Debra A. Komar,[1] *M.Sc.*

Decay Rates in a Cold Climate Region: A Review of Cases Involving Advanced Decomposition from the Medical Examiner's Office in Edmonton, Alberta

REFERENCE: Komar DA. Decay rates in a cold climate region: a review of cases involving advanced decomposition from the Medical Examiner's Office in Edmonton, Alberta. J Forensic Sci 1998; 43(1):57–61.

ABSTRACT: Previous research into postmortem interval (PMI) estimation has been restricted to temperate and arid climates. Results suggest that decomposition rates may be significantly slower in cold weather regions. Preliminary research to conduct a cold weather time since death study has begun in Edmonton, which experiences mean monthly temperatures below freezing five months of the year. A case review at Edmonton's Office of the Chief Medical Examiner from 1990 to 1996 provided background information on a sample of 20 cases involving advanced decomposition, with partial to complete skeletonization of remains. Cases with a PMI of less than seven months were compared with regional weather records to establish the mean PMI temperature. Results indicate that skeletonization can occur in less than six weeks in summer and four months in winter, despite freezing temperatures. In some cases, postmortem animal activity accelerated decomposition rates.

KEYWORDS: forensic science, decomposition, time since death

Recently, there has been an increase in the number of studies investigating methods of estimating middle and long range postmortem interval (PMI) (1–5). However, these studies have been conducted in the southern United States, primarily at the Anthropology Research Facility at the University of Tennessee, and are restricted in their application to temperate weather regions. Similar studies in cold weather climates typical of the northern United States and Canada have not been widely reported.

To provide background in preparation for such a study, a review of cases involving advanced decomposition was undertaken at the Office of the Chief Medical Examiner in Edmonton. Edmonton is located in central Alberta at an elevation of 671 meters (2198 ft). The city experiences an average annual temperature range of −17°C to 16°C, with mean monthly temperatures below freezing for five months of the year (see Table 1). Average annual rainfall is 33 centimeters (13 in.) and average annual snowfall is 132 centimeters (53 in.) (6).

The purpose of the review was to establish methodological parameters for subsequent field experimentation in this climate region, such as determining the types of environments from which bodies are recovered. Data were gathered on the age and sex of the individual, cause of death, location of the recovered remains, clothing associated with the individual, postmortem animal activity or damage, time elapsed since individual was last seen/reported missing, degree of decomposition, body parts or skeletal elements not recovered and the method of positive identification.

In addition, further analysis was done on all cases in which the time since death was determined to be less than seven months. Comparisons with local meteorological data for the PMI provided valuable information on natural decay rates for the various seasons and demonstrated that decomposition may occur more rapidly than previously expected, despite extreme winter conditions.

TABLE 1—*Mean monthly temperature in degrees celcius from Edmonton Municipal Airport for the years 1993–1996.*

Month	Monthly Mean	Mean Monthly High	Mean Monthly Low
January	−16.4	−10.8	−21.9
February	−12.5	−6.3	−18.7
March	−4.0	1.4	−9.4
April	5.1	11.7	−1.5
May	10.3	17.0	3.6
June	14.1	19.9	8.3
July	16.0	21.7	9.9
August	14.7	20.9	8.5
September	10.7	17.7	3.8
October	4.7	0.11	−1.9
November	−8.0	−3.2	−12.8
December	−9.8	−5.8	−16.8

Methods

A computer search of files from the years 1990 to 1996 selected cases in which the individual was initially classified by the keyword "unidentified." A manual review of these files produced a total of 20 cases involving advanced decomposition, characterized by partial to complete skeletonization of remains. Information was recorded from the autopsy report and medical examiner's summary, as well as from photographs where available. All individuals have subsequently been positively identified.

A subset of cases ($n = 10$) in which the elapsed time (the period from when the individual was last seen alive to when the body was discovered) was approximately 200 days or less was compared with data from the Environment Canada meteorological recording station nearest to the body recovery site (6).

