

Supplementary Materials

Investigating the smuts: common cues, signaling pathways, and the role of *MAT* in dimorphic switching and pathogenesis

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Ustma -MSSDPNFSL ISFLECLNEI EHEFLRDKGE --N-YPVLVR KLRELQ---Q
Malgl --MLTQEEVR QKLEFEYTL LDALTREVDE --SY-YSHLRQ LTEIVR---R
Malsy MPYIDQDPPAR HLLIEFEQAV LDALASNFGE -AE-YERLRV MSEDVK---S
Exova ---MAEHCL NNLSTIEQRL MNSFCYPDDQ -----EQLKI DLQOTF---H
Psegl MSDVASWTQV ANAVQAIWTI AVSFQAEQEKR -----LLR RQKDVA---D
Jamro MSVDCLNHVI EQLLQCVKSN DVSAALSTLAS --D-FHAMGQ ELRRHR---Q
Meimi ---MLSICK NDLQAFFENA EMEFLIALQE -NS-MQSFHA KFHASC---S
Meimi_3 ---MSLHSA NSLNALIENA ESFFLSFLKD -GL-LKNFLR EYKLAS---T
Meimi_2 -----
Viopa ---MASRPI ARLSDFIHEF LKAYLNDPQA ---LEIANK KLITIR---D
Psehu --MSAPFSI KSLHLSNEV ENDFLEAEG --N-SAALVN KLRVLH---Q
Tilwa -----MLSV HDLRVSLQEI EPALLQSCIE --P-GDALQR GVDRAVAUSA
Tescy ---MSADDLS TSLLCNLMV SDDLTAEDD --D-YSTICT RLTLQE---V
Tilan -----MNT NEVRHILKEL EEAVNKESKE SNSVYNPFIT TLELLKTKAQ
Spore -MTPPKFGF AGLLQSLRDI ERDLSADQD --D-YLGLVS RLEALQ---R
Cergu MSTQQQQPTL QSLALLSQS EEEALLAASN PAA-LHKFAQ SYGAIL---K
Acain -MMPFRLQTA KDLISFFLEA EESFLESND IDS-LREFDL RYRAC---E
Psean -MPSSTLSF SNLSTVLQEV EDGLLAKDQD ---LAISAV KLAQWP---D

KIPNDIANLP RDPETIQQIH QTTHRI --- RAVAQAIFIR DQKF-----
EPALQQEQGT LTNATLQGA RVSDRL --- EQLGHILHEQ RTQM-----
TISRLEFEMGQ LSQPTIRLGA SIGERI --- EQLKLVLINEH RAMM-----
GIEARAQGA FSQKELCLVY QQATRI --- KGIAMLCISFL TETG-----
DVMLLLKQQT RLSAAVTLPD RQHEDR --- KDCGQSDLHL LNVA-----
DLQLSKAERR ALIASAHRIA IFSTGLAIE ERNSQHLRDL ATDC-----
CLTDASLTAG ISQKDATRFS AIATRI --- RDMTKSLIVL VKEG-----
LLTESIKDKT VSENMVSKAR SALERI --- KAISEALLL SKAC-----
-----MERK RSPRDAHRHH KEGGGV ---
EIREDLAKGT IGRKDAATGF CIAGRL --- EAITSSFIGL EESL-----
ETSEHIASIA RDPDSIRQVH NAAGRI --- QLLADTFVYL DKQF-----
SPNQLRASGA LDDSTIELAH RVAQRT --- TIMSESLCRI ERGLAGVLLD
TARAICTQRT TDDTVADQIW QTSERI --- KIASTFLRL DEYR-----
SVNHAHQNG EAVPTFPQSH AAHRV --- EVWLHVLERL KCISEKRQAK
KAVIDIPTCS PDQKSAEAR QAIQRI --- QLVAQTRHRL EEMF-----
SLQSLPSLGT REHESIVTAV TRVERIAAHF RECEQEFARV RAAL-----
AAKSLAANER LSEEVATIIG ETTTRI --- KLVAETFHKL ESNV-----
KISKSKEHGG LDQASVDHLH HRVKRI --- QIVTKAWLRL EEVY-----

-----VSLC SE---VHGH TSKVMQEFN- -----V VSPDV-----
-----QRH SN---ASQE LVLLRSPH- -----P RSRAS-----
-----DELQ KS---TSDEI QSILEKESI- -----K LTQAF-----
-----TRVM SH---AKEE MQCFSAKP- -----V EKAIFFPEKMW

-----KELV ATSELASTKT TSTLRHHQG- -----T GTRGS-----
-----DMIA KE---AVEK TKAILSGRL- -----R KEQCS-----
-----SHIC EE---AVKD VNEVICDGH- -----E NPEVK-----

-----QIE KQAMIEQDEV FSEFVSKSR- -----K TEKPFDSAKP
-----VSLR AE---MIRD ASKCLQATE- -----K VQSDP-----
FRNGCABIL EKDNEELGARA GRASLQDRRM PSRLANS PAV TPQSVPTPA
-----KKIQ SG---LSSID LKQLQRDHR- -----Y GSDTK-----
VMAVLRGKE APAKLSKSF SPSIQACAGV- -----C SSSASSASAS
-----EELD GE---MLRE ANKAIQDNA- -----K SKQSL-----
-DHDCEKELA EH---RASL KRLSYRGL- -----S ESPPHLVDVA
-----LDDL KS---CSNR TKQILRSNT- -----E GSDKR-KEFP
-----SQLN SD---LKEN TFQISCKQG- -----Q HSRNT-----

