-RXUQDO RI *DVWURLQWHVWLQDO 'LJHVWLYH 6\VWHP

3XEOLVKHG E\ *DVWURLQW 'LJHVW

5HVHDUFK $UWLFOH 2SHQ $FFHVV

&RUUHODWLRQ EHWZHHQ 6SHFLILF %DFWHULDO 6HYHULW\ RI +DOLWRVLV $QG 3RVVLEOH %HQH

0DULR 'HO 3LDQR 0DUFR %DOODUHWL 3DJDQXFFL 0DUWLQD *LRYDQQL 0RJQD 6XVDQQD *LRYDQQL 0RJQD

*DVWURHQWHURORJ\ 8QLW 0DJJLRUH 'HOOD &DULWj +RVSLWDO 1RYDUD ,WDO\

'HQWLVWU\ 6SHFLDOLVW 0DJJLRUH 'HOOD &DULWj +RVSLWDO 1RYDUD ,WDO\

3UHVLGH +RVSLWDO ³, &HGUL´)DUD 1RYDUHVH ,WDO\

%LRGHE 5HVHDUFK /WG 1RYDUD ,WDO\

3URELRWLFDO 6S$ 1RYDUD ,WDO\

&RUUHVSRQGLQJ $XWKRU 3LDQR *DVWURHQWHURORJ\ 'HSDUWPHQW 0DJJLRUH 'HOOD &DULWj +RVSLWDO)D[(PDLO GHOSLDQR#DOLFH LW

5HFHLYHG GDWH 0D\ $FFHSWHG GDWH -XO\ 3XEOLVKHG GDWH -XO\

&RS\ULJKW ‹ 'HO 3LDQR 0 HW DO 7KLV LV DQ RSHQ DFFHVV DUWLFOH GLVWULEXWHG XQGHU WK XQUHVWULFWHG XVH GLVWULEXWLRQ DQG UHSURGXFWLRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO D

$EVWUDFW

2EMHFWLYH +DOLWRVLV LV D ZLGHVSUHDG SUREOHP QRUPDOO\ DWWULEXWDEOH WR V LQ WKH EUHDWK 7KH DLP RI WKLV VWXG\ ZDV WR ILUVW UHODWH KDOLWRVLV ZLW DQG VHFRQGO\ WR TXDQWLI\ VSHFLILF EDFWHULDO JURXSV LQ WKH RUDO FDY FRQFHQWUDWLRQV DQG 3URWRQ 3XPS ,QKLELWRUV 33,V LQWDNH)RXU VHOHFW SRVVLEOH UHGXFWLRQ RI KDOLWRVLV LQ VXEMHFWV ZLWK D WRWDO VDOLYDU\ EDF

0HWKRGV 6SHFLILF EDFWHULDO JURXSV QDPHO\ WRWDO EDFWHULD WRWDO FR ODFWREDFLOOL ZHUH TXDQWLILHG LQ VDPSOHV RI VDOLYD IURP VXEMHFWV WD 7KH DPRXQW RI WKH WKUHH 96& K\GURJHQ VXOILGH + 6 PHWK\O PHUFDSWDQ &+ WKH EUHDWK DQG +WKH SURSRUWLRQV ZHUH DOVR FDOFXODWHG

5HVXOWV 1R VLJQLILFDQW FRUUHODWLRQ ZDV IRXQG EHWZHHQ ZHOO DV ZLWK 3 EDVHOLQH EDFWHULDO JURXSV TXDQWLILFDWLRQ ORJ &)8 PO RI VDOLYD 33, JU YV S WRWDO FROLIRUPV YV S VXOILWH UHGXFLQJ EDFW ODFWREDFLOOL YV S $IWHU GD\V RI ODFWREDFLOOL VXSSOHPHQ EDVHOLQH JDYH WRWDO EDFWHULD YV S WRWDO FROLIRUPV EDFWHULD YV S WRWDO ODFWREDFLOOL YV S 1R VWDW QRWHG LQ 96& FRQFHQWUDWLRQV DW DQ\ WLPH

