

# 063RLV'0 \$ 1RYHO 3HSIWE D W L, R Q \$ W J R U L W K F IRU 7DQGHP 0DVV 6SHFWUD

6LPLQ =KX &KXDQMLH <DQJ :HQ\ D :X

&KLQD )LUH D Q Q V X W V F X H L Q M L W J &KLQD

\$EVWU D F Q G H P P D V V V S H F W U R P H W U \ 0 6 0 6 R S G D L Q S Q R H W W R I P I P H O U H F S I I  
7KRXVDQGV RI VSHFWUD FDQ EH JHQZ WDRW H G W L H Q J S P U R H G M U Q K H I [ \$ H U B P O B C  
FKDOOHQJLQJ SUREOHP LQ WDQGH P I E B H Q W S H L F W W D R Q Q D O V R L M W X P J S I  
LQWHJUDWHG V P H W L Q Q H Z Q L E W S I U C H R X F H G V D W W V W Q W F H Q D L O W K R Q I R K U P D W L R  
RIWHQ XQGHUYDO Q H R G U G H U W W K H I F R M E H L Q H R U I P H W Q R O R Q R S W E S I R W H D Q R Y H C  
FRQFHSW VFRULQJ G P R Q H D R Z K V R Q E D L W H H G E Z L W K R G R R R P S O \ X V H G F R P P  
VRIWZDUH 0DVFRW DQ G 6HTXHVW DW 0 L Y 5 U R V E K W W H D V Q G W M U W D R Z L 0 6 3 R I  
GDWDVHWV ZKLFK H U E H Q D V L Q L Q G W W R K P K O L D V O J R H U I H V S H P O 6 3 R L V ' 0 Z L O O E H I  
DSSOLHG W R R P K F V S V W X G L H V

.HIZRUG, QGHJ 7HUPV 7DQGH P 3 0 B W H 6 G H S W Q L W K E F D W L I R Q W O R I R 3 D L U \$ P L C  
\$FLG )UDFWXUH

, QWURGXFWRQ

WKH FRUHFV S W S W L G H V D G J H S W L W K I R Q  
0DVFRW 2066\$ > @ ; 7DQGH P > @

, Q ELRORJLFDQ VDPSON DQDO\VL 3URFHM% VSH@WURPHWU\ 06  
EDVHG SURWHRPLFV KDV HYROYHG 5 D Q V R P D Q D W R K L Q \$ H P R Q D E O H X V L Q J  
DSSURDFK > @ , Q SURWHRPLFSURSHILQ V P D W V S L R W H U L E X W D R Q D Q G  
EH FOHDYHG LQWR SHSWLGHV P D V H Q J G L W W H D E F W L H R Q W W K H Q F R U U H V  
VHSDUDWHG DQ G H Q W H U 0 6 I R U V E Y I H G H E Q M C O W P Q D H Y H I U D D > L Q W @ U Y D O  
7KRXVDQGV RI IUDJPHQWDWLRQ V S H F W U D L E Q I H W H U R D W H E C K L Q V P R W H W Q H P D I  
SURWHRPLFV H [ S H U Q I H Q S H S V R I Z G W S V S W X B G F H W K H Q E X L O W W K H L G H Q W  
D FKDOOHQJLQJ DQ G S U R S R V H 5 H S L W H Q W D L V L H Q W D O L F R D W L R Q V V X F K  
DOJRULWKPV DUH QHFHVVLW\ > > @  
\$OJRULWKPV P R Q H F W U H D W H O H I I L F L H P S L U D Q G Z H L J K W P D W F K L Q J P I  
DFFXUDF\ RI VHDUFKLQJ VSHFWUD G E I I @ U H G R U H Q S L X Q F D O R Z H L V W W K H W R  
FRUH RI SURWHLQ LGHQWLILFDW R R Q X D O H R Q F L W K R W H Q W M L U D W S G L W K H  
FXUUHQW DOJRULWKPV W I S H V W K H W F R X H G E H H G W D K E K H D L O O R V U R V V P @  
FDWHJRULHV DV IROORZV > 6 @ ' > @

