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Environmental effects on magnetic fluorescent powder development of fingermarks on bird of prey feathers

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Abstract

A comparison study of the effects of environmental conditions on the development of latent fingermarks on raptor feathers using green magnetic fluorescent powder was undertaken using both sebaceous loaded and natural fingermark deposits. Sparrowhawk feathers were stored in indoor conditions for 60 days (Study 1), and buzzard feathers were left exposed to two different environmental conditions (hidden and visible) for 21 days (Study 2), with developments made at regular ageing periods. In Study 1, latent fingermarks were successfully developed (Grade 1-4) on the indoor feathers up to 60 days after deposition – 98.6% of the loaded deposits and 85.3% for natural deposits. Under outdoor conditions in Study 2, both loaded and natural deposits were affected by environmental exposure. Latent fingermarks were successfully developed up to 14 days after deposition on the outdoor feathers, with some occasional recovery after 21 days. The visible feathers recorded 34.7% (loaded) and 16.4% (natural) successful developments (Grade 1-4), whereas the hidden feathers recorded 46.7% (loaded) and 22.2% (natural) successful developments, suggesting that protection from the environment helps to preserve latent fingermarks on the surface of a feather. Environmental exposure accelerated the deterioration of ridge detail and the number of successful developments.

Key Words: wildlife crime; persecution; fingermarks; environment; feathers

Introduction

In 2016, the Royal Society for the Protection of Birds (RSPB) recorded 81 incidents of raptor persecution in the UK, which included 40 confirmed shootings, 22 poisonings and 15 incidents involving traps. For the first time in over 30 years, there were no successful prosecutions of raptor persecutions [1]. Raptor persecution was one of six UK wildlife crime priorities set in 2013 by the National Wildlife Crime Unit, [2] however it can be difficult to achieve convictions due to a lack of evidence. Toxicological tests can prove poisoning but it cannot confirm human involvement in an offence. Recent examples of cases in Scotland where prosecutors refused to put video evidence of raptor persecution before the court, deeming it non-admissible [1], require other means such as fingermark development or DNA analysis, by which to prove human involvement in these crimes. Proof of human involvement would also be beneficial to the growing illegal parrot trade where exotic birds are captured, forced into small pipes or containers and then sold around Asia or smuggled around the world, [3].

There are a limited, but growing number of studies on the development of latent fingermarks on animals, most recently involving success with elephant ivory [4–7]. In a previous study, fingermarks were successfully developed on the feathers of birds of prey using green magnetic fluorescent powder [8]. These feathers were stored under laboratory conditions for up to 21 days after deposition, with 84% successful development (Grade 1-4). The majority of raptor persecution takes place in remote, isolated countryside therefore the effectiveness of the powder at developing latent fingermarks on feathers left exposed to environmental conditions needs to be established.

The composition of a fingermark has been found to change after deposition, and their subsequent development is affected by a number of factors including donor variability and environmental conditions such as air circulation, condensation, humidity, precipitation, temperature and light exposure [9]. A recent study [10], focusing on the development of latent fingermarks on black PVC surfaces using amino acid powders, found that the 'lifetime' of a fingermark was prolonged by dry conditions, in comparison to ambient conditions. Fingermarks stored in the light were also found to degrade more rapidly than those stored in the dark. However, previous research by Barnett and Berger [11] reported that, in general, the quality of a developed fingermark was influenced by the original quality of the deposition rather than the temperature and humidity under which it had been stored.

A feather can be a challenging substrate for latent fingermark development. Colour contrast between the background surface and a developed mark can be difficult to achieve on a feather due to their varied colours and patterns. The structure of a feather consists of tightly packed barbs and barbules, which can interfere with the clarity of a developed fingermark. Research undertaken on fabrics successfully developed latent fingermark and grab marks on fabric with a UK Home Office compliance of three threads per millimetre (mm), including silk and nylon [12,13] . Similar in structure, it has been determined that feathers with a barb count of three per millimetre (mm) can sustain a fingermark that can be successfully developed; however, feathers with a barb count of two per millimetre (mm), such as those from a golden eagle, can also sustain a developed fingermark [8]. This could be a result of the barbs being less porous than fabric materials.

With the majority of wildlife crime offences against raptors undertaken outdoors, this study examines whether green magnetic fluorescent powder, could successfully develop latent

fingermarks on bird of prey feathers that have been left exposed to environmental conditions. This study also assesses whether this particular powder would continue to work effectively when the deposited fingermarks have been aged for longer ageing periods under laboratory conditions.

Method and Materials

Sample Preparation

Due to the availability of specimens, both sparrowhawk and buzzard carcasses were used in this study. With a similar feather structure of 3 barbs per mm, these feathers are all capable of sustaining latent fingermarks [8]. The carcasses had been frozen for between 5 months and 10 years, with the length of time between death and freezing unknown. The carcasses were defrosted overnight prior to use and the wings were plucked the following day. The plucked feathers were stored at room temperature under normal laboratory conditions in breathable evidence boxes for one day before the deposition of latent fingermarks.

Fingermark deposition and ageing

This study investigated both sebaceous loaded and natural deposits. To facilitate this, the suitability of seven fingermark donors was assessed by the enhancement of their sebaceous loaded and natural fingermarks on a sheet of white, A4 paper using black magnetic powder. Five fingermark donors (all male), were selected based on the amount of ridge detail successfully developed. Three donors had good ridge detail development and two donors had poor development. The donors were asked to refrain from washing their hands for at least 30 minutes prior to fingermark deposition, [14].

