6XPPHU 8QGHUJUDGXDWH 5HVHDU
6\PSRVLXP

2FWREHU
8QLYHUVLW\ RI 1HZ (QJODQG
%LGGHIRUG &DPSXV

3UHVHQDWHD %XUJHVV è
0DMRU 8ULQH 6FLHQFH %LRORJ\
0LQRU 3SULOLHG 0DWKHPDWLFV
$GYLVRU 0HV 6XOLNRZVNL

3RVWHU

7KH 3K\WR *DPHV ,QWHUVSHFL F &RPSHW
3K\WRSODQNWRQ 'XQDOLHOOD WHUWLROH
7DKLWL L-Q L1XWUHG QV EX (QYLURQ PHQW

3UHVHQWHU 9ROOPHU è
0DMRUDULQH 6FLHQFH
$GYLVRU &DUOH %\URQ

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
7KH SK\WRSODQNWRQ VSHFLHV 'XQDOLHOOD WHUW
7DKLWL FDQ EH F-XOWXUHG GHDVDOLQIRU YDULRXV
0DQ\ UHSRUWV VXPPDUL]H WKH LQGLYLGXDO JURZ
FLHV EXW IHZHU ORRN DW VSHFL F UHODWLRQVKL
WKH LPSDFW RI QXWULHQW FRQFHQWUDWLRQ RQ L
'XQDOLHOOD WHUWLROHFWD DQG ,VRFKU\VLV JDOE
JURZQ LQ WDQGHP WR FUHDWH D- KQJKSDLWLHXO
WXUHV ZHUH JURZQ DW YDU\LQJ I PHGLD FRQFHQ
P/ wP OWHUHG VHDZDWHU w/ I PHGLD
ZDWHU DQG w/ I PHGLD P/ wP OWHUHG
ZKLOH PRQLWRULQJ FHOO GHQVLWLHV DQG FKO
WHUWLROHFWD ZDV WKH GRPLQDQW VSHFLHV FRP
WLRQ LQ WKH FXOWXUHV FXOWXUH ZKLOH QHLWKHU GL
GLXP QRU ,VRFKU\VLV FXOWXUH 7KUHH QXOO K\SR
129 VWDWLVWLFDO DQDO\VLV + &HOO GHQVL
WLRQV ZLOO EH HTXDO + &HOO GHQVLW\ LQ ERW
EH HTXDO + 1XWULHQW FRQFHQWUDWLRQ DQG
SHQGHQW IDFWRUV 6WDWLVWLFDO DQDO\VLV GLV
QGLQJV FDQ EH DSSOLHG WR IXWXUH FRPSHWLWL
WHFKQLTXHV

6WXGHQW IDFXOW\ RUHVWUDLQ[FRQWKUDEXWLRQV

3RVWHU

$QDO\VLV RI &RPPXQLW\ 6XVWDLQDELOLW
0DLQH 7KH 5OH RI 3XEOLF +HDOWK DQG

3UHVHQWHG E\ .OHPW è
0DMRU\ FKRORJ\
6HFRQG 0DMRU ORJ\
$GYLVHG E\ 0F5H\QROGV

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
7KLV UHVHDUFK GUDZV RQ D DUWLFOH SXEOLVKHG
DERXW FRPPXQLW\ VXVW DLQDELOLW\ DQG KHDOWK
FXVHG RQ FRPSRQHQWV RI FRPPXQLW\ VXVWDLQDE
EOH KRXVLQJ SRSXODWLRQ FKDQJHV VFKRRO V\V
LQGXVWULHV ,Q WKLV SURMHFW WKH SUHYLRXV G
HG DQG D QHZ DUHD RI FRQFHUQ ZDV DGGHG 7KU
LVVXH E\ XVLQJ LQWHUYLHZV VXUYH\ UHVSRQVHV
ZH FRQFOXGHG WKDW DFFHVV DIIRUGDELOLW\ DQ
ODQGV ZHUH DOO LPSRUWDQW IDFWRUV LQ VXVWD
MHFW KLJKOLJKWV WKH FKDOOHQJHV WKHVH FRPP
WDLQDELOLW\ DQG H[SODLQV WKH LQQRYDWLYH V
LQJ WR FRPEDW WKHVH FKDOOHQJHV

