7881 114th Avenue North
Largo, FL 33773
ph (727) 549-6067
www.nfstc.org

Project Information

Title: Swab Collection Study

Evaluation Type: Comparison Study

Stakeholder: Forensic Science Community

Start Date: 6/1/2011 End Date: 3/30/2012

Manufacturer Information

Products: Pur-Wraps® Sterile Cotton-Tipped Applicator, Pur-Wraps® Rayon-Tipped Applicator, Pur-Wraps® Polyester-Tipped Applicator, Pur-Wraps® Foam-Tipped Applicator, and Puritan® Self-Saturating Swab (Trace DNA Collection Device)

Manufacturer: Puritan Medical Products Co. LLC

Phone Number: 1-800-321-2313

Website: http://puritanmedproducts.com/

Distributor: N/A

Contact Person: N/A

Phone Number: N/A

Email: sales@puritanmedproducts.com

Product: Nylon® Flocked Swab

Manufacturer: Copan Diagnostics Inc.

Phone Number: 1-800-216-4016

Website: www.copanusa.com

Distributor: N/A

Contact Person: N/A

Phone Number: N/A

Email: info@copanusa.com

Product: SpinEze® Sterile PushOff™ Swab with Dacron Fiber

Manufacturer: Fitzco Inc.

Phone Number: 1-800-367-8760

Website: http://www.fitzcoinc.com/

Distributor: N/A

Contact Person: N/A

Phone Number: N/A

Email: Fitzco@FitzcoInc.com

Product: Trigger ID™ Swab

Manufacturer: Forensic ID

Phone Number: (317) 413-6249

Website: www.forensicid.net

Distributor: N/A

Contact Person: N/A

Phone Number: N/A

Email: N/A

Product: SecurSwab™ DUO-V Swab System

Manufacturer: Bode Technology

Phone Number: 1-866- 263-3443

Website: www.bodetech.com/

Distributor: N/A

Contact Person: N/A

Phone Number: N/A

Email: bode.service@bodetech.com

Evaluation Team

Robert O'Brien, Senior Forensic Specialist – DNA, (727) 549-6067, ext.108, Robert.O'Brien@nfstc.org

Debra Figarelli, DNA Technical Services Manager, (727) 549-6067, ext. 180, Debra.Figarelli@nfstc.org

Evaluation Overview

During the past two decades, biological evidence has become increasingly important in criminal investigations. DNA evidence can independently and objectively link a suspect and/or victim to a crime, disprove or confirm an account of a crime, and develop investigative leads. DNA evidence has also proven invaluable for exonerating the innocent.

The sensitivity of DNA analysis methods routinely used by forensic crime laboratories has changed the way the criminal justice system defines biological evidence. It is imperative that the collection of biological material is efficient and nondestructive and that contamination is minimized. This study was designed to determine whether some swabs are more efficient at the collection and release of dried biological fluids than others.

Swabs from five different manufacturers were tested in this study; all were commercially available at the time of testing. The swabs differ from each other primarily by the swab head type/material. Also, some of the swabs tested came pre-moistened with their own surfactant. Those that did not were slightly moistened as described in the Procedure section.

In most cases, the slightly moistened swabs were tested individually using a single-swab technique. However, since one of the swabs tested is a two-swab system, the study also examined the frequently utilized "double-swab" technique (which is a swabbing with a slightly moistened swab followed by a dry swab) to determine whether this extra swabbing is more efficient for collecting biological evidence than simply using single, moistened swabs.

This study consisted of two phases: Phase 1 tested the collection of a large volume (20µl) of blood, while Phase 2 tested the collection of a small volume (2µl) of blood.

Product Specifications

For questions about the swabs tested, please contact the study author, Robert O'Brien, Robert.O'Brien@nfstc.org.

Phase 1

Procedure

The purpose of Phase 1 was to evaluate the approximate amount of a large-volume (20µl) biological stain that each swab can collect.

The first step was to prepare sets of three bloodstained glass slides (marked A1, A2, A3; B1, B2, B3; … I1, I2, I3) for each of the nine swab types to be tested. An extra set of slides was also prepared (marked J1, J2, J3) to investigate the efficacy of the double-swab technique, as discussed in the Overview.

To prepare the slides, a quantity of 20µl of blood was placed on each slide and dried at room temperature overnight. The following day, the dried bloodstain on each slide was swabbed; the swabs were slightly moistened with sterile water unless the swabs came with their own surfactant.

To moisten, 2 to 3 drops of sterile water was placed on each swab using a Pasteur pipette. Less was used if the swab did not have the ability to retain that amount of water. The goal was to transfer the entire dried bloodstain onto the swab. The swabbing action was performed until this was achieved or until the swab became saturated and was simply spreading the stain around the surface of the slide. After the swab was saturated, the slide was photographed to document any remaining stain.

The swabs were left to air dry overnight unless they came with their own drying mechanism (desiccant), in which case that mechanism was used. The following day all the triplicate sets of swabs were extracted using the BioRobot® EZ1 Workstation using the Trace Tip Dance Protocol. This extraction method was chosen because it is specifically designed to be used on swabs. If any of the swabs could not work with this protocol, it was noted.

After extraction, the triplicate sets of swabs were quantitated using the Applied Biosystems Quantifiler® Duo quantitation system. The quantities were compared to each other and also to the control set of liquid blood extracted using the same extraction method.

One triplicate of each set was amplified using the AmpFℓSTR® Identifiler® Plus amplification kit and run on the 3130*xl* Genetic Analyzer to ensure that a full DNA profile could be developed.

At the end of Phase 1, the swabs were compared and ranked based on how much DNA was retrieved.