For all deposits, the donors were asked to make contact with the surface of the feathers for approximately 2 sec. Fingermarks were deposited in a depletion series of six contacts across the length of each feather from quill to tip. The deposition pressure was not controlled in this study; however, the donors were instructed to keep a constant pressure as much as possible down the depletion series [15]. In total, 450 of each deposit type (natural and loaded) were made for Study 1, and 720 of each were made for the outdoor investigation in Study 2.

Sparrowhawk feathers used in Study 1 were stored in breathable evidence boxes under normal laboratory conditions. Developments were made at 28, 45 and 60 days after deposition. This investigation was replicated 5 times using the same conditions and ageing periods.

Buzzard feathers used in Study 2 were transported to an outdoor compound, where they were left exposed to the environment for a period of 3 weeks. Developments were made at 1, 7, 14 and 21 days after deposition. This investigation was replicated 3 times using the same ageing periods.

Natural fingermarks

For both Study 1 (indoor conditions for 60 days) and Study 2 (environmental exposure for 21 days), natural fingermarks were deposited first. To assist with the build-up of natural sweat deposits, the donors were asked to make a fist with their right hand for 5 minutes, before rubbing their fingers together to even out the natural sweat residue. The donors then deposited a depletion series of six marks with their right forefinger onto the front-side of a feather. Where possible, the feather was held horizontally on the workbench and the deposits were made with the flow of the barbs. This process was repeated for each feather using the same finger.

Loaded fingermarks

For Study 1 and Study 2, the donors were asked to rub their hands around their neck or nose to build up sebaceous sweat on their hands before depositing a depletion of 6 fingermarks with their left forefinger. Where possible, these deposits were also made with the flow of the barbs. This was repeated for each feather using the same finger. The donors were asked to 'reload' their forefinger with sebaceous sweat between feathers.

Enhancement techniques

Green magnetic fluorescent powder (CSI Equipment UK) was applied parallel to the direction of the feather barbs with a standard magnetic brush.

The feathers were photographed before and after enhancement using a Nikon D200 with a 40mm f2.8 Nikon micro lens. A blue Crime-Lite® 82S (10% bandwidth 420-470nm with a 445nm peak) and a yellow long pass filter (1% cut-on point – 476nm) were used for visualisation during the development and photography of the latent fingermarks.

Fingermark grading

Following recovery of the feathers and subsequent enhancement, all of the developed fingermarks were graded according to the amount and quality of ridge detail present. The recommended grading scheme by the Home Office Centre for Applied Science and Technology (CAST) was used throughout (Table 1) [14]. Grade 2 developed fingermarks have ridge detail, but less than one third of the ridges are well defined. These can therefore be of identifiable quality but this is mark dependent, related to the number of characteristics contained within the developed area of ridge detailing. In general, the Home Office classify Grade 3 and 4 as identifiable, but for the purposes of this investigation, a successful development was classified as all latent fingermarks developed at Grade 1-4.

Table 1: CAST fingermark grading [14]

Grade	Level of Detail
0	No evidence of print
1	Some evidence of contact but no ridge detail present
2	Less than 1/3 of print showing clear ridge detail
3	Between 1/3 and 2/3 of print showing clear ridge detail
4	Over 2/3 of print showing clear ridge detail

Outdoor compound area

This was a wild-growing area of land, split into four sections that was completely fenced off to deter larger animals such as foxes from entering, although smaller mammals such as mice could get through the fence. Some feathers were hidden down pre-existing rabbit holes within the compound and covered with some vegetation and others were left visible at the mouth of the holes. Suitable rabbit holes were determined for use by their depth so that the feathers could be placed deep into

the ground to provide some protection from weather. As illustrated in Figure 1, during the experimental period, tall thistles had grown which contributed to the naturally thick ground coverage of long grasses. Daily maximum temperature (^{o}C) and precipitation levels (mm) were recorded from the local weather station, approximately half a mile from the investigation site. A daily average soil temperature (^{o}C) was also recorded via on-site equipment.

Figure 1: Compound area used in outdoor study: (a) overview of the compound area with tall thistles; (b) example of an investigation site marked with a coloured flag. The visible feathers mark the entrance to a rabbit hole.

Results and Discussion

Study 1 (Indoors)

Across a 5-replicate examination period of 28 – 60 days after deposition, the green magnetic fluorescent powder continued to work effectively under laboratory conditions, developing 98% of the 450 originally deposited loaded marks and 85% of the 450 natural marks. The results of the extended indoor study are tabulated below in Table 2.

Table 2: Results from the extended indoor study using green magnetic fluorescent powder to develop both sebaceous loaded and natural fingermark deposits at ageing periods of 28, 45, and 60 days after deposition.

Grading	Loaded			Natural		
	Time since deposition (days)			Time since deposition (days)		
	28	45	60	28	45	60
0	4	1	2	52	37	22
1	27	18	21	10	12	16
2	81	92	94	53	71	77
3	28	33	23	21	24	26
4	10	6	10	14	6	9
Total	150	150	150	150	150	150
Average	2.08	2.16	2.12	1.57	1.67	1.89
Nearest whole grade	2	2	2	2	2	2

A total of 66 loaded deposits and 38 natural deposits were developed at Grade 1 – touch/contact mark. Despite not being of identifiable quality, these marks indicate where the feather has been touched and indicate exact locations of human contact on the feathers. Evidence of human contact on the feathers was still visible 60 days after deposition. If no other fingermarks of a higher grade are present, then a Grade 1 developed fingermark identifies a target area for subsequent DNA investigations that help reduce costs by eliminating speculative swabbing. It was promising to note that both loaded and natural deposits were successfully developed at Grade 3 and 4 after 60 days, (33 and 35 respectively), and are of identifiable quality.