-----GC-RN LSEDLPAYHM RKHFLTLDN PYPTQEEKET LVRLTNESTA
-----GSLRDR RDPPTLNKHM RDWFLRHLGH PFPSPREDKEQ ILAETNACIR
-----VSSER RDAGLNAVQM RDWFLKMMGY PFPSPRSDKLR ILKTTNRQGA
EPAKSSKLN I NQDTLYSTVF REWFLDNLD PFCRQTKEE LVLTNNLLE
-----SSKY SEQSINAAM RRMWLEHIDH PFPNNHDKKE LAKETNRRAP
---QLRSQP PDSALNATVM ROWLLEHIDH PFPSPNEKRA LADESNNRGV
-----PT NQDSLNSQFL RRWFLEHIDH PFPSTVVKEE LAELTNAKLK
-----D KRERLESQPL RSWFLKHIDH PPSAKEKEK LIKLTNANLK
----- --GAVNLPFL HQWFIEHIDH PFPPTQEEENE LAMKMANLR
EMTKPQLPDD SQDSLPAATM ROWFLQNMHD PFPSPKAVKIK IADTNTATLR
-----QD ISENLPYYM RKHFLETLYS PYPTQEEKEA LVKITNESSA
STTAPTAATA AELQLNAVVL RRWFRENLS PFPPTKADKTA LVTETNALAT
----- LAESLPSSHL RRHFLSCLDD PYPPLPEEKNE LVKSTNEYVA
SPTSAPKWSI SSEQSANNIM RRFPIEHMNR PFPNKAEKEK MLAQARSVTP
-----EVEQD LSETLPSYHM RKHFLATLDN PYPSPQDKDT ILRPTNDSAA
PNAAQTPLSN VDWRNAVPL RRYWRENLYD PFPVNTTKEA LVREMAAMPK
LKSDETSEGS LSELNNAKVL RRWMLDNIAF PYPPTREEKEE LARHTNLQLG
-----GPPD LSESLPSYHM RKHFLEHLDN PYPPTQGDKEE LVEATNASAS

RVGQSSV--- ---N--- -RPPLEHVQL TLWFINARRR SGWSHILKFF
D----- ---R--- -TLRLKYTQI VLWFINTRRR SGWTAFLRHY
V----- ---K--- -SQVLKYNQV VLWFINTRRR SGWTKFLRRY
VLLLNKMGRL L---I--- -YQVVDLSQC SLWFINTRRR SNWTSFFRNF
S----- ---G--- -KSQLRPEQA TLWFINTRRR SGWTSWARRE
G----- ---T--- -KGKLPQGC TLWFINARRR SGWTLWARRF
DLESRDELPK FGPQSA--- -VKPISKQC QLWFINTRRR STWTEFYREY
E----- ---A--- -NKPMSREQC NQWFINTRRR STWKEFFIKY
DIETKIGLSS S---S--- -VSSRATKQC QAWFINARRR STWTEFYQRY
TSNRS----- ---S--- -FGPLTYNQV MLWFINARRR SGWTTMFRY
KDDPCST--- ---S--- -RPPLGVHQL TLWFINARRR SGWSHILKFF
GSDAGPSSAV AIPSVGAAA SNKTIYEQV VLWFINARRR SGWTDFFRKF
RNPCAEG--- ---S--- -QAMHNHSL ALWFINARRR SGWSSILRKY
E----- ---G--- -QKPLSASL SLFFINTRRR SGWTEFFRKY
GT----- ---G--- -RPPLDAHQL TLWFINARRR SGWTHILRKF
----- --- --- -AKRMNAEQC TLWFINARRR SGWTEFYRQF