Swab Sets

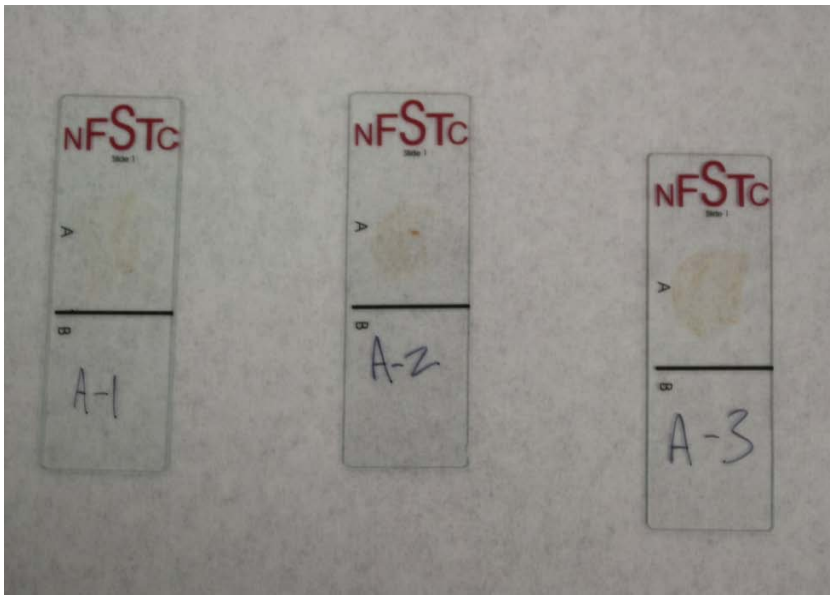
The following sets of swabs were tested in Phase 1:

A. Pur-Wraps® Sterile Cotton-Tipped Applicator
B. Pur-Wraps® Rayon-Tipped Applicator
C. Pur-Wraps® Polyester-Tipped Applicator
D. Pur-Wraps® Foam-Tipped Applicator
E. Copan Nylon® Flocked Swabs
F. Puritan® – Self-Saturating Swab (Trace DNA Collection Device)
G. Forensic ID – Trigger ID™ Swab
H. Fitzco SpinEze® Sterile Pushoff™ Swab with Dacron Fiber
I. Bode Technology SecureSwab™ DUO-V Swab System
J. Pur-Wraps® Sterile Cotton-Tipped Applicators – Double-Swab Technique

Observations During Phase 1 Swabbing

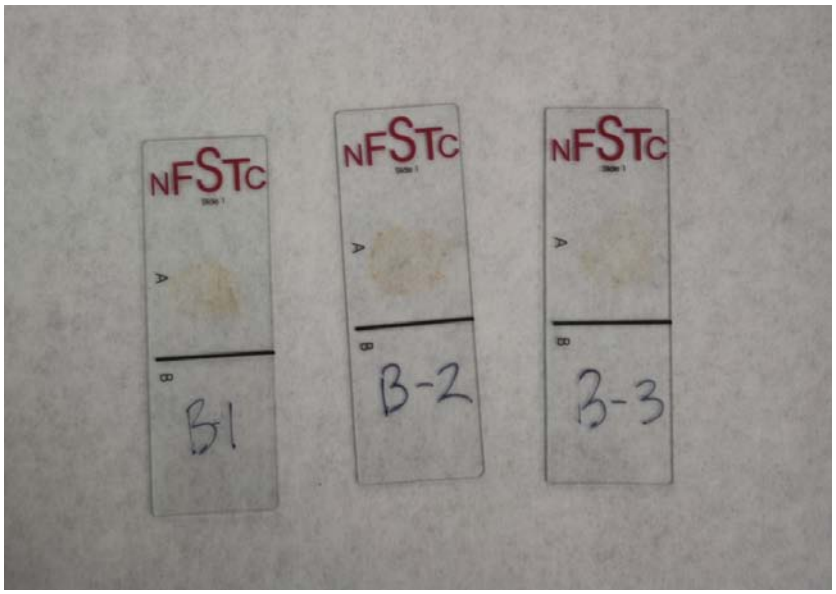
Swab A – Pur-Wraps Sterile Cotton-Tipped Applicator

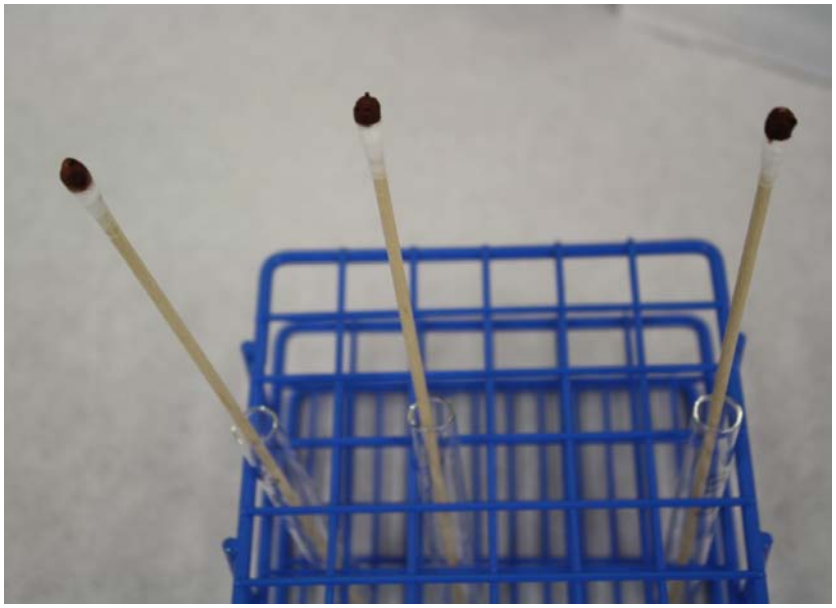
Two drops of sterile water was sufficient to saturate Swab A without excess water dripping off. Swabbing took up the majority of the stain; only a faint color of red remained on the slides. Each swab appeared to be saturated with blood; only the base of swabs did not contain blood.



