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Visualisation of Latent Fingerprint on Wild Bird Eggshells by Alternate Light Sources Following Superglue Fuming

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Abstract

The theft of the eggs of endangered or protected species of bird, and subsequent reduction in wildlife population, is a significant problem worldwide. Detection rates are comparatively low towards this type of crime and fingerprinting of egg shells is infrequently utilised due to the technical barrier. This paper explores a novel technique using cyanoacrylate (superglue) fuming in conjunction with fluorescent dye to visualise latent fingerprints upon avian eggshells assisted with alternate light sources. A systematic investigation of experimental parameters has also been carried out to optimise the condition for the fingerprint visualisation. This research project has successfully developed latent fingerprints upon smooth wild bird eggshells but was less successful on developing prints on more textured, porous eggshells.

Keywords: Fingerprint; Eggshell; Superglue fuming; Fluorescent dye

Introduction

In commissioning this study, the Forensic Working Group for the Partnership against Wildlife Crime aim to meet UK Wildlife Crime Priorities for prevention and detection of wild bird persecution through improvements in detection techniques for egg theft [1]. This category of crime is an ongoing problem for wildlife officers and wild bird conservationists, in spite of a change in the law in 1954 that made the taking or possession of wild birds' eggs illegal and subsequent introduction of custodial sentences in 2011 [2].

Latent fingerprints are the most common type of print found at a crime scene and on stolen goods [3]. The method used to detect and collect fingerprints is often dictated by their composition, the type of substrate the prints are found upon and the practicality of the technique in a given situation [4]. Eggs are generally not thought to be a favourable medium for development of friction ridge prints, a factor which can be attributed to shell structure and composition [5]. Very limited information regarding the detection of fingerprints on eggshells can be found in literature. Ferguson et al. in 2013 attempted to visualise latent prints on the surface of chicken eggs, amongst other foodstuffs [6]. Out of the seven foodstuffs tested, eggs (along with potato) were the least successful surface for enhancing latent fingerprints.

There is urgent need to address this challenging area and make fingerprint evidence available for use in possible criminal proceedings relating to the theft of bird eggs. Fingerprints on eggs may be deposited during collection and/or egg preparation. Shorrock (2005) details that the RSPB Investigations Section hold a database that compiles information on known egg collectors and information relating to egg theft from sought after species [5]. Analysis of fingerprints from criminal activities may highlight similarities to fingerprints contained within the aforementioned database. Additionally, analysis of fingerprints can assist in intelligence gathering relating to the collection and trade of eggs. Whilst eggs are reported to be problematic for the collection of fingerprints, housing units containing eggs (for example glass cabinets) may be helpful and be of value when the ownership of a collection cannot be established with a high degree of certainty [5]. However, recovery of fingerprints from eggs provides a positive, physical link and consequently stronger evidence. This paper explores the visualisation of latent fingerprints upon wild avian eggshells using the cyanoacrylate fuming method, which involves heating a sample of superglue in an enclosed chamber to allow polymerisation of the cyanoacrylate monomers [7]. This procedure is commonly used on non-porous surfaces such as metals, tape and plastics [8]. However, this project aims to show that it is also possible to carry out superglue fuming on avian eggshells, which are semi-porous [9]. Superglue fuming is rarely used in isolation and is often used in conjunction with stains or dyes due to the poly-ethyl-cyanoacrylate deposits being white and providing poor contrast against substrates that are pale in colour [10,11]. In this work, the eggshells were treated with Basic Yellow 40 dye solution before the visualisation under the alternate light sources. This methodology was indicated by the results from extensive preliminary studies on chicken eggs in our research group. Different combinations of excitation and viewing filters (in wavelength) are tested in order to achieve the optimal quality of the fingerprint images. In this research, superglue fuming combined with Basic Yellow 40 dye and fluorescence detection resulted in clearly enhanced quality of latent marks compared with other conventional development methods.

Materials and Methods

Materials

All the wild bird eggs investigated in this project were provided by The Royal Society for the Protection of Birds (RSPB) Investigations Section (under Natural England Licence Number: 20113799 and

Countryside Council for Wales Licence Number: 33410:OTH:SB: 2011), including Canada Goose eggs, Lapwing eggs, White Tailed Eagle eggs and Grey Partridge eggs. A selection of eggs from differing species was chosen to compare results on differing shell structures, colourings and composition. Eggs were gently cleaned with a cloth to remove old fingerprints, prior to depositing new prints on the egg's shell.

