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Rapid communication

A preliminary study of incisor exfoliation as an estimator of the postmortem interval using accumulated degree days☆,☆☆

Michelle A. Granrud, Gretchen R. Dabbs *

University of Arkansas, 330 Old Main, Fayetteville, AR 72701, United States

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ABSTRACT

This research shows the exfoliation of the anterior dentition has significant potential to aid in establishing the minimum length of the post-mortem interval. Accumulated degree days (ADD) were used to quantify the decomposition of the periodontal ligament, represented by post-mortem exfoliation of the incisors. After subjects were removed subsequent to disturbance by scavengers and time limitations on the study, the final sample size was 36 incisors from the maxillae and mandibles of seven pigs (*Sus scrofa*). Average daily temperature was calculated using hourly temperature data recorded using DS1921G thermochrons for the duration of the project (June 14–December 17, 2008). During this period, six teeth (16.7%) were exfoliated. ADD for these six teeth ranged from 1539.7 °C to 2006.7 °C. The average ADD required for exfoliation was 1788.0 °C (SD = 198.1 °C). No differences in ADD required for exfoliation were observed between the maxillary and mandibular teeth ($t = 2.085$; $p = 0.128$).

1. Introduction

Accurate estimation of the post-mortem interval (PMI) is of paramount importance to criminal investigations. Early in the decompositional process, a number of different sequential and concurrent biological and chemical processes are used to estimate PMI with high levels of both precision and accuracy. As the post-mortem interval increases, the precision of estimates decreases, as does the number of methods available for accurate estimation. Forensic entomology has long focused on the presence and developmental patterns of various insect species and how that information can be used to assess the time since death in extended post-mortem interval situations [1].

Forensic anthropology is especially useful in estimating long post-mortem intervals and forensic situations where insect access was prevented, or severely restricted. Using knowledge gained over the last 40 plus years of anthropological observation and research into rates and patterns of decomposition, anthropologists can now contribute significantly to the question "When did this person die?". Papers have been presented on the rate and pattern of soft tissue decomposition [2,3], on skeletal weathering [4] and many of the stages in-between.

Practiced forensic anthropologists and bioarchaeologists recognize post-mortem exfoliation of the anterior dentition as a common event. Since teeth can be important contributors to the process of positive identification, their retention and recovery for analysis is important to the criminal process. This paper examines the potential for using the post-mortem exfoliation of the anterior dentition as one method for estimating the post-mortem interval using accumulated degree days.

Previous experimental research on the post-mortem exfoliation of dentition suggests the decomposition of the periodontal ligament, which allows for tooth loss, follows the processes observed with other soft tissues with regards to seasonality and environment-warmer temperatures result in faster decomposition of the ligament and vice versa [5]. Retrospectively collected data on dentition exfoliation in archaeological and contemporary mass graves demonstrate the central maxillary incisor is the tooth most commonly lost post-mortem, followed closely by the remaining incisors of the maxilla and mandible [6]. The premolars, which have bifurcated single roots on the mandibular and second maxillary teeth, and simple twinned roots in the first maxillary tooth, with occasional paired roots, are lost second most commonly [7]. Canines and molars, those teeth with the largest and most complex roots are lost significantly less often [6,7].

This study is similar to that published by McKeown and Bennett, however significant methodological issues with the original study suggest this reassessment of the question provides new insight [5]. The original study, which was conducted on a

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* Corresponding author at: Southern Illinois University Carbondale, Department of Anthropology, 1000 Faner Dr., Mail Code 4502, Carbondale, IL 62901, United States. Tel.: +1 618 453 3298.
E-mail address: gdabbs@siu.edu (G.R. Dabbs).

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Fig. 1. Pictures shows sagittally sectioned head with guide for suspension wire through parietal keel.

small sample of human cadavers, indicates the researchers applied "slight pressure" to each tooth to detect separation from the alveolar bone [5:756] and removed detached teeth from the alveolar bone. The current researchers feel this procedure likely sped the process of exfoliation (post-mortem tooth loss) significantly, and does not reflect the conditions of actual forensic cases, where teeth would not be touched on a weekly basis, and certainly would not be removed from the alveola by mechanical means. Furthermore, introduction of the use of accumulated degree days allows this study to monitor exfoliation of the anterior dentition without the often problematic use of time as a measure of post-mortem interval. Accumulated degree day data can be back correlated to provide law enforcement an estimated length of the post-mortem interval when necessary.