PPLSMGLGES TNIGLS---- -GTPITSDQC ALWFTNGRRR SRWQEFNRTY
QKKKSEE--- ----R---- -GNDLQINQL TLWFTINARRR SGWSSILRKF

AREDRSRMKH LVRA-K---- --LSSSNQST PPSSTSDS-- --LSNNLDDV
ARGDKVKLFP LAQAIE---- --NEEGGTHE TROWSAGH-- -AITLTPASA
AQGDKTKMLE LVWALE---- --TSVGGTHA SRYWSSGIGP VSATKIRDGK
AHSKDNLMAR LVDCLK---- --REQDQIDA PE--TMGE-- -LEDLLKDEK
ANSDKARLRA IVAAIR---- --GEVLDIRG AEEVNDSD-- -LELVEAHD
CRNEPPLTRA IVAAIQ---- --GRFILPTT KSEAGEGD-- -EVDQIRQEQ
AFSEKSTMTK LVSTLK---- --GESESANG TSKSLARI-- --LTCGEDGR
GKSDITTMKK LIAILE---- --NESEKTIW TSEALAQF-- --WSFGKRK
AFSEKAVMTK LVSILK---- --GESENTNE TTDSLARL-- --WCGKDGK
ANKEKNRMVE IVEALR---- --REDNGQTD GKKPLEAI-- -LTQFGGSI
AREDRSRMKH LVRA-K---- --LNTSDLST SPSPTFGH-- -LPLTLDDI
AWSDKARMSA LVDALS---- VSASDRAVVE DATPALRP-- -LLTLSKEGR
ARNDRQLMKP LIQA-K---- --MMQEGLPV RALLSGEL-- -DTAHAVHAL
AGESHEVMSR VVQCLEEEKR RNMDQASVG TMRTTVGI-- -SLQGLLDEI
ARGDRSRMKV LVQT-K---- --MASSGLLA PVPSTG-- --LACSLDGV
AYGEKDRMRI LIQALE---- --KDRSAESK HLHEMFAI-- -DHKGRATF
GLNLRGRMEH IVEVIREHNE VHSNADDHST PCPALEDI-- -LKKDAKGGV
ARNDRQRMSL LMQT-K---- --MDACNMSS QHERSPAI-- --LVHSVDDV

LSDNLG---- -----RPLTPVD K----- QQF
VQANKPMLSD PNTSSGLSLQ SLLPNMDDIA R----- RAM
KERKIT---- ----RMTIK EYMPNANDYE L----- EKM
IDTISC---- -----PITLAAR L----- KKC
VKDRGL---- -----TKTELA L----- ELC
QPDRL----- DLIDPADDVE K-----G LNPTQLAELC
TREWFC---- -----ESLKKRV L----- AMC
TEWFD----- ----GTLRKRK L----- ISC
TRGWFC---- -----DSLKEHV L----- AKC
SAKQKA----- -----DKC
LRDNLG---- -----RPLTSAD K----- KVF
ARKKAD---- ----IEAD L----- VAC
LRKNLG---- ----KVNDKI Q----- KDF
QSGKTARKKF RKNSSAGSGT VQSPSPMAIR KTRRSTSTSA SEPPLDAETC
LSDNLG---- -----RPLTAAD K----- KEF
MKVND----- ----V----- KDC
VNKSKG---- ----DIAKMS L----- SEC
LRDNLG---- ----RLTDAD K----- KEF

EDDWASMIW IKYGVKEKVG DWVYDLCAAS KKTP--KPGM PR-----
KREWSNIVDR VRIGAKERIG DWVDEVISAP STAS--SSSQ SR-----
YSEWKKIVER IRYGVKERVG DWVEEVIGTS SDL-----
REAFITVTDW LRHISREKVA DWMDNIVQEA KVEL--QVEK AT-----
KAELLKVTDW IEQGSKERVG DWMDKVVSEA KATL--KRKK QD-----
RHEFEQVIDW VEQGANQRVG DWMERLAEET KQVA--VAKK GK-----
QDHVVKIMEW LEQRPHQQS DWLSQAIEEA TSEY--NQTR KS-----
WEHYSYVAY LELRPPFKKS DWLSEAVEDA TIVY--NRMS KR-----
KEHWMKIKEW QEOPQREN-D TWQKGSKPSR KDSR--RFSE ET-----
RQEWKKTCDW IRVGVKDRVG DWREVVVGE ADGE--DESQ RV-----
EDDWASMIW IKYGVKEKVG DWVYDLVAAN KKAP--KHGK AR-----
KAGFAKLIDW VHQTAREKVG DWLDVVLAEA AAER--QAKG LR-----
HDDFTSMISW IRYGVRDKTG DWVQDVVNAS KKKT--KHKR GA-----
RAEYEAIEH VAVKHPERVG DWIEQVVQAA AARAGQPIP SALLSFSSAQ
EDDWDSMLSW IKYGVKEKVG EWVYDLVAAS KPPP--KAGQ AR-----
IAAFERMLSW IHQGGQDRVG DWLDEVLAEA AAER--AALE AQGFDSPOAH
RKLFAHVIAM VSQSTKERVG PNVEDVIKKV VAEE--KQKQ KQ-----
EDDWTSMIW LKYGVKEKVG DWVYDIVANS KKPL--KAGQ PR-----

-----PV TTVAKRHPAR KTKPAKPKS RTANPRA--- -----STT
-----RHSTR RTTP-----
--MREQRRL LDLEDKAEIE RDHRKRKLV ARKKNVAKVA T-----GQS
-----RR AARKLLAEQR RRAAAATRD HKMEDSEDEL A-----EEQ
-----GK SKKRAREBAQ RKALAAPKR ARTSRAAQDK V-----RIR
-----KRQHR TENGSHA--- -----HQ5
-----QRNDR ETQEFKQKA AAH-----RSD
-----LTIL LDEYERNPHY ENHLDRDRIA KKTGLKPRQV TVWFQNRRSR
-----PTAS KTKGKKIKAR PVRKGSITS STMK-----TTK
-----TV NTAASRSPAR KTATATQSKP RKAKQRA--- -----SKT
-----DPSK PLAPVSPQAP REETPPAAL VTTANATRAI A-----GRK
-----SHIV TNAGNRPLR KQSCLSSSR GDPASQTRRA T-----SSK
TSSTAPESRA NSVAGAATGS MAKQSASRQG SKKEAKSKKR PISQVSGVGG
-----AV TPAKRAPAR KTATPAQSKP RPKQRA--- -----SKT
TSVEVAPTGP PTRPMRALPT RSAGKEPAEE SRPIRGSKRA G-----QRA
-----RA GRRRLREEQK KVQEQKPAEL GRGARLRRS SRSVAPYSTA
-----TV TTAANRTPVR KTTTSSRPKR ATRR-----ISK

