FORENSIC OSTEOLOGY

Second Edition

FORENSIC OSTEOLOGY

Advances in the Identification of Human Remains

Edited by

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With a Foreword by

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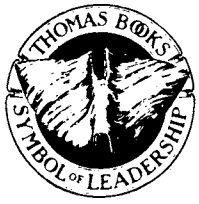
(With Thirty-two Other Contributors)



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FOREWORD

The foreword to the first edition of *Forensic Osteology* was written by Dr. Wilton M. Krogman, my doctoral advisor and longtime friend. I was pleased when Dr. Reichs asked me to write the foreword for the second edition. Although Dr. Krogman had many graduate students at both the University of Chicago and the University of Pennsylvania, I have followed Dr. Krogman's footsteps in research and publication in the forensic area more than most of his other students. Krogman and T. Dale Stewart, at the Smithsonian Institution, are viewed now as the founders of Forensic Anthropology. They both saw the beginning of an explosion of interest, research, and publication in the forensic application of osteology.

The phenomenal growth of the Physical Anthropology Section of the American Academy of Forensic Sciences is an excellent example of the scientific acceptance of the techniques in determining age, sex, race (ancestry), and stature estimations in human identification. The knowledge of the Forensic Osteologist is required today in mass disasters, in the identification of political and war dead, and in estimating the length of time since death. Research over the last decade has suggested that some of the criteria based on the study of anatomical collections may not be as appropriate in the identification of skeletal remains of modern populations. Many Forensic Anthropologists are now contributing metric and non-metric data from present cases to the Forensic Data Bank. This allows us to establish a data base on present-day populations.

Reichs has updated her very successful first edition and increased the number of chapters from 16 to 25, again an example of the growth in this area. Authors of three chapters in the first edition have updated their contributions and this edition contains twenty-two new chapters. If this rate of growth continues, the third edition will be almost too large to carry around.

Krogman was pleased to see the publication of the first edition. I am pleased that Dr. Reichs has combined the authors and information for this much expanded second edition.

WILLIAM M. BASS, PH.D., D.A.B.F.A.

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FORENSIC OSTEOLOGY

Part I

INTRODUCTION

INTRODUCTION

KATHLEEN J. REICHS

When *Forensic Osteology: Advances in the Identification of Human Remains* appeared in 1986, forensic anthropology was already firmly established as an important specialty in the medicolegal system. The Physical Anthropology Section of the American Academy of Forensic Sciences had been in existence for fourteen years, the American Board of Forensic Anthropology for nine. It was time to move beyond the basics and discuss advances in a rapidly expanding field.

Since then a decade has passed. As Reichs points out in Part II, Chapter 1, the field of forensic anthropology has undergone enormous growth during that period. The number of physical anthropologists calling themselves forensic anthropologists has increased, as has the number of board-certified practitioners. Average caseloads have increased dramatically.

Even more striking is the way in which forensic anthropology has expanded in scope over the past ten years. This new second edition reflects this. The twenty-five contributions to this volume demonstrate movement beyond the boundaries of the forensic anthropology of a decade ago. In three chapters (Weaver; Suchey and Katz; Gill) the authors update the contributions they made to the 1986 publication. The remaining twenty-two chapters are new. Only seven chapters in this book focus on the traditional techniques of age, sex and ancestry determination. The rest cover more specialized methodologies and discuss expertise considered peripheral just a decade ago.

Part III is devoted to the topic of recovery. In Chapter 2 Haglund discusses the role of the forensic anthropologist at scenes containing human victims, including multiple fatality incidents, fires, and serial murder investigations. He emphasizes the challenges to be met in the recovery of human remains. Using case examples, he demonstrates the importance of proper scene processing.

In Chapter 3 Burns examines the role of the forensic anthropologist in a unique type of recovery situation: death investigative work involving human rights violations. She outlines how the forensic anthropologist joins with other forensic scientists to reveal evidence of mass murder, genocide, torture, summary execution and political "disappearances."

As Murad points out in Chapter 4, not all remains presented to the forensic anthropologist will derive from traditional burial or surface contexts. Due to the growing popularity of cremation in North America, it is likely that the forensic anthropologist will be asked to analyze cremains at some point in his/her career. Murad discusses the cremation process, emphasizing variations that exist within the industry. He summarizes the impact these practices have on human remains, and outlines procedures for the analysis of suspected cremains.

