CHAPTER V

Elapsed Time Since Death: Contextual Evidence for Interpretation of Postmortem Events

V. A. General Considerations

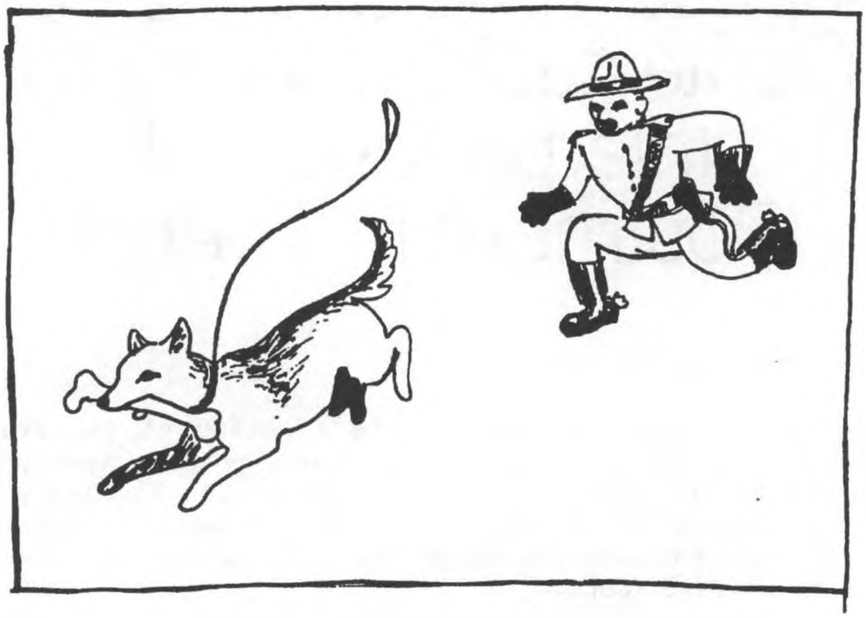
Not only are we interested in the identity of the remains, we wish to know when and where death occurred, by what agent, and what has happened to the remains subsequent to death; knowledge of which will help interpret the former questions. Answers to some of these can be had from the remains alone but the essential evidence lies where the bones were found.

The distribution of skeletal material can often suggest the kinds of variables which have acted on the body since death. Much surface skeletal material has been transported from the immediate locale of death by such agents as gravity, snow melt, water flow, and animal activity. Impediments to transport, such as heavy brush, must also be considered.

Generally speaking, observations should be made of slope, terrain, type and extent of vegetation or other cover, flood zone, river or creek flow rate throughout the year, prevailing temperature and moisture (for example, snowfall) conditions, annual temperature and precipitation ranges, altitude and freezing levels, leaf litter and shade.

Further observations should be made of bone "scatter" as some bone shapes are more easily moved (skull) than others (shoulder blades). Also one should look for evidence of animals (paths, tracks, SCATS, burrows, nests, gnawings, scratching, and rubbing) which could disturb or partially destroy the remains. Such evidence might be found in, or near, trees (porcupine, eagle) or in the ground (gopher, coyote).

Recent experience has shown that at least in our area (British Columbia) animals play a more significant role in events leading to death or, more usually, subsequent to death than previously suspected. Two cases illustrate this.



A male suicide whose death occurred more than a year prior to discovery in the bush had had in his possession a red handkerchief with a floral design. This was recovered from an animal (likely bear) scat, which had been dyed a colourful red from the dye seeping into the scat in which the handkerchief was incredibly wadded. The question arose as to when during the previous year the handkerchief had been swallowed. How long can a scat last and what kind of animal was involved? Interestingly, there were what appeared to be perforations from bear claws in one boot. The tearing pattern in the leather suggested this event occurred when the leather was soft and slightly rotted from moisture; i.e., significantly after death. Presumably then this animal activity, which was not recorded on the bones in any way, occurred at the same time as the eating of the handkerchief.

The second case involved a very elderly lady who wandered away and whose clothes, including an identifiable hearing aid, were found three and a half months later. The only human bone recovered was a small fragment of tibia, consistent in its microstructural characteristics with being from an aged human, likely female. This was found in a scat identified by the investigating officer as probably from a "big cat". If it had been possible to photograph and collect the scat without deforming it, then the species of animal might have been determined. It seems unlikely that cougars or bob cats would scavenge a dead body but there are documented instances of cougars attacking humans. Thus, if the animal scat could have been identified, it might have been possible to determine the manner of death.

