A subjective evaluation of suggested products to facilitate contaminant removal from feathers

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ABSTRACT

There are several contaminants that are particularly difficult to remove from wildlife. This study subjectively evaluates 15 different products (pre-treatment agents) that have been suggested as agents to facilitate dish detergent in removal of six different contaminants. The purpose of this project was to prioritize products to be used in objective tests performed by DuPont Chemical Solutions Enterprise. Results showed that six of the fifteen pre-treatment agents have potential to assist in cleaning contaminated feathers.

Introduction

Feathers play an important role in the natural history of birds: they allow many of these animals to fly, thermoregulate, and remain waterproof to varying degrees. A bird's ability to keep its feathers clean, aligned, and supple, combined with the innate structure of the feather, help to keep the bird waterproof. During a contamination event the feather structure is disrupted. Whether a bird comes in contact with crude oil due to a spill or lands on a building freshly coated in roofing tar, the contaminant causes the feathers to lose the ability to provide insulation and repel water.

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In order to restore the contaminated feather to its natural condition, the feather must be completely freed of both the contaminant and cleaning agent(s) (Dein & Frink, 1986; Miller & Welte, 1999). During the cleaning process natural preen oils or waxes are also removed, but are quickly restored during the course of post-washing rehabilitation. Several studies show preen oils to be less important in establishing water repellency and act more directly to condition the feathers, keeping them supple and aligned (Clark & Gregory, 1971; Mahoney, 1984). The most important components to thorough cleaning are the effectiveness of a product at removing the contaminant at physiological temperatures and the ease of rinsing away the cleaning products (Rijke, 1987).

In 1990, Tri-State Bird Rescue & Research, Inc. (Tri-State), along with DuPont Central Research and Development Department (DuPont), developed a method to subjectively and objectively evaluate surfactant efficacy for removing petrochemicals from contaminated feathers (Bryndza et al., 1991 & 1995). The results of that study demonstrated that Dawn® dishwashing liquid detergent (Dawn®) (Procter & Gamble, Cincinnati, OH) was the surfactant of choice among those products tested. Dawn® was more effective at 2% v/v concentration than any of the other cleaning agents, even when the other agents were tested at concentrations as high as 5% v/v.

As new products have been introduced into the field of oil spill response, Tri-State and DuPont have continued to examine different products for their efficacy in cleaning contaminated feathers. In 2000, 86 potential surfactants were evaluated as possible products to remove petrochemicals from wildlife (Miller et al., 2003). Then in 2005, the evaluation process was repeated on fifteen products (Miller et al., 2005). Dawn® was again shown to be the most effective product (Miller et al., 2003; Miller et al., 2005).

Although Dawn® is preferred for the removal of many petrochemicals from wildlife, there are many contaminants that are not easily removed with Dawn® alone. The previous studies have used standard oils (crude, vegetable and synthetic oil) in a one-step cleaning process, which is not always effective with these more difficult products. Many wildlife rehabilitators and oiled wildlife response professionals have found they need multiple steps during the wash procedure to remove certain contaminants. Furthermore, many individuals have begun to suggest using untested agents to facilitate the dish detergent in removal of such contaminants. These "pre-treatments" may assist in the original contaminant removal; by using these agents, an additional foreign substance is added to the feathers that now also needs to be removed effectively.

Many pre-treatments are already being used by wildlife professionals, although their efficacy has never been formally tested. This subjective project is the first step in determining the effectiveness of different pre-treatments on known contaminants that are difficult to remove with Dawn® alone. A total of fifteen different pre-treatment agents were tested on six different contaminants. The pre-treatments that proved to be most effective subjectively will then be used in an objective test to be performed by DuPont.

Materials and Methods

Fifteen potential pre-treatment agents and six contaminants were obtained for this subjective evaluation. Most of the pre-treatment agents were products that have been used by Tri-State and/or recommended by other wildlife rehabilitators; the remaining agents were tested at the request of the manufacturers. The contaminants were chosen as products representative of the contaminants commonly encountered on wildlife presenting for rehabilitation.

All pre-treatment agents were placed into uniform spray bottles and assigned an identification letter by an outside participant in order to reduce bias on the part of the evaluators. The entire list of pre-treatment agents and manufacturers is presented in Appendix A. The list of contaminants and manufacturers is presented in Appendix B. Methods followed were based on the previous surfactant studies developed and modified by Tri-State and DuPont in an effort to keep data comparable and repeatable (Miller et al., 2003).

All fifteen pre-treatments were tested on each of the six contaminants. Within each of these tests, two or three feathers were contaminated and removal was attempted with the pre-treatment and a standardized cleaning process. The contaminants were tested at two different time intervals: 1) after being contaminated for at least one hour (short), and 2) after being contaminated for at least three weeks (long). The long trial was especially important since birds are often not captured and/or treated immediately after becoming contaminated. Many contaminants change properties as they age and are exposed to different weather conditions. By allowing contaminated feathers to sit for specific lengths of time, the experiment simulated "weathering" of the products. Five of the contaminants (crude oil, used cooking oil, silicone, roofing tar and Tanglefoot®) were tested by three different people to evaluate the efficacy of the pre-treatment agents for both the short and long time intervals; only one person examined removing the sixth contaminant, Orimulsion®, from feathers for both the short and long time intervals.

Original Scent Dawn® Ultra Concentrated was used as the surfactant for all of the trials. Although Original Scent Dawn® (non-Ultra) is preferred for cleaning, it is more difficult to obtain, and Tri-State has begun using the ultra concentrated formula. The ultra concentrated formula was previously proven effective in removing standard petrochemicals from feathers (Miller et al., 2003, Miller et al., 2005).