&RUUHODWLRQ PDWFKLQJ P R G W A J U D W H P D W K R R D W K D D D F W H U L J H V  
VLPXODWLRQ RI SURWHLQ GLJHV W O R R U D Q G P P D Z D V V S E F W U R D E O W \ Z K L  
GHWHFWLRQ SURFHV V W K H W K H R U \ R I H Q J P H S H S W L G H V  
WUDQVIRUP LQWR WKH FRUHFV S R O G L Q S U H L F W H G D U E F L W U X S H W X Q W V  
WKH GHJUHH RI H I R Q S H O D W E R Q E Y S P X W X P D G G V K H P D L Q F K D U D F V  
H [ S H U L P H Q W D O V S H F W U X P Q H H G H G W R E H W K H Y D O X D W H G E R  
PDWFKHPDWLFDO G S W K R D B S U R E S U D W H R W H 6 H Y K H D W G ; 2 0 6 6 S G H P H D N L Q W  
UHVXOWV 5 H S L W K P W W D W F K Y D I V D G H R X P V W > @ D O G H U R I W H Q X Q G H U Y D O  
S) L Q G > @ X Q U H O L D E L O L W \ L Q R U G H U W R L C

3UREDELOLVWLF PDWFKLQJ P R G H O X W W L R Q N D Y R Y L O D H F O W L Q S I H P D O Q  
SUREDELOLVW ZKLFK REWDLQH G E P S H U D W L Y F L Q J W R H W D W H V W L P D O Q  
V H O H F W H I I L F Q G Q F W S B D N G W K H I U D J  
FHU W D L Q Y D O X H L Q D F H U W D L Q W H Q V R W \ U S B W H H Q Q S U R E X I L O W W K  
GDWDEDVH WR LQGLFDWH WKH F U D G R E L L W K P V R I P D W F K H Q W P F H O S Q F S U  
WKHQ FRQVWUX F W G R D L W H P V R Q G E R Y H D F R F K L Q S W R E K D W L R V O H E I D J H G Q R Q

PDWFKLQJ GLVBOLP... DEKDG... QSRFHV...  
 UHIOHFWHG WKH SURSHUWLHV RI...  
 DSSHQGHG PRUH...  
 LPSURYH WKH HILFLHQF\ DQG...  
 UHVXOWV > @  
 ,Q WKLV SDSHU ZH SURSRVHG D...  
 DOJRULWKP QDPHG 063RLV'0 ZKLFK...  
 QHZ FRQFHSW...  
 ,GHQWLILFDWLRQ...  
 UHDO PDWFKLQJ PHDQWLPH ZH EXLOW...  
 IRU DGGLQJ 3,, LQIRUPDWLRQ 7R YDOLGDWH WKH UHDELWLW\ DQG  
 DFFXUDF\ RI 063RLV'0...  
 YDULRXV PDVV VSHFWRPHWHU...  
 ZLWK ODVFRW DQG 6HTXHVW DWKH...  
 063RLV'0 VKRZHGH PRUH UREXVW...  
 UHVXOWV

0HWKRGV

063RLV'0 ,GHQWLILFDWLRQ...  
 063RLV'0 ZKLFK LQ YLUWXH RI...  
 FRQVWUXFW D QRYHO VFRULQJ PRGHO DQG...  
 3,, LQIRUPDWLRQ :H DGRSWHG ODWODE...  
 5 D DV WKH SURJUDPPHQJ ODQJXDJH...  
 WUDLQLQJ H[SHU...  
 LQIRUPDWLRQ ZDV FUXFLDO IRU...  
 +HUH ZH WKURXJK WKH IROORZLQJ...  
 WKH DOJRULWKP...  
 ,VRWRSHV GLVFDUGLQJ SOHQ...  
 VR H[SHULPHQW...  
 SHDNV OHG WR PRUH UDQGRP PDWFKLQJ...  
 PDWFKLQJ WKH NH\ RI GLVFDUGLQJ...  
 FRUUHFWO\ MXGJ...  
 DV IROORZLQJ LI WKH...  
 ZHUH FRQVLGHUHG DV LVRWRSH...  
 SHDN QHHGHG...  
 UDQGRP PDWFKHV DQG HQKDQFH...  
 3HDNV VHOHFWLQJ GLIIHU...  
 DOJRULWKPV KDG...  
 6HTXHVW DQG 64,' VHOHFWHG WKH...  
 LQ HDFK H[SHU...  
 GLYLGHG WKH...  
 WRS SHDNV...  
 LQWHQVH SHDNV LQ HDFK...  
 G\QDPLF DSSURDFK ZKLFK KDG...  
 WR VHOHFW SHDNV...  
 Da ZLQGRZ

Da ZLQGRZ

([WUDFWLQJ]... DQG...  
 DEXQGDQW FKDUDFWHUL]HV LQ...  
 DFFXUDF\ RI VFRULQJ DOJRULWKP...  
 PHDVXUH RI UHDO PDWFKLQJ RU...  
 H[WUDFWLRQ...  
 D 7UDLQLQJ GDWDVHW XWLOL]HG...  
 WUDLQLQJ ZDV H[WUHPHO\ LPSRUWDQW...  
 063RLV'0 ZDV H[WUDFWHG IURP...  
 ZKLFK ODVFRW...  
 FRQWUROOHG E\...  
 WUDLQLQJ...  
 E 6WDWLVLWLFDO PHWKRG...  
 JHQHUDWHG YDULRXV UHVXOWV...  
 LQ RUGHU WR REWDLQ 3,,