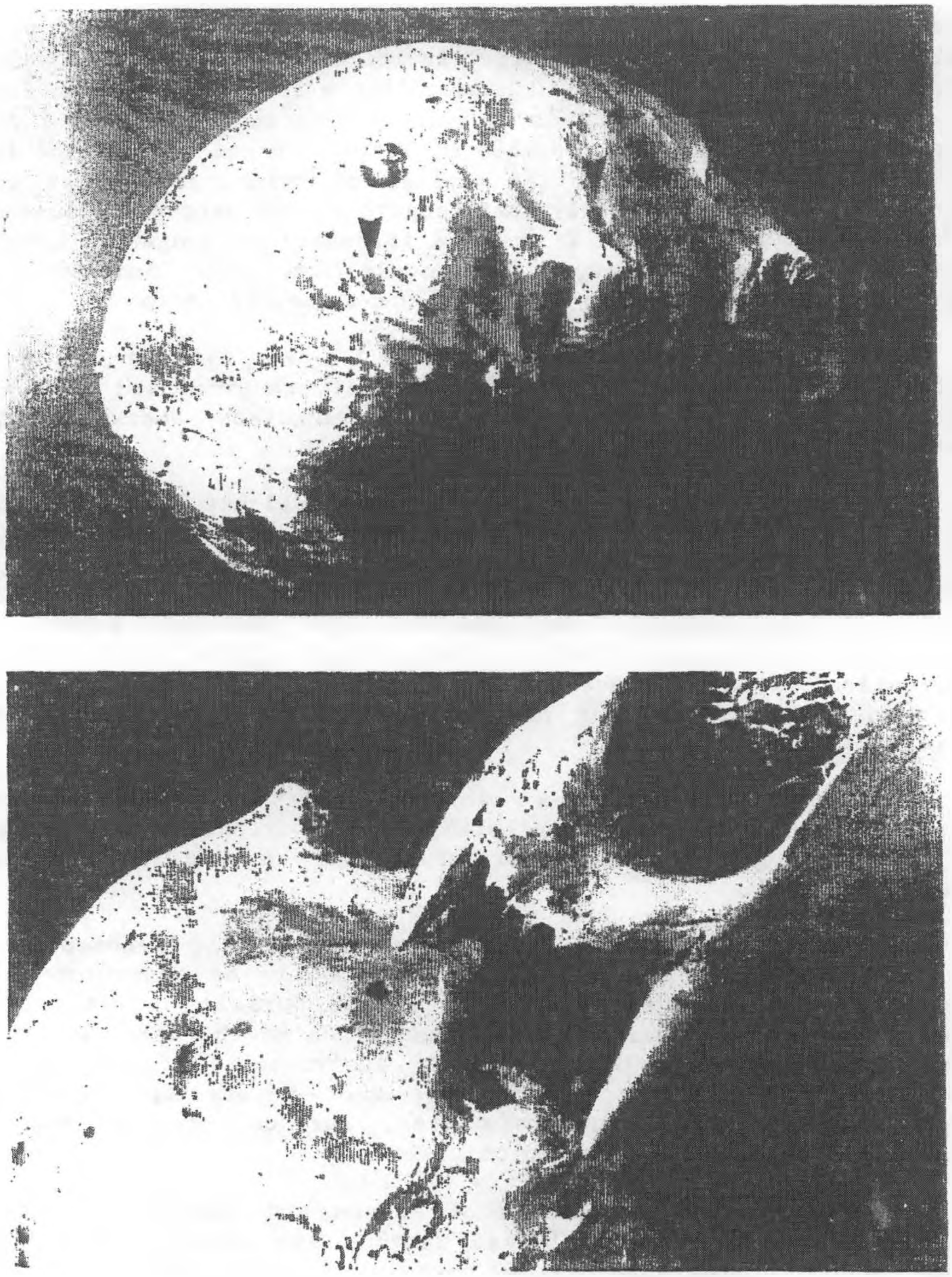
Both cases illustrate well that all scats, whether known to contain evidence or not, should be carefully recorded and collected without cleaning for forwarding to a luckless specialist for examination.

The forensic anthropologist can, but should not always have to, infer the presence of animals in the recovery area from chew marks on the bones. We recall one case in which a skull was diagnosed as having been peppered with buckshot from at least two directions. This conclusion was derived from observation of numerous partial or completely penetrating similar-sized holes in the bone. Closer examination revealed these to be puncture marks from the canine teeth of a bear, nibbling on the head of the (presumably) dead individual (Fig. 21).