6WXGHQW IDFXOW\ RU VWDII SXEOLFDWLRQ LQIRUPDWLRQ 2 %
7KDNNDU

3UHVHQWHG 0LOOV è
0DMRU 8QLYHUVLW\ 6FLHQFH
0LQRU 0DWKHPDWLFV
$GYLVHG E\ 'U %URZQ

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
7KH PRWLYDWLRQ EHKLQG WKLV ZRUN ZDV WR HVW
/ 1 DQG OLSLG IDWW\ DFLG SUR OH IRU $ODULD H
SURFHVV WR GHWULWXV LQ RUGHU WR LGHQWLI\ S
EHWWHU IDUP SODFHPHQW LQ PLQG 7KLV ZDV GRQ
WXPEOH FXOWXUHV IRU YH ZHHNV ZKLOH LW GHJU
WKH ZDWHU LQ WKHVH FXOWXUHV ZDV OWHUHG D
DQDO\VHV ZHUH SHUIRUPHG RQ WKHVH OWHUV 7K
WKDW LI $ODULD GHWULWXV LV QXWULWLRXV IRU
EH IRXQG LQ WKH HQYLURQPHQW WKURXJK HOG Z
GHWULWXV FDQ EH IRXQG VKHOO VK IDUPHUV FRX
SODFH VKHOO VK IDUPV ZKLFK JUHDWO\ HQKDQFH

6WXGHQW IDFXOW\ R&DVWUDLH F\QRVXUH LEXWRUV

3UHVHQWHG WR 6\PRQGV è
0DMRU \FKRORJ\
$GYLVRU 'U 3HWHUVRQ

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
7KH FXUUHQW UHVHDUFK LV LQWHUHVWHG LQ WKH
LQWR WKH QHFHVVDU\ DQG KRZ WKH LQFOXVLRQ RI RWK
WKH- FRQWH[W PLJKW VKLIW LQ UHVSRQVH WR URP

3RVWHU

2EVHUYLQJ WKH HHWKHLQWRVWUDGLRO RQ W
WK-VHSHLQHG VWLFNOHEDFN DQG PXPPLFKR

3UHVHQWHG \HVD .DXIROG è
0DMHQLPDO %HKDYLRU
0LQQHUDULH 6FLHQFH
$GYLVHG &RUULH %\URQ 7HUHVD ']LHZHF]\QVNL

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
(VWURJHQ LV WKH PDLQ LQJUHGLHQW LQ ELUWK F
ODFN RI SURSHU OWUDWLRQ WKURXJK ZDVWHZDW
GLVUXSWLQJ FKHPLFDO WKHQ JHWV LQWR WKH RF
RQ WKH PDULQH OLIH 7KLV H[SHULPHQW
((KDV DQ HIIHFW RQ W
FKRJV $QWLSUHGDWRU FRQVHFL F KHWHURSH
H[DPLQHG XVLQJ GLIIHUHQW WUHDWPHQW WDQV
HDFK ZHUH H[SRVHG WR GLIIHUHQW FRQFHQWUDW
GLIIHUHQW WUHDWPHQWV DQG YLGHR WDSHG 7K
VK DW ORZ FRQFHQWUDWLRQV RI ((EXW DQ\ HII
GXH WR WKH YHU\ VPDOO VDPSOH VL]H)RU UHVH
LPDFW RQ KRZ ZDVWHZDWHU LV WUHDWHG D PX
QHHGHG

3UHVHQWHG DW &RQJHU è
0DMRU .HPLVWU\
$GYLVRU 6WHSKHQ)R[

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
'LFRSSHU , XQLWV -HWWDO VKRZV WKDW DQG VXSSRUW
DQG EULGJLQJ KDOLGHV DQG PHUFDSWLGHV DUH
WHU PRGHO FRPSRXQGV