FKDUDFWHULJHWLRQIRUPDWLRQRIKHOSSHFLILFDVWKHILQDOVFRUHRI  
 GHWDLOVDVIROORZV  
 D)UDJPHQWPDWFKHV SURSRVHG D XOLYHUYDOVFRULQJ  
 IXQFWLRQIRUYDULRXV VWUDWHJLHVLEKIDUGUHIOHFWHG WKHFRQI  
 SUREOHP E\ XWQOGLQWU~~BEKWLRO~~W~~ERKLE~~EXLQFLHGW  
 DSSURSULDWHIXQFWLRQWKHIRUPXODRI3RLVYHQGLYVWUWEXW~~RO~~  
 DV EHZRZ

$$P_X = K^{-1} \cdot \lambda^K \cdot e^{-\lambda} / K$$

:KHUH UHIOHFWHG WKH QXPEHU RI RUPDWLRQ PDWFKHV VHSUDUW  
 UHIOHFWHG WKH SUREDELOZKMFRIIDVFKLHG DV FRQVHFXWLYH XHPPXDWFKWD  
 WKH FRQILGHQFH RI IUDJPHQW PDWFKHV RQWREWQWPHSHWKH RQ WISH D  
 WKHRUHWLFDOPHDQRI IUDJPHQW PDWFKHV HTXDO WKH PDVV RI D UHVLGXH  
 $\lambda$  FRXOG EH FDOFXODWHG IURP WKH IROORZLQJ IRUPXOD

$$\lambda = N$$

:KHUH UHIOHFWHG SUREDELOZKMFRIIDVFKLHG GHQRWHG WKH QXPEHU RI F  
 EHFDXVH RI ZH VHOHFWHG WKH WRS SHDNV IURP HDEK' D SUREDE  
 LQ WKH H[SHULHQWDO VSHFWUD UHIOHFWHG WKH QXPEHU RI  
 WKHRUHWLFDOPDWFKHV $\lambda$  @HDQWLPH ZKHU WKH  
 SUREDELOZGRVWRULEXHGRO[D]BXH  
 IROORZLQJ PHWKRQ

$$P_{BPD} = \epsilon^{-1} \cdot \lambda^\epsilon \cdot e^{-\lambda} / \epsilon$$

7KH SUHOLPLQDU\ IUDJPHQW PDWFKHV FDOFXODWHG N  
 IURP WKH IROORZLQJ IRUPXOD

$$S_{B3\downarrow} = V J Q - \epsilon \cdot O J \frac{P_{BPD}}{P}$$

:KHUH  $\frac{K}{N}$  UHIOHFWHG WKH

7DEOH 33, 9DOXH YDURPSXWNG\ LRQWISHDQG UHIOHFWHG WKH QXPE  
 LQWHQVLW\ LQWHUYDO

FRQVHFXWLYH IODLWFK SKURFEDUHSRU  
 3URSHN% UHIOHFWHG WKH QXPE  
 FRQVHFXWLYH KHDWFKHV WKH SUREDE  
 DUULYHG DW PD[LXP

> > > > > > > > > > >

$$P_{BPD} = \epsilon^{-1} \cdot \lambda^\epsilon \cdot e^{-\lambda} / \epsilon$$

E  
 E  
 1  
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 2

/LNH WKH VFRULQJ VWUDWHJ\ RI IUDJ  
 DOVR QHHGHG WR FIDLOXODWRH WKH ISR  
 PDWFKHV 7KH RFSHFV IROORZV

$$S_{B3\downarrow} = V J Q - \epsilon \cdot O J \frac{P_{BPD}}{P}$$

:KHUH  $S_{B3\downarrow}$  LV WKH SUHOLPLQDU\ VFRU  
 IUDJPHQW PDWFKHV 7KHQ WKH ILQDO  
 LQWHQVLWGRQ3DVLQRULORZVQJ IRUPXO