Environmental variables explain not only the current disposition of the remains, but also, most importantly, they may aid in interpreting the rate of DECOMPOSITION, as a clue to elapsed time since death.

The context of <u>buried</u> remains which, if not archaeological strongly suggest criminal activity, should be documented as carefully as <u>surface</u> material. For recent burials a fairly close approximation of the elapsed time since death may be possible (up to about three years in such a 'closed' environment) if observations are made of soil type, compaction, root penetration, overlying vegetation type and degree of cover, surface features such as hollows, depth of burial and so on.

The most useful indicators of season and elapsed time since death in both surface and buried remains are insect, POLLEN, and plant remains. Consequently we have dealt with these in greater detail below.



a

b

Figure 21. a) Arrows indicate penetrating impressions in the right temple and behind the right ear. b) The likely cause -- upper canines from bear.

V. B. Insect Remains

V. B. 1. *Rationale*

Insects often play a primary role in decomposition. In forensic investigation, the association of certain insect groups with decomposing human remains can provide reasonably accurate and valuable clues to the duration of the postmortem interval (Rodriguez and Bass 1983).

The life cycle of most insects is seasonally specific; that is, the stages through which an insect matures reflect an adaptation to specific seasons or environmental conditions. Drawing this correlation between an insect and its environment requires that the insect be identified **TAXONOMICALLY** as precisely as possible. It is of extreme importance therefore that anatomical parts characteristic of a species not be lost or distorted through poor recovery techniques.

Generally speaking, two Orders of insects are most often associated with decaying organic matter. These are **COLEOPTERA** (beetles) and **DIPTERA** (flies). Approximately 7,000 species of each are known in Canada with a considerable number yet to be identified. Furthermore, only a small proportion of the immature stages of these species has been described. Although most species will not normally be encountered in forensic contexts, it is evident that for purposes of identification, the collection of insects and their remains requires careful attention.

It is necessary that the state of decomposition of the human remains <u>at the time of discovery</u> be described in detail (for example, fresh, **PUTREFIED**, **DEHYDRATED**, **SAPONIFIED**, **SKELETONIZED**) as this both reflects and determines the kinds of insects present. Some insects are not **SAPROPHAGOUS** (**CARRION** feeders) themselves, but feed upon the carrion feeders, their eggs and **LARVAE**. In that either group can provide an estimate of minimum elapsed time since depth it follows that samples should be taken of all insects found associated with decaying human remains.

Both Coleoptera and Diptera are **HOLOMETABOLOUS**; that is, they **METAMORPHOSE** through four stages during the life cycle: egg-larva(e)-**PUPA**-adult. Any or all of these may be associated with decomposing animal matter. Thus one may find living insects at any of these growth stages (for example, **MAGGOTS** (larvae of Diptera) or **GRUBS** (larvae of Coleoptera)), quite possibly in association with the remnants of previous generations and their life stages, for example, dead or empty pupae, and cast larval skins.

The precision of taxonomic identification is of great importance. This precision increases with the stage of development of the insect, and with completeness of the remains. Certain body parts are more diagnostic than others: in Diptera, wing **VENATION** and hair-like **SETAE**; in Coleoptera, **TARSAE** (terminal segments of the legs) and antennae are important in this respect (Fig. 22). Accordingly when handling specimens care must be taken to avoid losing or damaging these parts. In the event that live maggots or grubs are encountered, it is preferable, from the point of view of identification, that they be reared to the adult stage (Peterson 1962). This requires special attention in their collection, preservation and transport. One of us (M.F.S.) must confess to killing live maggots inside the largely decayed cranial contents of one individual by immersing the skull in defleshing chemicals. Species identification was not possible since the larvae could not be raised to maturity.

V. B. 2. *Collecting techniques*

For forensic purposes the collection of insects and their remains assumes the possibility of subsequent precise taxonomic identification. Techniques of collection are directed therefore to finding all associated insects and doing minimum damage to specimens.

