Digital near-infrared photography as a tool in forensic snake skin identification

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This project demonstrates that near-infrared (NIR) imaging with an alternate light source (ALS) and digital photography are useful tools for revealing and documenting original dorsal skin patterns found on dyed snake leather products in the wildlife trade. We used an Omnichrome Spectrum 9000+ ALS at NIR wavelengths of 700 nm to reveal dorsal patterns on a tanned and dyed reticulated python skin (*Python reticulatus*) submitted for forensic analysis. Under NIR imaging, this pattern was easily photographed using a Fujifilm Finepix IS-Pro digital camera designed specifically for forensic ultraviolet (UV) and infrared (IR) photography. These methods have great potential for species identification based on highly modified animal products (such as dyed snake leather), thus contributing to CITES enforcement efforts.

Key words: CITES enforcement, digital photography, near-infrared (NIR) imaging, snake leather identification, wildlife trade

INTRODUCTION

"*A study of the skin by infra-red photography may reveal many things which are not apparent to the eye nor in a normal photograph*." Walter Clark (1934:128)

Over recent decades, herpetologists, forensic scientists and other researchers have increasingly collaborated to apply rigorous scientific techniques to legal investigations involving the identification of reptiles and amphibians in the wildlife trade (Brazaitis, 1986; Busack & Pandya, 2001; Baker, 2008; Cooper et al., 2008, 2009). Commonly referred to as wildlife forensics and forensic herpetology, the discipline often faces unique challenges not typically encountered by traditional field biologists. Foremost among these challenges 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.

Among the most common evidence items encountered by the forensic herpetologist tasked with species identification are leather products (Brazaitis, 1986), especially tanned snake skins used in the garment industry (Fuchs & Fuchs, 2003). Several snake species and specific populations commonly used to make leather may be protected by the countries in which they occur, by United States code, or by international treaties such as CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Examples include all boas (Boidae), all pythons (Pythonidae) and Asian cobras (*Naja* spp. and *Ophiophagus hannah*). International trade in these species is highly regulated, and accurate identification of these animals and products made from them is critical for wildlife conservation and enforcement efforts.

While the identification of whole, un-dyed snake skins may be a relatively simple task for the forensic herpetologist using traditional morphological characters such as dorsal pattern (Fuchs & Fuchs, 2003), analysis becomes more challenging when such skins are commercially processed - then dyed various colors, cut into smaller pieces and used to manufacture a wide range of leather goods including shoes, wallets, and purses. The tanning and dying processes (especially dark dye) typically obscure any original dorsal pattern, making species identification difficult. In these cases, the forensic herpetologist may rely on scale form and shape, such as keeled vs. smooth scale morphology, and dorsal scale row counts to determine if a leather item presents morphology that is consistent with that which is diagnostic for the species it was declared to be (Baker, 2006). In some instances though, these characters alone are insufficient for identifying a leather product to species. The tanning process typically degrades DNA in the skin, thus genetic methods for identifying leather goods are generally lacking. Other methods then are needed for analyzing dyed skins.

Here we show that near-infrared (NIR) imaging and digital photography are useful tools for revealing and documenting original dorsal patterns on dyed snake skins, and for facilitating species identification for law enforcement purposes. Alternate light source (ALS) techniques (including ultraviolet and infrared imaging) and digital photography are now commonly used by forensic scientists to detect and document a wide range of evidence not visible to the human eye under typical lighting conditions (Blitzer & Jacobia, 2002; Lennard & Stilovic, 2004; Page, 2006; Schneider, 2006). Examples include detection of obliterated writings (Leaver & Smith, 1999; Sugawara, 2004), bloodstains (Perkins,

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2005), gunshot residue (Bailey, 2007), fingerprints (Hardwick et al., 1990), tattoos that have decomposed or been deliberately removed (Bennett & Rockhold, 1999; McKechnie et al., 2008) and bite-marks, bruises and other skin wounds (Barsley et al., 1990; Klingle & Reiter, 2008). Similar techniques are also used in archaeology, art history, astronomy, biomedicine and aerial survey work (Verhoeven, 2008).