PSIDSTLDSS KLESTPELSM CSTADTSFST FGSSLSMSHY NPFQDGNLIL

NSIQKRKSNE RKEVYQYRKL PKVIVHTPDT SLGHIQFSDF SAGTASRSSH
VPAPARPLR PIRMPQQRN VSGASSSSC LSSMISGRLY PSGSSSAAAT
ESDADDDSD ELPASP-LAG KSTKGLPRVT GTQCTSSDY SAMSRNVSG
DDEDYSDQLQ SKKRVKRRT SDGHARPIRG SRRSRDSARK NVRRPSTMS
DDDDAEQVR SSKRAKNTNT SSTDQKTAG NSRSRDGANT NARRSSKSL
SENPLKEAT EKRRKREQDK CQGGDKRHA PIRTKSSQR- SVNQFPVSP
SGRKVKPTNK ELTIIAKQRF DYYTSSSESS CPNTATSASF DFSNEVAVQP
PSIESNTESE RFESTPELSM CSTSDTSSST LDSNLSMAY SPFDLGDLL
TRRLPKKTP RTPSPVDPK ASIGASPTT SLDQTKLAF TLPGAAQFSL
PDGWTPKQE REILDTSFNS CRSEDVAVG STTTETRFNI QMLDYLAGE
AGGVGGAGGA GDESGKEDDD DDDGSSSSK NKTDRSPST SHRRPSPFPF
PSIDSVADTS GLESTPELSM CSTADTSLSS FASNLSMMQY DPFQHRDDL
LGVNTGSTAR QAARNASSSS TESSSSSVPS LAMSQDSASS TAYSTISSAS


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-----T LGSSPLPLAA PRSRQGQSEW
-----

-----
-----
-----
IDASSLIDQY STFGQW---
HSVTGQSDDA VNYGGWLAWS GQMMTGEA--
RSPGVITIFE WSWTSRHN--
-----
-----
EPFKHEFDNE KEKNSTNECG KCFASWPS--
KHTKFDEETP VERNGKVEKT ETSKKEVAKP AASTPASGKK KRPAMDPFEG
DPFPLSQLLA IDSHRAHGAF GSLVLHDAPS QESIIRWRTPE HSQLEHAEEET
-----
GHSQGLSLNL AHDQHGHGHS SGLLFMHPSR AFDGAVSTGS GASMHSPIYHG
-----
ETNEADFLTL EFLNSVTEAN AQDKEIASWA VYNSDWPTPG LAGLSDFEPL
HNGRSDFAP STAAARSHSN SFSSSSTSSS TTG-----
-----
-----
-----
-----
-----
-----
-----
-----
-----
YDKPKTPKTE SAPTTKSTDS PASSPSKKQK KSKKSSAK-
RKTMRSPVD EALTLAAPS LSRNASQNSH MSS-----
MLFGD-----
-----
EALATQQ---
-----
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Figure S1 Alignment of bE (HD1) protein sequences. The bE protein sequence from *Ustilago maydis* (UMAG_00577) was used as a reference sequence to determine orthologs in all 16 Ustilaginomycotina genomes. Then, all orthologous sequences were used for the alignment using the MUSCLE algorithm performed in MEGA-X. Note that there are two duplicated bE genes in *Meira miltonrushii*. Species abbreviations are as follows: Acain, *Acaromyces ingoldii*; Cergu, *Ceraceosorus guamensis*; Exova, *Exobasidium vaccinii*; Jamro, *Jaminaea rosea*; Malgl, *Malassezia globosa*; Malsy, *Malassezia sympodialis*; Meimi, *Meira miltonrushii*; Psean, *Pseudozyma antarctica*; Psehu, *Pseudozyma hubeiensis*; Psegl, *Pseudomicrostroma glucosiphilum*; Spore, *Sporisorium reilianum*; Tescy, *Testicularia cyperi*; Tilan, *Tilletiaria anomala*; Tilwa, *Tilletiopsis washingtonensis*; Ustma, *Ustilago maydis*; Viopa, *Violaceomyces palustris*.

