A brief overview of forensic herpetology

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Abstract. The emerging field of forensic herpetology is reviewed. This research focus, defined here as the application of science to studies of reptiles and amphibians when these animals become the subject of legal investigations, has gained increasing attention in recent years. A diverse range of experts contributes to methods in forensic herpetology including forensic scientists, herpetologists, veterinarians, zookeepers, physicians, pathologists and toxicologists. The English language literature in forensic herpetology is reviewed and the most commonly asked questions of forensic herpetologists are summarized. Recommendations for continued and future research are highlighted.

Key words: Forensic herpetology; wildlife forensics.

Introduction

Increasingly, a broad range of experts is called upon by law enforcement officials and those involved in other forms of litigation to assist and provide forensic support in legal investigations involving amphibians and reptiles. Experts may include, but are not limited to, forensic scientists, herpetologists, veterinarians, zookeepers, ethologists, physicians, pathologists and toxicologists. Such collaboration was relatively rare several decades ago. One reason for the surge of interest in animal forensics is the implementation of international treaties such as CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora; implemented in 1975) and legislation — for example, in the United States of America (USA) including the U.S. Endangered Species Act (implemented in 1973) — which provide various levels of protection for endangered and threatened species (see Cooper, M.E., this volume). This has lead to increasing demand for detailed forensic analysis of animals associated with suspected crimes (Brazaitis, 2003), and the emergence of a discipline now often referred to as wildlife forensics (see Wilson, 1977 for an early bibliography on the subject). In addition, the proliferation in the USA and some other countries of television shows featuring fictionalized forensic scientists

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(e.g., CSI — Crime Scene Investigation) has led to what is termed "The CSI Effect", in which many jurors in real trials have very high expectations (often unrealistic) for forensic evidence (Schweitzer and Saks, 2007).

Forensic cases involving animals can broadly be divided into those in which the animal is viewed as (a) the victim, or (b) the perpetrator (Cooper and Cooper, 2008). In cases where amphibians and reptiles are suspected victims of crime, forensic analysis may address such broad issues as crime scene investigation, species identification, veterinary forensic examination, captive versus wild identification, geographic origin/sourcing, and recognition of individual animals. More commonly reported in the forensics literature, however, are instances in which reptiles or amphibians are perpetrators in a given case. Such cases are often tied to human death or injury investigations and are widely known as examples of medical herpetology. Examples include forensic cases involving human deaths or injuries from snake-bites, alligator attacks, toad-poisoning, bite/wound identification, infection from reptile contact and allergic reactions.

Here, I provide a brief overview of such cases and refer to them collectively as examples of forensic herpetology — defined here as that branch of science that relates to studies of reptiles and amphibians when these animals become the subject of a legal case (see other papers in this series). As reviewed by Cooper, M.E. (this volume), forensic-style investigations are also applied in such diverse areas as insurance claims, allegations of malpractice by veterinarians, environmental impact studies, etc. My focus here is on the most commonly asked questions of forensic herpetologists and a review of herpetological research published in the English language specifically for forensic purposes. Many of these subjects (especially crime scene investigation, postmortem techniques, and legal aspects) are treated in more detail throughout this series. Areas for continued and future research are also highlighted.

Early History

In the USA, early published examples of forensic herpetology focused primarily on medical herpetology and are found throughout the medical and human forensics literature. With the implementation of CITES and the U.S. Endangered Species Act, a major shift in forensic herpetology took place in which law enforcement officials (most notably within the U.S. Fish and Wildlife Service, an agency within the U.S. Department of the Interior) began seeking guidance from herpetologists (and other experts) to assist in the identification of animals and animal parts seen in the burgeoning trade in international wildlife. The most important papers on forensic herpetology from this early period are those of Brazaitis (1984, 1986, 1987, 1989) and King and Brazaitis (1971), who described detailed methods for identifying crocodilian species from leather products in commercial trade. Interestingly, the only published papers that use the term "forensic herpetology" in their titles appear to be those of Brattstrom (1998a, 1998b), who described two forensic case

reports involving reptiles. Dodd and Bartholomew (2002), in their review of the Fourth World Congress of Herpetology, noted the emergence of a new journal (*Applied Herpetology*; launched in 2003) that would include forensic herpetology as a specific area of focus. This marked a major milestone in the coalescence of forensic herpetology as a recognized area of research by herpetologists.

