

& DVH 5HSRUW

2SHQ \$F

5 D O V W R Q L % D 3 F L V F N U M P A L I D L

5 HQ X ND 3 D Q G H % DBX PUD Q LG 6 K DU PL O D 6 HQ J X SWD

'HS DUWPHQW RI &OLQLFD OLFURELRORJ\ %/. 6XSHU 6SHFLDOLW\ +RVSLWDO ,QGLD

&R UUH VS RQ GLQJ3 XQUDKWE LR % DUPDQ 'HS DUWPHQW RI &OLQLFDO OLFURELRORJ\ %/. 6XSHU 6SHFLDOLW\ +
SXUDEL EDUPDQ#JPPLQ FRP

5 H F G D \$ W H X V W \$ FF G D 2 W H W R E H U 3 X E G D 2 W H W R E H U

&RS\ULJKW 3DQGHF 5 HW DO 7KLV LV DQ RSHQ DFFHVW DUWLFOH GLVWULEXWHG XQGHU WKH WHUPV RI
XVH GLVWULEXWLRQ DQG UHSURGXFWLRQ LQ DQ\ PHGLXP SURYLGHG WKH RULJLQDO DXWKRU DQG VRXU
, QWURGXFWLRQ SDWLHQW ZDV VWDUWHG RQ D FRQGLWL

5 DO VWRQLDV 3D QNBHURLELF JUDP QHJ BWHYHU PHQ RQUDHQW DWLHQW UHFH
EDFWHULXP 3UHVXPHG WR EH DQ HQY LGRQ PSQHRSRQD BULDRF V&FLVR VSQRLU EGHQD QG
UHSRUWHG IURP VRLO ZDWHU DQG SODWV SD@LH QW HQD PPHO RSRW GRY YR FJUDWVH GIGI
QDWLYH KXPDQ IORUD LW FDQ EH D FPRH QD D4RQW KH X\$SNHJD4HGVS LU PWRSH
WUDFW DQG FDXVHV GLVHDVH LQ SDWLHQW VZLW K4DQKQ& LPRQHAWI ZH@H LOWH

\$V PHQWLRQHG LQ OLHUDWXUH DQG IZBR FRWIKHW RDWRKHSIHWAFQHUPDQFOLQHZDV LQVHUWHGDQGKH ZDV SXW\KWHPDVRSUHDVWRURWHSKRDQWZCRWKRYXWHQFPHURSHQHP JPLY KRXUO\ZDV VWDUSVHAFZDQGSDUDPHWHUVVWDELOLJHG WKRXJK WKHQVHXLURSRQOF WRFRGHISERWHDQFRQWSDUDPHWHUVVWDELOLJHG WKRXJK WKHQVHXLURSRQOF WRFRGHISERWHDQFRQWWR SHUVLVW 3DWLHQW GHWHULRUDWHSRQWQLIUDWMDQWQZDQVFKDQJHKGKDQFRGRSDFLWLHV ZHUh YLVXDOLJHG UDGWKRJSFWBHQWDQBUHQSRRWGDHKMDRVH(YHUVHFUHWLRQ DQG SDLUHG EORRG VDPHSOHGUZMLRQVDPQWYKSRSRXWVXHHPHDQYXHSURFDOFLWRQLQ OHYHO ZDV QJ POUJDQGRPWQDQHRHODQGEORRGFXOWXUHVDPSOHVERWKJUHZQRQDFWRVHIHUPHQWLQJFRORQLHVRQODFFRQNHDJDJU(7VHFUHWLRQJURZLQJ&ZLWQD&FRQHNSQHFRQWRI

7LPH WR 3RV LWLYLW\ '73 IRU WKH SDLUHG EORRG VDPSOHV ZDV PRUH WKDO
KRXUV 7KH FRORQLHV ZHUH FDWDODVH DQG RGHFDVH WKDW PVLKHS PWRQDWH
LGHQWLILHG DV VNLQ UDVVKHV DQG VHJYHUH GLDUUKHD
XQCHULRQH PC DOORHUQLE KWLUR FUGC W