The forensic anthropologist is often asked to determine postmortem interval, or time since death. The chapters in Part IV focus on this topic. In Chapter 5 Sledzik points out that, in the past ten years, controlled studies of decomposition have allowed a more precise approach to the estimation of postmortem interval. He discusses those factors affecting decomposition and provides a practical overview of recent techniques in determining time since death.

Chapter 6, by Sorg, David and Rebmann, bridges Parts III and IV of this volume. The authors describe the investigation of outdoor death scenes in which a search for a decomposed body is undertaken, or in which a decomposed body is found and must be recovered. Their contribution covers the topics of search, recovery, taphonomy, and postmortem interval. The authors provide detailed information on the use of cadaver dogs. They present data on postmortem interval and the condition of remains in the Northeastern United States derived from a twenty-year series of anthropological cases.

In Chapter 7 Rhine and Dawson provide standards for the assessment of time since death under markedly different environmental conditions. They emphasize that the sequence of skeletonization is universal, while the rate is highly variable and dependent upon environmental factors. They provide data on the sequence of skeletonization in the Southwestern United States.

Combined, the chapter by Sorg, David and Rebbman and that by Rhine and Dawson provide a general template for rates of decomposition in both arid and temperate woodland environments. From these data the forensic anthropologist can estimate time since death for a large part of North America.

Part V contains seven chapters focusing on the biological profile. The authors discuss refinements in traditional techniques and describe newly developed methodologies for the estimation of age, sex, and ancestry—the parameters so critical in establishing personal identity.

In Chapter 8 France provides an overview of the morphological and metric approaches to sex estimation from skeletal remains. She emphasizes the latter, bringing together information from a wide range of sources. Regression formulae and other statistics are presented in table format for easy reference.

Weaver has updated and expanded his 1986 contribution on the analysis of fetal remains. In Chapter 9 he outlines the maturation of the human fetus and neonate and discusses criteria for sex and age determination of fetal and neonatal material. He addresses the questions of biological affinity and indicators of life history for individuals in this age category, and provides recommendations for the recovery and analysis of fetal and neonatal remains.

Over a decade ago Suchey, Katz and Brooks took the general scheme of Todd and devised a modified system of pubic age determination using a documented modern sample. In 1986, statistical analysis showed that Todd's phases I, II, and III could be merged into one category, IV and V into another, and VII and VIII into another. The simplified system is called the Suchey-Brooks method. In Chapter 10 Suchey and Katz define the traits used in their pubic aging system, consider the problem of individual variation, and discuss the application of the system to forensic settings.

Histological methods have been used for three decades to estimate age at death. These methods differ in terms of which bone is used, where the sample is taken, and the amount of bone required. Opinions vary as to the accuracy of histological aging. In Chapter 11 Stout discusses factors that affect accuracy in histological age determination. He uses examples to illustrate the application of histological age estimation methods to unknown skeletal remains.

The four most commonly used indicators of subadult age are somatic, sexual, skeletal and dental maturity. Of these, the parameters most frequently used by the forensic anthropologist are skeletal and dental development. The most reliable standards are those derived from large, well-documented sample populations. In Chapter 12 Reichs and Demirjian describe a CD-ROM program with dental data from over 7000 subjects (Montreal Growth Study) and standards for hand/wrist development from over 3000 subjects (Tanner and Whitehouse study). The program contains a data base of cephalometric and anthropometric measurements, and radiographs of dental and skeletal development, thus providing forensic scientists a large archive of data, readily at hand for comparative purposes.

The use of cranial sutures for the estimation of adult age at death has long been controversial. Considerable uncertainty exists with regard to the application, interpretation, and evaluation of error rates of the various methods. In Chapter 13 Nawrocki re-examines the issue of sutural aging by addressing two points. He reports observations on all three sutural systems (endocranial, ectocranial and palatine) simultaneously, and he approaches sutural aging from a statistical perspective. He concludes that estimated ages for adults based on suture closure are not much worse than those derived from other techniques currently employed. His chapter includes equations for predicting age from cranial suture closure.

Over the past few years the notion of racial typology has come under critical review. In Chapter 14 Gill discusses the biological race concept and examines the problems inherent in attempting to categorize according to traditional racial taxonomies. He provides an overview of the craniofacial criteria most useful in the skeletal attribution of race, many of which were unstudied a decade ago. He compares recently developed metric methods with morphological means of estimating ancestry.