Appropriate safety measures were taken by all evaluators when handling the different contaminants and pre-treatment agents (Appendix C). All Material Data Safety Sheets were kept on file.

Feather collection

All feathers used in this study were body feathers from the carcasses of snow geese *(Chen caerulescens)* that were admitted to Tri-State's wild bird clinic. These birds either arrived dead or where euthanized due to the severity of their injuries. The feathers were collected by hand and separated from the down. All feathers appeared clean and not previously oiled.

Contaminating feathers

Plastic trays covered with aluminum foil were prepared containing 32-48 feathers (two to three for each pre-treatment and two to three for a control). There were a total of 32 trays of feathers; these were divided into different categories based on the type of contaminant and the length of time the contaminant was on the feather (Figure 1).

Figure 1. An example of contaminated feathers on an aluminum-foil covered tray. Feathers would remain like this for one hour to three weeks depending on which time trial was being tested for the contaminant.

Feathers were oiled individually by hand in an attempt to keep the contamination uniform between feathers. A total of 0.3 ml of contaminant was applied to each feather using a 1-ml syringe, with 0.15 ml applied to each side of the feather. When contaminating a feather with a new contaminant, a sterile syringe was used, but the same syringe was used when doing multiple feathers with the same contaminant. Once a feather was contaminated, it was placed on the foil-covered plastic tray and left undisturbed at room temperature until testing began.

Pre-Treatment Application

All pre-treatment agents were kept in a warm water bath ranging from 32°C to 44°C (90°F to 110°F) before and during the experimental period. When a pre-treatment agent was selected for testing, it was shaken three times before applying it to a feather. This helped to mix the contents of the bottle. The evaluator then applied the agent by spraying it directly onto the feather just prior to the cleaning process.

One full spray was applied to both sides of the feather and then rubbed with the gloved thumb and forefinger for three strokes in the direction of the feather growth. The pre-treated feather was then placed on a different plastic tray covered with clean aluminum foil, where pre-treatment was again applied with one full spray of the bottle. Then the feather was allowed to react with the pre-treatment for one minute without disturbance.

At this time the evaluator also noted if the pre-treatment agent had an obvious odor, which was then recorded on the observation form.

Cleaning Procedure

At the beginning of each testing period the water hardness was tested using the Hardness (Total) Test Kit (Hach Company, Loveland, CO). The pH was tested using colorpHast® Indicator Strips (EMD Chemicals, Inc., Gibbstown, NJ). All information was recorded on the test observation form.

After the pre-treatment agent was applied and left for one minute, each feather was cleaned by submerging it in a 7% Dawn® in water solution (360 ml water to 25 ml of Dawn®). The feather was agitated back and forth in the tub for 15 seconds and then allowed to remain in the solution for 45 seconds without agitation. While remaining in the 7% solution, the feather was gently stroked by sliding the gloved thumb and forefinger down the length of the feather for ten strokes. The feather was removed and allowed to drip for five seconds. It was then submerged in a 5% Dawn® in water solution (360 ml water to 18 ml of Dawn®) for one minute without agitation. After the minute, the feather was again stroked 10 times while still submerged in the solution. The feather was removed and again allowed to drip for five seconds before placing it in a tub containing 360 ml of clean water. In this tub the feather was agitated by moving it back and forth continually for 30 seconds. The feather was rinsed for 40 seconds (20 seconds/side) under high pressure water (~40-60 psi). Finally, the feather was placed on a clean plastic try for evaluation.

A high concentration of Dawn® and multiple tubs were used since Tri-State has found that the combination of contaminant and pre-treatment agents can be more difficult to remove from feathers than a single substance.

All water temperature was maintained in the range of 39oC to 40oC (102oF to 104oF).

Subjective Evaluation

Immediately after rinsing, each "clean" feather was subjectively ranked by the evaluator into categories:

- Excellent = feather appears perfectly clean and dry (fluffy)
- Good = most of the feather appears clean and dry, only small spots or edges still appeared to "stick" together
- Fair = feather appears mostly clean and dry during the rinse but is wet or out of shape when laid onto the tray

- Poor= feather does not rinse well, appears contaminated and/or wet after the cleaning process;the feather loses shape when placed onto the tray.

Analyzing Results

A value was assigned to each of the subjective rankings given by the evaluators in order to compile a numerical comparison (excellent = 4, good = 3, fair = 2, poor =1). An average score for each of the fifteen pre-treatments was complied for each of the six contaminants (separately for both short and long tests) by using the value of each ranking assigned by the three evaluators.

Results

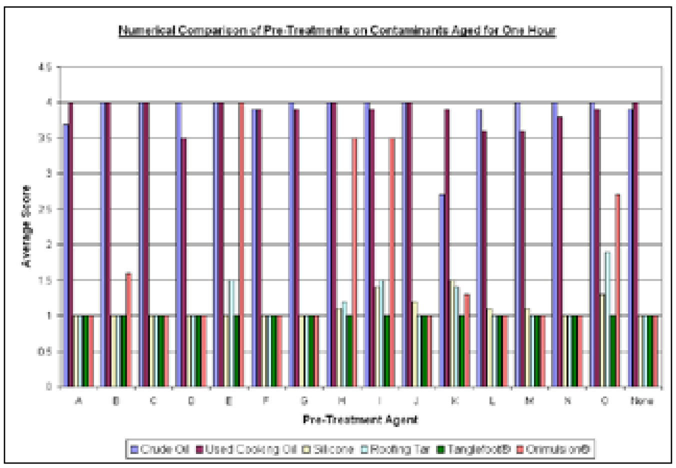

Figure 2. A comparison of the subjective evaluations of all 15 pre-treatment agents used on the six different contaminants after feathers had been contaminated for at least one hour. See Appendix A for index of pre-treatment agents.

