observed. In the study done by Myburgh (2010) however, it was suggested that seasonality have a great influence on the rate of decomposition for surface remains.

There was a notable difference during early phases of decomposition as the process for buried remains slowed down gradually, mostly resulting from the fact that buried remains displayed moist decomposition compared to surface remains already showing signs of desiccated tissue and mummification. The rapid decomposition of surface remains within 14 days is most probably due to exposure to factors such as temperature (Prangnell and McGowan, 2009) and insect infestation (Simmons *et al*., 2010). After rapid decomposition during the early phase, decomposition rates slowed considerably as remains reached what seemed to be a plateau phase where little change was noted after 32 to 33 days PMI (Table 2). A plateau phase, indicating little change (slow decomposition) during advanced decomposition, was also observed and described in the study by Sutherland *et al*. (2013). This plateau phase therefore seems to present itself regardless of size of the body and whether remains were decomposing in soil or on the surface.

No cases reached advanced decay up to the point of skeletonisation (TBS scores of 27+) within the 6 month (183 days) interval of this study. The most advanced decomposition observed within this time frame (TBS of 25) for buried remains was limited to moist decomposition with bone exposure less than one half of the area being scored. According to Troutman *et al*. (2014), the delay in decay of buried remains is mostly ascribed to the lower in-soil temperature and accessibility by insects on the remains. They state that buried remains can take up to eight times longer to decompose than surface remains (Troutman *et al.,* 2014). The results from this research suggest that buried remains, at an average depth of 0.75 m, can have a decay rate of between 55.2% to 82.9% less than surface remains with similar PMI's. The average TBS score difference for buried remains will therefore be 7.4 times less than that of surface remains.

Table 4 summarises the average TBS for all anatomical regions scored on buried remains. The most prominent change in decay was observed during the early stages of decomposition (7 to 14 days), which slows down considerably after 33 days of burial. When regions are viewed individually, a gradual increase in the rate of decomposition is evident. From Table 4 it can be argued that decomposition progressed more rapidly in the head and neck regions than the rest of the body. As cells becomes deprived of oxygen soon after death and the acidity increases due to the toxic by-products of chemical reactions, enzymes start to digest cell membranes and leak out as the cells break down. This usually begins in the brain, which has high water content (Costandi, 2015). Following rigor mortis and the predictable pattern known as Nystens' Law, rigor first appears in the small muscles of the face, and then spreads to the neck, trunk, upper limbs and lower limbs (Tracqui, 2000). Also, due to the small amount of fat and biomass on the head and ample bacteria in the mouth, it is possible that decay could progress faster in the head and neck regions (Costandi, 2015). As is expected, decay is slowest in the limbs.

Table 4: Summary of average TBS scores of all anatomical regions of buried remains

	PMI 7	PMI 14	PMI 33	PMI 92	PMI 183
Head and Neck	4	5	6.8	8.4	9
Trunk	3.2	5.8	6	6.4	7.2
Limbs	2.4	2.6	4.6	4.6	6
TBS	9.6	13.4	17.4	20.4	22.2

In Figure 5, the varying rates of decomposition follow a gradual increase, more especially during the later stages of decomposition. Figure 5 indicates much less variance in decomposition for buried remains as the graph follows a more linear pattern from early decomposition up to advanced decomposition when compared to surface remains which also follows an exponential pattern. The linear pattern for buried remains might possibly indicate a more predictable decomposition process.