As illustrated in Table 2, the mean developed mark quality did not significantly change across the 60-day investigation for loaded deposits: 2.08 at 28 days, 2.16 at 45 days and 2.12 at 60 days. These results differ from those of the original study for fingermark development on bird of prey feathers, where a mean loaded mark grade of 1.2 was recorded over an ageing period of up to 21 days [8]. The mean natural mark quality increased from 1.57 at 28 days to 1.89 at 60 days. The quality of a developed fingermark may be expected to decrease with time since deposition, as the different components of a fingermark evaporate (water first); however, chemical, physical and biological alterations over time will affect fingermark residue left on surfaces and potentially affect subsequent development [16]. A recent study [17] also identified a spreading of fingermark ridge detail from 1 – 31 days after deposition, after which time the migrated sections begin to degrade, which may help to improve the definition of the ridge edges, resulting in improved clarity of a developed fingermark. This may explain the apparent increase in quality of developed fingermarks under laboratory

conditions from 28 – 60 days in this study.

As can be seen in Figure 2, there were more negative (Grade 0) developments recorded with natural deposits (24.6%) in comparison to the loaded deposits (1.5%). The highest percentage of developments for both loaded and natural deposits was at Grade 2 (59.3% and 44.6% respectively). These can be of identifiable quality but this is mark dependent. Approximately 23% of the loaded and natural fingermark deposits were successfully developed at Grade 3/4 quality. Although this is a lower percentage of grade 4 developments, it is an improvement on the mark quality previously observed on feathers [8].

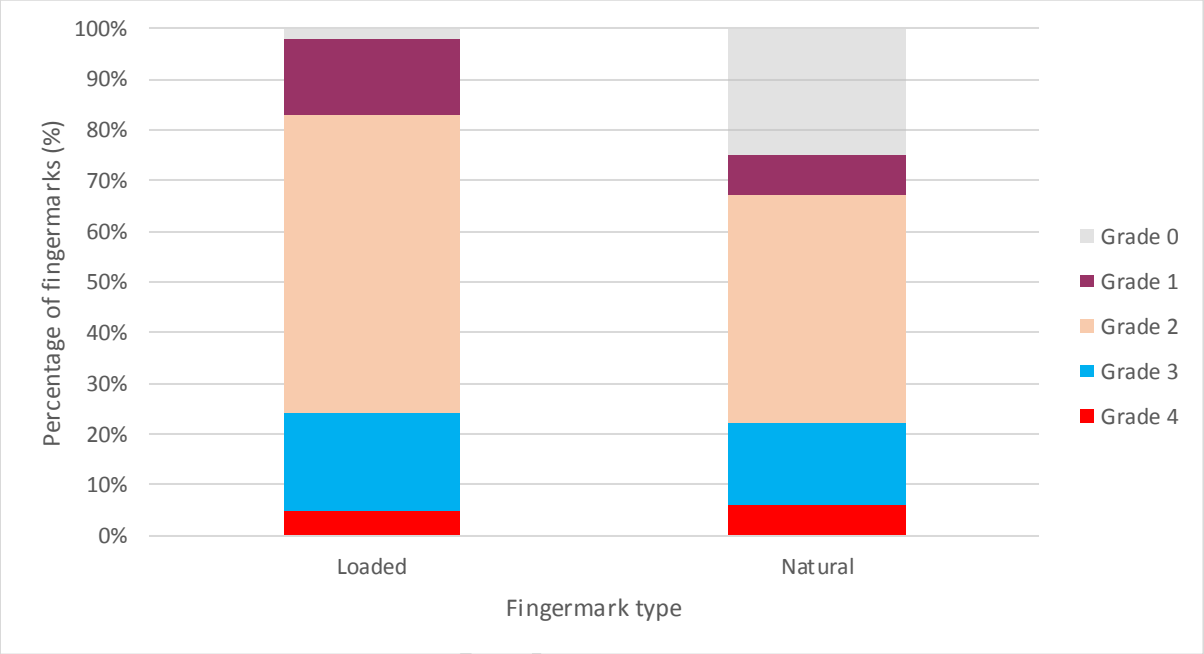

Figure 2: Comparison of total combined fingermark grades recorded at 28, 45 and 60 days after deposition for both sebaceous loaded and natural deposits.

Figure 3 illustrates loaded fingermark deposits successfully developed 60-days after deposition on a sparrowhawk feather using green magnetic fluorescent powder, and recorded as Grade 4 for ridge detail quality. Figure 4 illustrates a whole feather following successful development with green magnetic fluorescent powder. Areas of direct human contact are visible in a six-mark depletion across the length of the feather from quill to tip, all recorded as Grade 2 or 3 for ridge detail quality.