Results

A summary of the 20 cases is found in Table 2. All individuals were adult: 15 males, 5 females. The cause of death could not

[1]Department of Anthropology, University of Alberta, Edmonton, Alberta.

Received 15 April 1997; and in revised form 21 May 1997; accepted 21 May 1997.

TABLE 2—*Case summary.*

Case	Sex	Age	Cause of Death	Location of Body	Clothing Found	Elapsed Time	Post Mortem Animal Damage	Degree of Decay	Skeletal Elements Not Recovered	Method of Positive ID
1	M	48	Undetermined	Wooded area	Jeans, no shirt	4 months	Extensive rodent	Skeleton, little soft tissue	See Fig. 1, fleshed R hand recovered separat.	Fingerprints, AM X-ray
2	F	28	Drowning	River	Bra, shorts, shoes only	3.5 months	None	Advanced, adipocere	L hand, scalp, hair, nose	Dental X-rays
3	M	61	Drowning	River	Fully clothed	3.5 months	Moderate fish	Moderate	Face skeletonized due to fish activity	Wallet with ID
4	M	21	Hypothermia drug overdose	Frozen in park	Full winter w/coat	<2 months	Extensive carnivore	Moderate due to animals	Face and nose destroyed by animals	Fingerprints
5	M	32	Undetermined	Wooded area	Ski pants, socks, boots	18 months	Extensive carnivore	Skeleton, little soft tissue	See Fig. 1	AM X-rays
6	M	35	Undetermined	Gully	Overalls	1.5 months	Extensive carnivore	Advanced, no inter. organs	See Fig. 1	Dental records and X-rays
7	M	22	Drowning	River	Pants only	18 months	None	Advanced, no inter. organs	See Fig. 1, face/neck skeletonized	X-rays, video superimposition
8	F	26	Undetermined	Ravine	N/A	42 months	Moderate carnivore	Skeleton, dried soft tissue	Skull only, all postcranial absent	Dental X-ray
9	M	31	Drowning	River	Full winter w/coat	6 months	None	Partial skeleton	Left hand separated but recovered	AM X-ray
10	M	26	Gunshot	Wooded areas	T-shirt, jeans, socks/shoes	5 months	None noted	Skeleton, some soft tissue	See Fig. 1	Dental, video superimposition
11	M	71	Undetermined	Farmers field	Fully clothed w/jacket	18 months	Minor rodent	Completely skeleton	Phalanges from R/L hands, L foot	X-rays, video superimposition
12	M	23	Undetermined	Heavy woods	Full winter w/boots	16 months	Moderate carnivore	Completely skeleton	Most of L hand, most of hyoid	Dental records
13	F	22	Blunt cranial trauma	Buried	Wrapped in blanket	12 months	None	Advanced w/soft tissue	All skeletal elements retrieved	Dental records and X-rays
14	M	40	Undetermined	Shallow grave	None	2 months	Extensive bear	Completely skeleton	See Fig. 1	AM X-rays of frontal sinuses
15	M	53	Gunshot to head	Wooded area	N/A	8 years	Moderate carnivore	Completely skeleton	Skull only, maxilla, mandible absent	Video superimposition
16	M	27	Undetermined	Banks of river	T-shirt recovered	12 months	Moderate beaver	Partial skeleton	Some hand bones, L leg separated but recovered	Dental records
17	M	26	Gunshot to head	Wooded ravine	Shirt, jacket, pants	15 months	Extensive carnivore	Completely skeleton	See Fig. 1	X-rays, video superimposition
18	F	19	Undetermined	Dugout in hillside	Jackets, jeans t-shirt, boots	32 months	Moderate rodent	Advanced, mummified	L hand, T8, T9, 4 ribs, manubrium	Dental records, fingerprints
19	M	42	Undetermined	River bank	None	5 months	Moderate	Skeleton	See Fig. 1	X-rays, dental
20	F	35	Homicide with dismemberment	River bank/under bridge abutment	Torso in suitcase, head/legs in plastic	Torso-n/a head/legs—6 months	None	Head/legs—advanced, adipocere formation	All elements recovered	DNA

be determined in 10 of the cases; the remaining cases involved drowning, gunshot wounds, drug overdose and blunt cranial trauma. Two cases (1 and 20) involved dismemberment of the body prior to deposition, while a third (case 13) showed evidence of attempted dismemberment.