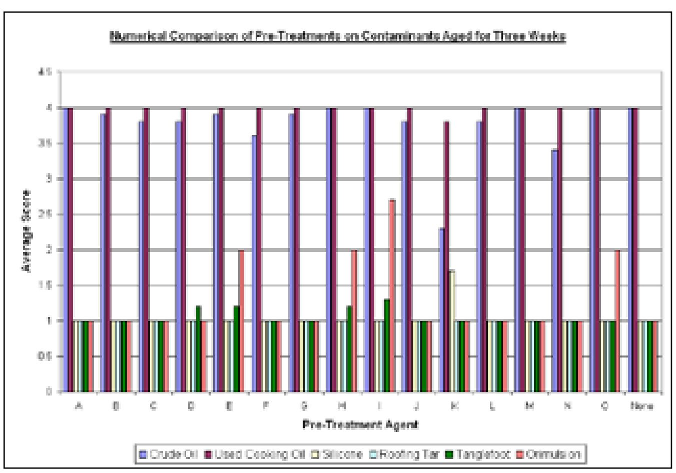

Figure 3. A comparison of the subjective evaluations of all 15 pre-treatment agents used on the six different contaminants after feathers had been contaminated for at least three weeks. See Appendix A for index of pre-treatment agents.

Overall, several pre-treatments consistently worked better then others in both the short and long tests on all of the contaminants (Figure 2 and Figure 3). These were methyl soyate, ArtWash!TM, ethyl oleate, and ethyl lactate. Elastol also proved effective on specific contaminants but did not work well on others. Several contaminants came off easily without the use of a pre-treatment agent in all tests (Figure 2 and Figure 3). Most pre-treatments came off the feathers successfully after being applied to a contaminated feather.

Control

A control was performed by placing each pre-treatment on to an uncontaminated feather; most pre-treatment trials on clean feathers received a score of Excellent; Elastol and Dawn® Power Dissolver received scores of Good.

Crude

The crude oil came off the feathers fairly successfully in all trials (Figure 4). Overall, it was slightly easier to remove the crude oil from feathers that had only been contaminated for at least an hour than those that had been allowed to "weather". All pre-treatments except Elastol received a scoring of Good to Excellent in both the short and long tests; Elastol received scoring of Fair to Good. Contaminated feathers washed without any use of pre-treatment received scores of mostly Excellent in tests of both time intervals (14 out of 15 feathers).

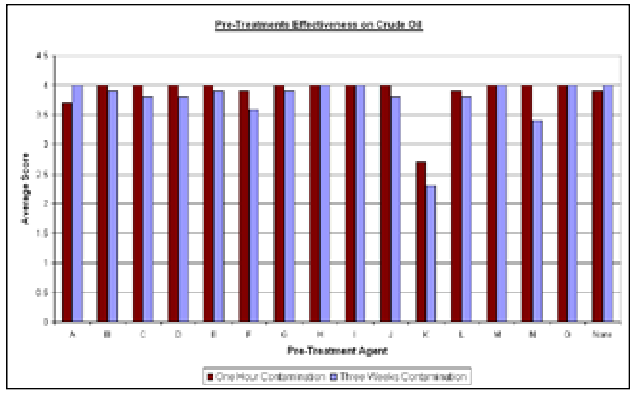

Figure 4. A comparison of the subjective efficacy of the 15 pre-treatment agents on removing crude oil when feathers had been contaminated for different lengths of time. See Appendix A for index of pre-treatment agents.

Used Cooking Oil

Used cooking oil washed off the feathers fairly successfully in all trials (Figure 5). Overall, it was slightly easier to remove the used cooking oil from feathers that had been contaminated for at least 3 weeks. All pre-treatments received a scoring of Good to Excellent in tests of both time intervals. Contaminated feathers washed without any use of pre-treatment received scores of all Excellent.

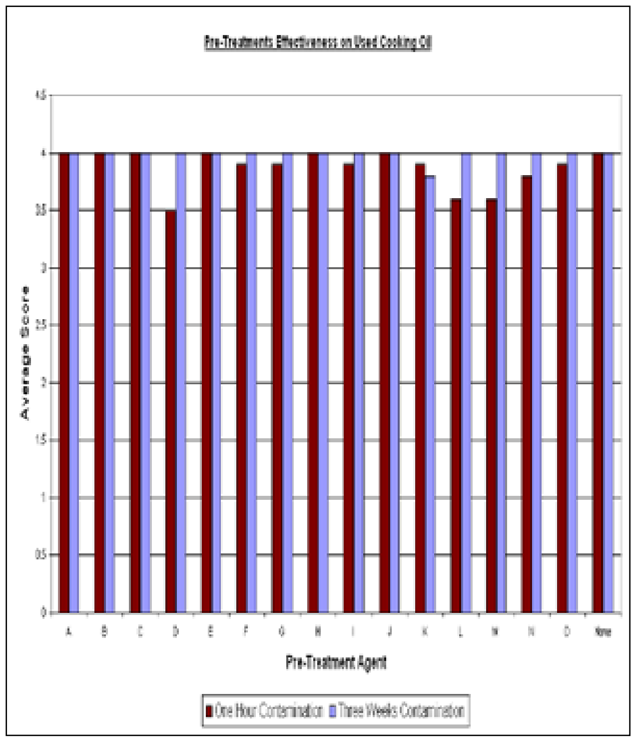

Figure 5. A comparison of the subjective efficacy of the 15 pre-treatment agents on removing used cooking oil when feathers had been contaminated for different lengths of time. See Appendix A for index of pre-treatment agents.