$$S_{B3\downarrow} \times e^{\sum_{j=1}^K II_j} \quad S_{B3\downarrow} \geq$$

:KHUH  $S_{B3\downarrow}$  LV WKH SUHOLPLQDU\ VFRUH RI IUDJPHQW  
 PDWFKHV WKH IXQFWLRQ VKRZHG WKH PRISH $S_{B3\downarrow}$  IUDJPHQW PDWFKHG  
 WKH KLJKHU VFRUH REWDLQHG Q RUGHU WR LQWHUYDO WKH 33  
 LQIRUPDWLRQ ZH QHHGHG WR UH'VFRUH WKH IUDJPHQW PDWFKHV RI F  
 FRUUHVSRRGLQX3PHUH PPI, DQG

$$S_{B3\downarrow} = \begin{cases} S_{B3\downarrow} \times e^{\sum_{i=1}^K PPI_i} & S_{B3\downarrow} \geq \\ S_{B3\downarrow} \times e^{-\sum_{i=1}^K PPI_i} & S_{B3\downarrow} < \end{cases}$$

UHVSHFWLYHO\ I, QG WKH YDOXH RI  
 IROORZLQJ IRUPXOD  
 $II_j = PPI_s + PPI_t$

F E \ LRQ PDWFKHV E \ LRQ ZHUHFKW DIFRDLQJ W UODRUPKPDVOWR S G EDXWWDH  
 XQGHU &,' HQYLURQPHQW (YDOXDWK HGGV WHD VHIHMF IRHQ FIDR MEZDV REWDL  
 LRQ PDWFKHV FRXOG LPSURYH WKHQWR EDXV RIDQXQ DFDWUDFQ KIQLYHUV  
 SHSWLGH LGHQWIK PLF DMLRQ Z B J RHOHLGHWHG E \ +&  
 WKH E \ LRQ PDWFKHV DV WKH LOONSRQGBQW B BTRUPDWZRIQ H QZWBHO \  
 VFRULQJ PRGHO UHVHDFK ZKLFK ZHUH DGRSWHG

$$P_X = K \cdot \lambda^k \cdot e^{-\lambda} / K$$

:KHUH UHIOHFWHG WKH QXPEHU YRRIPEW LRQ PDWFKHV PHUJH SO ZKLF  
 UHIOHFWHG WKH SUREDELRICQ PDWFKHV PDVFRW RIILFLDO ZHE 'WD IRUPDW IL  
 UHIOHFWHG WKH WKHRUHWLFDO PSDQRI E \ LRQ PDWFKHV DQGLGEMLRQ FULWHU  
 FDOFXODWHG IURP WKH IROORZLQJ PHWKRQ IRUL ODVFRWFKHV 6HTXHVV DQGLG  

$$\lambda = \cdot N$$

:KHUH ZDV WKH GERPLSUDREDELO BHWKLRQLQH 'D R[LGDWLR  
 WKH QXPEHWRUWKH LFDO E \ LRQ PDWFKHV YDULDEOH PRGLODFDWLRQLBQVSHXILIL  

$$\varepsilon = \lambda @ WKH SUREDELOKMPBELVDPXQDOXH$$

$$P_{BPDI} X = \varepsilon \cdot \lambda^\varepsilon \cdot e^{-\lambda} / \varepsilon$$

6LPLODUO\ WKH SUREDELOBQ PDWFKHV UFXPHOSRRLV'0 6HTXHVV  
 EH REWDLQHG E \ WKH IROORZLQJ IRUPXOD 3,7 ),7 3,7 ),7  

$$S_{B3\theta} = V JQ - \varepsilon \cdot O \cdot J \frac{P_{BPDI}}{P}$$

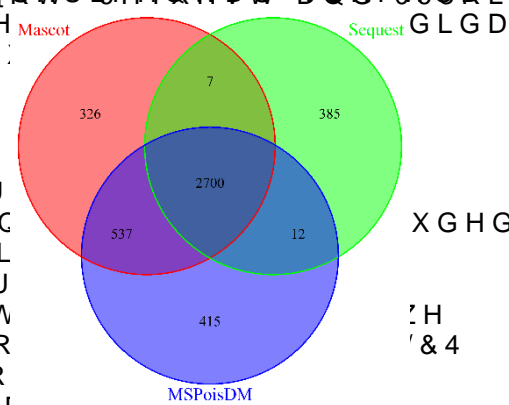
0HDQWLPH WKH ILQDO VFRUH RI E \ LRQ PDWFKHV DV IROORZV  

$$S_{Final} = \begin{cases} S_{B3\theta} \times e^{\sum_{k=1}^K PPI_{k,b,y}} & S_{B3\theta} \geq \\ S_{B3\theta} \times e^{-\sum_{k=1}^K PPI_{k,b,y}} & S_{B3\theta} < \end{cases}$$