Adult insects are usually mobile, and in many cases short-lived (exceptions can be found in many Coleoptera). When live specimens are found with human remains these should be carefully collected and killed as soon as possible in a killing bottle (see Appendix 4), so as to minimize damage to diagnostic parts. The immature forms of saprophagous insects are perhaps more likely to be found in forensic work. The larvae of Coleoptera and Diptera, if discovered alive upon decomposing remains, are probably not yet ready to pupate, as in most instances larvae will leave the food source when they have finished feeding, and prior to **PUPATION**. Therefore, when collecting live larvae, an alternate suitable food source must be provided for as long as necessary for the adult stage to be reached (days or weeks). Preferably, an adequate sample of the decomposing soft tissue could be removed and placed in the rearing container (Appendix 4). Failing this, a meat substitute will do (not hamburger as preservatives are harmful to the insect). If the larvae are feeding upon decaying vegetable matter associated with the remains, this should be placed into the rearing container. All larvae found should be collected, if possible, as rearing is a difficult procedure, and a high mortality is to be expected. Where morphological dissimilarity in larval forms is obvious, these should be kept separate. In Appendix 4 can be found a description of

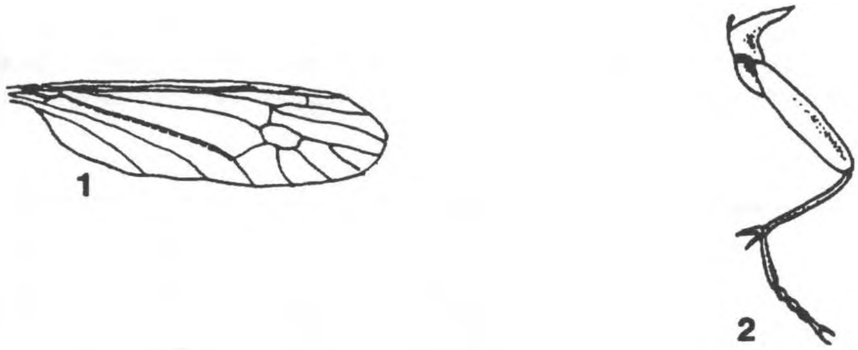


Figure 22. Diagnostic portions of insects. 1) Venation of Dipteran wing. 2) Tarsal segment of Coleopteran leg.

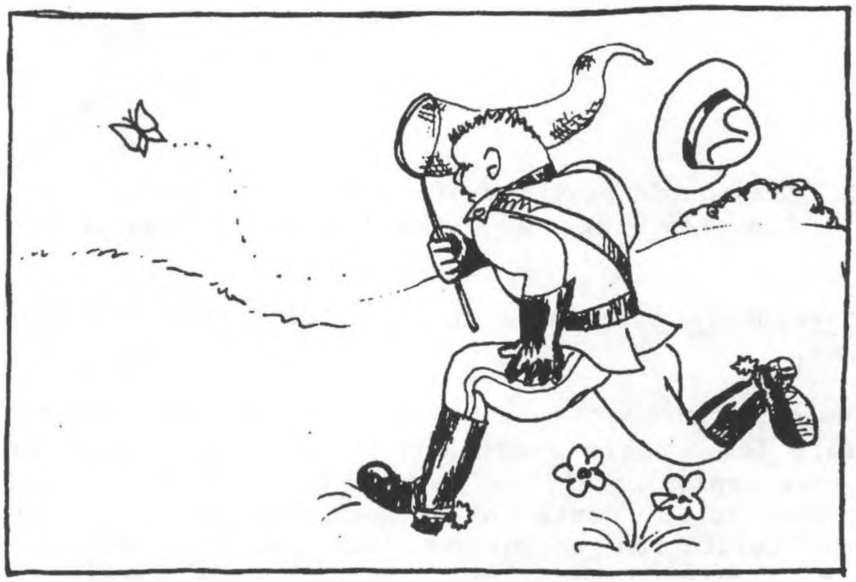
suitable temporary containers for the collection and transport of live larvae.

As noted, for most species, larvae that are ready to pupate will usually leave their food source. It is therefore recommended that an area approximately 0.5 meters around the periphery of the remains, and to a depth of 5 centimeters, be subjected to appropriate collection techniques (see below). In the case of burials, all screened material from above the remains should be searched thoroughly for insect remains, noting the depth from which the soil was taken. The earth beneath the remains can also be examined when it is certain that all other evidence has been found.

In the event that all insects recovered are dead (regardless of stage of development), or that only remains of previous stages or portions of insects are observed, it is sufficient that these be placed separately in suitable containers (for example, glass or plastic vials with screw-type or childproof caps) with 75 percent ethyl (grain) alcohol. These should be labelled appropriately and forwarded to the proper specialist for identification. If doubt exists as to whether the insect is in fact dead, treat it as if it were alive.