METHODS

The tanned snake skin illustrated in Fig. 1A was submitted to our laboratory for forensic analysis and species identification. The skin was imported into the United States without proper documentation. The partial dorsal skin is dyed black and measures approximately 60 cm long x 17 cm wide. The dorsal scales are unkeeled in rows of approximately 40 scales. The narrowing of the skin (not illustrated) suggests this piece was from near the tail of the snake, rather than the mid-body. Thus, dorsal scale counts on this item could not be relied on for comparison to published mid-body ranges of large snakes.

Overall, however, the generally large size of the skin, general scale shape and lack of keeling on the dorsal scalation suggested it might be from a python (Pythonidae), all of which are protected under CITES. To test this hypothesis, we examined the skin with an alternate light source (ALS) in both the ultraviolet (UV) and infrared (IR) range to see if the original dorsal skin pattern and pigmentation could be detected under the black dye. We experimented with preset wavelengths in the range of 400–700 nm (400, 450, 485, 530, 570, 700 nm) with a variety of coloured viewing goggles (red, orange, yellow) to determine which variables might produce the best results.

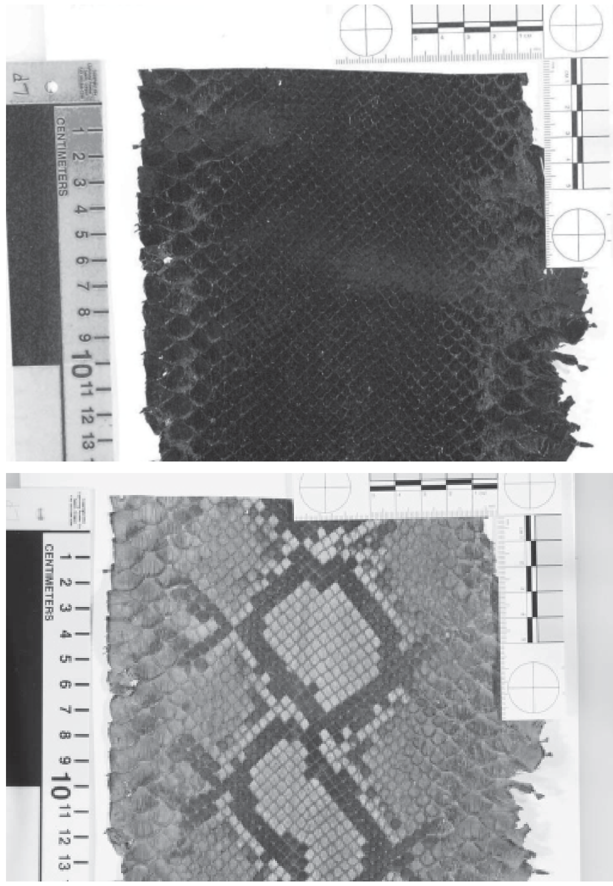

Fig. 1. Tanned and dyed snake skin submitted for forensic analysis and species identification (A) photographed with a standard digital camera (Kodak DCS Pro 14n) under normal lighting conditions, and (B) same skin illuminated with an alternate light source in the near-IR range (700 nm) and photographed with a Fujifilm Finepix IS-Pro forensic digital camera.

Infrared imaging

What we commonly call "light" consists of radiation waves on the Electromagnetic (EM) Spectrum. From shortest to longest wavelengths, the EM Spectrum includes gamma rays, X-rays, ultraviolet radiation, visible radiation and infrared radiation. This is followed by microwaves and radio waves (Verhoeven, 2008). The radiation is transmitted in packets called photons. Ultraviolet (UV) and infrared (IR) imaging are techniques commonly used in forensics to detect pigments not clearly visible on the visible light portion of the EM Spectrum. UV and IR radiation is measured in nanometers (nm).

The visible light perceived by humans' ranges from wavelengths of approximately 380–750 nm (Verhoeven, 2008). Absolute thresholds vary from person to person and according to viewing conditions. Wavelengths from approximately 10–380 nm are termed ultraviolet. The IR portion of the spectrum ranges from approximately 750 nm–1 mm, with near-infrared (NIR) ranging from 750–1400 nm (Verhoeven, 2008). Objects exposed to NIR radiation (such as from an alternate light source) absorb, reflect and transmit these photons to varying degrees. Such infrared imaging extends the range of visibility of some pigments, allowing the examiner to see patterns or features that were originally obscured. Klingle & Reiter (2008) note that light waves begin penetrating the surface of human skin around 200 nm and increase in depth of penetration (up to 3 mm) as you go up the IR spectrum (to 790 nm). Because UV and IR radiation penetrates the skin, it can be a useful tool for detecting pigments otherwise not visible on the surface of the skin.