Remains were discovered in a variety of environments, with 11 cases recovered from isolated wooded areas, 4 individuals retrieved from the North Saskatchewan River, and 3 recovered on or near its banks. Two cases involved burials.

The elapsed time interval ranged from six weeks to eight years. A total of 12 cases were discovered within one year of the individual's disappearance.

At least partial clothing was recovered in 70% of the cases. Evidence of postmortem animal activity was seen in all but six cases. Animal damage was evident in one of the two cases of burial, in which bears had uncovered the shallow grave and consumed the majority of the remains.

The degree of decomposition was recorded as described in the autopsy notes, with 2 cases presenting moderate decomposition (partial exposure of bone, loss of body parts, adipocere formation); 6 cases showing advanced decomposition (loss of internal organs, moderate bone exposure, extensive adipocere); 5 cases involving partial skeletonization (complete exposure of some bony elements, only desiccated soft tissue remaining) and 7 cases with complete skeletonization (no soft tissue recovered). An inventory of the body parts/skeletal elements not recovered can be found in Table 2 and Fig. 1.

Table 3 summarizes the ten cases involving an elapsed time interval of less than seven months.

Discussion

Previous reports have detailed the impact of various factors on decomposition rates, including: temperature and humidity (1,2) aqueous versus terrestrial deposition (7), burial (2,5), sun exposure (8), trauma to the body (2,9), insect, carnivore and rodent activity (2,4,10), clothing, and body size (2). Of these, temperature is by far the most influential (1,2). Decomposition rates are dramatically reduced or arrested during period of cold or freezing (2). Galloway et al. (3) found that skeletonization was reached in one fifth the time in summer as compared to winter in southern Arizona.

Results demonstrate that, during the summer, reduction to skeletal remains can occur in the Edmonton region in less than six weeks. Previous reports show that in summer complete skeletonization can occur in six months in central New Mexico (4) and southern Arizona (3), and in as little as two weeks in eastern Tennessee (2) and Mississippi (11).

Winter decomposition rates in this study appear slower than those of summer, with one case (Case 1) showing skeletonization in under four months with a mean PMI temperature of -7.1°C. It is important to remember, however, that skeletonization could