2. Materials

The heads of 15 market age (between 180 and 270 days) pigs (*Sus scrofa*) slaughtered for commercial use were used in this project. Three of these heads were whole, complete with hide bristle, and all associated tissues. The remaining 12 heads were bisected sagittally during the commercial preparation process, and the hide was removed, leaving exposed facial muscle tissue (Fig. 1). The bisected specimens chosen for this project were examined closely for disturbances of the anterior dentition. In order to be included in the study, the bisection had to be imprecise, leaving at least one complete tooth or tooth socket from the opposite side of the skull (example: left side must include right maxillary central incisor). Additionally, the dentition, gingiva, and oral environment of each included research subject were macroscopically examined to identify potential accelerants to the exfoliation process, including trauma and periodontal disease. No potentially expediting condition was observed on any of the subjects included in this study.

Pig teeth are similar in size and morphology to human dentition, and are considered an acceptable model for human teeth (Fig. 2) [8]. To minimize complications resulting from morphological differences, and to focus on the teeth most likely to be naturally exfoliated during the post-mortem interval, this study only included the central two incisors of the maxillae and mandible of each pig, and pigs were only included in the study if all four/eight incisors were present. Juvenile domestic pigs possess a more primitive mammalian dental condition than do humans, with 28 deciduous teeth (formula 3:1:0:3). The maxillary and mandibular third incisors and canines are erupted before birth, and the remaining anterior dentition erupts by 98 days postpartum [9,10], well before market dates. Additionally, the first and second incisors are not typically exfoliated until 11–14 months [10,11]. Thus, the deciduous dentition of focus is fully developed before the pigs are in market condition, and not lost until long after market weight is reached. The total initial sample size was 72 incisors. Several research subjects were eliminated from the study for reasons described below, reducing the final sample size to 36 incisors (Table 1).

Northwest Arkansas lacks facilities to conduct forensic anthropological research, whether on humans or pigs. This study was carried out on private property in Farmington, AR (Fig. 3), a small semirural town. Two sites were chosen to conduct this research. Site one is located within a small stand of woods adjacent to a hayfield. The ground cover is common grasses, and vine undergrowth. The tree cover is thick, and the research subjects were protected from sun exposure during most of each day, the exception being during the early morning hours. The second site was located along the eastern edge of an open hayfield, approximately 2 km from the first site. A tree line stands to the east of the research site, shading the site during the early morning hours. During the remainder of the day, the site was exposed to full sunlight until dusk.

To protect the research subjects from scavengers each site was established with a wire dog kennel (1.2 m long, 0.9 m wide, 0.9 m high). The open mesh of the kennel

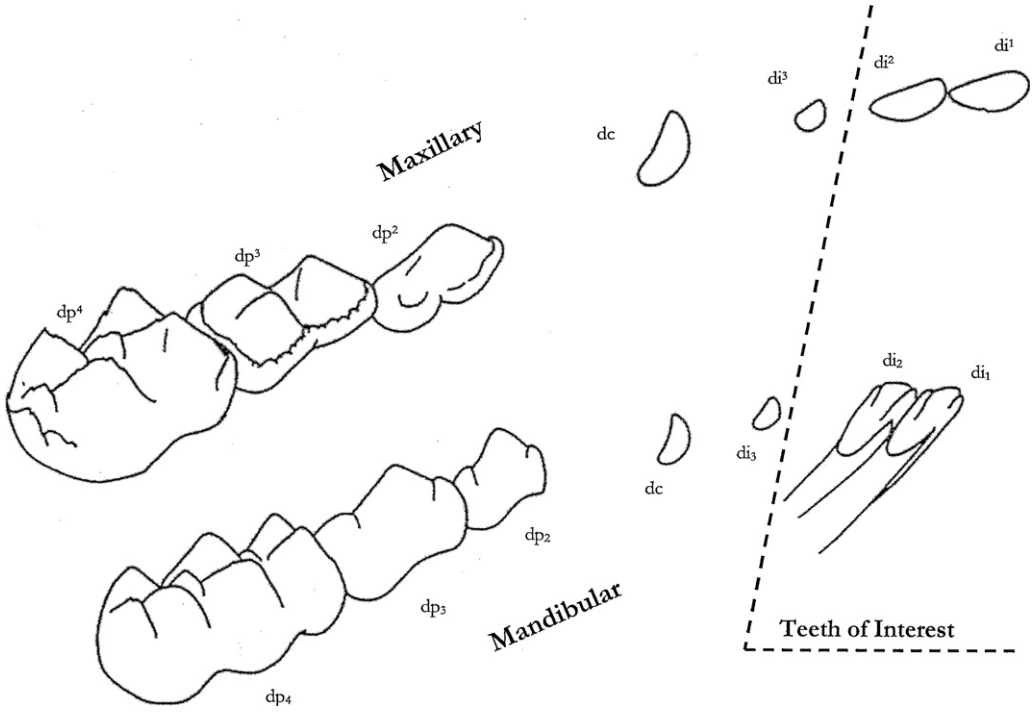

Fig. 2. *Sus scrofa* deciduous dentition, after Hilson 1986 (33).