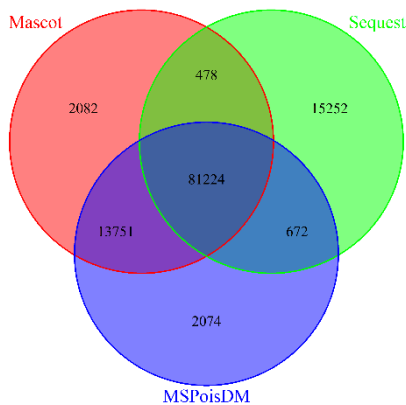
:KHUH  $S_{Final}$  ZDV WKH VFRUH RI E \ LRQ PDWFKHV 063RLV'0 ZDV FRPSDUHG ZLWK ODVFRW  
 G 7KH VFRUH RI FDQGLGDWH SHSWLGHDFKODWEREW WKH BQVMDPRLD  
 SHSWLGH FRXOG EH FDOFXODWHG ERZHG IROORZLQJ ODVFRW DDKDG KLJ  

$$S = S_{Final} + S_{Final} + S_{Final}$$

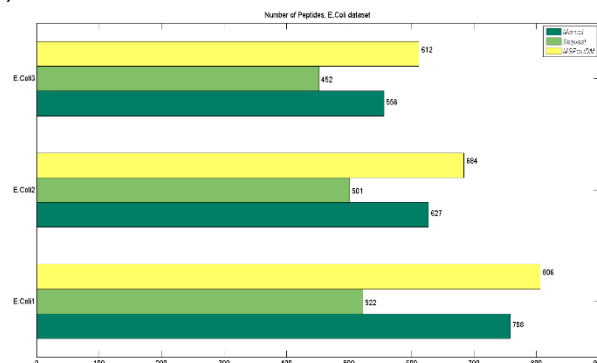
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 WKH VLPLODUO\ GHJUHH EHWZHHQ D HFWULPHQWV DQGLGEMLRQ FULWHU  
 WKHRUHWLFDO VSHFWUD 7KH KLJKH Mascot  
 SHSWLGHV ZDV MDDWHG DFKWQJ UHV: Sequest



0606' DMHW DQ6HDFK ( QJQH  
 :H XWLOLJHG YDUZKRXK GDVHGMRUWHQ W  
 LQVWUXPHQW SDQWIRUPXU HGWBIQGDSU  
 REWDLQHG IURP IRXU W\SHV RI 06 LC  
 7KHUPR )LQQLJDQ /74 )7 7KHUPR )L  
 '(&\$ 7KHUPR )LQQLJDQ /74 DQG 0LFU  
 472) 8OWLPD ,Q RUGHU WR QDUUDW  
 DEEUHYLDWHG WKH QDPHV RI PHQWLR  
 /74 DQG 472) DQG SXEOLF GRZQOR  
 KWWSV UHWHPZBERORJ\ QHW 3XEOL  
 7KH SXEOLF GDWD VHWV RI ( FROL GRZQORDGHG IURP  
 KWWS PDFURGDWHDO DEVBBJ 06 ZKLFK  
 FRQWDLQHG WKH BHFGE GROWLDVHWROL DQG  
 ( FROL 6 SQHXPRQLDH ' GDWDVHW EDVHG RQ /74  
 2UELWUDS ZDV REWDLQHG IURP  
 KWWS ELRMQRHDFVURRWDZDE QRW  
 RQO\ VHUYHG DV WKH WUDLQLQJ GDWD VHW IRU H[WUDFWLQJ 33,