6WXGHQW IDFXOW\ RU 6WDII KHDGV RU

&XUUHQWV DQG &RQWURYHUVLHV LQ WKH 6WXG\ RI 0RGHUQ W

3UHVHQWHG WR WKH *UDGXDWH \è
0DMRU 'HDQ 6WXGLHV DQG 0DULQH $IIDLUV
$GYLVRU 'U]LHZHF]\QVNL

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
(QGRFULQH GLVUXSWLQJ FKHPLFDOV - VXFK DV WKH
HWKLQ\OHVWUDGLRO ((DUH UHOHDVHG LQWR W
VRXUFHV DQG DUH SUHYDOHQW DQG SHUVLVWHQW
SRVHG WR WKHVH FKHPLFDOV H[SHULHQFH PRUSKR
\HW WKH HIIHFWV RI H[SRVXUH RQ EHKDYLRUV EH\
XQGHUVWXGLHG 7R DGGUHVV WKLV PXPPLFKRJV
SRVHG WR GLIIHUHQW DPRXQWV RI ((FRQWURO
EROGQHVV ZDV H[DPLQHG LQ IRXU GLIIHUHQW DVV
PHQW 6KRDOLQJ)RUDJLQJ RQF-H D ZHDQGRZHRX
H[SRVXUH &KURQLF H[SRVXUH WR ((FDXVHG FKD
(PSW\ 7DQN DQG 6KRDOLQJ DVVD\V 7KH KLJKHU G
EHKDYLRU VXFK DV LQFUHDVLQJ WKH DPRXQW RI
WKH)RUDJLQJ DVVD\ 7KH UHVXOWV VKRZ WKDW H
GHSHQGLQJ RQ WKH H[SRVXUH OHYHO OHQJWK RI
LPSDFWHG EHKDYLRUV WKDW DUH UHODWHG WR W
WLRQDU\ FRQVHTXHQFHV %HFDXVH GRSH DQG GXU
VSHFL F DVVD\ LQ ZKLFK EHKDYLRU ZDV PHDVXUHG
EHKDYLRUDO FKDQJHV WKH VWXG\ VWUHVVHV KRZ
KDYLRUDO HIIHFWV RI XQLQWHQWLRQDO SKDUPDFH
WH[WV DQG DW PXOWLSOH H[SRVXUH OHYHOV

6WXGHQW IDFXOW\ RU 6\QRSVLV)RUPDW 3UHVHQWDWLRQ (XWRDVFNH
VD 'U]LHZHF]\QVNL

6WXGHQW

3UHVHQWHG WR WKH
0DMRU 'HSDUWPHQW
0LQQHVRWD 6WDWH
$GYLVRU&RPPLWWHH 7LOEXUJ

3RVWHU

6XUYLYRUVKLS UDWHV RI FRPPHUFLDOO\ F
FODPV 0\D DUHQDULD LQ WKH SUHVHQF
JUHHQ FUDEV &DUFLQXV PDHQXV

3UHVHQWHG E\ 'DYLGVRKQ è
0DMRU DUHD %LRORJ\
0LQRU TXDFXOWXUH DQG $TXDULXP 6FLHQFH
$GYLVRU &DUULH %\URQ

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
7KLV SURMHFW DLPHG WR GHWHUPLQH WKH HIIHFW
&DUFLQXV PDHQXV XSRQ VRIW VKHOO FODPV 0\D
%\ XVLQJ DQ H[SHULPHQWDO GHVLJQ WR FRPSDUH
FOXVLRQ WKH DFWXDO UHVXOWV RI JUHHQ FUDE
TXDQWL HG WKURXJK VXUYLYRUVKLS UDWHV EHWZ
VFHQDULRV 7KHUH ZHUH WKUHH GLIIHUHQW VFHQ
FU-DEQO\ H[FOXVLRQ DQG QR SUHGDWRU H[FOXVLR
PHWKRGV ZH H[SHFWHG WR QG WKHUH ZDV D KLJ
SUHVHQFH RI SUHGDWRUV FRPSDUHG WR QR SUHG
UHVSRQVLEOH IRU D PDMRULW\ RI WKH FODP PRU
7KH UHVXOWV VXSSRUWHG ERWK K\SRWKHVHV ZL
UDWH EHWZHHQ WKH FRQWURO DQG FRPSOH
DQG WKH QGLQJ WKDW RI DOO SUHGDWLRQ GX
FUDEV

3UHVHQWHG .DQGRO
0DMRU\ DW 60&&
$GYLVHG %XUNKROGHU

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
6DOPRQHOOD HQWHULFD -DYLDQD LV DQ HPHUJLQJ
VHYHUH JDVWURLQWHVWLQDO LQIHFWLRQV /LWWO
ZLWK LQWHVWLQDO HSLWKHOLDO FHOOV RU RI SR
WH-UKLRDVW LQWHUDFWLRQ; 8KXLRQJQWKHW+7VWLQDO HS
OLQH DQG ODFWDWH GHK\GURJHQDVH UHOHDVH DV
• `U ðH•LRQY–ñ X° À@O