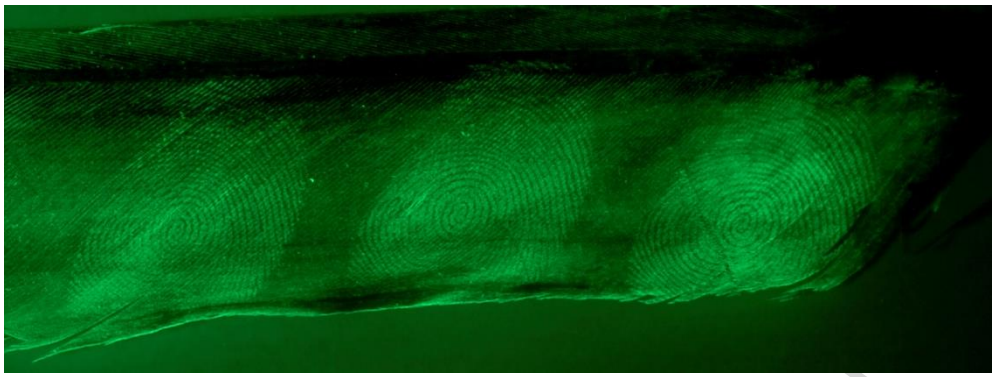

Figure 3: Successful developments: Grade 4 loaded fingermark deposits on a sparrowhawk feather developed 60 days after deposition (Donor 1).

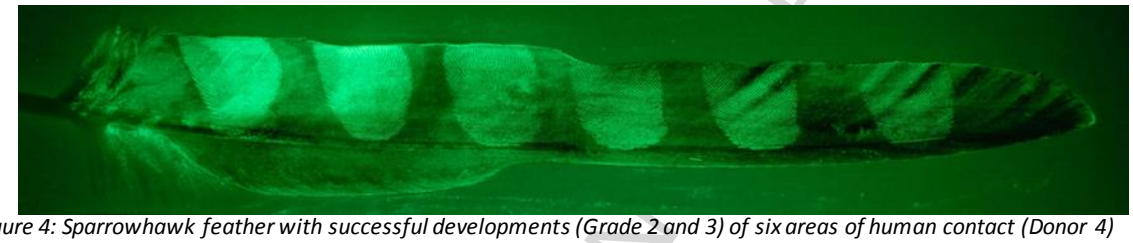

Figure 4: Sparrowhawk feather with successful developments (Grade 2 and 3) of six areas of human contact (Donor 4)

Study 2 (Outdoors)

A 3-replicate examination across a 21-day ageing period was undertaken to establish if the green magnetic fluorescent powder was as successful at developing latent fingermarks on feathers after exposure to environmental conditions (hidden and visible). The results of this outdoor investigation are tabulated below in Table 3.

Table 3: Results from the outdoor study using green magnetic fluorescent powder to develop both sebaceous loaded and natural fingermark deposits at all ageing periods and depositions under different environmental conditions. Note that the No Sample (NS) results have not been included in the average value calculations for each ageing period.

	Loaded Hidden				Loaded Visible			
Grading	Time since deposition (days)				Time since deposition (days)			
	1	7	14	21	1	7	14	21
No Sample (NS)	4	15	25	39	1	2	2	11
0	1	31	33	44	0	68	76	75
1	34	31	23	7	53	20	10	4
2	45	11	8	0	28	0	2	0
3	6	2	1	0	6	0	0	0
4	0	0	0	0	2	0	0	0
Total (minus NS)	86	75	65	51	89	88	88	79
Average	1.65	0.79	0.65	0.14	1.52	0.23	0.16	0.05
Nearest whole grade	2	1	1	0	2	0	0	0

	Natural Hidden				Natural Visible			
Grading	Time since deposition (days)				Time since deposition (days)			
	1	7	14	21	1	7	14	21
No Sample (NS)	10	6	3	36	3	3	6	20
0	24	69	78	54	29	86	84	70
1	6	2	2	0	9	1	0	0
2	44	9	7	0	47	0	0	0
3	6	4	0	0	2	0	0	0
4	0	0	0	0	0	0	0	0
Total (minus NS)	80	84	87	54	87	87	76	70
Average	1.40	0.38	0.18	0.00	1.25	0.01	0.00	0.00
Nearest whole grade	1	0	0	0	1	0	0	0

The highest number of successfully developed (Grade 1-4) loaded marks were recorded at Grade 1 (182 of the 720 original deposits). The most natural marks successfully developed (Grade 1-4) were recorded at Grade 2 (107 of the 720 original deposits). The natural feathers recorded the most Grade 0 (no development) fingermarks - 494 natural deposits in comparison to 328 loaded deposits.

After 1 day of environmental exposure, the mean fingermark quality grade ranged from 1.65 for feathers that were hidden with loaded fingermark deposits, to 1.25 for feathers that were left visible with natural fingermark deposits. These values gradually decreased over the 21-day investigative period until no natural fingermarks of any quality could be developed after 14 days for both feathers left hidden and those that were visible. The feathers with loaded fingermarks still recorded some successful developments 21-days after deposition with a mean quality grading of 0.14 for the hidden feathers and 0.04 for the visible feathers. It should be noted that all of the successful developments at 21-days for the loaded fingermarks were no better than Grade 1 (touch mark).

Figure 5 illustrates that the most negative (Grade 0) developments were observed for the feathers with natural fingermark deposits that were left visible at the entrance to the rabbit holes (74.7%), in comparison to the feathers with loaded fingermark deposits that were hidden in the rabbit holes (30.3%). The most Grade 1 (touch mark) developments were observed on hidden feathers with loaded deposits (26.4%) and on visible feathers with loaded deposits (24.2%), both suggesting areas of direct human contact but with no identifiable ridge detail. The highest percentage of Grade 3 developments was recorded with natural deposits on hidden feathers (2.8%). Feathers with loaded deposits that were left visible recorded the only Grade 4 developments (0.6%) across the 21-day investigative time period. There was little difference in the mark quality observed for both hidden and visible feathers (loaded and natural) after 1 day ageing; however, the loaded marks and hidden feathers decreased less rapidly with time. These results would appear to be in agreement with those reported by De Alcaraz-Foussoul [18] who found that sebaceous fingermark deposits are more durable than natural deposits after exposure to environmental conditions for prolonged periods of time.