For this analysis, we used an Omnichrome Spectrum 9000+ alternate light source to illuminate the tanned and dyed snake skin illustrated in Fig. 1A. The skin was examined in a dark room with no overhead lights using only the alternate light source. We tested a range of wavelengths in the ultraviolet and infrared range, and found best results in the near-infrared range of 700 nm. Care must be taken when using IR imaging because objects generate heat when they absorb radiation at these wavelengths. An evidence item can become hot, damaged or even catch fire if the IR light source illuminates an area for too long. Documenting the results of an IR analysis is now a relatively easy process using recent advances in digital photography (Tetley & Young, 2007).

Digital Photography

Prior to digital photography, UV and IR photography was accomplished using film cameras. The advent of digital cameras has greatly simplified the process (Tetley

& Young, 2007, 2008a, 2008b). Most digital cameras, however, have an internal filter that prevents the passage of UV and IR radiation. Thus, not all digital cameras are capable of documenting the results of UV and IR analysis. Recently, Fujifilm developed a series of digital cameras specifically for law enforcement and forensic UV and IR photography. One of the recent models is the Fujifilm Finepix IS-Pro (Tetley & Young, 2008a). The camera lacks the "hot mirror" from the charge-coupled device (CCD) allowing spectral sensitivity ranging from 380–1000 nm (Tetley & Young, 2008a).

Fig. 1A illustrates the skin photographed with a standard (non-IR) digital camera (Kodak DCS Pro 14n; 60 mm lens) to show how it appears when illuminated only with light in the visible spectrum (overhead fluorescent light). We then used a Fujifilm Finepix IS-Pro (with the same 60 mm lens) to photograph the same skin illuminated with an alternate light source (ALS) in the near infrared (NIR) range of 700 nm. The skin was photographed using only the default settings of the camera. Care should be taken to adjust the distance and direction from the light source to the skin surface to assure the optimum contrast and detail. This is made possible with the live-view feature available on this model camera. The operator has the ability to turn on the live-view mode to view the dyed surface while experimenting with a variety of different wave lengths, filters and lighting techniques.

For this experiment, no additional filters (available for optional purchase), coloured goggles or other special lighting were required to achieve the results seen in Fig. 1B. The resulting image was converted into black-and-white mode using Adobe Photoshop CS3 Extended and is shown in Fig. 1B. While the Fujifilm Finepix IS-Pro may be cost prohibitive to many researchers, it is increasingly possible to modify non-IR digital cameras to produce similar results (Verhoeven, 2008).

DISCUSSION

NIR imaging revealed the original dorsal skin pattern of this snake hidden under the black dye. The reticulate, net-like pattern seen in Fig. 1B is diagnostic of reticulated python (*Python reticulatus*). Pythons are commonly exploited for the leather trade (Dodd, 1986; Groombridge & Luxmoore, 1991; Shine et al., 1999; Keogh, et al., 2001), with hundreds of thousands of skins of *P. reticulatus* alone taken each year from the wild (Shine et al., 1999). Forensic analysis in this case resulted in identification to the species level and provided evidence confirming the original suspicion that the skin was from a python.

We have shown here that near-infrared imaging and digital photography of dyed snake skins are useful forensic tools for species identification of snakes that display diagnostic patterns of pigmentation when utilized in highly modified animal products in the wildlife trade. Over the years (Morrell & Reinholz, 1999), our laboratory has had similar success identifying dyed snake skins on finished leather products such as shoes and handbags. Species we have identified using these techniques include pythons (*P. reticulatus* and *P. molurus*), anacondas (*Eunectes*), puff-faced water snakes (*Homalopsis buccata*) and Bocourt's water snakes (*Enhydris bocourti*). Further research remains to be conducted on bleached leathers and a wider range of dyes and manufacturing techniques. While successful results are not achieved in every case (presumably due to varying tanning techniques and chemical dyes), these IR methods are often helpful in identifying skins that would otherwise go unidentified. The technique is fast, safe, non-destructive and can be used to rapidly evaluate and document a large number of skins or finished products with minimal effort, and thus has great potential for CITES enforcement efforts.

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