(WKDQ :HVWHU è
2FHDQRJUDSK\
0DWKHUPDWLFV
&KDUOHV 7LOEXUJ

$TXDFXOWXUH LV VLJQL FDQW LQ FRDVWDO HFRO
SRSXODWLRQ 7R IXOO\ XQGHUVWDQG DTXDFXOWX
WKDW LW LV EXLOW LQ PXVW EH XQGHUVWRRG :D
VKHULHV DUH LPSDFWHG E\ WKHLU HQYLURQPHQW
RI WKH ORFDO ZDYH HOG 5HVHDUFKLQJ WKH ZDY
FXOWXUH DFWLYH ORFDWLRQ $ PDMRU IDFWRU LQ
KLJK SULFH RI WKH HTXLSPHQW 2XU JRDO LV WR
KHLJKW VHQVRUV LQ WKH 6DFR %D\ 2QFH WKH\ D

3UHVHQWHG WR WKH 1HXEDXHU è
0DMRU UHVHDUFK
0LQRU &RQYLURQPHQWDO 6WXGLHV
$GYLVRU &KDUOHV 7LOEXUJ

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
)UHG 6LQJHU DQG 'HQQLV $YHU\ DUH FRDXWKRUV R
:DUPLQJ (YHU\ <HDUVë %RWK 6LQJHU DQG $YH
FOLPDWH FKDQJH LV D QDWXUDO RFFXUULQJ F\FO
\HDUV DQG KDV EHHQ GRLQJ VR ORQJ EHIRUH KXPD
ê8QVWRSSDEOH *OREDO :DUPLQJ (YHU\ <HDUV
WKH \HDUDWLRXG0u ^ ly„CE €Q €VFU G0d ^±G

QGP€DUDWLU

3RVWHU

2SWLPL]DWLRQ RI VXSHUFULWLFDO FDUER RUJDQLF FRPSRXQGV WRZDUGV SODQHWDU &DUOR VLPXODWLRQV

3UHVHQWHG E\ 0HL è
0DMRU &KHPLVWU\
$GYLVRU 6WXEEV

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
6XSHU FULWLFDO FDUERQ GLR[LGH KDV YDVW DPRX
 HOG RI FKHPLVWU\ $PRQJ WKH SRWHQWLDO XVHV
FXOHV IRU WKH SXUSRVH RI VSDFH H[SORUDWLRQ
GXH WR WKHLU FUXFLDO UROH LQ WHUUHVWULDO E
PHFKDQLVPV RI OLIH 7KH SXUSRVH RI WKLV H[SHU
LW\ RI XWLOL]LQJ VXSHU FULWLFDO FDUERQ GLR[L
PROHFXOHV IURP D SODQHWDU\ H[SORUDWLRQ SHU
FRPSRXQGV ZH DUH LQWHUHVWHG LQ SRWHQWLDO SRO
DFLG JO\FLQH DQG DODQLQH 7KHVH ZHUH FKRVH
LQ H[WUDWHUUHVWULDO HQYLURQPHQWV RU UHSU
WUDWHUUHVWULDO HQYLURQPHQWV 7KH SK\VLFDO
WKHVH RUJDQLF FRPSRXQGV LQ VXSHU FULWLFDO
LQJ FRPSRVLWLRQV WHPSHUDWXUH DQG SUHVV
&RPSRXQGV ZHUH PRGHOHG XVLQJ DQG 7,3(3 IRU
 HOGV 7KH SDUDPHWHUV UHVHDUFKHG ZHUH WHPS
SUHVVXUHV RI DQG 03D DQG VXSHU FULWL
DQG ZDWHU 3UHOLPLQDU\ UHVXOWV LQG
WZHHQ WHPSHUDWXUH SUHVVXUH ZLWK FRPSRVLW
VXSSRUWHG WKH K\SRWKHVLV WKDW WKH SUHVHQ
FUHDVHV VROXELOLW\ RI RUJDQLF FRPSRXQGV E\ D

3UHVHQWHG 5LYDUG è
0DMRUKHPLVWU\
6HFRQG 6SHDNHU 0DWKHPDWLFV
$GYLVRQ 6WXEEV

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW

-EDVH '1$ VWUDQGV ZHUH DQDO\]HG XVLQJ ZLWK YDULHG FRPSOHPHQWDU\ VWUDQG OHQJWHV DQG ERXQGDU\ 7KHLU UHVSHFWLYH K\GURJHQ ERQGLQJ HQHUJLHV RRNHG DW WR XQGHUVWDQG WKH UHODWLYH ZKHQ WKH WDUJHW VWUDQG XQGHUJRHV RY