Perhaps the greatest expansion for forensic anthropology over the past decade has been into the area of trauma analysis. A combined knowledge of biomechanics and osteology place the forensic anthropologist in a unique position to interpret fracture patterning. Part VI contains five chapters dealing with the topic of trauma analysis.

As Sauer states in Chapter 15, one of the most important considerations in a forensic evaluation of trauma is associating an injury to the skeleton with the time of death. In his contribution he discusses antemortem, perimortem, and postmortem damage to the skeleton. Using a case study he outlines factors to be considered in distinguishing among these injury categories.

Cases in which human remains are compromised due to decomposition, burning, fragmentation, skeletonization or other processes are coming more frequently to the forensic anthropologist for trauma analysis. In these cases accurate fracture interpretation may be the only objective means of determining cause and manner of death. In Chapter 16 Berryman and Symes introduce the basics of bone fracture mechanics, emphasizing gunshot and blunt trauma to cranial bone. They discuss the identification and location of impact sites, the analysis of multiple impact sites, the sequencing of blows, and the establishment of characteristics of the impacting object.

Saw and knife marks in bone provide valuable information about postmortem body treatment. In Chapter 17 Reichs discusses the macroscopic examination of cut marks in bone. As she points out, the tool type(s), the anatomical distribution of cuts, the placement of cuts in relation to joints, the cutting sequence, and the directionality of blade progress may indicate patterning in cases of suspected dismemberment or mutilation. Such patterning may provide information about the behavioral preferences or intent of a perpetrator.

In Chapter 18 Symes, Berryman and Smith discuss the microscopic analysis of tool marks on human bone. They describe the basics of saw construction and explain the fundamental principles behind cutting action. They provide details concerning saw blade and tooth size, set, shape, power, and cutting direction, and discuss how these characteristics contribute to saw class or subclass identification.

In Chapter 19 Houck discusses the individualization of knife marks in bone. He describes a technique employing the scanning electron micro-

scope and provides a basic outline for applying the method in forensic situations.

Physical anthropologists have long relied on statistical analysis in their research. During the past decade practicing forensic anthropologists have come to do so more and more in the conduct of their casework. The chapters in Part VII are devoted to the topic of statistics and data bases.

In Chapter 20 Klepinger and Giles review some statistical concepts used in the field and discuss techniques already familiar to epidemiologists that are equally applicable to forensic anthropology. They emphasize potential pitfalls that may lead to overly confident conclusions or to erroneous interpretations.

Perhaps the single most important development in the field of forensic anthropology over the past decade has been the founding of the Forensic Data Bank (FDB) at the University of Tennessee, Knoxville. In Chapter 21 Ousley and Jantz discuss the establishment and the layout of the FDB, emphasizing its role in keeping forensic anthropology current with the changing U.S. population. They provide information on the demographic breakdown of FDB cases and discuss the FORDISC software package which became available in 1996.

Part VIII contains four chapters, each focusing on a specialized technique or procedure employed in forensic anthropology. In Chapter 22 Wilczak and Kennedy discuss the anatomical irregularities of human skeletal and dental tissue which result from habitual and protracted movements. These activity-induced features, known as MOS, or markers of occupational stress, may prove useful in the establishment of personal identity. The authors discuss problems in the analysis and assessment of MOS. They provide tables listing the most common MOS, linking each to the habitual activities which may have caused it.

Facial approximation may be the most subjective specialty within forensic anthropology. It is, at best, a technique of last resort. In Chapter 23 Reichs and Craig review the traditional methods of facial approximation and discuss the use of computer enhanced or generated images. Using a case study approach they point out the problems and pitfalls encountered in the use of facial approximation.

Over the past ten years the microscope has come to play a critical role in skeletal analysis. It is essential for small particle analysis, for the detection of non-bone inclusions in fragmentary remains, for taphonomic assessment, for age evaluation, and for trauma analysis. In Chapter 24 Ubelaker discusses the expanding role of microscopy in forensic anthropology.

The past decade witnessed a fascination with the remains of celebrated individuals. The bodies of the Romanovs, Josef Mengele, Zachary Taylor, Huey Long, Carl Weiss, and Francisco Pizarro were exhumed and examined.