Forensic Science

As defined here and elsewhere throughout this series, forensic science is the application of science in a legal context. This legal context then is what distinguishes forensic herpetology from other aspects of applied herpetology (Colbert et al., 1999). It is important to note that, while sound science is central to all aspects of investigation, forensic practice is also contingent upon the legal system in which such work is conducted. Rules of evidence vary throughout the world, and what may be admissible in one legislature may not be acceptable in other jurisdictions (see other papers in this series). In federal court systems in the USA, for example, judges — not scientists — serve as gatekeepers for what evidence may be presented in court as science (Giannelli, 1993). In addition, the criteria by which scientists are designated as expert witnesses are often distinct from those that dictate what may be presented as science.

As emphasized throughout this series, the application of forensic herpetology brings with it a stringent set of protocols and standardized methods, to ensure the integrity of the investigation for presentation in court. This may require detailed training in crime scene investigation, chain of custody maintenance, evidence handling and storage, digital photography, forensic documentation, biosafety, and expert witness testimony, in addition to the expert's specific area of expertise (see Frye, this series). Accreditation of the laboratory where the work is conducted can also be important for quality control purposes (see Hart and Budgen, this series). In some instances, these stringent criteria are beyond the scope of the practicing herpetologist and therefore must be considered carefully before agreeing on what terms s/he can participate in a forensic investigation.

Amphibians and Reptiles as Perpetrators in Forensic Cases

As noted previously, many examples of forensic herpetology involve aspects of human forensics and medical herpetology. These are most commonly related to human injury or cause of death investigations. Examples are provided below. In respect to cases where reptiles/amphibians have bitten or attacked another animal or person, it is important to be aware of the instinctive reaction of a particular species/individual to the perceived threat. Most species will behave in an expected or "ritualistic" manner in a given situation, although temperaments will vary among individuals. Useful advice can be sought in legal cases from a trained animal behaviorist.

Snake-bite

Foremost among these are studies of snake-bites. Examples include forensic investigations of accidental bites (Eaker et al., 1969; White and Pounder, 1984; Tu, 2001; Wankhede, 2004; Brunda et al., 2006a, 2006b), attempted murder using venomous snakes (Brattstrom, 1998a), and cases of attempted suicide (Knight et al., 1977; Sutherland et al., 1978; Yadlowski et al., 1980; Morgan et al., 2006). The literature on snake bites is too voluminous — and exists in many different languages — to permit it to be summarized here. The subject is of particular concern for forensic herpetologists given the diverse range of venomous snakes now kept as pets and potentially encountered at crime scenes.

Other bites/wound identification

Harding and Wolf (2006) provided a recent review of American alligator (*Alligator mississippiensis*) attacks in Florida, USA, and described methods for distinguishing alligator bites from those of other aquatic predators in a forensic context. Other wounds of potential interest to medical examiners include those caused by constricting snakes (Cooper, 1967; McCarty et al., 1989; Kleinman et al., 1998) and iguanas (Merin and Bush, 2000; Bibbs et al., 2001), both commonly kept as pets.

Toad venom

Several forensic studies have focused on various aspects of toad venom. These include dried toad venom in traditional Chinese medicine (Barry et al., 1996; Ko et al., 1996), bufotenine drug abuse (Chamakura, 1994), and toad soup and egg toxicity (Chern et al., 1991; Keomany et al., 2007; Kuo et al., 2007).

Allergies

A number of case reports of forensic interest have documented human allergies to reptiles and amphibians. These include allergies to iguanas (Kelso et al., 2000), cobra venom (Prescott and Potter, 2005), and frog legs (Steurich, 1996).

Infection/disease transmission

Pathogens that can be transmitted to humans through contact with reptiles include *Salmonella* species, especially from chelonians (Marschang and Chitty, 2004), *Serratia marcescens* cellulitis from iguana bites (Hsieh and Babl, 1999), and various organisms from alligator bites (Raynor et al., 1983). Lavarde and Fornes (1999) presented an interesting case-report of lethal infection in a human from a snake parasite. Rattlesnake capsules consumed in Mexican folk-medicine can cause *Salmonella* infection (Cone et al., 1990), as can contact with a wide range of reptiles.