These results suggest that the act of hiding protects the feather from weather damage and direct sunlight, which in turn protects the deposited fingermarks from environmental exposure. Overall, the loaded deposits were more robust to withstand the environmental conditions in comparison to the natural deposits. These results are considerably different from those recorded in Study 1, however the effects of uncontrollable environmental exposure such as varied temperature and precipitation levels are known to reduce both the number and quality of successfully developed fingermarks, [9–11,17,]. The regular patterned background caused by the feather barbs (figure 6) could also have a negative effect on the quality of the developed fingermarks for both Study 1 and Study 2, however the use of an imaging-processing tool to remove the background interference may allow the developed ridge detail to become clearer to the observer.

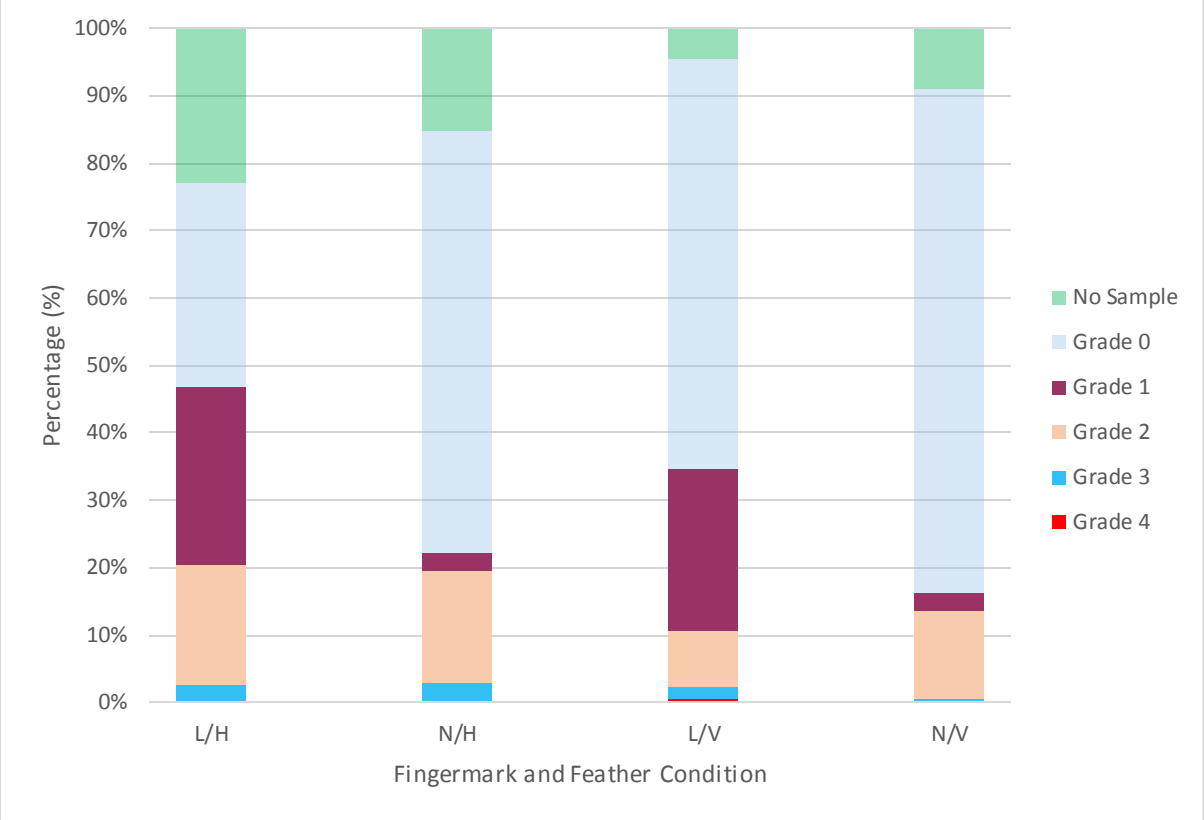

Figure 5: Total grades across all 3 outdoor replicates over 21 days: (L/H) - loaded/hidden feathers; (N/H) - natural/hidden feathers; (L/V) - loaded/visible feathers; (N/V) - natural/visible feathers.

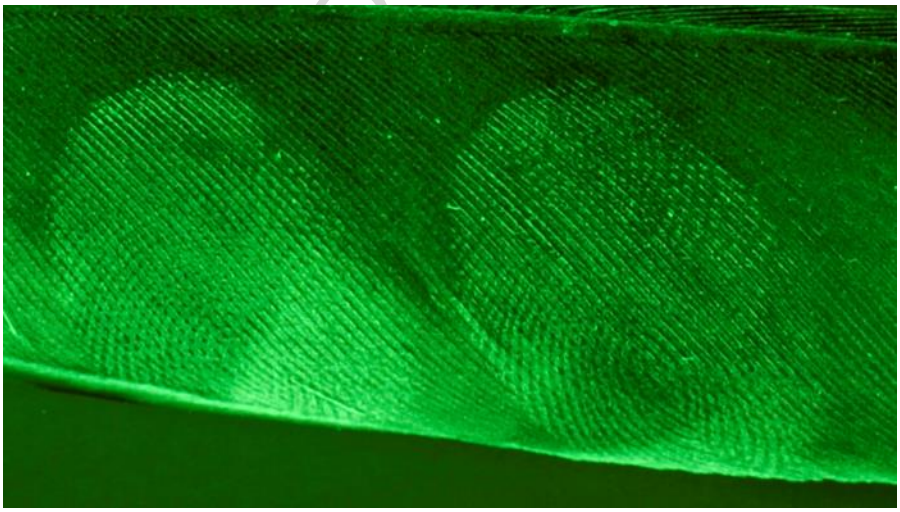

Figure 6: Outdoor ridge detail development: Grade 3 loaded fingermarks on a buzzard feather after 1-day environmental exposure – visible feather (Donor 4).