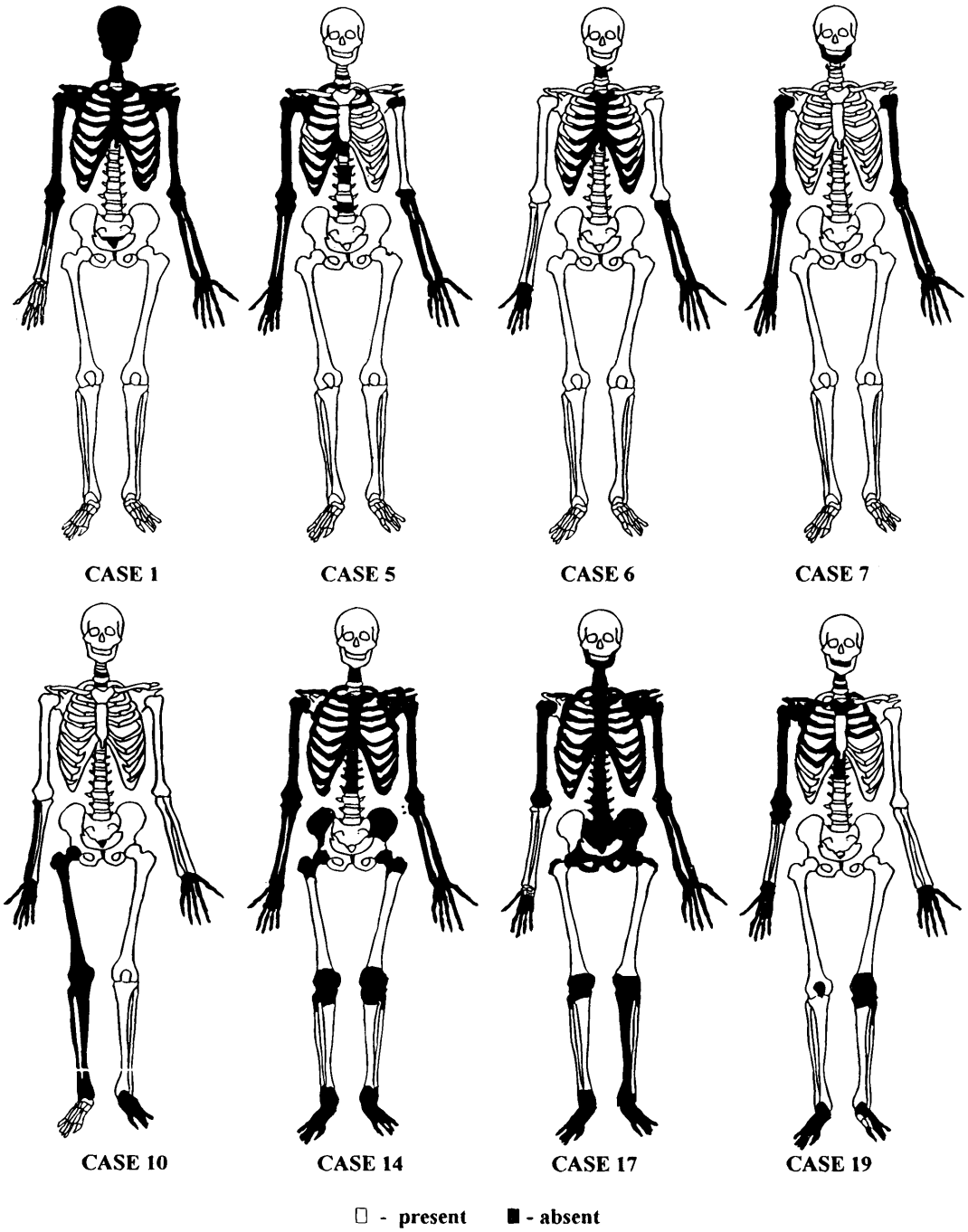

FIG. 1—*Summary of skeletal elements absent for select cases.*

TABLE 3—*Mean temperature during elapsed time for cases with time since death of <200 days.*

Case	Location of Body	Clothing Found	Animal Damage	Degree of Decay	Months Missing	Elapsed Time (Days)	Mean Temp During Elapsed Time	Mean High During Elapsed Time	Mean Low During Elapsed Time
1	Wooded area	Jeans, no shirt	Extensive	Skeleton	January–April	116	−7.1 C	0.3 C	−14.5 C
2	River	Bra, shorts, shoes only	None	Advanced	June–October	109	13.9 C	18.5 C	9.2 C
3	River	Fully clothed	Moderate	Moderate	February–May	108	−0.8 C	4.1 C	−5.7 C
4	Frozen in park	Full winter w/coat	Extensive	Moderate	December–February	52	−13.7 C	−8.7 C	−18.7 C
6	Gully	Overalls	Extensive	Advanced	May–July	46	14.6 C	18.3 C	10.8 C
9	River	Full winter w/coat	None	Skeleton	December–June	197	−3.1 C	3.5 C	−9.7 C
10	Wooded areas	T-shirt, jeans, socks/shoes	None	Skeleton	June–November	167	11.6 C	18.2 C	5.0 C
14	Shallow grave	None	Extensive	Skeleton	June–August	45	12.2 C	20.2 C	4.3 C
19	River bank	None	Moderate	Skeleton	June–November	144	11.7 C	17.0 C	6.3 C
20	River bank	In plastic	None	Advanced	July–February	202	−0.7 C	4.1 C	−5.5 C

have occurred earlier and that, unlike studies of PMI in which decay rates are observed, observations in this study relied on body recovery times and therefore may not represent the minimum amount of time needed to reach that stage of decay. Micozzi (9,12) found that animals which were frozen and then thawed disarticulated at a faster rate than fresh killed animals as a result of the mechanical disruption of tissues caused by freezing. It is possible that similar tissue disruption may explain, in part, the rapid rate of decay and disarticulation seen in remains left exposed during winter (9).