&RQFOXVLRQV 7KH LQWDNH RI 33,V GLUHFWO\ FRUUHODWHG ZLWK WKH RYHUJU FDYLW\ EXW WKHUH ZDV + QR \ FRU ZLWK 16& FRQFHQWUDWLRQ 7KH VLJQLILFDQW EDFWHULDO JURXSV DQDO\VHG DIWHU WZR ZHHNV VXJJHVWHG WKH LPSURYHPHQW WUHDWHG ZLWK 33,V

.H\ZRUGV 3URWRQ SXPS ,QKLELWRUV +3,V ODFWREDFLOOL VDOLYD *LORVLWLV RUDO EDFWHULDO RYHUJURZWK /DFWREDFLOOXV &RPSRXQGV 96&

,QWURGXFWLRQ

+DOLWRVLV RU EDG EUHDWK LV D UHGRO DSSUHKHQVLRQ IRU LW LV YDOXHG WR SHRSOH WR VHHN GHQWDO FDUH IRORZLQJ GHQWDO EDFWHULDO SURSRUWLRQV ,W LV UHSRUWHG WKDW DERXW RI WKH JHQHUDO SRSXODWLRQ VXIIHUV IURP LW WR VRPH HWHQW >@ ,Q DO\ FDVH WKH DPRXQW RI HSLGHPLRORJLFDO UHVHDUFK RQ EDG EUHDWK LV OLPLWHG VLQFH WKLV WRSL VWLOO D ODUJH EXW XQGHUVWLPDWHG 'LDJQRVWLF PHWKRGV LDOLWRVLV 7KH 1HWKHUODQGV VKRZHG WKDW KDOLWRVLV RQH RI WKH PRVW FRPPRQ RUDO H[DSHUDWLRQV 716 VSHFLILF PROHFXOHV LQ WKH EUHDWK 0HQ DQG ZRPHQ VHHP WR VXIIHU LQ WKH VDPH SURSRUWLRQV ZKHUHDV ZRPHQ VHHP WR VHHN IDVWHU IRU SURIHVVLRQDO KHOS WKDQ PHQ >@

2I WKRVH SHRSOH ZKR KDYH KDOLWRVLV LV FDXVHG E\ VRPHWKLQJ LQ WKH PRXWK EDFWHULD SUHVHQW EHORZ WKH JXPOLQH 7KH UHPDLQLQJ RYHUDOO LV DFFRXQ EH WKH WKLQJ PRVW UHVSRQVLEOH FRQGLWLRQV LQFOXGLQJ GHQWDO FDULHV WRRWK GHFD RUWKRSDHGLF DSSOLDQFHV VWRPDFK RU HQGRFKHUH > @ SV\FKRORJLFDO SURFHVV SURFORJLFDO SURGXFHV DQG GHSUHVVLRQ DQG VRFLDO DQ RUDO FDYLW\ EDFWHULD 7KH PRVW FRPPRQ VXOILGH JDV D fJRGHQ VWDQGDUG L SDWKRORJLFDO KDOLWRVLV UHFRJQL]LQJ WKDW PRVW

H[FOXGLQJ RU DIWHU VXFFHVVIXO WUHDWPHQW RI DOO RUDO SDWKRORJLHV LQ
RI UHPDLQLQJ IHWRU H[RUH LGHQWLILFDWLRQ DQG WUHDWPHQW RI EDG EUHDW
RIWHQ UHTXLUHV PXOWLGLVFLSOLQDU\ DSSURDFK > @

6XEMHFWV ZHUH WKHQ GLYLGHG LQWR WZR JURXSV ,Q GHWDLO VXEMHFWV ZHUH EHLQJ WUHDWHG ZLWK 33,V IRU DW OHDVW PRQWKV *URXS $ ZKLOH VXEMHFWV ZHUH HQUROOHG DV FRQWURO SRSXODWLRQ *URXS %