Silicone

Silicone was very difficult to remove from the feathers. Feathers that had only been contaminated for the short time interval had slightly better results then feathers that had silicone on them for 3 weeks prior to wash (Figure 6). Several evaluators noted that the silicone peeled off slightly after the rinse when using certain pre-treatments on the long-exposure trial set. Elastol received the highest scoring, especially when the silicone had been on the feather for 3 weeks; one evaluator got all of the silicone to come off completely using Elastol.

When attempting to remove silicone without any pre-treatment in both the short and long tests, the feathers received a scoring of Poor.

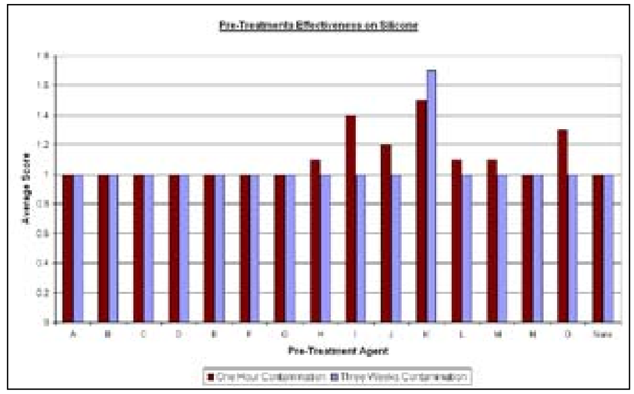

Figure 6. A comparison of the subjective efficacy of the 15 pre-treatment agents on removing silicone when feathers had been contaminated for different lengths of time. See Appendix A for index of pre-treatment agents. NOTE the scale in this figure is expanded to accentuate minor differences in results.

Roofing Tar

Roofing tar was also very difficult to remove from feathers. Feathers that had only been contaminated for the short time interval had slightly better results then feathers contaminated for the longer interval (Figure 7). No pre-treatments scored higher then a Poor if the roofing tar had been left on the feather for at least 3 weeks. Methyl soyate, ArtWash!TM, ethyl oleate, ethyl lactate and Elastol did receive some scores of Fair and Good during the short trial. Ethyl lactate received the highest scoring during these trials.

Figure 7. A comparison of the subjective efficacy of the 15 pre-treatment agents on removing roofing tar when feathers had been contaminated for different lengths of time. See Appendix A for index of pre-treatment agents. NOTE the scale in this figure is expanded to accentuate minor differences in results.

When attempting to remove roofing tar without any pre-treatment in both the short and long interval tests, the feathers received a consistent scoring of Poor.

Tanglefoot®

Tanglefoot® was very difficult to remove from feathers. Feathers that had been contaminated for at least 3 weeks had slightly better results (Figure 8). Ethyl oleate received scores of Fair, and Simple Green All Purpose Cleaner, methyl soyate and ArtWash!TM were given a score of Poor/Fair by one evaluator for feathers contaminated for 3 weeks. Both the short and long intervals for all other pre-treatment agents and for no pre-treatment received a score of Poor.

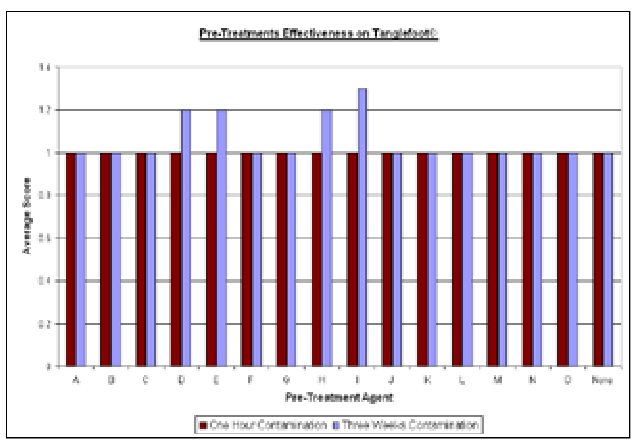

Figure 8. A comparison of the subjective efficacy of the 15 pre-treatment agents on removing Tanglefoot® when feathers had been contaminated for different lengths of time. See Appendix A for index of pre-treatment agents. NOTE the scale in this figure figure is expanded to accentuate minor differences in results.

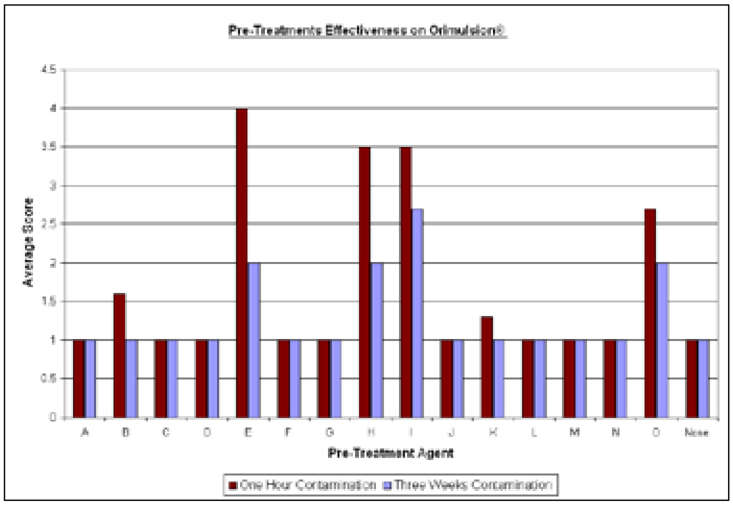

Figure 9. A comparison of the subjective efficacy of the 15 pre-treatment agents on removing Orimulsion® when feathers had been contaminated for different lengths of time. See Appendix A for index of pre-treatment agents.