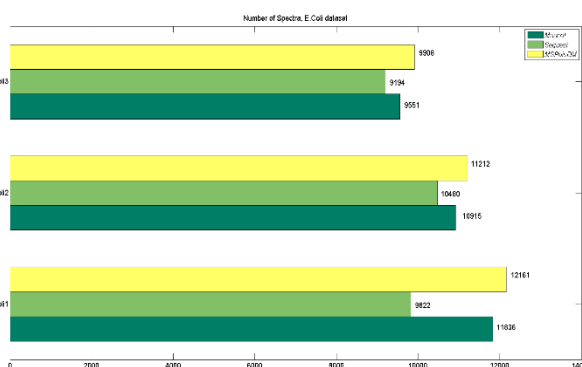


DQG VXSHULRULW\ 6SHFLI\ GHWDLOV  
)LJXUH

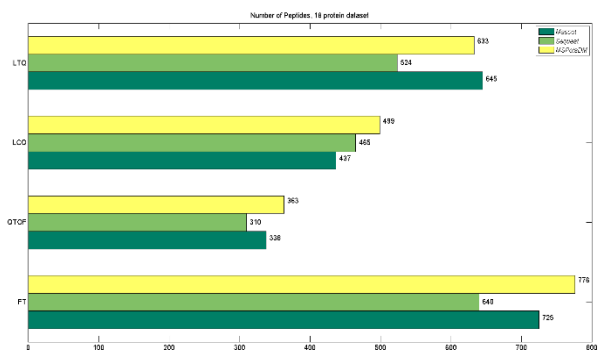


)LJ 2YHUOSD EHWZHHQ WKH WZR IURP UDVFRW 6HTXHVW DQG  
063RLV'0 EDVHG RQ 6 SQHXPRQLDH ' )GDWDGHQWLILHG SHSWLGHV IURP ( FROL  
QXPEHU RI LGHQWLILHG SKISWKGH VSHFWUD DQG 063RLV'0  
VHSFWUD

7KH GDWD VHWV RI VWDQGDUG P  
LQVWUXPHQWV FRQWDLQH )7  
063RLV'0 LGHQWLILHG SHSWLGH  
DOJRULWKPV ZKLFK PHQWRQH  
H[FHSW /74 VKRZHG LWV UREXV  
063RLV'0 LGHQWLILHG PRUH VSH  
DQ\ 06 LGVWUXPHQW )L  
LGHQWLILHG SHSWLGHV KDG GRXSH  
PHQWRQH DERYH UHVSFWLYH



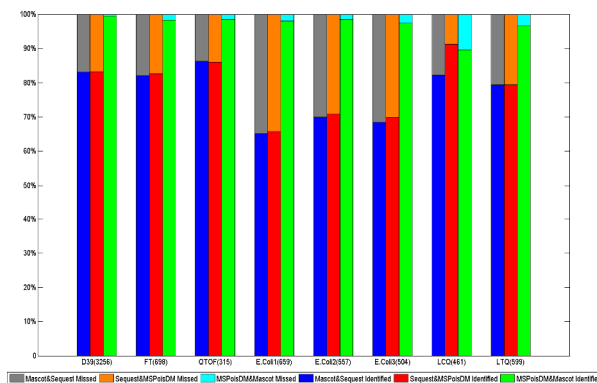
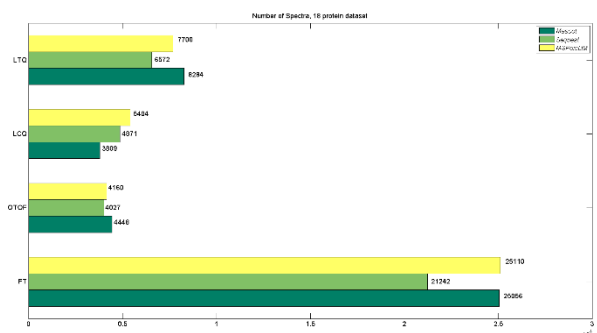
FK  
NV  
ZHUH



)LJ ,GHQWLILHG VHSFWUD IURP ( FROL  
6HTXHVW DQG 063RLV'0

)RU YHULILQJ WKH DREXWDFZH VKR  
FDOFXODWH WKH RYHUODS EHWZHHQ  
DOO 7KH SHSWLGHV ZKLFK LGHQWLIL  
HQLQHV ZHUH GHILQH DV KLJK F  
\$FFRUGLQJ WR WKH )LJXUH DQG  
063RLV'0 KDQILHQFH SKISWKGH  
RWKHUV

)LJ ,GHQWLILHG SHSWLGHV IURP  
6HTXHVW DQG 063RLV'0



V

)LJ ,GHQWLILHG VHSFWUD IURP ( FROL  
6HTXHVW DQG 063RLV'0

7KH GDWD VHWV RI ( FROL ZKLFK  
( FROL ( FROL WKH LGHQWLILHG SHSWLGHV IURP ( FROL  
VSHFWUD IURP ( FROL WKH LGHQWLILHG SKISWKGH VSHFWUD  
VHDFK HQJLQHV VKRZHG 063RLV'0 KDG KLJK LGHQWLILHG

7DEOH +LJK FRQILGHQFH SHSWLG  
 063RLV'0 IURP YDULHV GDWD

0 6 6 03 0 0 03<sup>6</sup> +B3  
 03

)7

472)

E.coli

E.coli

E.coli

/ & 4

/74

7DEOH +LJK FRQILGHQFH VSHFWL  
 063RLV'0 IURP YDULHV GDWD

0 6 6 03 0 0 03<sup>6</sup> +B6  
 03

)7

472)