A number of feathers were damaged and had visible signs of small mammal and invertebrate activity (eaten), wind damage (broken barb structures) or were missing from an investigation site. A total of 19.2% and 6.7% of the Grade 0 results achieved were for recorded damage on the hidden and visible feathers respectively, across all three of the outdoor replications. These feathers have been recorded in this study as 'No Sample' and although fingermark development was attempted on some feathers, (e.g. wind damaged feathers) where the damage was too extensive for any successful development to be gained, a decision was taken not to process them for fingermarks. As a result, these feathers have not been included in the analysis.

It was observed that after 14-days of exposure to environmental conditions, limited ridge detail was developed using the green magnetic fluorescent powder. The majority of developed fingermarks at this stage were of Grade 1 quality (figure 7). In this study, environmental conditions were taken to the extreme by only exposing single feathers. It should be noted that in a realistic wildlife crime situation, often a wing or full carcass is found and therefore these results are indicative of a worst-case scenario for the effect of environmental exposure on subsequent fingermark development.

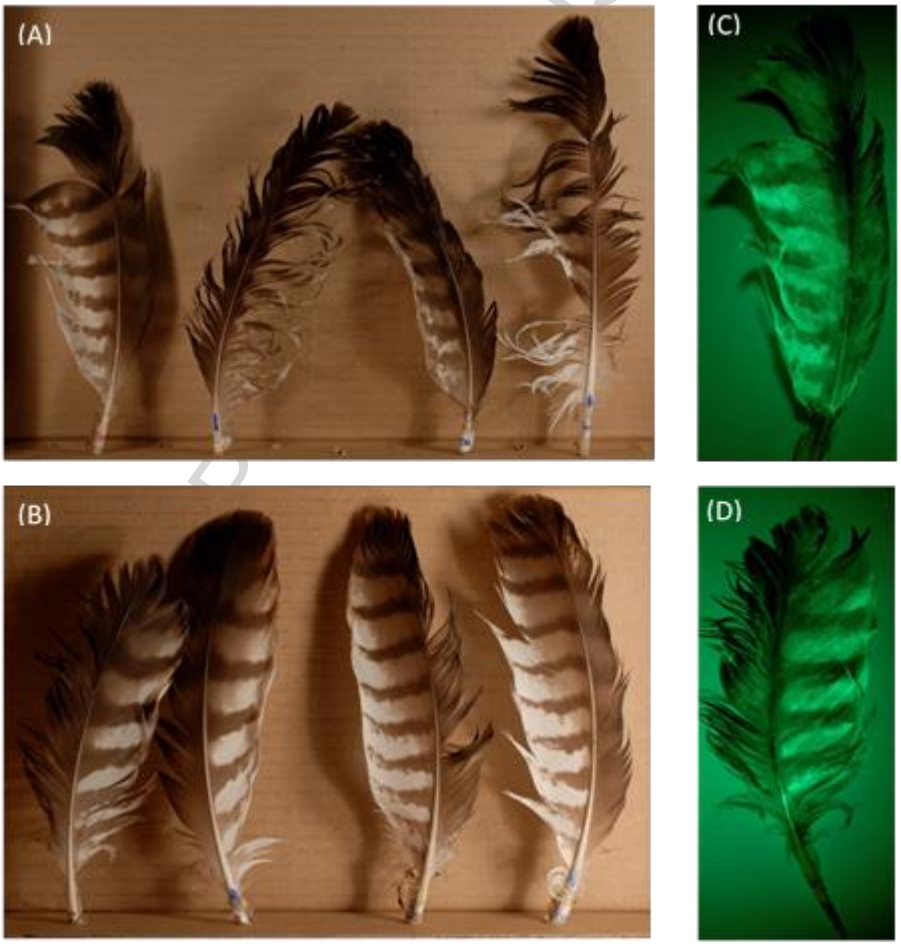

Figure 7: Examples of the varied condition of recovered individual buzzard feathers after environmental exposure: (a) after 7 days for replication 1; (b) after 14 days for replication 2. Successful Grade 1 (touch mark) developments using green magnetic fluorescent powder: (c) after 7 days; (d) after 14 days. Environmental effects on the condition of the feathers after exposure is evident here. Replication 1 (a) was wetter and windier than replication 2 (b), causing the feathers to appear in better condition at the longer ageing period.

Environmental Effects

For the duration of Study 2, daily readings of maximum daily temperature (°C), precipitation levels (mm) and a soil temperature (°C) recorded 30cm below the surface, were taken to establish if fluctuations in environmental conditions were affecting the number of successful developments and/or their quality. Figure 8 illustrates the accumulated rainfall days (mm) for all replications and ageing periods (1, 7, 14 and 21 days), in relation to the mean grade of developed fingermark for each ageing period and environmental condition.