Basic Yellow 40 dye working solution was produced by dissolving 0.6 g of Basic Yellow 40 powder (Tetra Scene of Crime Ltd., see Figure S1 for chemical structure) into a beaker containing 300 ml of methanol. The solution was then poured into a sealable glass container and shaken to ensure the powder had dissolved and the solution was thoroughly mixed. Cyanoacrylate superglue (general purpose) was purchased from RS Components (Figure S2 for chemical structure).

Fingerprint deposition

The donors were requested not to wash their hands for at least an hour prior to fingerprint deposition. Four types of eggs of different colours and textures (as mentioned above) were selected. The donors were requested to rub their hands together for 10 seconds prior to deposition to evenly distribute the eccrine secretions. The eggs were picked up using the thumb and forefinger and held for 10 seconds, applying approximately the same pressure to each egg.

The cyanoacrylate fuming process

Whilst preliminary studies were carried out using facilities at the North Wales Police Scientific Support Laboratory, the project reported in this paper was conducted at Glyndwr University, simulating realistic operating conditions yet avoiding continued interruption of public laboratory workloads. The fuming chamber was set up based on a home-made upright container. A beaker containing 300 ml of ordinary tap water was placed onto a hotplate, set at 200°C, and the chamber was sealed until the atmosphere inside was at 80% relative humidity (RH, measured by Exo-Terra Humidity Meter). When the RH reached the desired level, the cover was removed and the eggs were placed inside on a stand and 0.5 g of superglue was added to the foil tray on the hotplate. The cover was quickly replaced ensuring that no gaps were present in order to maintain RH and the eggs were left to fume for ten minutes. During the fuming process the RH was maintained between 73% and 76%, which had dropped slightly from 80% due to the chamber being opened. Once fuming was complete the eggs were removed from the chamber and allowed to stand in the fumehood for a further ten minutes to ensure that all harmful fumes were removed.

The Basic Yellow 40 dye treatment

The eggs were lowered carefully into the dye using tongs, taking care not to destroy the fingerprints. The eggs were left in the Basic Yellow 40 dye solution for 20 seconds. The excess dye was then rinsed off gently for ten seconds using de-ionised water and the eggs were left to air dry for approximately 18 hours.

Examination of latent fingerprints

After treatments have been applied, the marks are viewed using variable light sources, to facilitate further enhancement, and photographed using a digital SLR camera. Visualised fingerprints are graded according to the workable quality of the print and potential suitability for comparison with the national fingerprint database (Table 1).

Print Grade	Criteria
0	No development of fingerprint
1	Evidence of a fingerprint but < 1/3 of the fingerprint showing continuous ridges
2	Between 1/3 and 2/3 of the fingerprint showing continuous ridges
3	> 2/3 of the fingerprint showing continuous ridges
4	Full development – whole mark has clear and continuous ridges

Table 1: Fingerprint grading system as used in the UK [12].

Examination of the eggs was carried out in a dark room using a Mason Vactron Quaser 40 MH instrument, which helps visualise and improve the clarity of latent fingerprints that contain fluorescent components. Various wavelengths from a high powered light source were selected using filters. The clarity may be further enhanced by a series of viewing filters that block out particular wavelengths of light. The excitation and viewing filter combination that provided the best clarity and contrast of latent fingerprints was optimised.

All images were captured using a Canon EOS 5D Mark II, a 100mm f/2.8 L-series macro lens and shot in manual mode. All fingerprints were graded in accordance with the CAST system as given in Table 1.

Results and Discussion

Immediately following the cyanoacrylate fuming process, there were no prints visible on the Canada Goose and White-Tailed Eagle eggs, but faint prints could be seen on the Lapwing and Grey Partridge eggs.

Lapwing egg (Patterned Egg)

A single fingerprint was developed successfully by cyanoacrylate fuming and Basic Yellow 40 dye submersion. When examined without filters the best clarity and contrast was seen at 280-413 nm producing a grade two print. It was apparent that as the excitation wavelength increased, the ridges became less continuous and the clarity decreased eventually becoming a grade 0 from 468-526 nm upwards. Shorter wavelengths have higher energy causing the print to fluoresce more strongly but longer wavelengths do not have sufficient energy to promote the fluorescent molecules to an excited state, resulting in little or no fluorescence.

Viewing filters had a significant impact on the quality of the fingerprint and as the filter number increased, the clarity and contrast of the print also increased as shown in Figure 1. The best clarity and contrast was seen at 385-469 nm excitations using a 510 nm viewing filter. Viewing filters also help to overcome the strong background patterns, making the fingerprint appearance more prominent. Without a viewing filter, the fingerprint is a grade one (for 385-469 excitation wavelength) but when viewed through filters (510 nm and 529 nm) the contrast and clarity improves, becoming a grade three. A further increase in the filter wavelength diminishes the quality back to a grade one suggesting that the 593 nm filtration is ineffective at this excitation wavelength. Table 2 provides a summary of results for the Lapwing egg.