Swab B – Pur-Wraps Rayon-Tipped Applicator

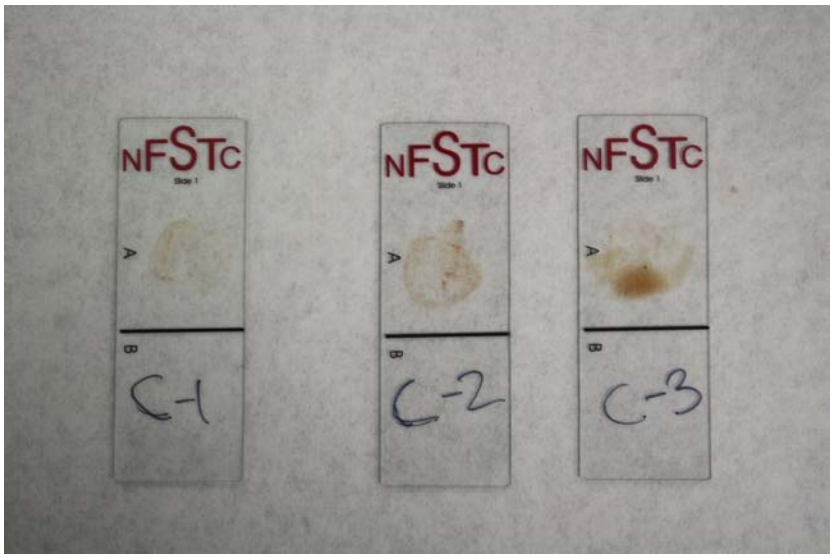
One drop of water successfully saturated the tip of Swab B ~5mm from tip. This 5mm portion readily absorbed water, but the rest of swab appeared to be slightly hydrophobic. The water was repelled off and was not absorbed on this portion of the swab; therefore, the swabbing action was confined to the tip.

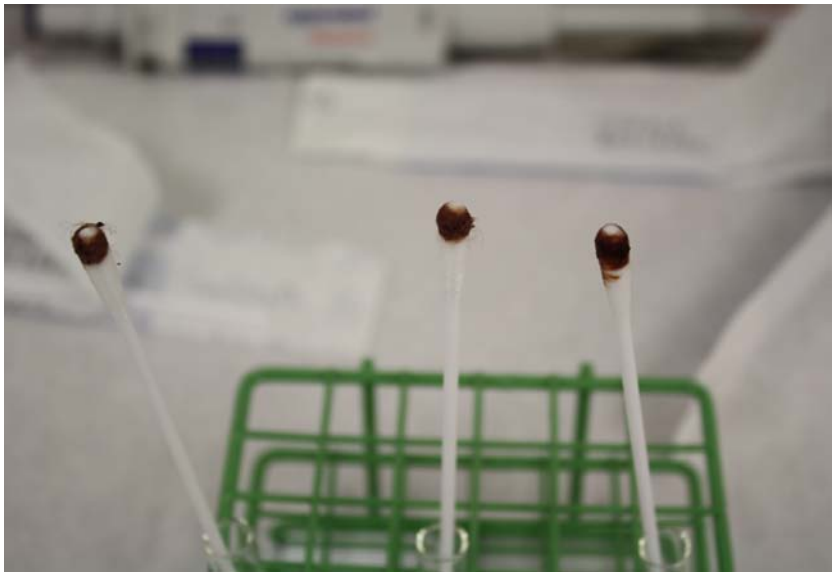




Swab C – Pur-Wraps Polyester-Tipped Applicator

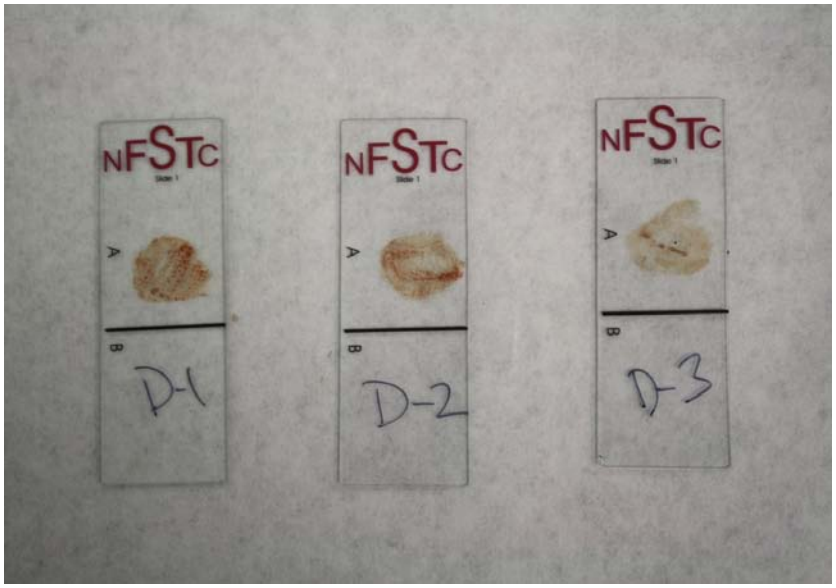
Swab C was larger and more absorbent. Approximately 3 to 4 drops of water were required to moisten the swab with no excess dripping. Fibers from the swab came unraveled during the swabbing process. More staining was left behind on these slides than for the other swabs.





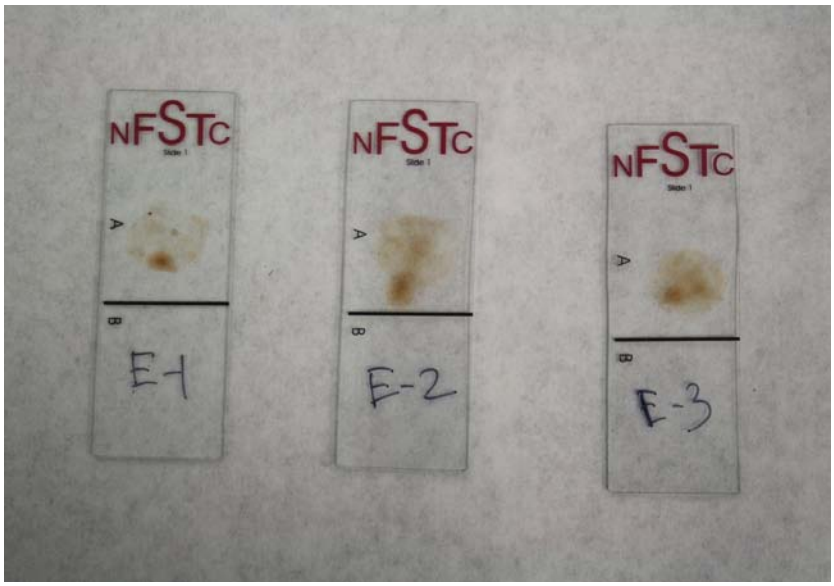
Swab D – Pur-Wraps Foam-Tipped Applicator