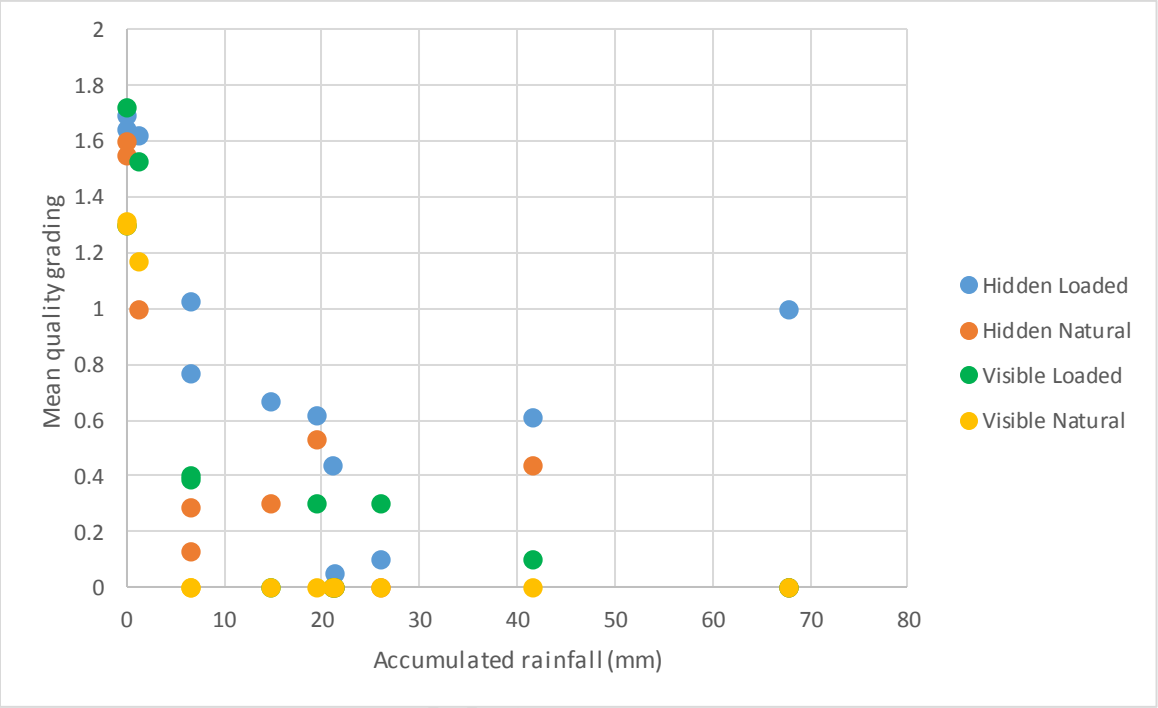

Figure 6: Accumulated precipitation (mm) for all feathers in relation to the mean quality grading across all replications and ageing periods.

Replication 1 had high levels of precipitation in the first 24hrs (1 day) of the investigation, as did replication 2. This appeared to have a considerable and immediate effect on the quality of any developed fingermarks with little to none then observed after 7 days of environmental exposure. Only the loaded fingermarks that were on hidden feathers were still developed after both 14 and 21 days of exposure. Replication 3 was the driest, with little rainfall recorded in the first 7 days. As a result, natural fingermarks on hidden feathers were still successfully developed (Grade 1-4) after 14 days of environmental exposure, with some loaded fingermark development on visible feathers possible after 21 days of exposure.

As can be seen in Figure 8, as the amount of rainfall increases, the mean quality grading of developed fingermarks decreases, despite the environmental conditions they were subjected to (hidden or visible). It is evident that natural fingermark deposits have a greater sensitivity to precipitation than loaded fingermarks – no natural deposits were observed after 1 day of environmental exposure on the wettest replication (2.6mm in the first 24hrs) for the visible feathers and after 7 days for hidden feathers. Natural deposits were still developed after 14 days on hidden feathers during a drier replication. This suggests that with a higher level of precipitation, the lower the mean mark grading for natural deposits.

The maximum air temperature (°C) and soil temperature (°C) recorded 30cm below the surface for all replications and ageing periods (1, 7, 14 and 21 days) was analysed in relation to the mean grade of developed fingermark for each ageing period and environmental condition.

In particular, the results for replication 2 demonstrated a relationship between feathers and air temperature, in particular that of a milder air temperature. The visible feathers for both loaded and natural deposits recorded greater mean mark grades (1.72) when the air temperature was mild i.e. without major fluctuations - a range of 14.4°C to 19.8°C, compared to a mean mark grade of 1.3 for warmer, but wetter conditions. The natural fingermarks demonstrated less of a relationship than the loaded fingermarks but this is likely due to the difference in mark type; however, overall, the air temperature did not appear to have any significant effects on the mean mark grades of all ageing periods across all replications, in comparison to those experienced with varying amounts of precipitation.

There is also an indication that the soil temperature creates some form of preservation effect for the hidden feathers with dry and warm conditions preserving the deposited fingermarks for longer than wetter and colder conditions in the rabbit holes, 30cm below the surface. The mean mark grading for hidden feathers with loaded deposits increased from 1.62 with an average soil temperature of 12.7°C, to 1.69 with an average soil temperature of 14.3°C. The mean mark grading for hidden feathers with natural deposits increased from 1.0 to 1.6 under the same soil temperatures. The act of hiding the feathers appears to provide protection from environmental exposure with both the loaded and natural fingermarks being developed after 14 days of exposure, and the loaded ones still being developed after 21 days of exposure. As the results are not normally distributed, the use of non-parametric tests, such as the Kruskal-Wallis test, was considered; however, the high number of variables made this difficult unless they were assessed independently. As hypothesised, a t-Test (paired two sample for means) showed a significant difference for the fingermark gradings observed for loaded and natural marks under both hidden and visible conditions.