Ustma ----- --MTLPP--- ----- -----LP
Malgl ----- ---MHPELD FLDECLCTLR H----- ---VR
Malsy ----- ---MSQELG FVEACLMLK SL----- ---SA
Exova ----- ---MTA SDLLCLESTA STAETCLKVL A----- ---LH
Psegl ----- ---MSHLSLLE DYLSCSNRLL DVLSKDC--- -----LL
Jamro -MSCKKERRG ANVRFDEDTV ARPQAQGFV PFAPTPGPR LSRGTQTRQP
Meimi ----- ---MVDSSKQ NDLREIIVKS NALMQQ--- -----FD
Viopa ----- ---MMSDRFSL QSLRRIQEIS SLFK----- ---VK
Psehu MRLPLFPSSS IRNAFSRPYT NMLKETMTDV DFFSQVLSLT SQISTN--LT
Tescy ----- -----
Tilwa ----- ---MTSARL DILAEIHRLS TLVHHTVGRS LGQCSERDTP
Tilan ----- ---MLNEST AIIRLLKELR EALAQSAEHD NLQPLDNQEH
Spore ----- ---MTAATV STLTOVHALI TEIISS--- -----LP
Cergu ----- ---MVEGCLS DSLKAINKTA HAMLR--- -----VM
Psean ----- -----
Acain ----- ---MPFSLC NFLEEVVRAA SIFDD--- -----LP

RISQTAPRPT CFLP---LS LEGPNQQA-- -----
GTSTFVLPSP VMDAPDAQLD LQSVHSQS-- -----
SDETLPLSPG IYSPLAE-LN LRDINAVS-- -----
HTSEKTDTP NARQNTL-LN LPDVDSQS-- -----
PVQQDMNTST VTVPH---LP KQGTFAAE-- -----
PSHLPSPRYF SFQMTDLOHI LRGIADRVNV FLEEFVAVG ATAAPSSSKL
ITDACSSKE DKGSMWPKPR LSYPLVNA-- -----
IGSTILPTEA SKFPVDP-LY LNSDCTYC-- -----
TASSPIRKTV KLTATIP-LN LGYVEEDS-- -----

LGPRSQPASQ SFQRSL--TL LRDEAIAS-- -----
MGHLPSPRRTS TANIWASQLS LAKKD--- -----
KAAEPVHCSP PFVRLDL-LN LMSPPSEV-- -----
GAEPPLASTSD RISPSLRPLL LDAPRDEL-- -----

TSFQPQSTST SNGGAT--FD LPHCDVRS-- -----

----- ---LSR-KL SKLIGSVCR DTLEEIFIEY LRKLRVYEA
----- ---FVA-AL RLRPVSNDVY DALIDLYERV LEQLKRYMD
----- ---FMS-AI RERPLSNDQA VLLIRLYERV LIKLKGASME
----- ---LHQ-EL SKGGITSTSL LKVLQFYQSE AQIARENFNL
----- ---LRA-RL HSRALGETLI ESICDLYQSR CCIWQEKIQV
NEDLIPPISW FTGRLQS-LL KALPLDESLR QOIINIFTEL GQARRLQVLE
----- ---FDR-SF RHLNLSLHMK RRYEKFTEV SDQLHSLCLA
----- ---LQE-EL GSRPLRPETR FLITKAFKKG ACDLQKTFRT
----- ---FSL-DL SGLAVDKAYH DALLMLEKNQ LVDLEEAYQI

----- ---LET-DL SERPLRADVR SSVLVARFSVA CDESLSAVQR
----- ---LQS-RL LQTRLQPHEI SELLRVFSAH AADAITSLTI
----- ---ILP-DL LIFKLPQEQQ EALIGLYHSQ MEALRVVYLD
----- ---LSGFNL KLYPISPSAR NALEEKYVEM CNVWTRQANA
----- ---MLSLIFSRK DKPESPFKSL SVSLSSANSF
----- ---FRS-RL AQRSSISSDAS ERLHNLRYRG LQQFRAEYVE

QYENAFVTWQ QENLY---EE AYDQAFRKL NRLFAMHSQE TWHMVLDEVS
HFHDAQMRWG SA-----RQ RVLPOIQRLF EVQCCMAARD MQKAILSVDL
KFTQIQRRWG SA-----RR RALPRMEQLF KQCQLAATR MODALLGID
HWHANFDSFI SAQ-----DE EFKALQDVF RQRFIEHLTS LRDRLVAVIS
EWIKSYTRLV GLGG---KA STLRMLQKAC IANLSRGMQC MQDDVLSLID
RATSALQSLV SLEG---TS EQDDLYIKAL QSQYSRRTME CIQVLYDSLK
EVVVIASSLH GK-----HN CDFEKIVRIT ETSLSVNSQ LHSSMMATIQ
QHETLTCGLQ SLFVDEDERV FKLDLVKKCL EARFHGAIEE LLKIIIVSMID
EYDKAVTVMR QENLY---EE AHDEAFRGLL TRLFATDSQR VWHVILEEVR
----- ---MIDLK
GRATALHETS LP-----SA QYLAQVEQAL LQSLRSRLCS NRQTLRVLVD
AQQAMYRVLY PSP-----AA SARGPHETSL RFLYQQWLDQ EVSTIMATVR
TYKKSATSLQ YHGQP---DE TFFTSFRTTL EHNFSQAGT MNVYLLEEVH
HYLEAYRYLT ALSTP---EA SYLESMAQAF RRKHAQGLSR MQDVLICQIR
SIASEFGRLI SDG-----EQ -----
KTAKLLQALP KQH-----EQ SSAANIEVAL TRVYLMNVAN LQRAILVEVD