Amphibians and Reptiles as Victims in Forensic Cases

Increasingly, herpetologists and other experts are asked to assist with legal investigations in which reptiles and amphibians are the target of suspected crimes. While this field of inquiry is very diverse, the most common issues involved are summarized below. Evidential material may range from live animals in the pet trade to decaying carcasses, bones, teeth, leather goods, meat samples, shed skins, eggs, blood, venom, internal organs, traditional medicines and numerous other curios made from reptiles and amphibians and sold to tourists in many parts of the world.

Crime scene investigation

Forensic herpetologists are occasionally asked to assist with crime scene investigations, documenting and collecting evidence where suspected crimes may have occurred. Crime scene investigation requires specialized training (see Lawton and Cooper, this series, and Cooper and Cooper, 2007 for detailed reviews) and in the forensic herpetology context, may require experience in the handling of venomous snakes. If the forensic herpetologist lacks training with venomous snakes, zoo personnel who work with such animals on a daily basis or an animal behaviourist who has studied and handled such species may be able to assist. Brazaitis (2003) provides interesting accounts of his experiences assisting at crime scenes involving reptiles.

Species identification

Species identification is probably the most common request made of the forensic herpetologist. Determining whether a crime has been committed against an animal often depends upon the latter's identity. This is especially true of CITES enforcement issues, where international trade in CITES-listed species is regulated. The primary challenges for the forensic herpetologist in such situations are (a) the geographic origin of the evidence is rarely known with certainty and (b) the evidence is rarely complete — consisting instead of parts of or products that are manufactured from animals. In cases where traditional field identification guides and dichotomous keys prove inadequate, new methods must be developed for identifying such remains. In addition to traditional morphological techniques (Brazaitis, 1986; Busack and Pandya, 2001; Fuchs & Fuchs, 2003), such methods increasingly include genetics (see McDowall, this series) and analytical chemistry (Espinoza et al., 1996, 1999; Espinoza et al., 2007).

While the topic of species identification is too broad to cover in detail here, there is a growing body of literature on the recognition of herpetological species as applied specifically for use in forensic cases. For crocodilians, see: King and Brazaitis (1971), Fuchs (1974), Brazaitis (1984, 1986, 1987, 1989), Charette (1995), Busack and Pandya (2001), and FitzSimmons et al. (2001). For turtles, see: Woodley and Ball (1996), Charette (1999), Roman et al. (1999), Roman and Bowen (2000), Moore et al. (2003), Hsieh et al. (2006), and Rohilla and Tiwari (2008). For

snakes and lizards, see: Tu (2001), Chattopadhyay (2003), Fuchs and Fuchs (2003), Wong et al. (2004), Chattopadhyay and Guha (2005), Baker (2006), and Guha and Kashyap (2006). For amphibians, see: Yang et al. (2002).

Veterinary forensic examination

Veterinary examinations are often required in forensic herpetology cases. These may consist of postmortem (necropsy) examinations, or evaluations of live animals. Questions of concern include the cause of death, cause of ill-health during life, overall health and pathology of the animal, and assessment for possible evidence of abuse. For detailed treatment of the subject, see Cooper, J.E. (this volume) and Cooper and Cooper (2007, 2008), Sinclair et al. (2006) and Merck (2007). Warwick et al. (1995) discussed the health and welfare of reptiles in captivity; this multi-author work remains an important text in legal cases relating to the welfare of these species.

Examination of a reptile/amphibian may be requested to assess the animal's welfare and, depending on the legislation, whether or not it has "suffered". Methods of assessing welfare in animals, including reptiles and amphibians, include measurement of physiological and immunological parameters, presence of lesions or clinical signs of disease, productivity (eggs, etc.) and behavioral responses to various stimuli. Morton and Griffiths (1985) recommended guidelines for the recognition of pain, distress and discomfort in laboratory animals. This can serve as a template that can be modified for the assessment of other species, in other environments, including reptiles and amphibians. Welfare assessment is not easy once an animal has died; however, lesions associated with pain can be verified by a pathologist and used as evidence. Documenting the husbandry conditions under which the animal was kept (crime scene investigation) can also be important in these cases.

Geographic origin

In addition to the basic questions of "What species is it?" and "How did it die?", investigators are often interested in the geographic origin of the animal. It may be necessary to know where the animal was taken from the wild to determine if a crime has been committed. From a scientific perspective, such questions are typically difficult to answer and may require detailed research including the investigation of isotopes (Hobson, 1999; Bowen et al., 2005) or population genetic studies (Encalada et al., 1994; Withler et al., 2004). Such base-line forensic data are lacking for most reptile and amphibian species. This is an area of much-needed research. In some cases, morphological variability may provide clues to geographic origin.