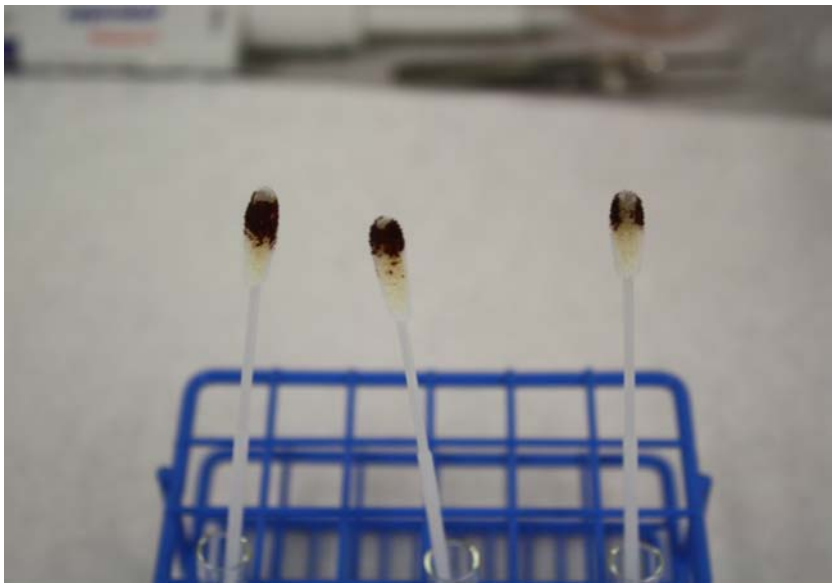
Swab D was not very absorbent. The majority of the water was repelled and rolled off of the swab, so less than a drop of water was absorbed by the swab. During swabbing, the tip appeared damp enough to swab the surface; however, Swab D appeared to become quickly saturated with blood and began to spread blood around the slide instead of being transferred onto the swab.



Swab E – Copan Nylon Flocked Swab

Swab E was not very absorbent; 2 drops of water readily rolled off. Water from the swab came off easily onto the stain, liquefying the stain. This caused the stain to smear and left a significant amount of the blood behind.

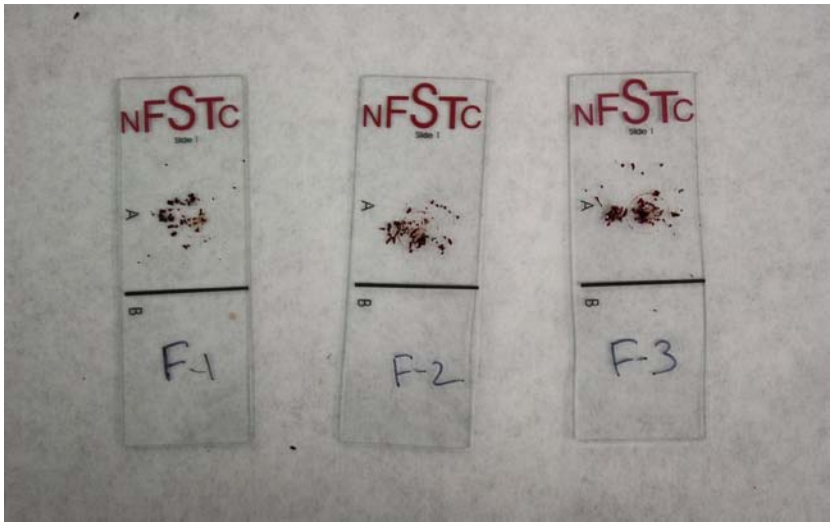




Swab F – Puritan Self-Saturating Swab (Trace DNA Collection Device)

Swab F comes with its own liquid, 91% isopropyl alcohol and 9% deionized water solution, contained in a popule within the stem of the swab. One of the three Puritan swabs originally selected to be used did not contain any liquid, so it was replaced by another swab. The swabs are about half the length of other swabs, so the user's hands are in closer proximity to the stain. Breaking the popule in the stem caused splashing of the liquid out of the tip of the swab. The liquid contained in the swab was alcohol-based, and even though the tip appeared to be sufficiently moistened, there was not enough liquid to solubilize the stain, so the stain flaked off of the slide. Some of the flakes stuck onto the swab, but most of the flakes remained on the slide and would not adhere to the swab.

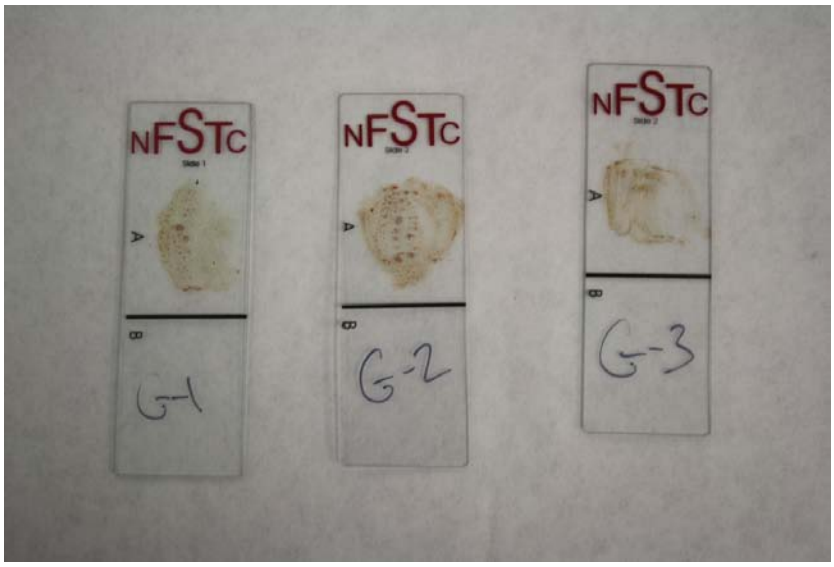
The flakes on the swab did not solubilize; as a result, when the swab dried the flakes fell off, which was problematic during the extraction process. Blood flakes could potentially fall off the swab head during cutting of the swab, which may raise concerns of contamination and loss of evidence.