E.coli1

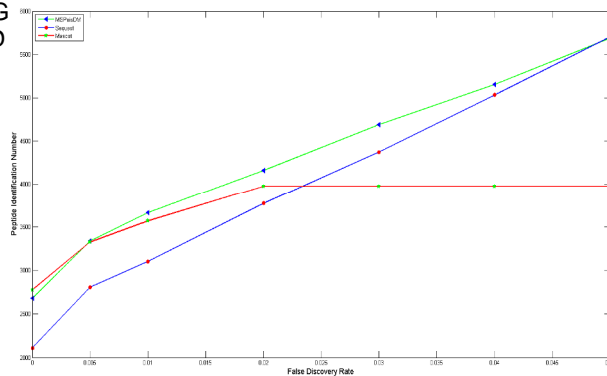
E.coli2

E.coli3

/ & 4

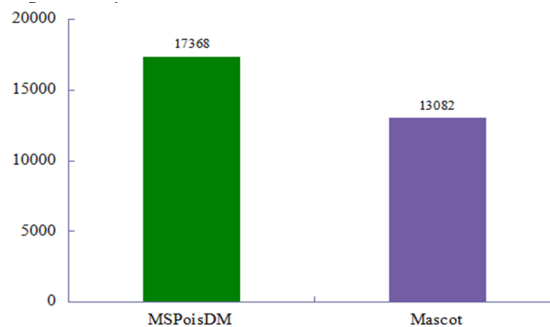
/74

)LJXUH VKRZHG )'5 IURP WKH UHQHURGHV RI DOO WKH PHQWLRQHG SHSWLGH LGHQWLILFDWLRQ DOJRULWKPV  
 063RLV'0 LGHQWLILHG SHSWLGHV ZDV WKH PRVW LQ a  
 RI DOO WKH PHQWLRQHG SHSWLGH LGHQWLILFDWLRQ DOJRULWKPV  
 VKRZLQJ LWV UHOLDEOH DQG VLJQLILFDWLYH VLRLQ

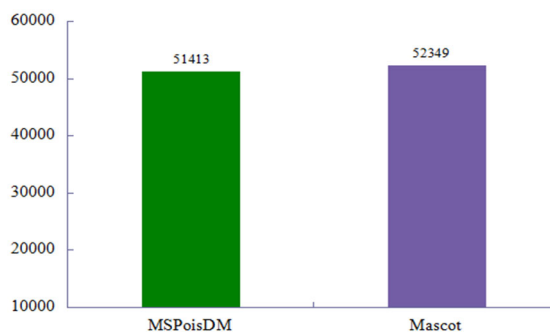


)LJ )'5 IURP WKH UHQHURGHV RI DOO WKH PHQWLRQHG SHSWLGH LGHQWLILHG SHSWLGHV ZDV WKH PRVW LQ a

)RU YHULI\LQJ WKH JHQHUDOLW\ RI DOO WKH GDWD VHW RI \HDVW ZKLFK ZDV VHDUFKLQJ UHVXOWV VKRZHG 063RLV'0 SHSWLGHV WKDQ ODVFRW )LJXUH D LGHQWLILHG SHSWLGHV DQG VSHFWUD UHVSHFWLYHO\



)LJ ,GHQWLILHG SHSWLGHV RI DOO WKH PHQWLRQHG SHSWLGHV ZDV WKH PRVW LQ a



063RLV'0 SURSRVHG D QRYHO SHSWLGHV DOJRULWKP RSWLPLJHG IRU WDQGHV LQWHJUDWHG WKH LGHQWLILHG SHSWLGHV ZDV WKH PRVW LQ a WKH GLYHUVLW\ GDWD VHWV IURP G VKRZHG 063RLV'0 UREXVW DFFXUD 0HDQWLPH IRU YHULI\LQJ WKH JHQHUDOLW\ DGRSWHG WKH \HDVW GDWD VHW IURP 063RLV'0 LGHQWLILHG PRUH SHSWLGHV

063RLV'0 ZDV D SHSWLGH DOLGHQW SURWHLQ RQGHW DQGLFFD WDRQ VSBFW  
DOJRULWKP IRU WDQGHG PDVV VSHFWURPHWU\ QIRUPDWLFV

\$FNQRZOHGJHPHQWV

:H DUH JUDWHIXO WR %HLMLQJ VSHFWURPHWU\ FRPSUHKHQVLYH  
HPHUJHQF\ GULODWFK KQRORFHUIRVLW KH &KHSQ\ -- )RXUQLHU &7 HW D  
RI WKH DOJRULWKP GHVLJQ DQG SURSHODV HDUFK\$OJRULWKPV ZLW  
3URWHLQ3URILQBLQRWHRXHQSHOIRDUF