Postmortem animal activity was seen in the majority of terrestrial deposition cases. Indigenous scavengers in the central Alberta region include coyote, red fox, wolf, black bear, and porcupine (13). Extensive bone dispersal and gnawing associated with domesticated dogs has been reported previously (2,14) and several cases in this study showed similar patterns of canine activity. Individuals recovered from or near the river showed less animal damage, although single cases bore evidence of fish and beaver activity.

Of the ten cases seen in Table 3, skeletonization occurred in five. Of these, animal activity was noted to be moderate to extensive in three and absent in two. Of the five cases not associated with the river, animal damage was extensive in all but one case. Carnivores may become more aggressive during cold periods (15). Moderate to extensive animal activity was seen year round and appears to play an important role in the rapid decomposition rates experienced in the Edmonton area.

Entomological studies have shown a correlation between decay rates and carrion insect activity (10,16), with the majority of soft-tissue disappearance being attributed to insect larvae feeding (2). Unfortunately, in this review insect activity was rarely noted in the autopsy reports and could not be reliably determined from photographs, and as such the role of insects in this climate requires further study. Preliminary reports from entomological investigations involving pig carcasses in southwestern British Columbia have been published (17); however, meaningful comparisons with this study are not possible as results focus on summer decomposition in a far more temperate climate.

Depositional environments clearly influenced rates of decay. Bodies retrieved from the river mirrored the disarticulation sequences for aqueous environments outlined by Haglund (7). The two burials also resembled previous reports by Rodriguez and Bass (5), in that shallow burial resulted in rapid decay, while deeper burial resulted in greater tissue preservation despite a longer PMI.

The effects of associated clothing were similar to those reported by Haglund (7) in that clothing retarded the disarticulation process in aqueous deposition cases and the presence of shoes retained foot and ankle bones in terrestrial and aqueous cases. Contrary to the findings of Mann et al. (2), clothing did not accelerate the decay process by protecting maggots from sunlight, but rather appeared to protect underlying tissues from animals, wind, rain and sunlight which in turn retarded decay rates. In several cases, lower limb bones encased in pants retained soft tissues while the unclad upper torso was reduced to skeleton.

Animal activity, depositional environment and clothing all influenced what portions of the body were ultimately recovered. Hands and upper limb bones were rarely recovered, even for individuals experiencing only moderate to advanced decompositional changes. While skulls were often recovered, mandibles and hyoids were not. Body regions most often recovered included the lumbar vertebrae, pelvis and lower limb bones, although bone ends were often absent due to animal gnawing.

Recovery methods may also play a role in determining how much of the body is ultimately retrieved. Investigator inexperience or bias (18) may have affected recovery rates in those cases in which trained pathologists or anthropologists were not present at the recovery scene. In addition, heavy snowfall hindered recovery of skeletal remains in at least one case, necessitating a second search of the area following the spring thaw. Such delays prolong exposure to elements and increase animal scavenging opportunities, resulting in the potential loss of skeletal elements.

Conclusions

A review of advanced decay cases from the Edmonton Medical Examiner's office revealed that decomposition to skeletal remains may occur in less than six weeks in moderate summer temperatures

and in less than four months in extreme winter conditions. Accelerated decomposition rates in all seasons were often accompanied by moderate to extensive animal activity.