-

3UHVHQWHG E\ 'U 6DUDK %DUNDV è
0DMRU 0LFKHPLVWU\
0LQRU LQ $SSOLHG 0DWKHPDWLFV
$GYLVRU 'U 5RVH %DOJ

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW
7KH 6UF KRPRORJ\ 6+ LV D PRGXODU SURWHLQ
LQ D ZLGH UDQJH RI SURWHLQV 6+ LV FRPPRQO\
LQJ LW DQ DWWUDFWLYH-EXVHG LQWHUIDFH WR VS
VWUXFWXUHV IXQFWLRQV DQG PHFKDQLFDO SURS
HV EHWZHHQ 6+ DQG LWV SURWHLQ LQWHUDFWLRQ
:H DUH GHVLJQLQJ H[SHULPHQWV WR TXDQWLI\ WK
HQJLQHHUHG SURWHLQ SRO\PHUV ZLWK YDULDEOH
)RUFH 0LFURVFRSH $)0 :H KDYH SURGXFHG D JHO
GRPDLQ ZLWK D VXEVWLWXWLRQ WKDW SHUPLWV D
VL-WH

3UHVHQWHG E\ 5D\PRQG è
0DMRU 4XLPDO %DKDYLRU
0LQRU 4XYLURQPHQWDO 6FLHQFH DQG (GXFDWLRQ
$GYLVRU 6WHYHQ 7UDYLV

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW

$Q LPSRUWDQW [WXUH RI 1HZ (QJODQG VDOW PDU
WDW IRU QDWLYH SODQWV DQG DQLPDOV DQG SUR
VHD LV WKH PDUVK JUDVV 6SDUWLQD DOWHUQL RU
O\ SURGXFLQJ ODUJH VZDWKV RI PDUVK ZLWK PLQ
WKLV IRXQGDWLRQDO JUDVV LV 3KUDJPLWHV DXVW
QDWHV LQ (XURSH $V LW VSUHDGV LQWR D PDUVK
RUD IRU VSDFH 7KH DLP RI RXU VWXG\ ZDV WR Q
WR EUHHG LQGLYLGXDOV RI 6 DOWHUQL RUD WR F
FHVVIXOO\ FRPSHWLQJ ZLWK 3 DXVWUDOLV 3UHYL
RUD PD\ EH VDIHO\ EUHG ZLWK LQGLYLGXDOV IURP
GXFH YLDEOH RIIVSULQJ 6WDUWLQJ LQ 6FDUERU
OHFWHG VDPSOHV RI 6 DOWHUQL RUD HYHU\ N
VLWHV ZLWK DQ DGGHG RXWOLHU a NP DZD\ LQ
WKHVH VLWHV ZHUH EURXJKW EDFN WR 81(ZKH
EH EUHG ZLWK SROOHQ FROOHFWHG IURP WKH UHI
VHHGV-LQ WKH QJWK VHDZDWHU DQG XVH WKHP LQ F
JURZLQJ VHDVRQ :H DOVR FRQGXFWHG HOGZRUN
DOWHUQL RUD DQG 3 DXVWUDOLV JURZ LQ FRQWD
WHU XQGHUVWDQGLQJ RI WKH FRQGLWLRQV XQGHU
ZLOG

6WXGHQW IDFXOW\ RU UHVHDUFKHUV FRQWULEXWHG

3UHVHQWHG WR WKH
0DMRU &RFKHPLVWU\
0LQRU 6XESROHG 0DWKHPDWLFV
$GYLVRU 'HYHDX =DFKDU\H0LOOHU

'HVFULSWLRQ RI UHVHDUFK DEVWUDFW

8 ODFWXFD LV LQGLJHQRXV WR 0DLQH ZDWHUV 'X
DWXUHV LQ WKH *XOI RI 0DLQH LW LV K\SRWKHVL]
ELRPDVV ,I FRPPHUFLDO XVHV RI WKLV LQFUHDVH
WKHQ IDYRUDEOH HQYLURQPHQWDO LPSDFWV ZLOO
DQG HFRQRPLF SHUVSHFWLYHV FRXOG EH DFKLHYH
SURSRVH WR FRQWLQXH VWXGLHV H[SORULQJ WKH
WLHV RI 8 ODFWXFD KDUYHVWHG IURP %LGGHIRUG
WKH FKHPLFDO FRPSRVLWLRQ DQG VWDELOLW\ RI
8 ODFWXFD H[WUDFWV LQ UHIUHQFH WR DQWLPL
PLFURELDO HIIHFWV ZLOO DOVR EH FRUUHODWHG
WXUHV DW WKH WLPH RI KDUYHVW

6WXGHQW IDFXOW\ RU VWDII @p(°@ /l–ñBu ^ `€ WðDF