Orimulsion®

The removal of Orimulsion® was much more successful when using methyl soyate, ArtWash!TM, ethyl oleate, and ethyl lactate after the short contamination interval than after the long contamination interval (Figure 9). Methyl soyate received scores of Excellent, while ArtWash!TM, ethyl oleate, and ethyl lactate received mostly scores of Good. Canola oil and Elastol showed some potential for removing this contaminant, receiving scores of at least Fair by the sole evaluator. All other pre-treatments scored Poor.

Orimulsion® became more difficult to remove after it remained on the feathers for 3 weeks. Methyl soyate, ArtWash!TM, ethyl oleate, and ethyl lactate received the highest scores. Ethyl oleate scored mostly Good (2 of 3) while methyl soyate and ArtWash!TM received all Fair scores, and ethyl lactate was highly variable, receiving a Good, Fair and Poor respectively for the three different feathers it was tested on. All other pre-treatments agents scored Poor.

When attempting to remove Orimulsion® without any pre-treatment in both the short and long tests the feathers received a scoring of Poor.

Discussion

Before discussing the contaminants and the efficacy of the pre-treatment products, there are several additional factors to be examined: the pre-treatment's odor, the reaction of the pre-treatment agent with the contaminant, and the hardness and pH of the water used to wash and rinse the feathers. These are all factors that may influence the results of the tests and the ability to use a certain pre-treatment on contaminated feathers.

Odor

Odor of the pre-treatment agent was important for two main reasons: 1) people working with the product, and 2) animals to which the product might be applied. If a pre-treatment agent worked very well but had an offensive or strong odor this might not be the best choice for incidents involving many animals. These types of odor could affect the volunteers and staff working with the product for long periods of time. Also, the odor could remain with the animals after the wash process was finished. None of the evaluators noted a strong or offensive odor to the pre-treatments that worked best on the contaminants tested in this study.

Reaction with Contaminant

Each evaluator was asked to make comments on whether the pre-treatment agent seemed to react with the contaminant. “React” was defined as whether or not the contaminant seemed to change (i.e., contaminant started dripping off or was softened, and dissolved off the feather while resting) once the pre-treatment was sprayed onto the feather and while the feather was allowed to rest for one minute after pre-treatment application. Many pre-treatments had a strong reaction with the contaminant, helping to remove much of the contaminant; however, not all the product was removed, so they still received scores of Fair or Poor. Using this type of information, one evaluator was prompted to do some additional tests including lengthening the period of time a pre-treatment was allowed to remain on the feathers and increasing the amount of agitation given to the contaminated feathers before starting the wash procedure. By altering the procedure in this manner, agents that initially received scores of Fair or Poor, now had their scores changed to Excellent or Good.

Water Hardness and pH

Water hardness and pH were checked before testing began on each set of contaminants. Water hardness has been shown to affect the wash process (Bryndza et al., 1990), so it was important to monitor these levels to insure that the hardness was not affecting the results. There were four days when the water hardness was over the current acceptable range of 3.5 ppm, but it never reached higher then 4.1 ppm. When comparing the results of the tests run on these days with the results from the same variables (contaminant type, time contaminant was on feather) but different evaluators, there was no obvious difference in scoring.

The pH remained fairly consistent throughout the experimental time period. The small variation in pH did not seem to make a difference in the scoring between tests with the same variables but different evaluators.

The Contaminants

The used cooking oil applied to the feathers during this experiment was obtained from a local elementary school cafeteria, which had used the vegetable oil for preparing food. Tri-State has seen many different species of birds that have been contaminated by cooking oils due to open waste barrels or to dumping of waste oil down storm drains. Although the vegetable oil used in this experiment did not need any pre-treatment product to assist in removal from the feather, this does not mean all used cooking oils act in the same manner. Knowing what type of cooking oil has contaminated the bird is essential in deciding on cleaning procedures.

Crude oil was obtained from a local oil refinery in Marcus Hook, Pennsylvania. It was an Escravos crude oil and was chosen as a representative of the crude oils commonly refined in the areas (Pennsylvania, New Jersey and Delaware) neighboring Tri-State. This type of crude oil did not need any pre-treatment to assist in removal from the feather. There are many different types of crude oil, and their unique properties may make certain types harder to remove. However, Elastol performed the worst and could be exempted from any further experiments using crude oils. This pre-treatment, although reacted with the contaminant was difficult to remove from the feather; after the wash and rinse process there was still Elastol on feather, decreasing the feather's ability to regain waterproofing.

Tanglefoot® Bird Repellent (The Tanglefoot Company, Grand Rapids, MI) was obtained from a local agricultural feed store. According to the manufacturer, "Tanglefoot Bird Repellent adheres to all surfaces while retaining its soft, sticky elasticity. It simply deters nuisance birds from their resting places by making roosting areas undesirable" (www.tanglefoot.com/products/birdrepel.htm). Songbirds are frequently found with this material adhering to their body and wing feathers. Removal of Tanglefoot® worked better after the product remained on the feathers for 3 weeks. This suggests that birds arriving at a rehabilitation facility with this product should potentially not be washed right away, especially if the contamination occurred recently. During the experiment feathers freshly contaminated and then washed seemed to have the Tanglefoot® distributed to other parts of the feather when agitated by hand. On a whole bird this might cause further contamination of previously clean feathers.