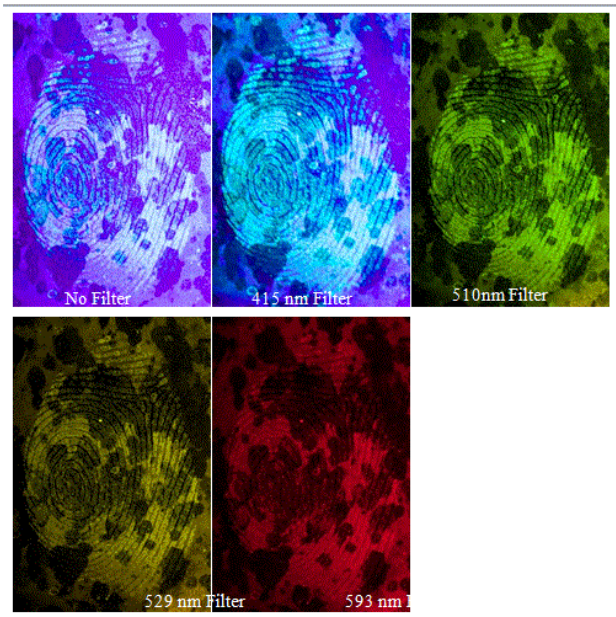

Figure 1: The effect of viewing filters on a Lapwing egg at 385 – 469 nm wavelength of excitation.

Excitation Filter (nm)	Grade without filter	Grade with lowest filter number	Grade with middle filter number	Grade with highest filter number
280-413	2	1	2	0
385-469	1	2	3	1
385-509	1	1	3	1
468-526	0	0	1	0
473-548	0	0	1	0
491-548	0	0	0	0
503-591	0	0	0	0

Table 2: Summary of fingerprint grades for the Lapwing egg.

It was also noted that the dark areas of the eggshell's pattern gave better contrast than the lighter areas when using certain combinations of excitation and viewing filters (Figure 2). The wavelength emitted from the print may be too similar to the eggshell background, giving poor contrast between the two. This suggests that Basic Yellow 40 dye may be more successful and produce higher-grade prints on eggs that have a darker shell. When using a higher numbered viewing filter, the surface pattern of the egg is less prominent and the print has more clarity.

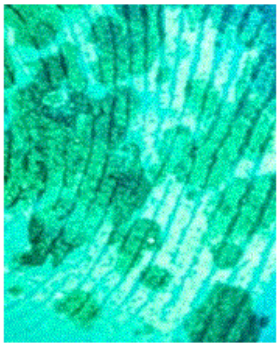

Figure 2: Contrasting areas of a Lapwing egg viewed at 385 – 509 nm using a 476 nm filter.

Grey partridge egg (Glossy Egg)

The smooth, glossy surface of the Grey Partridge egg enabled good print deposition and a single print was successfully visualised. As seen with the Lapwing egg, an increase in the excitation wavelength caused the ridge detail of the print to be less clear becoming a grade 0 from 468-526 nm upwards. The clarity and contrast of the print was best at 280-413 nm producing a grade one print.

When examined through viewing filters, the results were similar to the Lapwing egg and an increase in print quality was observed as the viewing filter number increased (Figure 3). The best clarity and contrast was seen at 385-509 nm using a 510 nm viewing filter.

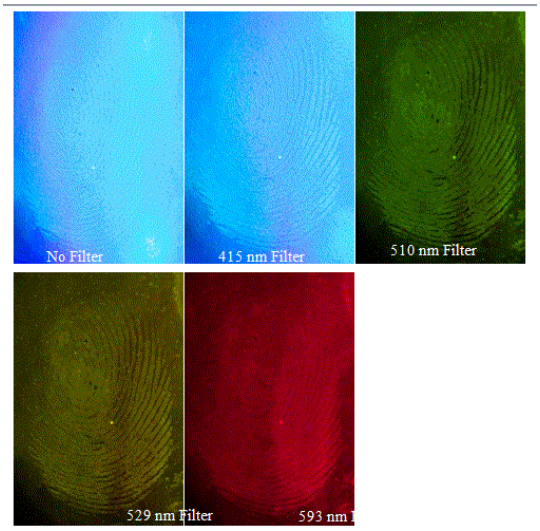

Figure 3: The effect of viewing filters on a Grey Partridge egg at 385 – 509 nm.