XQGHUJRQH DQ DOORJHQLF VWHP FHOO W
KHU EDFN WUXQN DQG DUPV \$ +LFNPD
+HPDWROJLFDO LQYHVWLJDWLRQV UHYH
OHXFRF\WH FRFXHQD\V WD DQG \$ODOMONHWV
ELRSV\ UHYHDOHG PXFRVDO HGHPD ZLWK
ZLWK WKH GLDJQRVLV RI JXW *9+' 7K
LPPXQRVXSSUHVVLYH GUXJV F\FORVSRULC
JLYHQ HPSLULFDOO\ ZHUH L Y PHURSHQ
PHWURQLGD]ROH L Y PJ NJ 2Q GD\ V
PHDVXUHG \&R+E\ WRWDO OHXFRF\W\OFVX
DQG SODWHOHWV GLSSHG WR FHOO V
SRVLWLYH RQ %' %\$&7(&70 V\VWHP JUHZ
QRQSLJPHQWHG VPRRWK FRORQ\HSL FT\KHHW
E\ 9LWHN FRPSDFW 7KH SDWLHQW ZDV S
KRXUO\ DV SHU VXVFHSWLELOLW\ UHSRU
WUHDWPHQW DQG ZDV GLVFKDUJHG RQ 'D\

'LVFXVVLRQ

5 SLFNGHQWLLILFDWL RQ DQG DQWLELRWLFVXVFHSWLELOLQWZDV
GRQH RQ 9,7(. FRPSDFW V\VWHP %LRPHULHJW 7KHDQDODFVWTRXGQJURQH PDQ
VHQVLWLYH WR FHIWDJLGLPH FLSURQDQJDFQ3UDQ@RXXWQJPLGWKRSWUJLHG DV
VXOIDPHWKD[R]ROH 7KH SDWLHQW ZDVQGSXWSHOGHQWFMWPDVYSLPH@ (PBUQDQJ DV
+RZH YHU KLV UHQDO SDUDPHWHUV GHWHULRUDWHG XUWKHUV DQG RDWLGHDURWH
SDWLHQW VXIIHUHG D VXGGHQ FDUGLDF DUUHLYVKAQDQVLEHFRQOGHQ R WLEH QJHWX VFDXWDP

& DVH 5HSRUW

\$ \HDU ROG FDVH RI DFXWH O\PSKR_EQD\W\X\H\Q\W\X\N\H\U\RLD E\Z\VR\B\G\H\W\W\H\G\W\D\Q\W
IRU DOORJHQLF VWHP FHOO WUDQVSODP\W\X\Q\Z\T\RP\G\SR\U\PL\VR\AG K\H\G\J\Q\PL\G\X\DO\Z\B\Y\W\K\I
JP GO WRWDO OHXFRF\WH FRXQW F\H\O\Q\W\L\W\O\H\Q\G\S\R\Q\R\W\H\A\LO\W\Z\K\L\K P\W\O\K\D\Y\K\H\G

, Q RXU VHFRQG DQSSL AWHDWGL BI RDW H GR LU RFX OMZXQH '73 ZDV SRVLWLYH VXJJH
 VHWV RI EORRG FXOWXUH LQ DEVHQF HQ RH F DQSLC GWHQDMLW DIEQH E QHQF W HSHR U W
 + HSDULQ IOXVK ZDV FXOWXUHG WR OR FNR Q RVD PQLQH W R QUEQ WEDWY HQ R XIR XRCG XWRL R
 VWHULOH 7KHUH ZDV D +LFNPDQQ FDWQHQ UNLOV O LZKHLF K F RQ OZG UQR WQEJL VPHC