Pre-treatments Simple Green All Purpose Cleaner, methyl soyate, ArtWash!TM, ethyl oleate and Elastol, all had either notable reaction with Tanglefoot® when first applied or received higher scores during the trial with feathers contaminated for three weeks. These products might need to stay on the feathers for a longer period of time before starting the wash process. Additional subjective tests should be performed using these pre-treatment agents before the objective tests begin.

The roofing tar (Gardner Asphalt Corporation, Tampa, FL) was obtained from a local hardware store. Birds often become contaminated with roofing tar during the spring and summer months when new sealant is being applied to building tops. There are many different types of roofing tars, and this study only tested one, so pre-treatment results may vary.

Roofing tar did not fully wash off of the feathers in any of the tests, although a few pre-treatments did have some strong reaction with the contaminant. During the short contamination period, evaluators noted that the tar started to drip off of the feather with the application of the pre-treatments that received a score higher then Poor. Canola oil also had a strong reaction with the tar, but still received an overall score of Poor. The same reaction with the contaminant was observed with these pre-treatments on the feathers that had been contaminated for at least 3 weeks. However,, in the long interval trials, all the pre-treatments received scores of Poor by all evaluators.

These pre-treatments should be tested again and the pre-treatment agents allowed to stay on the feathers for longer then one minute. The results may receive higher scores, and a pre-treatment agent may be found that will remove roofing tar with greater ease.

Since roofing tar was slightly easier to remove when a feather was freshly contaminated, all efforts should be made to remove this contaminant as soon as the bird is stabilized.

The silicone used in this study was GE Silicone II* 100% Silicone Sealant for Window & Door (General Electric Company, Huntersville, NC), obtained from a local hardware store. Over the past few years Tri-State has received birds and taken calls concerning birds getting caught in sealants such as silicone. This product is used as caulk around the outside of windows and swimming pools. The birds most impacted by these contaminants are songbirds which land on surfaces that have recently been caulked but the silicone has not yet cured.

The silicone was very sticky and wet when first applied to the feathers; this may be why it seemed a little easier to remove during the short tests. Some of the product probably stuck to the gloves of the evaluators and small amounts could be rubbed off when agitating by hand. Still, much of the fresh silicone remained on the feather and the agitation seemed to spread the remaining product to other parts of the feather. The scoring for all the pre-treatments and non pre-treated feathers remained low, with only one pre-treatment receiving a score of Fair by at least two of the evaluators. Once the silicone had fully dried on the feathers, several evaluators noted that it seemed to peel away from the feathers. Elastol did remove some of the silicone.

Silicone appears to be a contaminant that comes off easier after it has dried fully, especially since when it is fresh it can easily be re-distributed to other parts of the feather. If attempting to remove silicone when fresh, it might inadvertently contaminate feathers that were previously clean.

Orimulsion® (Bitor America Corporation, Boca Raton, FL) was obtained from the manufacturer. Orimulsion® is used as a commercial fuel for power plant boilers worldwide; a spill involving this product could easily contaminate seabirds and waterfowl. Only one evaluator attempted to remove Orimulsion® after one hour and after three weeks of contamination time. This was decided because past studies have shown Orimulsion® very difficult to remove (Miller et al., 2005).

Methyl soyate might be a useful pre-treatment to remove Orimulsion when a bird has recently been contaminated. ArtWash!TM, ethyl oleate and ethyl lactate did not perform quite as well, but may be viable substitutes. Since ArtWash!TM, ethyl oleate and ethyl lactate did not perform as well after one minute on the feather, allowing them to remain on the feather for longer periods of time before washing may help to increase their ability to facilitate in contaminant removal.

After Orimulsion® remained on the feathers for three weeks it was more difficult to remove. Ethyl oleate performed better then methyl soyate, ArtWash!TM, and ethyl lactate; however, if these pre-treatments remained on the contaminated feather for longer than a minute they may receive higher scorings.

Additional Testing

When evaluators noted that a pre-treatment agent was reacting with a particular contaminant, a few further tests were performed resulting in higher scoring of the feather condition. When a pre-treatment that appeared to be "working" or strongly interacting with several of the harder contaminants to remove, those pre-treatment agents were allowed to remain on the feathers longer before washing; the pre-treatment agent remained on contaminated feathers for five, ten, or fifteen minutes to see if there was a difference in the feather after the wash processes. There was also additional hand agitation on the feather when the pre-treatment was applied, by stroking the feather three to five times half-way through the longer resting period.

The results from these changes in the procedure increased the scoring of some of the pre-treatment agents. Other pre-treatment agents had no difference as compared to the standard protocol. The subjective evaluators noted that there was a higher success at removal of the contaminant when the consistency of the pre-treatment agent was similar to that of the contaminant. An example of this was Elastol; Elastol seems to have potential to remove thicker products such as silicone and Tanglefoot®. This product seemed to bind with these contaminants and allow them to fully come off the feather. When Elastol was used with used cooking oil, crude oil, roofing tar and Orimulsion®, it reacted with the contaminant but could not easily be removed from the feathers.

When Elastol was left for 15 minutes on feathers contaminated with Tanglefoot® for at least 3 weeks, all of the Tanglefoot® was removed, and the Elastol was given a score of Excellent. Further testing is needed to confirm this result, as it was only performed on one feather. Tests are also needed to see whether or not Elastol would have the same results with feathers that had been contaminated for at least one hour, and if other pre-treatment agents would perform better when left on the feather for 15 minutes.