6XEMHFWV RI *URXS $ ZHUH GLUHFWHG WR FRQWLQXH WKHUDS\ ZLWK WKHLU VPHFLILF 33, GUXJ DW WKH VDPH GRVH WKURXJKRXW WKH GXUDWLRQ RI WKH VWXG\

4XDQWLILFDWLRQ RI SODVPD 96&V LQ WKH EUHDWK FRQFHQWUDWLRQV RI WKH 6WKUHH 96& K\GURJHQ VXOILGH + PHWK\O PHUFDSWDQ & LPHWK\O6 VXOILGH &+ EUHDWK ZHUH GHWHUPLQHG E\ JDV FKURPDWRJUDSK\ 2UDO&KURPD 7KH 2UDO&KURPD LV D SRUWDEOH JDV FKURPDWRJUDSK RIIHULQJ ORZHU FRVW KLJKHU SHUIRUPDQFH DQG PRUH XVHU IULHQGO\ RSHUDWLRQV WKDQ FRQYHQWLRQDO JDV FKURPDWRJUDSKV E\ OLPLWLQJ WKH WDUJHW JDVHV WR WKU W\SH9 &6+ DQG &+> @

'HWHFWLRQ RI *DVHRXV 96&V LQ WKH 3UHVHQFH RI *SIOHZDV* DOVR PHDVXUHG XVLQJ DDKLWWXPSDWKRORJ\ HYDOXDWLRQ RI ELRSVLHV +LVWRSDWKRORJ\ FRXOG EH UHJDUGHG DV DFFXUDWH DV WKH 3&5 RI ELRSV\ ,Q GHWDLO JDVWULF ELRSV\ VSHFLPHQV ZHUH LPPHUVHG LQ IRUPDOLQ DQG IL[HG LQ SDUDIILQ EHIRUH VWDLQLQJ ZHUH VWDLQHG E\ DQG HRVLQ ?GLHPVRDG LIG@HGRQWRVWRPDWRORJLFDO **HYDOXDWLRQ** DQDO\VLV RI WKH VWRPDWRORJLFDO DVSHFWV RI WKH HQUROPHQW DV ZHOO DV WKH HYDOXDWLRQ RI GLIIHUHQW LQGLFHV ,Q SDUWLFXODU WKH SURWRFRO LQFOXGHG WKH SODTXH LQGH[DFFRUGLQJ WR 6LOQHVV DQG /RH > @ WKH EOHHGLQJ LQGH[3 % , DFFRUGLQJ WR DQG[HDUQG XKOHPD>QQ@ :LQKHWRQJXH FRDWLQJ LQGH[:7&, > @

4XDQWLILFDWLRQ RI VSHFLILF EDFWHULDO JURXSV LQ WKH RUDO FDYLW RI HDFK VXEMHFW ZDV VDPSOHG RYHU D PLQXWH WLPH LQ D VWHULOH WHVW WXEH SUHYLRXVO\ ILOOHG ZLWK PO RI $PLHV WUDQVSRUW OTXLG %' ,WDOLD $OO PDWHULDO&DZQGV VHUYHG UHDG WR WKH ODERUDWRU\ %LRODE 5HVHDUFK /WG 1RYDUD ,WDO\ ZLWKLQ KRXUV DIWHU FROOHFWLRQ 6DPSOHV ZHUH SURFHVVHG DV VRRQ DV UHFHLYHG DQG LQ DQ\ FDVH ZLWKLQ KRXUV DIWHU FROOHFWLRQ 6DPSOHV ZHUH ZHLJKHG GLOXWHG ZLWK $PLHV OTXLG WR DFKLHYH ZW YRO KRPRJHQLVHG DQG WKHQ GHFLPDOO\ GLOXWHG