Swab G – Forensic ID Trigger ID Swab

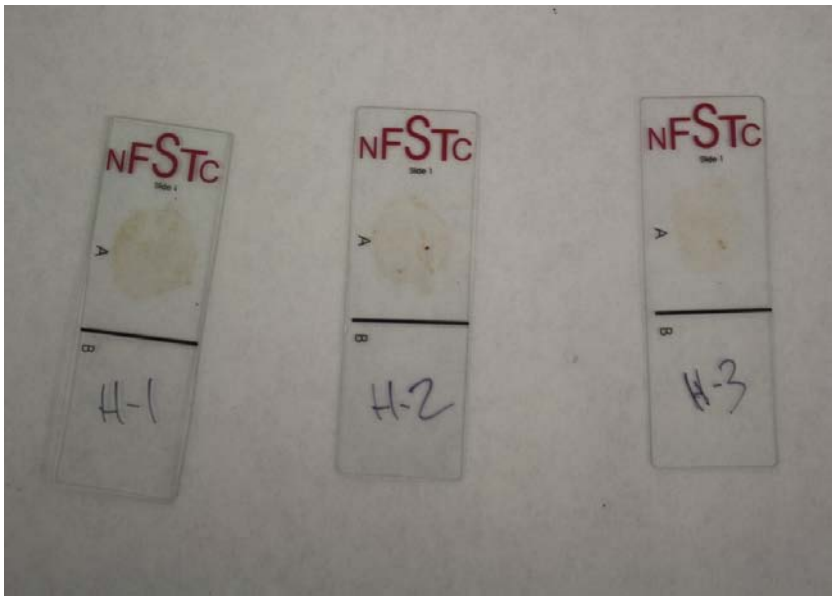
Swab G comes with its own liquid and storage vial. One of the swabs did not contain enough liquid to moisten the swab, causing the stain to flake and not transfer onto the swab. This swab was replaced and the procedure was conducted successfully.

The liquid takes some time to flow through the head of the swab. It took approximately 30 seconds for the swab to become moistened enough to work as intended. If used before the swab is moistened sufficiently, the stain flakes and is not solubilized. During the study, the stain did flake and the tester had to run the swab along the side of the slide to absorb most of the stain. In addition, when placing the swab in its protective travel cap, some of the blood was transferred to the side of the cap, making it irretrievable.



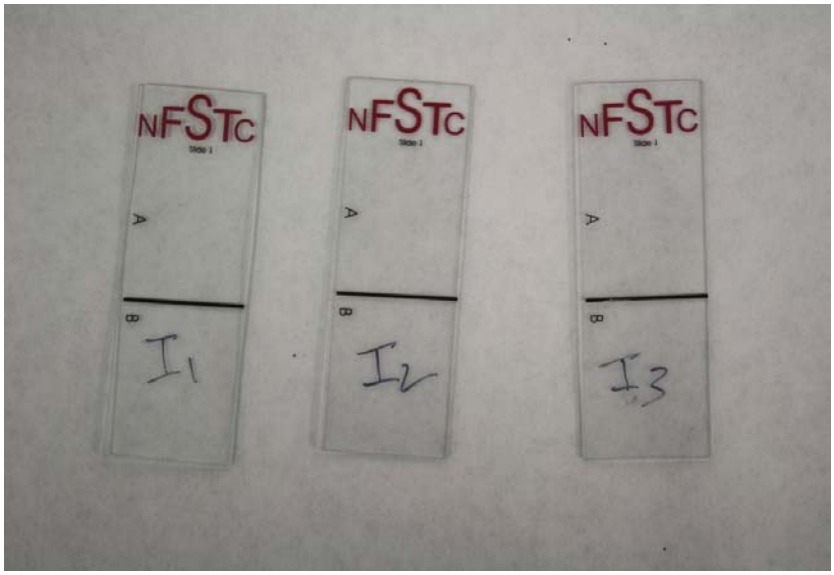
Swab H – Fitzco SpinEze Sterile PushOff Swab with Dacron Fiber

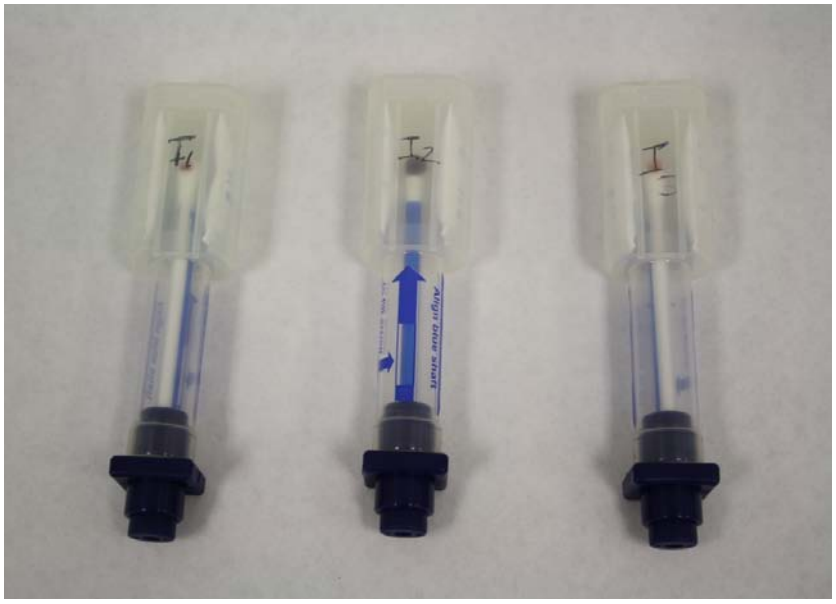
Swab H was very absorbed. It easily absorbed water, but it did not dispense as easily onto the slide to solubilize the stain. Therefore, some flaking of the stain occurred; however, after swabbing, most of the stain appeared to be collected.