Methyl soyate, ArtWash!TM, ethyl oleate, Elastol and ethyl lactate were allowed to remain for five minutes on feathers that had been contaminated with roofing tar for three weeks, and then were cleaned following the standardized protocol. There were slight to no differences noted with ethyl oleate, Elastol and ethyl lactate; only methyl soyate, and ArtWash!TM received a score of Fair. The results changed when the pre-treatments stayed on for ten minutes: Ethyl oleate and methyl soyate worked the best. Ethyl oleate received a score of Excellent, and methyl soyate received a Good; in these two trials both feathers had only a small amount of staining remaining on their tips. These tests were only performed on one feather each by one evaluator, so further tests are needed to confirm these results.

Silicone was removed from feathers contaminated for at least 3 weeks when Elastol was left on for five minutes; the cleaned feather was given a score of Excellent. This test was performed by three different evaluators on one feather each. One noted that the feather did seem a little damaged, but it was not determined if the damage occurred from the silicone or was pre-existing.

When the pre-treatments were initially chosen, the harmful effects on skin exposed for a short time seemed negligible as deduced from reading the material data safety sheets. Increasing the time exposure to remove the contaminant from the feathers may lead to more skin problems for the animals. This possibility should be addressed, and consultation with a veterinarian and/or toxicologist should always occur before choosing any pre-treatment option.

Potential Sources of Error

As mentioned earlier, pH, water hardness, and water temperature were considered as possible sources of inconsistency/error in the procedure. However, the results demonstrated that variations in these factors played little if any role in affecting the results. Other variables that may have affected the results include true time of contaminant exposure, the malfunction of one spray bottle, and variation in evaluators' techniques.

The goal at the beginning of the experimental period was to have the short contamination period be only one hour. The total time to run a trial of one contaminant testing all fifteen pre-treatment agents was between four and six hours, depending on the number of feathers tested and the individual evaluator. It proved difficult to efficiently run the short tests and also keep all the feathers' contact time with the contaminant close to an hour. All feathers ended up being contaminated at the same time and allowed to sit for an hour before the cleaning began. As a result, by the time the last feather was tested it may have been contaminated for up to seven hours. Consequently, products tested last may not have worked as well as the products tested first. The contaminant may have "weathered" onto the feather and caused a decrease in the scoring result. This potential for error was minimized by having each evaluator test the pre-treatment agents in a different order, so that no one agent was always tested last.

All of the feathers that needed to be contaminated for three weeks were contaminated at the initial set-up of the experiment. Schedules changed for the evaluators who were volunteering their time to run the tests. Consequently, several of the long-term contaminated products did not get tested for an additional one to two weeks.

The initial spray bottle containing pre-treatment ArtWash!TM malfunctioned, and an identical spray bottle could not be found to replace it. ArtWash!TM was then placed in a different spray bottle, so the amount sprayed onto the contaminated feathers may have been different. This might have affected the results for this pre-treatment product, causing it to score either higher or lower then it would have in a bottle identical to the others.

Since this experiment was a subjective evaluation, individual judgment was used to score and evaluate the effectiveness of each of the pre-treatment agents on the different contaminants. Human error or differences in personal technique can play a role in experimental error. Because of this, every effort was made to minimize these potential errors: each evaluator repeated the process two to three times, several different evaluators conducted identical tests to remove potential bias, and each step and the evaluation scoring were standardized.

Due to some unexpected limitations of the volunteers' availability, two additional Tri-State staff members assisted in the project. As a result, all pre-treatment agent testing on long-exposure to Tanglefoot® was conducted by staff members, while testing on short-exposure to Tanglefoot® was conducted by one staff member and two volunteers. One complete set of all the three-week trials (crude oil, used cooking oil, silicone, Tanglefoot® and roofing tar) was performed by a staff member, while the corresponding one-hour trials were conducted by volunteers. Only one evaluator tested all of the pre-treatment agents on all six of the contaminants for both the short- and long-exposure tests. Due to the variation in evaluators, there many have been slight subjective differences, especially for the results on Tanglefoot®.

Changes for Future Experiments

The scoring used was similar to that used in the experiments testing surfactants. This was done to keep consistency between projects, but it often proved difficult during this experiment. Several times a feather would receive a lower score because of a small amount of contaminant remaining on the feather. The feather would appear clean and waterproof everywhere else, but due to that small amount of contaminant, that pre-treatment would be scored Poor. When attempting to remove the same contaminant without a pre-treatment agent, often nothing would come off, and an evaluator would give it the same score of Poor. There was an obvious difference between the pre-treated feather and the non pre-treated feather's overall clean status, but this was not reflected in the four scoring categories.

Involving Tri-State's volunteers was an important part of this process; the two individuals who participated in this study were part of the Core Team, a group of very skilled and dedicated volunteers. Having volunteers involved in the study helped to reduce bias, and allowed for a more realistic evaluation of how the pre-treatment agent might work when used by different individuals washing a whole bird. As volunteers, however, they had a limited amount of time to assist with testing, and only tested two feathers with each pre-treatment agent, while staff evaluators tested three feathers on every trial. In future tests of this nature, the same evaluators should perform all the tests with all of the different variables (contaminant type and length of contaminant on feathers). This would ensure that the subjective evaluations remained constant throughout the whole experiment.

Wildlife professionals do not usually receive a bird directly following a contamination event, which is the reason for a test performed after three weeks. One hour is a very short period of contaminant exposure, so changing this to 24 hours might be more realistic given the normal treatment of oiled wildlife. Even if brought to a rehabilitation center directly following the contamination event, most animals need to be stabilized and given a rest period before cleaning can be attempted. This paper is not suggesting that these practices be changed. A bird's overall health must be taken into consideration before addressing the removal of the contaminant.