Captive versus wild identification

Whether an animal was taken from the wild or was bred in captivity is another topic of forensic interest. Captive-bred animals may be exempt from certain wildlife laws

in some countries. While the presence of a "designer color-morph", i.e., a color-form of the animal that is not found in the wild, may suggest to the investigator that an animal was produced in captivity, little forensic research has been published on the subject (see also Frye, this series). Areas for future study include differences in parasite numbers in wild/free-living versus captive-bred animals, along with baseline research on isotope profiles (see *Geographic origin* above). For example, if a reticulated python (native to Asia) confiscated in an investigation yielded isotope profiles consistent with birth in the Midwest of the USA, this would suggest that the animal was produced in captivity. Genetic studies may also prove useful (Renshaw et al., 2006), as would amphibian studies verifying whether or not toxin levels (e.g., in dendrobatid frogs) can be used to distinguish captive versus wild individuals in a forensic context.

Recognition of individual animals

In contrast to the topics of geographic origin and captive versus wild identification, comparatively substantial research has been published in the herpetological literature on the individual recognition of reptiles and amphibians (based primarily on the necessity to recognize individuals in field ecology studies). The subject is of forensic interest in cases where an analyst may be asked to match a photograph of an animal with a carcass found at a crime scene. Most studies on individualization (the recognition of individual animals) are based on morphological characters (see review by Ferner, 2007), but, increasingly, genetics may be useful (Lang et al., 1993). In the forensic community, species identification is considered to be a "class character"-based identification, whereas individualization is "individual character"-based. Individualization receives a very high level of scrutiny by forensic scientists and is more likely to be challenged in court. This is another area where research in forensic herpetology is needed.

Scientific dating

A final question often asked of wildlife evidence is "How old is it?" As posed here, the question relates to the calendar year in which the animal died, not whether the animal was a juvenile or adult at death — nor its time of death (see Cooper, J.E., this volume). The question is important in some forensic cases (O'Bannon, 1994) because historic antiquities or prehistoric specimens may be exempt from some wildlife legislation. While radiocarbon dating is occasionally applied to wildlife cases, I know of no published examples in forensic herpetology where such chronometric techniques were used, in contrast to work on mammals. However, such methods have considerable potential in legal cases where the age of artifacts made from reptiles is critical to the investigation.

Miscellaneous applications of forensic herpetology

As noted by Cooper, M.E. (this volume), forensic-style investigations are also applied in such diverse areas as insurance claims, allegations of malpractice by veterinarians, and environmental impact studies. A case of unscrupulous marketing of snake-bite antivenoms was recently published by Warrell (2008). Food contamination cases involving lizards have also been reported (Chattopadhyay, 2003; Chattopadhyay and Guha, 2005; Guha and Kashyap, 2006). Hoser (1994) commented on the link between snakes and illegal drugs. Cooper and Cooper (1996) noted potential legal implications of using snakes in traditional dancing in Africa. Cengiz et al. (2002) used analytical chemistry to predict the death location of a sea turtle in a forensic investigation. Brattstrom (1998b) described the unusual application of forensic herpetology and vertebrate taphonomy to a suspected child molestation case.

Summary

The forensic application of herpetology continues to expand as law enforcement officials and others increasingly encounter reptiles and amphibians in legal cases. Most researchers who are conducting forensic herpetological casework will have expertise in a specific sub-discipline (such as taxonomy and species identification, veterinary pathology, analytical chemistry, toxicology, etc.). Casework often requires interdisciplinary interaction, and multiple experts may be needed to investigate a single case. Standardized methods and formal protocols are an important aspect of the discipline. Continued and new avenues of research are needed in many areas of forensic herpetology, including alpha-taxonomy, refining our understanding of the distribution of species, and new and enhanced methods in species' identification and individualization. Critical research is also need in the areas of geographic sourcing and the identification of captive-bred versus wild-collected animals. A more detailed review of the history of forensic herpetology is needed (especially as applied in different parts of the world and in languages other than English), as are more published case studies documenting the broad application of herpetology to forensic investigations.

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