Swab I – Bode Technology SecurSwab DUO-V Swab System

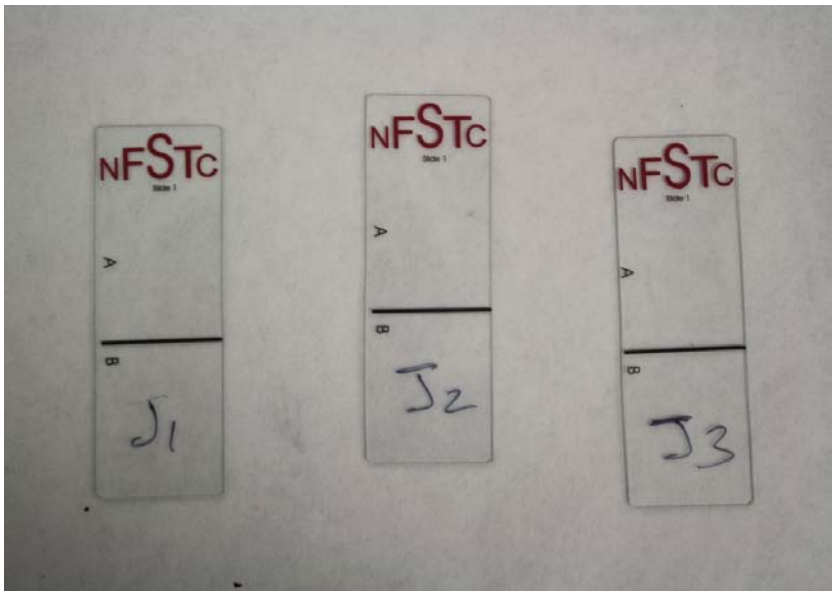
This double-swab system comes with two swabs, a travel container and a chamber containing desiccant. Due to the positioning of the two swabs in the travel container, only one side of each swab was available for swabbing the stain. However, using both the wet and dry swabs, virtually all of the stain appeared to be recovered from the slide.

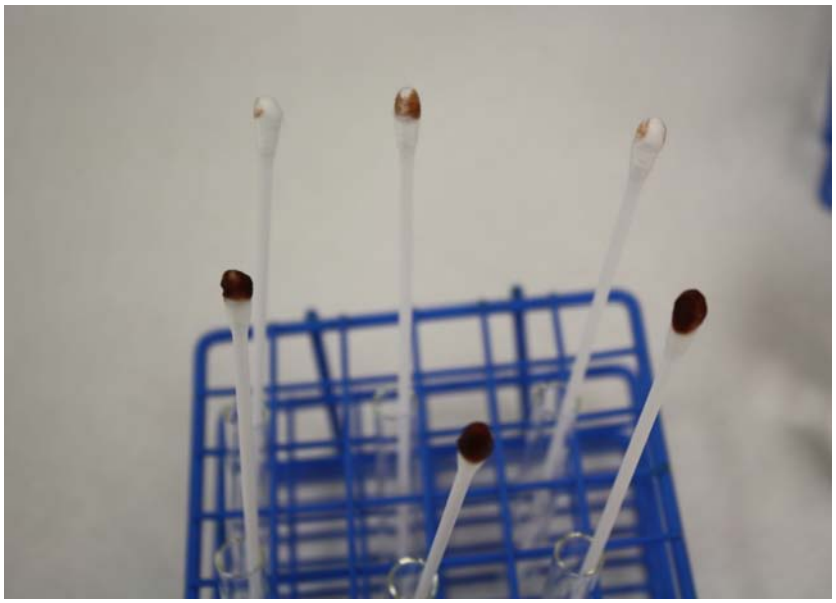




Swab J – Pur-Wraps Sterile Cotton-Tipped Applicators – Double-Swab Technique

Swab J was added to the study to determine if the advantage of using Swab I, the Bode DUO-V swab, can be duplicated by using two regular cotton swabs (Pur-Wraps Sterile Cotton-Tipped Applicators). At the end of the double-swabbing, there was no staining visibly present on the slide.





Observations During Extraction

- Swab A (Pur-Wraps Sterile Cotton-Tipped Applicator) – It was easy to cut off cotton from the head of the swab.
- Swab B (Pur-Wraps Rayon-Tipped Applicator) – It was easy to cut off rayon from the head of the swab.
- Swab C (Pur-Wraps Polyester-Tipped Applicator) – It was easy to cut off polyester from the head of the swab.
- Swab D (Pur-Wraps Foam-Tipped Applicator) – It was very difficult to remove the head of the swab; in the process, blood transferred to cutting surface. On one swab it was easier to just cut the entire head off and not attempt to remove material from the head of the swab; therefore the entire head was placed in tube for extraction.
- Swab E (Copan Nylon Flocked Swab) – It was very difficult to remove the material from the head of the swab.
- Swab F (Puritan Self-Saturating Swab (Trace DNA Collection Device)) – Blood flakes came off onto the cutting surface while removing the head of the swab.
- Swab G (Forensic ID Trigger ID) – The material on the head of the swab strongly adhered to the stem. The stem was also difficult to cut and during the process the head flew off the cutting surface. The swabs were also still moist and as a result the stain transferred onto the cutting surface.
- Swab H (Fitzco SpinEze Sterile PushOff Swab with Dacron Fiber) – This swab is designed to allow the head of the swab to be popped off easily into the extraction tube. This worked well, but it places the entire head of the swab into the tube. It is usually desired to have just the outer layer, since the entire swab will absorb all of the extraction buffer used. Additionally, if it is desired to retain a portion of the stain on the swab for future retesting, it would not be useful to place the entire head of the swab into the extraction tube.
- Swab I (Bode Technology SecurSwab DUO-V Swab System) – It was easy to cut off cotton from the head of the swab.
- Swab J (same as Swab A – Double-Swab Technique)
- Control – This was 20ul of liquid blood put directly into the extraction tube

Findings

DNA Recovered from Swabs – Phase 1 (Large-Volume Recovery)