5HIHUHQFHV

3HUNLQV '1 3DSSLQ '-& &UHDV\  
;LDR &/ &KHQ ;= 'X </ HW DO 'BVSHEE\$OIRWHDDMMIGLSURWHLRQQELGV  
3HSWLGH 6FRULWKPJ %DVRIG RQ 3HSWLGHGFH GDWDEDVHV XVLQJ PDV  
0DWFKLQJ 'LVF@LPBQBFLDQW\>- (OHFWURSKRUHVLV  
H H /HORQJ & 7ZR GLPHQVLRQDO JHO  
\*HHU /< 0DUNHDDN3-\$RZVDO 2SHSURWHRPLFV 3DVW SUHVHQW DQ  
6SHFWURPHWU\ BHDUFKQDOORUBVBRWRWRPLFV  
5HVHDFK 7RZQVHQG & )XUXNDZD \$ 6FKZRF  
%DIQD 9 (GZDUGD SUREDELEOLVW&FFPRGHFXUDWH ZKROH OLEUDU\ V  
IRU VFRULQJ WDQGHG PDVV VSHFWURPHWU\ JSHSWDQGHG PDV  
GDWDEDVH %LRLQIRUPDWLFV %LRRUJDQLF 0HGLFLQDO &KHPLV  
%MRUQVRQ 5' &DUULHUR 1 - &RODQJHOR & HW DO HW DO  
; 7DQGHG DQ LPSURYHG PHWKRG DIRU SXQLQJ H Q ;= ' X  
; WDQGHG LQ \$DOHFOHQRQRFR FSHFDEWOLW\ GLVWULEXWLRQ P  
FRPSXWHUV -RXUQDO RI 3URWHRPHWU\ BOJRWDQGHG  
VSHFWURPHWU\ XQWBOQLQW\ SHORU  
&KL + 6XQ 5; <DQJ % HW DO -RXUQDO RI SURWHRPH UHVHDFK  
SHSWLGH VHTXHQLQJ DQG LGHQVLYFDWLRQDULQJDK' ' 0DVV:LJ  
VSHFWUD -RXUQDO RI 3URWHRPHWU\ BOJRULWKP ZLWK WDUJHV  
SLSHOLQH IRU WDQGHG PDVV VSHF  
&KLFN -0 \*\JL 63 1XVLQRZ SURWHRPH UHVHDFK PDVV  
WROHUDQW GHWDFMHHWDDOKJH SURSRUWLRQ  
RI XQDVVLJQHG VSHFWUD LQ VKRWJXQ SURWHRPLFV DV  
PRGLLHG SHSWLGHV 1DWXUH %LRWHFKQRORJ\

'RUIHU 9 3LFKOHU 3 6WUDQJO 7 HW DO 06 \$PDQGD D  
8QLYHUVDO , \$OQRULWKPWDSQ\ LPLJHG IRU  
+LJK \$FFXUDF\ 7DQGHG 0DVV 6SHFWUD >-@ -RXUQDO RI  
3URWHRPH 5HVHDFK  
(ULNVVRQ - )HQ\ ' 3URELW\ D SURWHLQ LGHQWLILFDWLRQ  
DOJRULWKP ZLWK DFFXUDWH DVVLJQPHQW RI WKH VWDWLVWLFDO  
VLJQLILFDQFH RI WKH UHVXOWV -RXUQDO RI 3URWHRPH  
5HVHDFK  
\*RHPLQQH /- \*HYDHUW . &OHPHQW / ([SHULPHQWDO  
GHVLJQ DQG GDWDEDVHV TXDQWLWDWLYH  
/& 06 SURWHRPLFV \$ WXWRULDO ZLWK 06T5RE -RXUQDO  
RI 3URWHRPLFV  
-LDQ / 1LX ; ;LD = HW DO \$ 1RYHO \$OJRULWKP IRU  
9DOLGDWHLQJ G3HCSMILLUGFFD VDLRQRWJXQ  
3URWHRPLFV 6HDUFK (QJLQH -RXUQDO RI 3URWHRPH  
5HVHDFK  
.100 / 6WRUH\V-'0-0DFWRD \$VVLJQLQJ  
VLJQLILFDQFH WR SHSWLGHV LGHQWLILHG E\ WDQGHG PDVV  
VSHFWURPHWU\ XVLQJ GHFR\ GDWDEDVHV -RXUQDO RI  
3URWHRPH 5HVHDFK  
/L ' )X < 6XQ 5 HW DO S)LQG D QRYHO GDWDEDVH  
VHDFKQLQJ VRIWZDUH V\ VWHP IRU DXWRPDWHG SHSWLGH DQG