Where insects occur in direct association with decomposing flesh they will in most cases be seen readily. (An exception will be those which have made their way into the skull.) In these instances, direct hand collection, perhaps with the aid of delicate tools (for example, small soft hair brushes), is the most effective and simple method. Live adult forms should be placed in killing bottles, and pinned when dead, or put into alcohol. To collect specimens from the peripheral soil matrix the technique of

FLOTATION is recommended. This entails placing samples of the soil into a basin of water, and with gentle agitation allowing freed insects to float to the surface. In most cases the **PUPARIA** of insects are water-tight, and this technique should not result in death of the insects.



The following is suggested as the minimum information required for an adequate interpretation of the recovered insect sample:

1) Precise site location.

2) Site description -- describe in detail the nature of the terrain, vegetation, proximity of water, and weather conditions.

3) Note whether a surface find or burial; if the latter, be sure to indicate approximate depth from which insects were taken.

4) State of decomposition -- fresh, putrefied, dehydrated, saponified, or (semi-) skeletonized.

5) Nature of sample -- eggs, larvae, pupae and/or adults. Record the obvious presence of more than one species.

6) Nature of association -- note if insects were found directly associated with the remains, where they were found, and the degree of infestation. If recovered through hand sorting or flotation note the association of the matrix to the body.

7) Method of recovery -- for example, hand collection, flotation, sieving.

8) Method of preservation -- note methods used to kill adults and preserve them (for example, ethyl alcohol). Describe rearing container and any alternate food source.

9) Ancillary records (for example, photographs) -- note their existence.

V. C. Plant Remains

V. C. 1. *Rationale*

The utility of plant remains in forensic investigation should not be underestimated. Plants can provide information on geography, seasonality, and even the specific year of a significant event. Careful notation of the types and nature of vegetation present but not collected should be made as this may affect the interpretation of the samples recovered.

Plant identification is based on external, internal and microscopic features depending in part on the species involved. Surface features include such things as leaves and needles, bark, buds and seeds. As in most groups of living organisms, some parts are more diagnostic than others; for instance, some plants can be identified accurately to species by parts of leaves while others might require the whole leaf simply to place the item at the generic or higher level. Internal features include gross wood structure and colour. Microscopic features include finer aspects of internal plant and wood structure as well as very small items like pollen and spores. Tree rings, whose growth has been affected by an event associated with a person's death or disposal, can be examined microscopically to determine elapsed time since death, possibly to within a season of a particular year.

It should be noted that it is not always necessary to identify the plant remains to obtain some significant information. Examples would be inferring season of death from the flowering stage of plants trapped beneath a fallen body, or degree to which vegetation beneath the body has died, estimating the age of a burial by the depth and state of decomposition of the surface litter layer, or from disturbed plant roots growing back into the soil above a burial.

In cases where human remains occur on the surface, leaves, needles, seeds and the like may accumulate on the body or even within the skull where they might subsequently be protected from the external environment. Recovered plant remains should be placed in plastic bags, sealed and labelled accordingly. It is also suggested that these kinds of remains be collected from beneath the body (or those skeletal parts in contact with the ground, for example, skull), since these areas, which were last exposed prior to deposition of the body, may reveal plant remains whose characteristic pattern of growth was affected at that moment in time.

If clothing is present it should be removed as soon as possible, labelled and sealed in sterile plastic bags for transport to a facility where a systematic search for local or exotic seeds and pollen can be undertaken. Any dirt adhering to clothing, shoes, etc. must be saved. In the event that removal of the clothing in the field is not possible, precautions should be taken to insure against loss of these kinds of information. This might entail placing plastic bags over likely areas of seed and pollen accumulation when the person was alive, such as pant cuffs, shirt collars and pockets. It must be stressed that the bags containing or protecting these materials should not be opened or removed prior to their arrival at a sterile facility for examination. This is to avoid contamination of older pollen with current 'POLLEN RAIN'.