K---VFRTDS SLTVTQR--D NASYEGAPL- -KTGRGHDS AVRILEQAFK
DRLKTFADA NAPH----- -ETHRPHSVR ATAILERAF
ERLKNFQDAA NEPT----- -DAHRGHSPK AVAILEKAFE
QKLALFWRDA EASAQSE--S ESCSEDGL-- -FIPRGHSRL AIMILEKAYT
ERIEKYRIDS EAAASAS--S GDQFSDSDDD -DNARGHSAE AVAILEAAYA
KRFVAYQVDV DSAASTA--E SSESDDGD-- -GCPRGHRPA AVMILERAYA
NKIKAFHADA AFSDVES--S GESS----- -VAQKHSRR AVAILEKVPF
ERIAQYEQEV ASSDSLQ--E DDE----- -QPGRGHRST AIAILEKAFE
RAPLAIARQS KPVSTGA--G CLVFSDDGETH -KVRGHDS AVRILEQAFE
RQEMFHQGT FQGL----- -SEYAGHNQR AVSILEQAYQ
DAVARFRSDA EAAAAAPFG DESEYGGPQQ PEDARSHRSA AVAILEKAFE
QNMCTKPPSH IS----- -SSRRLHEES AIQILEYAFS
RFTGAGHPFK AGPYDFG--S LASSKEAQS- -KTARGHDS AVRILEQAFE
DGVTRFNNDL FPEHKHD--S ATSNLDTAH- -GVSHGHS TAALLEKAFE

TAIARFHADA EASAQSE--G ESSSSSEDG LNVSRGLPPL ATKMFVAVYA

H-SPNITPAE KFRLSEVTG- LKPKQVTIWF QNRRNRKGGK NLNVE---PT
H-APNITQAE KYKLAQATG- LQPRQVTIWF QNRRNRRAHA RRAAIVDSGL
H-APNITQAE KYKLAQATG- LQPRQVTIWF QNRRNRSHS RRTT-----
R-TANISRAE RIRLAALTK- LEPRQVTIWF QNRRNRKAKA LASKT-----
Y-TTNIQAE KRRLAQATG- LEPRQVVIWF QNRRNRKVK S RTEAG-----
H-AQNIQAE KRKLALGTG- LQPRQVVIWF QNRRNRKVKT QRRSV-----
Q-TTINKSE KLQAKATN- LEPRQVTIWF QNRRNRKPTA QAHSN-----

H-TPNITQAE KYKLAEATG- LLPRQVTIWF QNRRNRKAAK SKNAA----A
H-TPNITQAE KFQLAEATG- LQPKQVTIWF QNRRNRKGGK GSKLA----I
H-TPNITQSE KYKLAEAVTG- LQPRQVTIWF QNRRNRKAKA PPKPLKKSAAK
H-AQAITIAE KQRLAAATG- LEPRQVTIWF QNRRNRKTKD GEARY---VS
HCSESVTAAE RQWLAEIIGC LNERQVMIWF QNRRNRGGSR RSIH----
I-TPNITQAE KFRLAEVTG- LQPKQVTIWF QNRRNRKGRK GMALK--HVA
R-AHSITMAE KHRLAAATG- LEPRQVTIWF QNRRNRKTKQ GTHKY--HAR
H-TPNITQAE KYRLAEVTG- LQPKQVTIWF QNRRNRKGRK GAKGA----
R-TDKITQAE RDRLSEASG- VPPRSVTIWF QNRRNRPRRT TKVKT----

ESTQPDLSPS RHESPPSSP SRDFTLSE-- ----- --KKRKSYG
VSPEPELPPP PRLEAPPPP SVAAARVGQT D----- --DGKDDML
----- --VEPSPAFL TSKTTLGS-- ----- --PSKSPLN
-----GNE CELTPVCATP IKSS----- ----- --RKRKAEG
----- --APSTAV HTVSPSAH-- ----- --LARKRKM
-----LEVK QEDDAAASP PAS----- ----- --RKRQR--
-----TK SQKQSSSLP LR----- ----- --RKRKS--
AANDPKQQE EIGGGGEEA ATTKTATS-- ----- --ERKRKTA
TSQSDSDPLS FKNGSPSSP MRDFTLSE-- ----- --KKRKSYG
SQPEPKSQA PQQIPPATVP VPLFFLASAY LTRSPTYQLT QLTSKRKP
GSAKSTAAEP SASSPAADF SRDADAAGAA AQQRA----- --SGKRKSM
----- --ST LRSFSPST-- ----- --
QSPDTLSPAK REATPPSSP TRDFTLSE-- ----- --KKRKSYG
GGAHETIKTD LSLFPDFDAT SVTSSSIS-- ----- --SKRK--
KNSHARVTAR AQSPNDCFP PRDFTLNE-- ----- --KKRKSYG
-EAQAEIDL RATPLLPSSP VATSPPLV-- ----- --GRKRKAG