Victims were not ignored. Those of Lizzie Borden and Alferd Packer also peaked the interest of the forensic community. In Chapter 25 Finnegan and Kysar describe the exhumation of Jesse Woodson James. They outline problems to be anticipated in such endeavors and provide recommendations for the opening of the graves of the famous and infamous.

Physical anthropologists have applied their knowledge of osteology and human variation to the analysis of unknown skeletons for almost a century. Twenty-five years ago forensic anthropology emerged as a distinct subspecialty within anthropology, having gained recognition in the broader forensic science network. In the past decade forensic anthropology has grown dramatically in the number of practitioners and in the number of cases submitted to those practitioners.

More striking, however, is the expansion of forensic anthropology in terms of breadth of application. Forensic anthropologists are now applying their knowledge of human biology, skeletal anatomy, biochemistry, and biomechanics to a wider range of medicolegal problems. Forensic anthropologists are no longer restricting themselves to the reconstruction of biological profiles from skeletal remains. They are addressing questions, and qualifying as experts, in areas considered outside the boundaries of forensic anthropology just a decade ago.

The composition of the second edition of *Forensic Osteology: Advances in the Identification of Human Remains* reflects the changing face of forensic anthropology. Though knowledge of osteology continues as the foundation, in 1996 forensic anthropologists are engaged in more diverse areas of research and casework than they were a decade ago. Ten years hence, the boundaries may have expanded even further.

Part II

THE FIELD OF FORENSIC ANTHROPOLOGY

Chapter 1

FORENSIC ANTHROPOLOGY: A DECADE OF PROGRESS

KATHLEEN J. REICHS

INTRODUCTION

Forensic anthropology is a subdiscipline of physical anthropology that applies the techniques of osteology and biomechanics to medicolegal problems. It is relatively new as a recognized specialty, it's modern beginnings dating only to World War II when forensic anthropologists first began to organize. Formal recognition began with the formation of the Physical Anthropology Section of the American Academy of Forensic Sciences, and with the establishment of the American Board of Forensic Anthropology. During the past decade forensic anthropology has experienced the greatest growth of any subdiscipline in Anthropology.

American Academy of Forensic Sciences

The American Academy of Forensic Sciences, established in 1949, is this country's most prominent professional organization for forensic scientists. Fellowship within the Academy is recognized by U.S. courts as an important consideration in qualification of an expert witness. The Academy is composed of sections representing the various disciplines. In addition to Physical Anthropology, these include Criminalistics, Engineering, Jurisprudence, Odontology, Pathology/Biology, Psychiatry, Questioned Documents, Toxicology, and a General section.

The Physical Anthropology Section was established at the 1972 annual meeting in Atlanta, by unanimous vote of the fellows of the Academy. The section began with 14 members. By 1986 section membership had grown to 88, reflecting an increase of 528%. Between 1986 and 1996 overall Academy membership rose from 2,677 to 4,413, an increase of approximately 65%. In the same decade, the Physical Anthropology Section grew to a total of 209 members, an increase of approximately 138%.

In 1972, anticipating the birth of a separate section, four papers were presented by forensic anthropologists in a joint "Odontology and Anthropology Section" session. In 1986 a total of 373 presentations were made at the Academy, including 353 oral and 20 poster presentations. Anthropologists

were responsible for 33 presentations, or just under 9% of the total. At the 1996 meeting in Nashville, Tennessee, anthropologists gave 38 of 452, or approximately 8.5%, of all presentations at the Academy scientific sessions, an impressive figure for a section representing less than 5% of the overall Academy membership.

Regional Forensic Anthropology Groups

In the past decade a number of regional Forensic Anthropology associations have been organized. In the West there is the group calling itself the Mountain, Desert and Coastal Forensic Anthropologists. Their counterpart in the Southeast is the group called the Mountain, Swamp and Beach Forensic Anthropologists. In the northeastern U.S. and Canada (meeting in Kingston, Ontario, Canada in 1996) is the North East Forensic Anthropology Association (NEFAA). The most recently formed is that in the Midwest, the Midwest BioArchaeology and Forensic Anthropology (BARFA) group.