Next Steps

There are two additional steps planned to complete this project: the objective testing by DuPont, and further subjective testing. Based on the results of this subjective screening test, DuPont will be testing specific pre-treatments on specific contaminants (Table 1).

Table 1. Pre-treatment agents that subjectively worked the best on four of the contaminants tested.

DuPont will objectively test the pre-treatment agents with the contaminants listed in this chart. Used cooking oil and crude oil came off of feathers and received a high score when no pre-treatment agents were applied.

Contaminant	Pre-Treatment
Tanglefoot®	Simple Green All Purpose Cleaner
	Methyl Soyate
	ArtWash!™
	Ethyl Oleate
	Elastol
Orimulsion®	Methyl Soyate
	Ethyl Oleate
	ArtWash!™
	Ethyl Lactate
Roofing tar	Methyl Soyate
	ArtWash!™
	Ethyl Oleate
	Elastol
	Ethyl Lactate
Silicone	Elastol

Since the used vegetable cooking oil and Escravos crude oil in this trial were both easily removed, and we see different types of these oils on a regular basis, testing different types of these oils might prove useful. Used and unused cooking oils derived from animal fats are traditionally more difficult to remove from birds, so these products will be examined in future trials.

There are several other petrochemicals that can be difficult to remove depending on their stage of refinement and length of time remaining on the birds, such as #6 oil. The pre-treatment agents that consistently performed the best during this experiment should be evaluated on other oils to see if they might be effective on these products as well.

Conclusions

This project was highly subjective; however, the tests did reveal some usable information:

- The results show that the pre-treatments methyl soyate, ArtWash!TM, ethyl oleate, Elastol and ethyl lactate have the potential to remove a variety of contaminants from feathers.
- Choosing a pre-treatment agent specific to the type of contaminant and how long it has been on the feathers is important. At this time the authors have not found one pre-treatment agent that removes all contaminants with equal efficacy.
- These results might not be true for mammals; additional testing is needed to understand what works best on fur and hair.

With the information gathered from this project, additional testing is still needed. Further subjective testing will help refine the procedure and continue the evaluation of these products as well as several pre-treatment agents that arrived at Tri-State during or after the testing period. Objective testing by DuPont is needed to confirm and quantify all of these results.

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Appendix A: Index of Pre-Treatment Agents Tested Subjectively

A Vapor Remed (Sarva Bio Remed, Trenton, NJ, www.sarvabioremed.com)

B Canola Oil

C Botanic Gold (PureTec International, Milpitas, CA, www.symmetrydirect.com)

D Simple Green All Purpose Cleaner (Simple Green, Huntington Harbour, CA, www.simplegreen.com)

E VertecBio Gold (Methyl Soyate) (VertecBio, Downers Grove, IL, www.vertecbiosolvents.com)

F Spill Remed (Marine) (Sarva Bio Remed, Trenton, NJ, www.sarvabioremed.com)

G Murphy's® Oil Soap (Colgate-Palmolive Company, New York, NY, www.colgate.com)

H ArtWash!TM (Rembrandt Graphic Arts, Rosemont, NJ www.rembrandtgraphicarts.com)

I Ethyl Oleate (Spectrum Laboratory Products, Inc., Gardena, CA, www.spectrumchemical.com)

J Asphalt Stain Remover (DuPont Chemical Solutions Enterprises, Wilmington, DE)

K Elastol (Design Engineering Systems Analysis, LLC, Alexandria, VA, www.elastol.com)

L Extreme Simple Green Aircraft & Precision Cleaner (Simple Green, Huntington Harbour, CA, www.simplegreen.com)

M Spill Remed (Freshwater) (Sarva Bio Remed, Trenton, NJ, www.sarvabioremed.com)

N Dawn® Power Dissolver (Procter & Gamble, Cinicnnati, OH, www.pg.com)

O VertecBio EL (Ethyl Lactate) (VertecBio, Downers Grove, IL, www.vertecbiosolvents.com)

Appendix B: List of Contaminants

Crude oil: Escravos crude obtained from a local refinery in Marcus Hook, Pennsylvania

Used cooking oil: Clear vegetable frying oil obtained from a local elementary school in Mount Laurel, New Jersey

Silicone: GE Silicone II* 100% Silicone Sealant for Window & Door (General Electric Company, Huntersville, North Carolina)

Roofing tar: Fiber Roof Coating (Gardner Asphalt Corporation, Tampa, Florida)

Tanglefoot®: Tanglefoot® Bird Repellant (The Tanglefoot Company, Grand Rapids, Michigan)

Orimulsion®: Orimulsion® (Bitor America Corporation, Boca Raton, Florida)

Appendix C: Safety Protocols

Required PPE:

Nitrile Gloves

Tyvek Sleeves

Apron

- There will be a specific labeled trash can for any items that have contaminant or pre-treatment agents on them (i.e., syringes used to apply contaminant, nitrile gloves, dirty Tyvek sleeves, feathers).
- All syringes should be separated into two parts before placing in the trash.
- Contaminated water needs to go in to the waste tanks.
- When contaminating, applying pre-treatment and washing/rinsing feathers, proper PPE must be worn at all times.
- A new pair of nitrile gloves should be put on before applying a different pre-treatment agent to a contaminant. When repeating a test with the same pre-treatment/contaminant combination, it is ok to reuse nitrile gloves. A new pair of nitrile gloves should be put on before working with a new contaminant.
- Keep nitrile gloves on during the rinse procedure.