Swab	Quantity ng/µl	Total (ng)	Mean (ng)	SD (σ)	Average Percentage Recovered
A1	2.07	103.5	204.2	60.4	69.9%
A2	4.41	220.5			
A3	3.76	188.0			
B1	4.23	211.5	202.1	41.6	69.2%
B2	3.86	193.0			
B3	5.45	272.5			
C1	3.15	157.5	148.2	24.2	50.7%
C2	2.78	139.0			
C3	2.19	109.5			
D1	4.65	232.5	221.1	28.7	75.6%
D2	3.51	175.5			
D3	4.2	210.0			
E1	3.41	170.5	173.5	38.5	59.3%
E2	3.53	176.5			
E3	4.8	240.0			
F1	0.575	28.8	25.3	7.9	11.3%
F2	0.755	37.8			
F3	0.439	22.0			
G1	1.32	66.0	79.8	46.5	27.2%
G2	1.87	93.5			
G3	3.13	156.7			
H1	3.54	177.0	162.2	59.4	55.6%
H2	2.95	147.5			
H3	1.25	62.5			
I1	4.85	242.5	242.2	74.3	84.6%
I2	4.84	242.0			
I3	2.27	113.5			
J1	4.36	218.0	201.2	37.3	71.5%
J2	3.69	184.5			
J3	2.87	143.5			
Control1	11.8	295.0	292.5	2.5	
Control2	11.7	292.5			
Control3	11.6	290.0			

Note: All samples used in the calculations were within one standard deviation of the mean. Outliers not within one standard deviation are shown in dark blue in the table and were not used in the calculations.

Discussion on Recovery of DNA and Blood Stain Left on Slide

1. A full DNA profile was able to be developed for every swab tested.
2. The double-swab technique, whether conducted with the Bode Technology SecurSwab DUO-V Swab System or Pur-Wraps Sterile Cotton-Tipped Applicators, was the most effective in sample recovery. With the Bode Technology SecurSwab DUO-V Swab System, only one half of each swab can be used.
3. The Pur-Wraps Foam-Tipped Applicator did not appear to collect as much stain as some of the other swabs based on the amount of blood left on the slide after swabbing was completed, but it still gave a very high yield of DNA. This could be due to the swab's ability to release stain during the extraction process. A double-swab technique using this swab was added in Phase 2 (as Swab K) to determine if this would be more effective than the Bode Technology SecurSwab DUO-V Swab System.
4. The Puritan Self-Saturating Swab (Trace DNA Collection Device), which did not solubilize the stain and collected flakes, proved to be the least effective swab. It did not collect much of the stain and, because the stain did not bind to the swab after it was dried, the flakes came off easily, resulting in a loss of sample.
5. The Bode Technology SecurSwab DUO-V Swab System had a very secure transport case, and the swab was completely dried by the next day using the desiccant.

Ranking of Swabs for Large-Volume Recovery Based on Percentage Recovery

1. Bode Technology SecurSwab DUO-V Swab System
2. Pur-Wraps Foam-Tipped Applicator
3. Pur-Wraps Sterile Cotton-Tipped Applicator – Double-Swab Technique
4. Pur-Wraps Sterile Cotton-Tipped Applicator
5. Pur-Wraps Rayon-Tipped Applicator
6. Copan Nylon Flocked Swabs
7. Fitzco SpinEze Sterile PushOff Swab with Dacron Fiber
8. Pur-Wraps Polyester-Tipped Applicator
9. Forensic ID – Trigger ID Swab
10. Puritan – Self-Saturating Swab (Trace DNA Collection Device)

Phase 2

Procedure

The purpose of Phase 2 was to repeat the testing conducted in Phase 1, but with a smaller volume (2µl) of biological stain. This testing was performed to determine if some of the swabs that did not collect all of the large stain were more effective for the retrieval of smaller stains. As before, the results were compared from swab to swab and from swab to control (liquid sample).

As in Phase 1, the first step was to prepare sets of three bloodstained glass slides (marked A1, A2, A3; B1, B2, B3; … I1, I2, I3) for each of the swab types to be tested. (Note: Swab I slides were prepared in duplicate, not

triplicate.) For Phase 2, two extra sets of slides (marked J1, J2, J3 and K1, K2, K3) were prepared for testing the double-swab technique – set J for cotton swabs and set K for foam swabs.

To prepare the slides, a quantity of 2µl of blood was placed on each slide and dried at room temperature overnight. The following day, the dried bloodstain on each slide was swabbed; the swabs were slightly moistened with sterile water unless the swabs came with their own surfactant.

To moisten, 2 to 3 drops of sterile water was placed on each swab using a Pasteur pipette. Less was used if the swab did not have the ability to retain that amount of water. The goal was to transfer the entire dried bloodstain onto the swab. The swabbing action was performed until this was achieved or until the swab became saturated and was simply spreading the stain around the surface of the slide. After the swab was saturated, the slide was photographed to document any remaining stain.

The swabs were left to air dry overnight unless they came with their own drying mechanism (desiccant), in which case that mechanism was used. The following day all the triplicate sets of swabs were extracted using the BioRobot® EZ1 Workstation using the Trace Tip Dance Protocol. As in Phase 1, if any of the swabs could not work with this protocol, it was noted.

After extraction, the triplicate sets of swabs were quantitated using the Applied Biosystems Quantifiler® Duo quantitation system. The quantities were compared to each other and also to the control set of liquid blood extracted using the same extraction method.

One triplicate of each set was amplified using the AmpFℓSTR® Identifiler® Plus amplification kit and run on the 3130*xl* Genetic Analyzer to ensure that a full DNA profile could be developed.

At the end of Phase 2, the swabs were compared and ranked based on how much DNA was retrieved.

Swab Sets

The following sets of swabs were tested in Phase 2:

A. Pur-Wraps® Sterile Cotton-Tipped Applicator
B. Pur-Wraps® Rayon-Tipped Applicator
C. Pur-Wraps® Polyester-Tipped Applicator
D. Pur-Wraps® Foam-Tipped Applicator
E. Copan Nylon® Flocked Swabs
F. Puritan® – Self-Saturating Swab (Trace DNA Collection Device)
G. Forensic ID – Trigger ID™ Swab
H. Fitzco SpinEze® Sterile Pushoff™ Swab with Dacron Fiber
I. Bode Technology SecureSwab™ DUO-V Swab System
J. Pur-Wraps® Sterile Cotton-Tipped Applicators – Double-Swab Technique
K. Pur-Wraps® Sterile Foam-Tipped Applicators – Double-Swab Technique

Observations During Phase 2 Swabbing

Because the quantity of blood (2µl) was so small, there was no stain remaining on any of the slides after swabbing. Therefore, no photographs were taken of the slides.