-RXUQDO	<HDU SXEOLVKL	SHIHUHQF QQXPHEHU	H1R SDWLHQ	R6RXUFH WEWFWHUHPLD UHSRUWHG	\$QWLELRWLF VHQL LI	LWEXQH VSDDWQH WQH	WQH
-RXUQDO R OLFURELRORJ\	FOLQLFDO > @			&KORUKH[LGL DTXHRXV VR OKHMDRQOLQ WHWUDF WULPHWKRSULP VXOSKDPHWKR[D]ROH	LQHQVLWLYH WR 1RDMP SPLFQ WORQXICLYHG		
&OLQLFDO 'LVHDVHV	,QIHFWRXV > @			,QWUDYHQRX 5DQLWLGLQH VROXWLRQ	XVRW PHQWLRQHG 1RW PHQWLRQXICLYHG		
-RXUQDO R OLFURELRORJ\	FOLQLFDO > @			3RUW D FDW K6HQVLWLYH WR FHIWDJLGLPH	K6HQVLWLYH WR LPPFLSPHSQURPP LDQG XUYLYHG		
-RXUQDO R +HPDWRO 2QFRORJ\	3HGLDWU > @			3RUW D FDW K1RW PHQWLRQHG	K1RW PHQWLRQHG FRPSURPLVHGXUYLYHG PDOLJQDQF\		
3HGLDWU ,QIHF -RXUQDO	'LV > @			+HSDULQ IO +HSDULQ IO VXOSKDPHWKR[D]ROH	VXOSKDPHWKR[D]ROH 1RW PHQWLRQXICLYHG		
%UDJLOLDQ LQIHFWRXV	MRXUQDO GLVHDVH	R > @		'LDO\VLV VIV V6HQVLWLYH WR WDJREFFWDP FHIWULD[RQH FHIHSLPH PHURSHQHP DQG VXOSKDPHWKR[D]ROH	V6HQVLWLYH WR WDJREFFWDP FHIWULD[RQH FHIHSLPH PHURSHQHP DQG VXOSKDPHWKR[D]ROH &KUSRIQBLFLO FLSURHORHDFLQ FHIWDJLGLPH LPLSHQHP WULPHWKRSULP VXOSKDPHWKR[D]ROH		
,QGLDQ -RXUQDO RI PHGLFDO PLFURELRORJ\	> @			1RW PHQWLR QHQVLWLYH WR WLJHF\FOLQH	QHQVLWLYH WR WLJHF\FOLQH FRROPLSMURLPQV PDOLJQDQF\		
(XURSHDQ MRXUQDO RI FOLQLFDO PLFURELRORJ\ DQG LQIHFWRXV GLVHDVHV	> @	OXOWLS UHSRUW > @	OHXIDWLSOH VUHSRUW ZKPKD KDV EHHQ LVRODWLG IURP 5DOVWRQLD	OXIDWLSOH FDVH UHSRRISURPLVH \$OO VXUYLYHG	OXIDWLSOH FDVH UHSRRISURPLVH \$OO VXUYLYHG		

7DEOHD OVWRQL%DFLFWHHLWLD a %ULHI 5HYLHZ RI /LWHUDWXUH

\$QWLELRWLFV ZKLFK KBDYAWHWWLWSHUQBDQHOLQ HW DO KDYH UHSRUWHG 9,0
 WDJREFFWDP FHIWULD[RQH FHIHSLPHUORP DLSLQHDFLQHFLQ UERORGDFL@ FR
 WULPD[D]ROH DQG PHURSHQHP > @ \$OVR LW KDV EHHQ UHVHDUFKHG WKDW WK
 EDFWHULD SURGXFHV PDQ\ EHWD ODFWDPXHV \$QYHPLS1QH&KQURDNSRDQW
 HQ\PH 2;\$ KDV EHHQ LVRODWLG IURP 5DOVWRQLD > @ 5HFHQWO DFFRUGL

\$QWLELRWLFV	LVRODWHLQWHUSUHWDLRQRODWHLQWHUSUHWDLRQRODWHLQWHUSUHWDLRQ					
\$PLNDFLQ	•	5	•	5	•	5
*HQWDPLFLQ	•	5	•	5	•	5
&HIWDJLGLPH		6		5		6
&HIHSLPH		,		6		6
&,SURIOR[DFLQ		6	" p E0\$3B... st(P)igB... TM-pVv%` Å ý7ñ òh@6€ \ç7ñ TM%o1 ` P			