American Board of Forensic Anthropology

In the past two decades the courts have become increasingly concerned with the professional qualifications of those appearing as expert witnesses. The Rules of Evidence define an expert witness as one qualified by knowledge, skill, experience, training, or education to opine when scientific, technical or other specialized knowledge will assist the court to understand evidence or to determine a fact in issue. A forensic anthropologists is no exception. He/she is not simply a physical anthropologist, or even an osteologist, but a specialist with unique training and unique expertise in the application of physical anthropology to the legal process.

Recognizing the need to establish and maintain standards of proficiency and training, beginning in the 1970s, forensic anthropologists, along with their colleagues in the other forensic sciences, began to develop tighter professional requirements for qualification of experts. With a grant from the Law Enforcement Assistance Agency of the U.S. Department of Justice, the Forensic Science Foundation provided funds for the various disciplines to develop certification procedures. The American Board of Forensic Anthropology was established in 1977 under the auspices of the Law Enforcement Assistance Administration, the American Academy of Forensic Sciences, and the Forensic Sciences Foundation, and was approved by the Physical Anthropology Section of the Academy.

According to Ellis Kerley, its first president, the ABFA was established "in response to an accepted need, among physical anthropologists active in the practice of forensic work, for some regularization of the practice of Forensic Anthropology, its acceptance by the courts, and the exclusion of those indi-

viduals who have not prepared to practice Forensic Anthropology or testify in court by virtue of training, experience or research" (1978:164).

As listed on the ABFA homepage (http://www.csuchico.edu/anth/ABFA/), the objectives of the board are:

1. To encourage the study of, improve the practice of, establish and enhance standards for, and advance the science of forensic anthropology;
2. To encourage and promote adherence to high standards of ethics, conduct, and professional practice in forensic anthropology;
3. To grant and issue certificates, and/or other recognition, in cognizance of special qualification in forensic anthropology to voluntary applicants who conform to the standards established by the board and who have established their fitness and competence thereof;
4. To inform the appropriate branches of federal and state governments and private agencies of the existence and nature of the ABFA and the professional quality of its diplomates for the practice of forensic anthropology;
5. To maintain and furnish lists of individuals who have been granted certificates by the board.

The ABFA makes available to the judicial system, and to others, a practical and equitable system for readily identifying those persons professing to be specialists in forensic anthropology who possess the requisite qualifications and competence.

While forensic anthropology is the only specialty within Anthropology with a process of board certification, the concept is not new. Board certification is a long established precedent for specialized physicians. It is becoming the norm for the forensic sciences as well. Those currently recognized by the Academy include the American Board of Forensic Document Examiners (ABFDE), the American Board of Forensic Odontology (ABFO), the American Board of Pathology, certification in Forensic Pathology (ABP–FP), the American Board of Forensic Psychiatry (ABFP) and the American Board of Forensic Toxicology (ABFT). Most recently formed (1996) is the American Board of Forensic Entomology.

Recertification: Annual Report of Diplomate Activities

Since 1984 the American Board of Forensic Anthropology has required that each diplomate provide a report of that year's professional activities for annual recertification. Diplomates must submit information on the source of their cases by agency (local law enforcement, medical examiner/coroner, state/provincial police, sheriff, military), and by geographic derivation (one's own state/province, other states/provinces, outside the U.S.). Since 1986

diplomates also report on the source of civil cases (defense or plaintiffs' attorney, insurance company, private, etc.).

Diplomates provide information on case types (fresh, decomposed, mummified, burned, isolated skull, skeletal, etc.), on non-forensic material initially presented as forensic (animal, prehistoric or historic human), and on procedures (scene searches, dental identifications, radiographic identifications, microscopic bone or dental aging, facial approximations, photographic superimpositions or comparisons, etc.).

Diplomates report on court-related activities (depositions, testimony, written reports etc.), on whether they appeared for the defense or plaintiff/prosecution, on the nature of the trial (civil or criminal), and on the nature of their expertise (identification or trauma analysis).

The data supplied by diplomates permit the analysis of trends within the field of forensic anthropology. The information documents historic shifts in diplomate activity and clarifies the pattern of activity among practitioners in any given year. The following is a summary of what diplomates of the American Board of Forensic Anthropology have been doing over the past decade and how they are currently engaged.