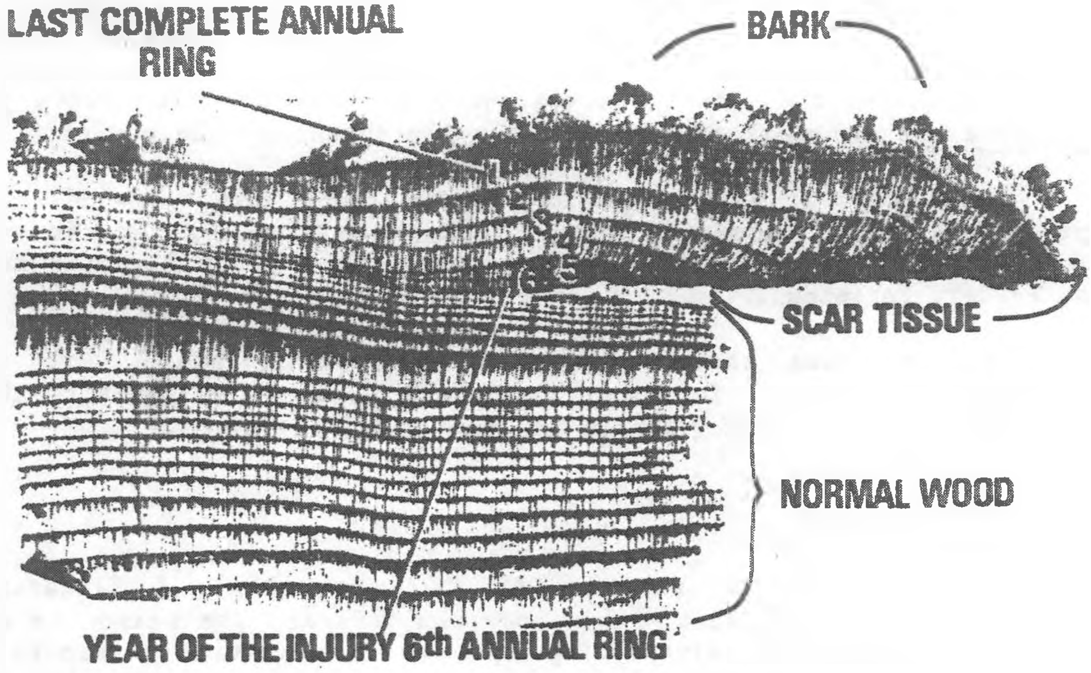
V. C. 2. *Tree rings*

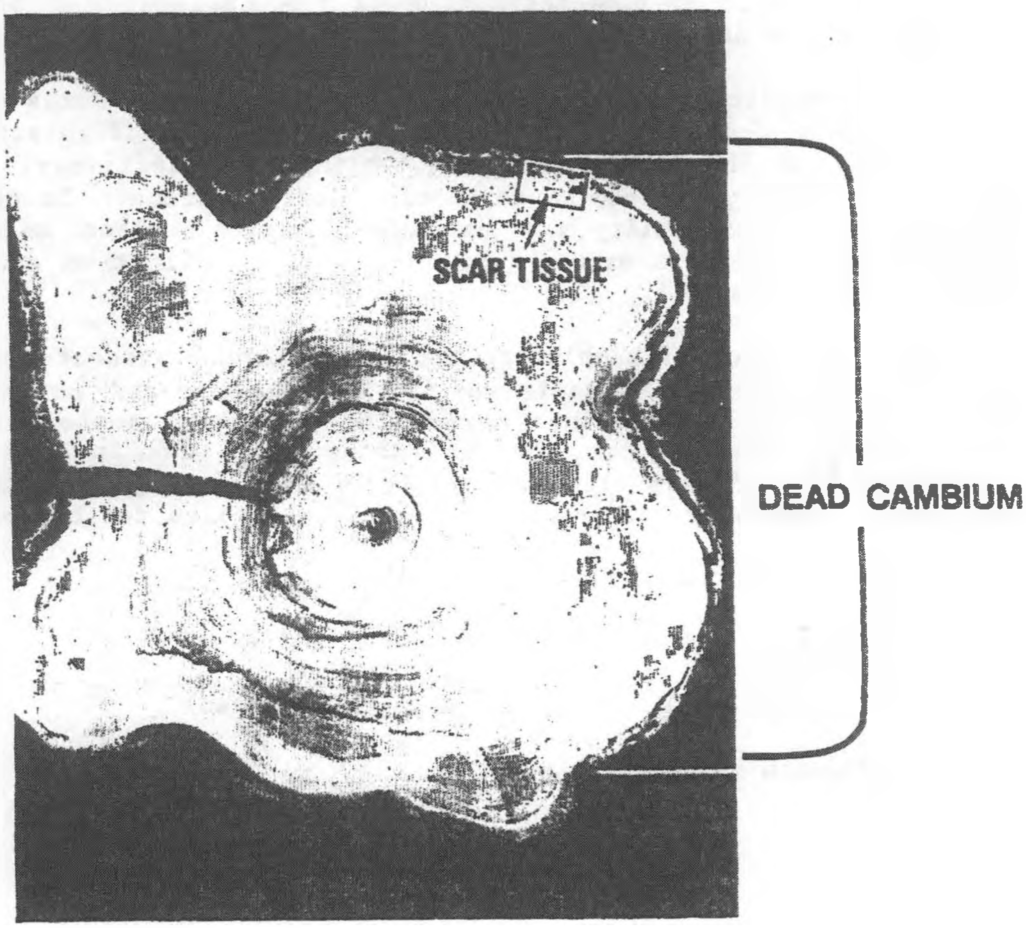
The analysis of annually-occurring tree rings ("dendrochronology") can indicate when a forensically significant event happened (Jozsa 1982). There are basically two reasons for this. First, tree rings grow with a certain rhythm which permits their calibration within the yearly cycle. In many species (especially conifers) a particular growth season can be determined from difference in width, density or colour patterns of the tree ring corresponding to that year's growth (i.e., "early" and "late" wood, denoting the beginning and end of the growing season, respectively).