VLGRSSPDCT DPDSDSPSS LKKPR---V SS----VCS KLSDGSSSS-
VEGEESGASS LSDWASATTV PSDSL----- --SFD APIREFGSS
FVKSEIACEI DAESDFGFY QEGAT----- --HSE SEHDSQPMK
LYDGETRQ-- -----P SQMR----- --TSTPDNSCL
SCNDAAS--P RRPSSFVT-P EKKAR---L PD----- --MPPPID-
--DHEREDD SQPPPPYEH IKRPR----- --TTA LATPPPMFD-
-----D EMDGIVPSTP KHRRR---M SD----- --
NLNSDVSDHP LYPGTLPSVL QPLNRQEEH DQ----HHD QSKWTKRRM
ALGRASLDSS SYDSDSPSSL PKKPR---L PS-----AES EVSDGSASS-
GLGLSIPDVS DTESNASSCA SKKRRTARIA SDDSFNSTCT IDTDTAFS-
ALDDERDDAP RLPSTFGHDA DKRRR---M AD-----GS TQRTGSGSSA
----- --EDGTSSEP QSSAM----- --
ALGRSSSDFS DSDSDSPSS LKKPR---L PS-----ACS DSEGSASS-
--GRTLHAEI SLPSEL---Y QKRQR---L PN-----GSA RRISSSTGSDG
ALGVASSSSS DSDSDEG--F LKKPR---L PR-----AHS GLSDASTSS-
LYDDEVGVRM PSDD-----P RQRRR---L SI-----STD LLSLSP-----

YEYNDVFTQW GSPSSHSTSL SSES----- --SGLSDFESPR
PAQLANSTFS TSPLSSTSSL IL----- --HASQPHMSPQ
LDAESDYED GRSQIVTEIP TISLP----- --VLPSVSESSS
SRYTNHYTSS SSSSPSSSS SSVS----- --SFDNLSFGR
RRLSGSSNA SVGSSIDERT ES----- --LLSCWAGSER
RRLFSSSSG SLASSVDSGS ----- --SLLSWHRDQR
SGMSPGLSRD VTPFSSIRG RS----- --SSVDLFEAGH
LEDGRIVSSS SSSSSTFSS SSSAAAPSGD RYTSYSSYGY IPPPHLGDPA
YEHHAFTCW STPSSHNSL SLDL----- --SGMSDFDPSR
LDLSTSYNAW SASSNSGSL SDD----- --WAGQVNEAHH
SSLASRSSS SLGSSHTSWD SVPRSAKARG GSGSGTIVT SMESWAPMSY
----- --
VDLINAFTPW STPSSRSTSS SSASS----- --SHSDIFDPSR
SSEADLQSW TADSSAAQOR NLSGVS----- --SLDITVING
SAHTASFTAW SSPSSRSTSS SSVS----- --SPDCFDPSG
PRHSGSSS SSSMTASSND ----- --SLSWSQEAA

RPRNIFDYM FRAMDGKAVA A-----MP RLTI----- SAPQPHCAT
MQTQAQMPV PQAHTQTAQ G-----HT QLPIQVASHP PPSIPLQSQ
DPIHNYVGAE ACEDNVLDVW SSS---MP VTSI-----
GRHGQRNDS SDSSELEVD P-----VG VIEF-----
YGOQ--RAVS SESAATSYTS PSICSSFAST LASE-----E CSSSTRVNAQ
QPDA--SSET TFSPLSNS P-----AS VWH-----
AMSSGTSYDD SFSAYQISV S-----PP RSTF-----
KPRNPSQSH SSSSFVSSV ATSLLDNFH NPIVMHNSLL LPPPTLGSVD
KPRNVFYMK PRTLNVKAIT S-----MP KITI-----P APQGHASTNA
DPNSVAGNV RSVSHFTPDQ P-----MP EVTMTDAAA MAAQHTSDV
KPPG--MSLT GAAAHMSEVE L-----QP VWLA-----G SQSQGSLHGG
----- --SP KLSA-----
RPHNLKYIS P-KYEGRADV S-----MP HLTI-----G TPQKMAHQGL
RPSTPFDDLT SDTRLQLGYN R-----HT TLAC-----
KAHNFRLLN PLKYDARAK D-----MP AVTM----- --ATPSLMPYQ
ERLRNVSWDT NFSSTYDRT T-----M -----

ASDQKSPF-- ----- --LYELQDSTF FDGTRLDLGS
ASMSMTPF-- ----- --QAP ASPATLSTAA
----- --LEYS
EARRKQPA-- ----- --SVRSEQE
----- --
NVFHRKSS-- -----EM GENFND----- --HMLFRPD HCLPMLDLD
TLGQRSPF-- ----- --LCDIATSKV ATGANLDFSG
TSSLSSAFRL YTPETSCTSV GSSFASPKQP EELDVFVNTTE TGNALDLAD
GLSQQCM-- ----- --