TRENDS: 1986-1995

Caseloads

The total number of cases reported by diplomates has increased steadily over the past ten years (Fig. 1). In 1986 diplomates reported a total of 759 cases. In 1995 the figure had risen to 1,845 cases. This increase is due in part to a growth in the number of diplomates reporting. In 1986 there were 34 diplomates, of whom 30 submitted their annual update forms (88%). In 1995 41 diplomates (100%) reported. While the number reporting increased by 36.6%, the total number of cases increased by 143%. The average annual caseload in 1986 was approximately 25 per diplomate. This had risen to approximately 45 cases per diplomate in 1995.

Another factor contributing to this rise is the increasing participation of diplomates in combat, mass disaster, and aviation death situations. During the past decade, for example, diplomates were involved in identifications resulting from Operation Desert Storm, from the Oklahoma City bombing, and from the crashes of Pan Am flight 103 and TWA flight 843. The processing of large numbers of individuals by a few diplomates may function to artificially inflate the true averages for individual practitioners. Controlling for three diplomates who reported a total of 648 cases deriving from aviation disasters and the Oklahoma City bombing, and one diplomate who reported 334 skeletons received as ME/coroner cases, the average drops to approximately 21 cases per diplomate for the year 1995.

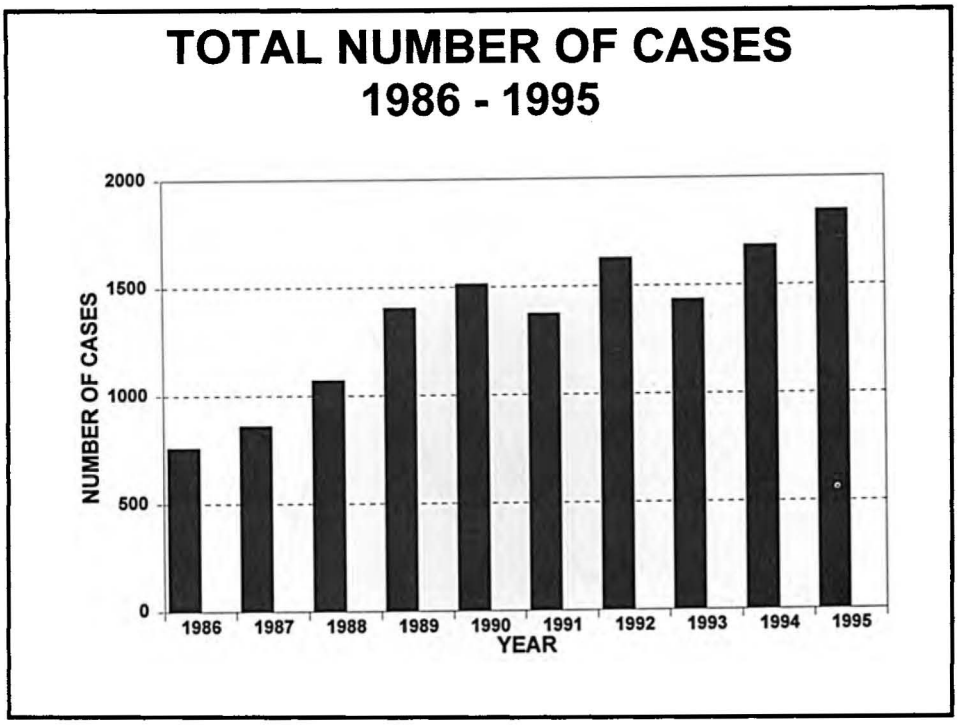

Figure 1. Total number of cases reported by ABFA diplomates for the period 1986–1995.

Cases by Source Agency

Figure 2 plots the number of cases reported by source agency between 1986 and 1995. Several trends are obvious. Medical examiner/coroner systems continued as the single largest source of forensic anthropology cases. In 1986 diplomates reported 334 cases derived from medical examiner/coroner offices, accounting for 44% of all casework. In 1995 the figure had risen to 876, representing approximately 47% of all cases reported. The medical examiner/coroner category experienced a growth of over 160% over the past ten years.