Second, the criteria of ring width and density are independently susceptible to local effects of the environment. In the case of human burials, soil disturbance, nutrient enrichment through body decomposition, and shovel trauma can produce changes in the growth of tree roots which are observable through microscopic or densitometric (x-ray) examination of the subsequent growth rings (Denne 1977) (Fig. 23).

It is necessary to show that the observed effects on the tree rings, postulated to be the result of a criminal act, are not attrib-

Figure 23. Determination of elapsed time since death from tree ring analysis (upper figure -- magnified cross-section of scar tissue, from rectangular area marked in lower figure).


LAST COMPLETE ANNUAL RING
BARK
SCAR TISSUE
NORMAL WOOD
YEAR OF THE INJURY 6th ANNUAL RING


SCAR TISSUE
DEAD CAMBIUM

utable to natural phenomena. This requires obtaining unaffected plant material which is not in direct association with the human remains. If pieces of root which enter a grave are being recovered, it is suggested that similar sized roots be obtained from trees of the same species which are growing at a distance from the burial.

In one case of human cremation, nearby trees were scorched. It proved possible to determine when the body was burned to within two months of the date alleged by an informant (analysis by L. Jozsa and M. Parker, Forintek).

As tree ring characteristics vary between species, it is advisable to collect a few leaves and seeds in order to identify the species. A colour photograph of the tree would be useful.

V. C. 3. *Pollen*

Pollen grains are the male **GAMETES** (sex cells) of flowering plants and when associated with a body can indicate the season of an individual's death. Analysis of pollen can also provide information as to the movements or geographic location of the deceased prior to death. This would be especially true if the decedent had been in the proximity of an exotic or rare species (Erdtman 1969).

The identification of pollen is based on three features of the outer covering or **EXINE** (Fig. 24). These are the configuration of apertures, the shape, and the sculpturing. Collectively, these criteria provide very precise taxonomic identification. In certain circumstances, seasonality may be inferred from pollen analysis. For inferences of this nature, extreme care in collection and note taking is essential.

The collection of samples for pollen analysis presents special problems and therefore demands special precautions and procedures. This is particularly critical during the flowering season typical for the region in question, as the intensity of the 'pollen rain' significantly increases at these times. The following is a list of possible reservoirs of pollen which should be sampled for collection:

1) Dirt under nails

2) Clothing and adhering dirt

3) Hair and soil immediately beneath the head

4) Stomach and bowel regions

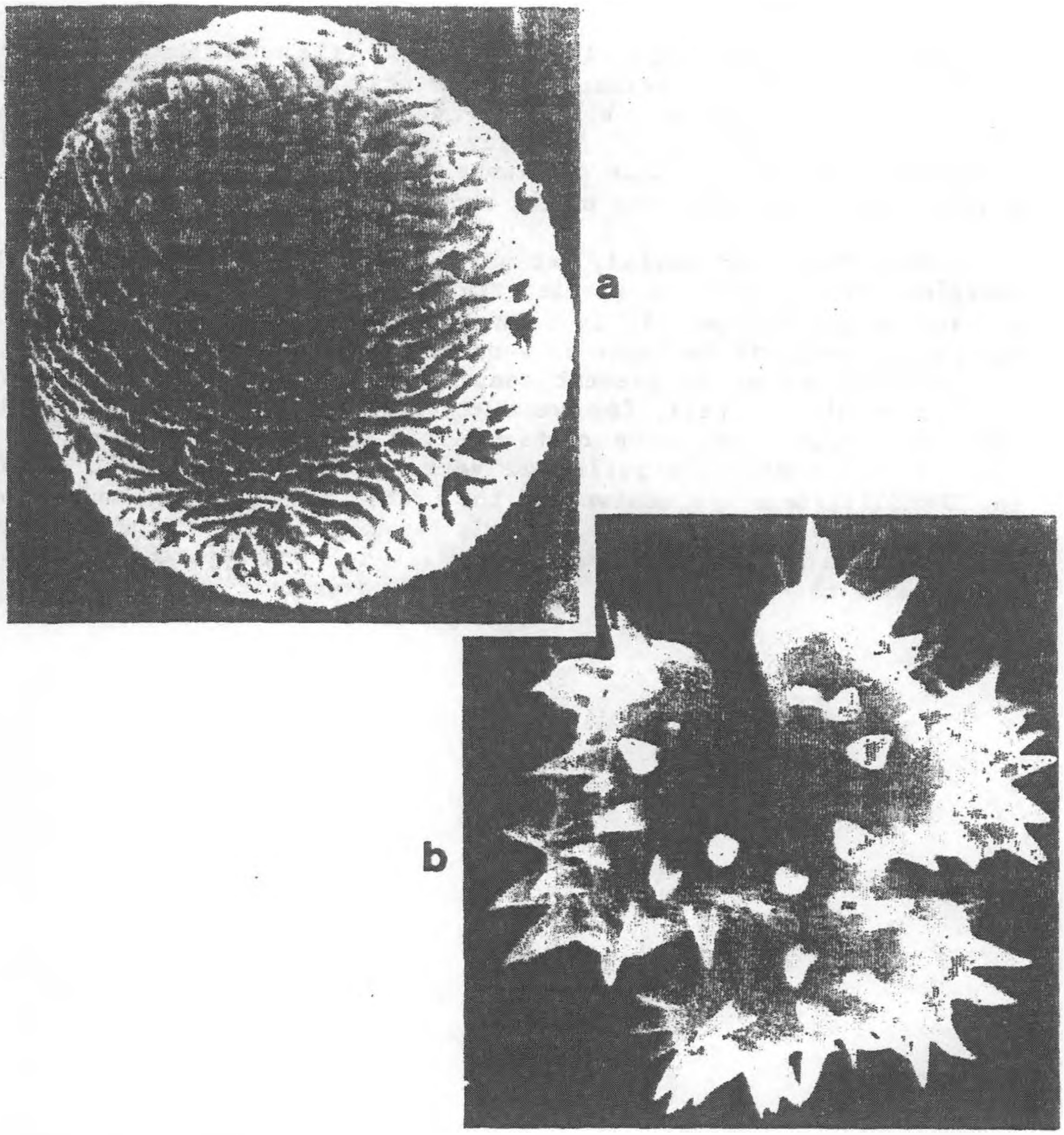


Figure 24. External surface features (exine) of pollen grains. Note variation in apertures, shape and sculpturing -- the basic characteristics used in species identification. a) *Polemonium corneum* (Jacob's Ladder), b) *Arceuthobium californium* (Dwarf Mistletoe). (Dr. Rolf Mathewes, palynologist with the Biosciences Department, Simon Fraser University, kindly supplied these scanning electron microscope photographs.)

5) Tracheal (lung) region

The first three apply to more recent (fleshed) human remains, the latter two pertain primarily to skeletal material recovered from a burial or protected by some means from continuous pollen deposition. As pollen is, in many cases, wind-borne, it can be expected to be found within our lungs and ear wax as well as within the food and fecal contents of the abdomen.

After death and burial, but prior to decomposition, the pollen contained in the body is static; that is, the kinds and quantities present do not change. It is imperative therefore that soil samples for pollen analysis be taken as soon as possible after uncovering of the remains, so as to prevent contamination from the ever-present 'pollen rain'. As well, for comparative purposes, samples should be taken from the earth at a distance from the burial. An adequate size of soil sample for pollen analysis would be on the order of 10 to 20 milliliters -- equivalent to a shot glass or egg cup. As always the samples must be properly labelled. If a considerable time between collection and analysis is anticipated, it is recommended that the samples be frozen for preservation.