Based on information compiled in the review, subsequent field experimentation in the Edmonton area should take into account the following considerations: 1) the inclusion of both male and female subjects; 2) although cases involving subadults were absent, age cohorts should include subadults to control for variations due to body size; 3) experimental design must include a variety of depositional environments, particularly wooded areas, rivers and burials; 4) unrestricted access to the decay subjects by insects and animals is necessary to reproduce natural conditions; 5) the effects of various types of clothing need to be represented; and 6) the portions of the body most likely to be recovered and therefore most appropriate as a focus of study include the lumbar vertebrae and pelvic girdle, lower limb long bones and feet, and the skull minus the mandible.

Acknowledgments

The author wishes to thank Dr. Bernard Bannach, Assistant Chief Medical Examiner and Dr. Graeme Dowling, Chief Medical Examiner for the province of Alberta, for granting permission for this review. Thanks also to Barb Hinman and Cyril Chan of the Office of the Chief Medical Examiner, Alberta, for their assistance in obtaining access to records and photographs. Finally, thanks to Owen Beattie, University of Alberta, for his editorial advice and support in this research.

References

1. Vass AA, Bass WM, Wolt JD, Foss JE, Ammons JT. Time since death determinations of human cadavers using soil solutions. J Forensic Sci 1992;37(5):1236–53.
2. Mann RW, Bass WM, Meadows L. Time since death and decomposition of the human body: variables and observations in case and experimental field studies. J Forensic Sci 1990;35(1):103–11.
3. Galloway A, Birkby WH, Jones AM, Henry TE, Parks BO. Decay rates of human remains in an arid environment. J Forensic Sci 1989; 34(3):607–16.
4. Schoenly K, Griest K, Rhine S. An experimental field protocol for investigating the postmortem interval using multidisciplinary indicators. J Forensic Sci 1991;36(5):1395–415.
5. Rodriguez WC III, Bass WM. Decomposition of buried bodies and methods that may aid in their location. J Forensic Sci 1985;30(3): 836–52.
6. Environment Canada. Edmonton: Atmospheric Environment Service for Alberta, 1990–1996.
7. Haglund WD. Disappearance of soft tissue and the disarticulation of human remains from aqueous environments. J Forensic Sci 1993; 38(4):806–15.
8. Shean BS, Messinger L, Papworth M. Observations of differential decomposition on sun exposed v. shaded pig carrion in coastal Washington State. J Forensic Sci 1993;38(4):938–49.
9. Micozzi MS. Experimental study of postmortem change under field conditions: effects of freezing, thawing, and mechanical injury. J Forensic Sci 1986;31(3):953–61.
10. Rodriguez WC, Bass WM. Insect activity and its relationship to decay rates of human cadavers in East Tennessee. J Forensic Sci 1983;28(2):423–32.
11. Stewart TD. Essentials of forensic anthropology. Springfield: Charles C Thomas, 1979.
12. Micozzi MS. Frozen environments and soft tissue preservation. In: Haglund WD, Sorg MH, editors. Forensic taphonomy: the postmortem fate of human remains. Boca Raton: CRC Press, 1997.
13. Quinn M, Butler JR, editors. Forest wildlife. Edmonton: Dept. of Forest Science, University of Alberta, 1987.
14. Wiley P, Snyder LM. Canid modification of human remains: implications for time-since-death estimations. J Forensic Sci 1989; 34(4):894–901.
15. Bass WM III. Outdoor decomposition rates in Tennessee. In: Haglund WD, Sorg MH, editors. Forensic taphonomy: the postmortem fate of human remains. Boca Raton: CRC Press, 1997.
16. Catts PE, Haskell NH. Entomology and death: a procedural guide. Clemson: Joyce's Print Shop, 1990.
17. Anderson GS, VanLaerhoven SL. Initial studies on insect succession on carrion in Southwestern British Columbia. J Forensic Sci 1996;41(4):617–25.
18. Haglund WD, Sorg MH. Method and theory of forensic taphonomy research. In: Haglund WD, Sorg MH, editors. Forensic taphonomy: the postmortem fate of human remains. Boca Raton: CRC Press, 1997.

Additional information and reprint requests:
Debra Komar
Department of Anthropology
13–15 HM Tory Building
University of Alberta
Edmonton, Alberta
Canada T6G 2H4