Observations During Extraction

Extraction observations from Phase 1 apply to Phase 2 also. Additionally, for Swab K (Pur-Wraps Foam-Tipped Applicators – Double-Swab Technique), the observations are the same as for Swab D.

Findings

DNA Recovered from Swabs – Phase 2 (Small-Volume Recovery)

Swab	Quantity ng/µl	Total (ng)	Mean (ng)	SD (σ)	Average Percentage Recovered
A1	0.573	28.7	17.9	6.9	25.2%
A2	0.418	20.9			
A3	0.298	14.9			
B1	0.569	28.5	30.0	8.4	42.2%
B2	0.63	31.5			
B3	0.314	15.7			
C1	0.406	20.3	32.8	10.9	46.2%
C2	0.76	38.0			
C3	0.804	40.2			
D1	0.431	21.6	25.7	2.5	36.4%
D2	0.516	25.8			
D3	0.518	25.9			
E1	0.565	28.3	33.2	4.3	46.7%
E2	0.716	35.8			
E3	0.71	35.5			
F1	0.175	8.8	7.7	4.1	10.9%
F2	0.0176	0.9			
F3	0.134	6.7			
G1	0.678	33.9	33.3	5.0	46.9%
G2	0.76	38.0			
G3	0.562	28.1			
H1	0.544	27.2	28.1	0.8	39.6%
H2	0.574	28.7			
H3	0.567	28.4			
I1A+I1B	1.0039	50.2	43.5	9.5	61.2%
I2A+I2B	0.73425	36.7			

Swab	Quantity ng/µl	Total (ng)	Mean (ng)	SD (σ)	Average Percentage Recovered
J1A+J1B	0.756	37.8	38.1	2.6	53.5%
J2A+J2B	0.763	38.2			
J3A+J3B	0.849	42.5			
K1A+K1B	0.8187	40.9	43.4	2.6	61.1%
K2A+K2B	0.8632	43.2			
K3A+K3B	0.922	46.1			
Control1	1.43	71.5	71.0	5.3	
Control2	1.31	65.5			
Control3	1.52	76.0			

Note: All samples used in the calculations were within one standard deviation of the mean. Outliers not within one standard deviation are shown in dark blue in the table and were not used in the calculations.

Discussion on Recovery of DNA and Blood Stain Left on Slide

1. A full DNA profile was able to be developed for every swab tested.
2. Based on the results of the small-volume test, the best recovery came from the Bode Technology SecurSwab DUO-V Swab System. This collected the most amount of blood from the surface and gave the highest percentage of recovery.
3. The Pur-Wraps Foam-Tipped Applicators also performed very well when using the double-swab technique. This was followed by the Pur-Wraps Polyester-Tipped Applicator and then the Pur-Wraps Sterile Cotton-Tipped Applicators using the double-swab technique.
4. From these results it is clear that both the material and composition of the swabs and the technique employed affect the swab's performance. The double-swab technique (a wet swab followed by a dry swab) seems to work best to collect the maximum amount of substance from a surface. The Bode Technology SecurSwab DUO-V Swab System with its desiccant allows for quick drying of the swab, protects the swab from contamination and makes transportation easier.
5. Sterile water worked better as a surfactant than did the alcohol-based liquid contained in the Puritan Self-Saturating Swab (Trace DNA Collection Device), which failed to dissolve the stain, resulting in very low amounts of the stain being picked up by the swab and in turn resulting in a lower yield of DNA from the collected material.

Ranking of Swabs for Small-Volume Recovery Based on Percentage Recovery

1. Bode Technology SecurSwab DUO-V Swab System
2. Pur-Wraps Foam-Tipped Applicators – Double-Swab Technique
3. Pur-Wraps Sterile Cotton-Tipped Applicator – Double-Swab Technique
4. Forensic ID – Trigger ID Swab
5. Copan Nylon Flocked Swabs
6. Pur-Wraps Polyester-Tipped Applicator
7. Pur-Wraps Rayon-Tipped Applicator
8. Fitzco SpinEze Sterile PushOff Swab with Dacron Fiber

9. Pur-Wraps Foam-Tipped Applicators
10. Pur-Wraps Sterile Cotton-Tipped Applicator
11. Puritan – Self-Saturating Swab (Trace DNA Collection Device)

Price Point Comparison

Swabs varied in prices as shown below. The prices given are the approximate price per swab or pair depending on how they are packaged. These prices are subject to change based on the distributor from which they are purchased and quantity purchased.

A.	Pur-Wraps Sterile Cotton-Tipped Applicator	$0.17
B.	Pur-Wraps Rayon-Tipped Applicator	$0.11
C.	Pur-Wraps Polyester-Tipped Applicator	$0.19
D.	Pur-Wraps Foam-Tipped Applicator	$0.39
E.	Copan Nylon Flocked Swab	$1.22
F.	Puritan – Self-Saturating Swab (Trace DNA Collection Device)	$1.15
G.	Forensic ID – Trigger ID Swab	$5.00
H.	Fitzco SpinEze Sterile PushOff Swab with Dacron Fiber	$0.64
I.	Bode Technology SecurSwab DUO-V Swab System	$2.95

Conclusions

When selecting the swab that best suits the needs of a biological evidence collection process, one should consider many factors: performance of the swab, the swabbing technique, cost of swabs and convenience.

The double-swab technique is a far superior method for collection of samples than using a single swab; however, this will double the cost spent on swabs. Based on the low price of some of the swabs, this may not be of concern to the laboratory, especially since most of these swabs are packaged in sets of two. Other, more expensive swabs that may be overlooked because of cost should also be given consideration. The Bode Technology SecurSwab DUO-V Swab System, for example, is relatively expensive compared to others tested, but this swab provides certain advantages. Since it does not have to be air dried before packaging, it reduces the potential to introduce contamination. Packaging of wet swabs can also lead to transfer of sample to the container, thus reducing the amount of DNA left on the swab for testing and possible degradation of the DNA. The Bode Technology SecurSwab DUO-V Swab System solves both of these problems. It would be up to the laboratory to determine if the advantages provided by a more expensive swab are worth the extra cost.

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