&ROLVWLQ	•	5	•	5	•	5
,0,&±PLQLPXP LQKLELWRU\ FRQFHQWUDWLRQ 5 UHVLVWDQW 6 VHQLWLYH , LQWHUPHGLDWH						

7DEOH &RPSDULVRQ RI 0,&i EUHDNSRLQWV RI DQWLELRWLFV IRU WKUHH LVRODW

\$OVR LW LV ZRUWKZKLOH \$HSQWANURQOL WKBHW L(V \$ODW\$R QHPLUNDID (\$GLQ +, \$EORRG LQ WKUHH SDWLHQWV FDQQRW EHZWHDYHG RDADQWRAVPE\$HFDNW \$QOEWFH SDWLHQWV ZHUH GPLWWHG LQ GLIIHUH \$WUWXLPH \$HPYLREVR I \$KUHBRHUV \$WRW DQWLPLFURELDO VXVFHSWLELOLW\ RI DOO WKHVH LVRODWHV ZHUH YDULDEOH >)HUQDQGH] & :LOKHOPL, \$QGUDGDV (*DV 1RYHO JUDP QHJDWLYH EDFLOOL OLNH \$DORFW RQDOD RXUHEULQHNUHDVALQJNOKRGEHLQJ LVRODWHG IURP LQWHQVLYH FDUH DQG RQFRORJ\ XQLWV \$OO RXU FDVHV FRXOG OLQH DVVRFLDWHG \$Q DWWHPSW WR ORRN LQWR WKH SUREDEOH FDXVH RI WKH LVRODWHV ZDV QRW GLDJQRVWLF DQG ZDV LQFRQFOXVLYH +RZHYZU LQIHFWRQ FRQWURO SURWRFROV KDYH EHHQ UHLQVWLWXWHG DQG ZH DUH YLJLODQW IRU QHZ FDVHV 7KH OLPLWDWLRQ RI RXU VWXG\ LV WKH LQDELOLW\ WR VHTXHQFH WKUHH VWUDLQV 7KLV ZRXOG KDYH VKHG OLJKW RQ WKH H[LVWLQJ KRVSLWDO Z HSLGHPLRORJ\ 3UHYLRXVO\ EHLQJ UHSRUWHG DV %XUNKROGHULD VSHFLHV DQG UHFHQWO\ DV 5DOVWRQLD HPSKDVLHV WKH REVHUYDWLRQ WKDW LGHQWLILFDWLRQ QRW HDV\ DQG PLVGLDJQRVLV LV DQ LVVXH ,Q GHYHORSLQJ FRXQWULHV ZKHUH VRSKLVWLFDWLG 0LFURELROJ\ ODERUDWRULHV DUH IDU IURP UHDOLW\ LW L LPPHQVHO\ GLIILFXOW WR FRUUFWO\ LGHQWLIL WKHVH QRQ IHUPHQWHUV :KDYH XVHG 9LWHN *1 FDUG IRU LGHQWLILFDWLRQ DQG \$671 SDQHO IRU DQWLPLFURELDO VXVFHSWLELOLW\ 5HSURGXFELOLW\ RI WKH 9LWHN FRPSDFV\ V\WHP LV ZHOO HVWDEOLVKHG QRZ .QRZOHGJH DERXW ORFDO HSLGHPLRORJ\ DQG WKHVH QRYHO EDFWHULD KDV LPPHQVH VLJQLILFDQFH LQ GHVLJQLQJ LQIHFWRQ FRQWURO SROLFLHV DQG DQWLELRWLF VWHZDUGVKLS SURJUDPPHV

5HIHUhQFHV

&RHQAH9DQGDPPH 3 /L3XPD - ,QIHFWRQ E\ 5DOVWRQLD 6SHFLHV LQ &VWLF)LEURVLV 3DWLHQWV ,GHQWLILFDWLRQ RI 5SLFNHWLL DQG 5PDQQLWROLO\WLF E\ 3RO\PHUDVH &KDLQ 5HDFWLRQ (PHUJLQJ ,QIHFWRXV 'LVHDVHV %DHUH6WH\DHUW 6 :DWHUV * 9HRW BORULV - &RHQAH 7 &ODVV LILFDWLRQ RI 5DOVWRQLD 3LFNHWLL ELRYDU dWKRPDVLLdVWUDLQV 3LFNHWLL DQG RI QHZ LVRODWHV UHODWHG WR QRVRFRPLDO UHFXUUHQW PHQLQJLWLV DV 5DOVWRQLD PDQQLWRO\WLF VS QRY ,QW - 6\WV (YRO 0LFURELRO 'RWELV3ULQWJD 1 2UIDQRX \$ 3DSDFKULVWRX (3DSDFKULVWRX) 3HULWRQLWLV GXH WR 5DOVWRQLD PDQQLWROLO\WLF LQ D SHGLDWULF SHULWRQHD GLDO\VLV SDWLHQW 1HZ 0LFURELRO