Nonetheless, as with air temperature, the effects of soil temperature on the mean mark grades for all ageing periods across all replications are not as significant as those experienced with varying amounts of precipitation. Therefore, it can be concluded that the success of fingermark development on feathers left exposed to environmental conditions is more reliant on the amount of precipitation experienced by the feathers, rather than on temperature.

From Study 2, it is clear that green magnetic fluorescent powder can effectively develop latent fingermarks (sebaceous loaded and natural) on bird of prey feathers that have been exposed to environmental conditions for up to 21 days after deposition. These results have been achieved using single feathers, so it is likely that a full wing or carcass could provide more protection from the environmental conditions and as a result improve the quality of fingermarks developed. To reach the location of many cases of raptor persecution, a certain amount of physical exertion may be required (e.g. hill walking) and this stress on the body may lead to an increase in the components of a fingermark deposit, resulting in a better quality development.

Further work will investigate the effectiveness of one-step cyanoacrylate fuming (Lumicyano) and gold/zinc vacuum metal deposition (VMD) in comparison to the use of green magnetic fluorescent powder for latent fingermark development on bird of prey feathers.

Conclusion

This study investigated the development of latent fingermarks on bird of prey feathers that were left indoors for an extended ageing period, and on feathers that were left exposed to environmental conditions for up to 21 days. It was found that green magnetic fluorescent powder can successfully develop (Grade 1-4) latent fingermarks (sebaceous and natural) on bird of prey feathers stored indoors for up to 60 days after deposition with a mean ridge detail quality of Grade 2. It was also identified that latent fingermarks (sebaceous and natural) can be successfully developed (Grade 1-4) on bird of prey feathers that have been exposed to environmental conditions for a period of 21 days, with the optimum ageing period for the development of ridge detail being 14 days after exposure. Following this time, development was limited with only Grade 1 quality fingermarks developed beyond 14 days. These would not be of identifiable quality, but could indicate areas of direct human contact with the bird of prey. Grade 2 developed fingermarks may be of an identifiable quality but this is dependent on the amount of ridge characteristics visible within the developed ridge detail.

These results also suggest that if a bird of prey carcass is found hidden from view, as the feathers would have protection from the environment, any successfully developed fingermarks are likely to be of better quality for longer than those developed on a carcass left visible. Therefore, this evidence type would be of use to raptor persecution investigations for longer – up to 14 days after initial human contact.

Although there would appear to be no difference in the overall mean quality grade for developed fingermarks between indoor and outdoor conditions (Grade 2), the effect of environmental exposure appears to accelerate the degradation of the latent fingermarks and the loss of ridge detail.

Table 4: CAST fingermark grading [16]

Grade	Level of Detail
0	No evidence of print
1	Some evidence of contact but no ridge detail present
2	Less than 1/3 of print showing clear ridge detail
3	Between 1/3 and 2/3 of print showing clear ridge detail
4	Over 2/3 of print showing clear ridge detail

Table 5: Results from the extended indoor study using green magnetic fluorescent powder to develop both sebaceous loaded and natural fingermark deposits at ageing periods of 28, 45, and 60 days after deposition.

Grading	Loaded			Natural		
	Time since deposition (days)			Time since deposition (days)		
	28	45	60	28	45	60
0	4	1	2	52	37	22
1	27	18	21	10	12	16
2	81	92	94	53	71	77
3	28	33	23	21	24	26
4	10	6	10	14	6	9
Total	150	150	150	150	150	150
Average	2.08	2.16	2.12	1.57	1.67	1.89
Nearest whole grade	2	2	2	2	2	2

Table 3: Results from the outdoor study using green magnetic fluorescent powder to develop both sebaceous loaded and natural fingermark deposits at all ageing periods and depositions under different environmental conditions. Note that the No Sample (NS) results have not been included in the average value calculations for each ageing period.

	Loaded Hidden				Loaded Visible			
Grading	Time since deposition (days)				Time since deposition (days)			
	1	7	14	21	1	7	14	21
No Sample (NS)	4	15	25	39	1	2	2	11
0	1	31	33	44	0	68	76	75
1	34	31	23	7	53	20	10	4
2	45	11	8	0	28	0	2	0
3	6	2	1	0	6	0	0	0
4	0	0	0	0	2	0	0	0
Total (minus NS)	86	75	65	51	89	88	88	79
Average	1.65	0.79	0.65	0.14	1.52	0.23	0.16	0.05
Nearest whole grade	2	1	1	0	2	0	0	0

	Natural Hidden				Natural Visible			
Grading	Time since deposition (days)				Time since deposition (days)			
	1	7	14	21	1	7	14	21
No Sample (NS)	10	6	3	36	3	3	6	20
0	24	69	78	54	29	86	84	70
1	6	2	2	0	9	1	0	0
2	44	9	7	0	47	0	0	0
3	6	4	0	0	2	0	0	0
4	0	0	0	0	0	0	0	0
Total (minus NS)	80	84	87	54	87	87	76	70
Average	1.40	0.38	0.18	0.00	1.25	0.01	0.00	0.00
Nearest whole grade	1	0	0	0	1	0	0	0

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