In 1986 diplomates worked on 47 military cases. This number represents approximately 6% of all cases reported that year. The number of military cases rose between 1989 and 1991, with totals over 200 reported for these years. Beginning in 1992 there was a sharp decline in this category. In 1995, 3 diplomates reported a total of 71 cases deriving from the military, less than 4% of all cases reported. The decline in this category reflects the situation at the U.S. Army Central Identification Laboratory-Hawaii (CILHI), where, as of 1995, there was no board-certified anthropologist on staff. Two of the

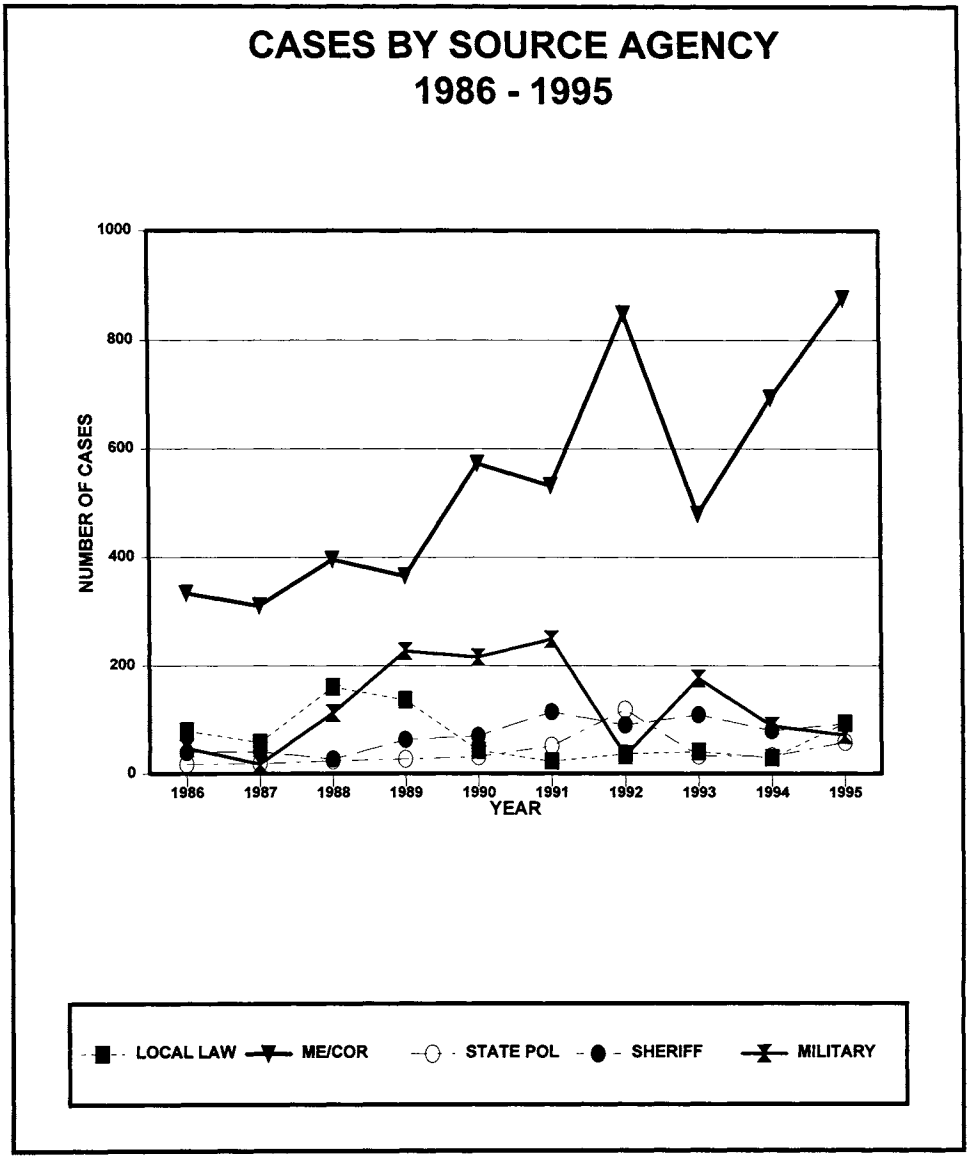

Figure 2. Number of cases reported by ABFA diplomates by source agency, 1986–1995 (local law enforcement agencies, medical examiner/*coroner systems, state/provincial police agencies, sheriff's departments, and the military).*

diplomates reporting military cases work as external reviewers for CILHI, the third is on staff with the Armed Forces Institute of Pathology.

The category showing the largest increase is that designated "civil," including cases derived from defense and plaintiffs' attorneys, insurance