Without a filter the print is a grade one but as the viewing filter number increases, the contrast improves becoming a grade two at 510 nm. A further increase in the filter number diminishes the quality back to a grade one suggesting that the 593 nm filter has no effect within the

385-509 nm excitation range. Table 3 provides a summary of results for the Grey Partridge egg.

A quick comparison to Table 2 reveals that the combination of certain excitation and emission wavelengths does not always result in the optimum visualisation for different eggs. We suggest the reason could be down to the difference in the surface profiles of different eggs, both physically and chemically. Certainly this is an area worth further investigation.

Table 3 shows an anomaly at 385-469 nm where there is a reduction in quality when the lowest viewing filter is applied. This is due to the presence of excess cyanoacrylate residue fluorescing too strongly, causing the ridges to overlap and lose clarity. During the fuming process, eggs with good surrounding air circulation appeared to have more cyanoacrylate residue adhering to the surface. Those that were slightly shielded by the test tube rack appeared to have less residue present as seen on an undyed Lapwing egg (Figure 4).

Excitation Filter (nm)	Grade without filter	Grade with lowest filter number	Grade with middle filter number	Grade with highest filter number
280-413	1	1	2	1
385-469	2	1	2	1
385-509	1	1	2	1
468-526	0	0	1	0
473-548	0	0	1	0
491-548	0	0	0	0
503-591	0	0	0	0

Table 3: Summary of fingerprint grades for the Grey Partridge egg.

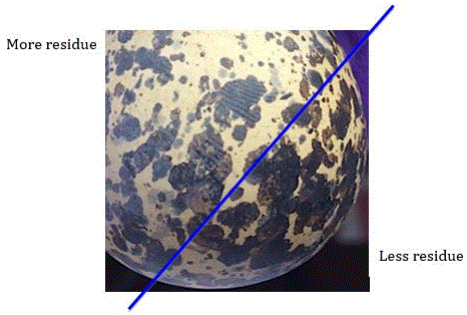

Figure 4: A Lapwing egg showing the differing levels of cyanoacrylate residue.

Canada Goose (textured) and white-tailed eagle egg (porous)

When examined without the use of viewing filters, the Canada Goose and White Tailed Eagle eggs showed no evidence of a print at any excitation wavelength. However, viewing filters did not help to visualise a print and both eggs achieved a fingerprint grade of zero.

The eggs were cyanoacrylate fumed in parallel with others that displayed good print development, suggesting that the egg itself rather than the fuming method contributed to the development failure. The Canada Goose and Eagle eggs were dull and had a rougher surface texture than the other eggs, which may make print deposition more difficult. There were also large pores visible on the surface of the Eagle egg along with a degree of surface contamination (Figure 5).

Figure 5: Surface contamination and porosity of the White-Tailed Eagle egg (left) in comparison to a smooth Goldeneye egg (right).

It may be that a print was deposited but was washed off more easily during the rinsing stage of the development process. It is also likely that more porous surfaces may absorb too much dye resulting in the entire eggshell surface fluorescing thus obscuring the print, as discussed in the HOSDB fingerprint development manual for porous and non-porous surfaces [11].

It is believed that the moisture contained in a fingerprint plays a vital role in cyanoacrylate fuming [13]. It is crucial that this process is carried out in a chamber with 80% relative humidity (RH). Below this level, the print is underdeveloped and above this level the background development is too high [14]. In this work it was not a concern because prints had been successfully developed at a similar RH in a different experiment. However, caution must be given if using a dye post fuming because some dyes may degrade or destroy a fingerprint [14].

Conclusions

In conclusion, the described method reveals that fingerprints can be recovered from eggshells with complex patterns and colours. The latent prints on the Lapwing and Grey Partridge eggs were developed successfully and an improvement in the clarity and contrast was seen when examined using viewing filters. The prints improved by up to two grades and, at certain wavelengths, the fluorescence was strong enough to overcome any eggshell surface patterns. The eggs in this experiment were all fumed using the same method suggesting that the surface texture of an egg has an impact on the quality of a fingerprint.

On the other hand, superglue fuming followed by Basic Yellow 40 dye submersion was unsuccessful on the Canada Goose and White Tailed Eagle eggs. This is likely due to the physical characteristics of the eggs, for example, the shell being of a rougher texture compared to the Lapwing and Partridge eggs. Furthermore, the Canada Goose and White Tailed Eagle eggs appeared to have more surface pores, which may have prevented good adherence of the fingerprint residues, resulting in poorer deposition. It is also possible that the surface pores allowed absorbance of the Basic Yellow 40 dye causing the whole surface to fluoresce and the print to be obscured.

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