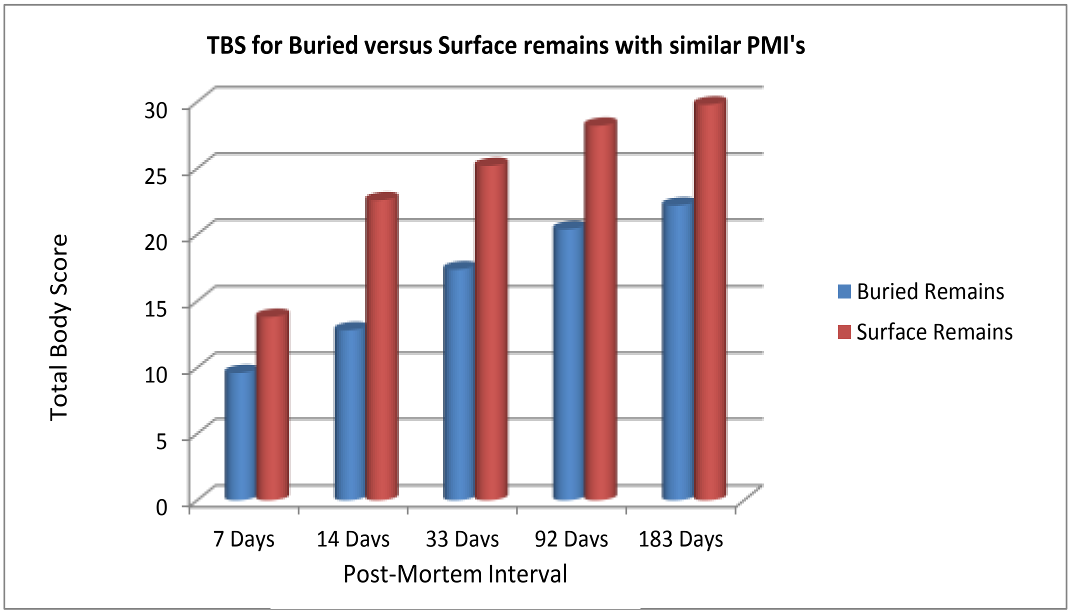

Figure 5: TBS for buried (N=25) and surface remains (N=25) with similar PMI's

A possible reason for the improved result of using ADD in surface remains compared to buried remains may be due to greater temperature fluctuations on the ground surface. Although temperature fluctuations occur in the soil, the temperature changes are not as large as those on the surface. This emphasises the importance of the effects of temperature (on surface remains) on the process of decomposition. The variation in the decomposition process is much less for buried remains than compared to surface remains. Overall, buried pigs decomposed at a much slower rate, reaching lower TBS values relative to similar PMI's than in surface remains.

The substitution of pigs for human cadavers is not ideal, but continues to be a viable alternative for decomposition studies due to the complications of conducting actualistic research on donated bodies. Pig carcasses are more readily available and therefore sample sizes can be increased with future studies. It should be kept in mind that, pig carcasses are considered appropriate proxies due to the fact that their internal anatomy, fat distribution, skin and general lack of hair is comparable to that of humans (Anderson and VanLaerhoven, 1996; Schoenly et al., 2006). Moreover, pigs and humans are omnivorous and it is suggested they share a similar gut flora (Anderson and VanLaerhoven, 1996). However, differences may occur in the rate and pattern of decomposition between human corpses and pig carcasses due to individual intrinsic factors (body weight, etc.) and extrinsic factors such as seasonality.

5. Conclusion

This study took a quantitative approach to observe decomposition of buried remains, an area in the realm of forensic anthropology with few experimentally supported findings within a South African setting. Data collection for taphonomic studies is extremely important to understand the complex process of decomposition in different settings. It must be kept in mind that decomposition is a continuous process which makes it difficult to characterise all regions of a body into the same decompositional state due to interindividual variation. As the possibility of subjectivity exists when characterising remains into stages of decomposition, the need for standard stage definitions that would reduce the potential for personal interpretation is accentuated.

The stages of decomposition for both surface and buried remains were very similar (Marais-Werner *et al*., unpublished); however there was a vast difference as far as the rate of decomposition was concerned. This is ascribed to variables associated with decomposition. Variables such as insect activity and temperature are related to aspects of decomposition. Where insects are considered the most significant environmental decomposer (Simmons *et al*., 2010), temperature is considered the most important variable (Mann *et al*., 1990). Lower in-soil temperatures will have a significant effect on the decomposition process (Rodriguez *et al*., 1985). It was evident in this study that decomposition of buried remains occurred at a much slower rate than that of surface remains, which correlated with the observations reported from similar studies (Mann *et al*., 1990; Dent *et al*., 2004; Goff, 2009; Comstock *et al*., 2014).

Furthermore, literature reports on a distinct foul smell, observable maggot masses, skeletonised head, expulsion of liquids from the mouth, collapse of the abdomen and spilling of intestines after 13 days of burial (Pinheiro, 2006; Schoenly *et al.*, 2006; Parsons, 2009; Niederegger *et al.,* 2015). From our observations the flesh on the head was still relatively fresh after 14 days of burial. During active decay the remains displayed a great loss of mass as a result of purging of decompositional fluids, and the odour remained very distinct.

However, in contrast to what was reported by Gennard (2012), buried remains entered what is described as advanced decomposition by Megyesi *et al*. (2005) anywhere between 14 and 183 days (caving in of the abdominal cavity, some bone exposure and adipocere development) whereas Gennard (2012) refers to an average time of 2.8 years for advanced decay to manifest on buried remains. This shows that the rate of decay is variable and that advanced decay can be reached after unexpectedly short time periods.

From the results found in this study, PMI estimations based on decomposition rates only is not advisable. As various taphonomic factors contribute to decomposition of remains, factors such as burial depth, soil type, body weight etc. should be taken into account when attempting to estimate a PMI. The standard uses of quantitative variables such as ADD and TBS facilitated the comparison of data regardless of environmental factors as this approach incorporates variability associated with temperatures and seasons. This allows for the development of prediction models for a specific geographical region. With this study, ADD was found to be a better descriptor of decomposition for surface remains as ADD is useful for standardising the effect of temperature. On the other hand, TBS was found to be a better descriptor of observations for buried remains. It is important to note that environmental exposure can alter expected assumptions on decomposition rates and patterns at times. This highlights the importance of taking context into consideration for each forensic case.

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