APAQRSPF-- ----- --TS ---DIHAGTN SQMGRIDLSG
----- --FTA
CAEDRSPP-- -----S SDAANGMYG GPORLQFARE AMQHEVDFGG
----- --

LQLNLGGFAD DKDFRESVQM ALSMSSS-EQ GSSRSASSSS -WASTQATTD
 TATNNTTRAS SLSSSTTTTCM PSASTAPIVS LDQLLDLDNA ---RQCLVFS
 MSYPSTSNSD SHTHGPAAVL FCGSSSQFMQ TGHASALDDE ---GQYLVFS
 GKNDLQGVST PFAMGDNVVE KEKQQLSCNN ETKEEDALTT -----MLF
 QAFARQLLPS SPAHGHRAPP PAEIAHFND QOEHLASCGL -WGSNFLFT
 -----SPCK SRSTNTAAPP LGPNPVLAP -SGETYIFQD
 ---GASSFD EQIVRFNAK NSGSSSNSSS NGNSRNSNT ---SNEMMF
 LGLDAITLQR TFNVNWKVAM GGVESPSIGT GAVTPKRNVD VDVATCPGTE
 LYFNLDVAD DQSFRESVQR VLSNMSGYEA DISRNVSSSS -WSSQQTTD
 LELIEDSLTQ ALQDLSKAF DFSSALKTPA SHTQVLEDD -WIESVAFTP
 -RQHDEHISQ SLSMMDTAYA APQSSQASSD GSPPEPSCT -PLPGDMLLL
 -----P NQAIESTTDS FMTRPSVAQE -----GFA
 LQLNMGEAFD RDFRESVQRV FSG--SGFDV GSYRSVSSSS -WGSQA-VTT
 SPHTEQLSVF STSIKGFERQ HPELSSEGAS TEPSPYACSE -RYEDAALLF
 LQFDADAMGR DL---CESV QRVLEMNFSS FADRSMSDSS -WGSTMQSAT
 -----EDDVSEKKG EKKDKGKGS LIDSPVLSEV ---EMPMLF

 DDG--WVDE EDFDSGFAAC HTKPIDRLL -----GQASLT
 PLDLLPRLDF DDLRLDVPTI ENWLG----- ---LPSTPG
 PVD SMPRLDF ADLNLNIDAL EE----- ---CFGLSM
 SETGVTLQDF DDLGLDLDSM VIDLPS---F -----GDFDST
 DSDVPRLDLDF DDLGLEPADF GKESLLEDF AAPPAGGAGQ LWQRGPPMVG
 EETNVPQLGF EELQLDPQSL NENKLSF--- -----DGLAAG
 NENGELLLDW DDLELNLDDF TGTQSLTPT -----DNQNG
 DFNDGWMDE DDDQAANWGE SSTLA----- ---AGKKTLL
 DDG--WEDV DD-SIASHVN GGWQVQISS----- ---GPTQVD
 NNNDVWVNI DEFTRAPKKQ SRPLW----- ---SMSQEE
 DAYGQQLLDW DDLELDASLN GALVL----- ---SPEQLD
 DQE--WL----- ---
 DDDG--WVDE DDFDASLDGR HETPVDA----- ---VQGNNS
 DAYGVAQLDW DDLCLDSHLS AAL----- ---GAAENA
 DDDG--WVDE DEPSAS----- ---TTPVPI
 DSRGNVQLGF ADLQLDLGYL KERLS----- ---GAAGPS

 PPDHCNSNTA PGQASRQEIF QAPCVSG--- -SHPANHSQT SADENP---
 VSSLHVPPIS AGAMRSAKLA LSQPLNA--- ---PDELMGR AADEGW---
 ESDNMTIRVR KFEQEEVRTA EYLCNSP--- FNVTEELSR ATEEDW---
 FALPQPIWMI SSSAKTSVN NSPLAQQ--- ---PCFATPQ V-PTSTLHAA
 VPSGTLHNQY PFAATSTTTL GYALDPSA--- ---SAQDRTS SRPRHFTDVA
 TQPGLVNGWQ RSDVTNCTPG LAGVAAGR--- ---HDQDKES LMEANAFGLA
 ILAGLDLPSN AHSTQETNDL VSI FARK--- ---LVEES FNPEEF---
 RSRGKAIKHI SNKAGSQVNY DDVDATPKQE DFNQFHHHQA SSPKFR---
 AMPSQEAPQT TLLPRAQSA LDQTNNG--- -----
 QTPPTVARVN AGDKSNNTAG ISGFASG--- -SCPQTPRP GCESPF---
 LASGLSAELQ A--AGWSPGG MDLTPRQ--- ---PSFAQSA STPVSP---
 -----TVPI S VHGDTPG--- ---
 MMPPAFHSVN TPMLGQTPLO VLQPSV--- ---PPTMPGA GADTTP---
 LLSGLTTPKL R--PGTAPSA TSLMSPRKSG FRSPSLAPNA ASDPSA---
 SASNNVLPQQ PDAHVLSQPT QGAMQLGHVA FTSAPVHSA VSTAPW---
 FTIAQPGGLS PDDAESEPM GTSETSQQ--- ---SSASSR LSPTSPLLMA

 -----S ISIPFSQAL FDS-DSFGLD QLFE----- ---S
 SLSEQLTPLW NV----- ---PTDAH RLSD----- ---LS
 -----DISS IITRELTRSL DGK-EMQDLS VRLE----- ---GISS
 TILNNTVDA LEBIRRAQOI EEW-AFGTNA ILEEDT--- ---DNKGSYF
 ESLNEGDFNL FAALASLPTF KDM-SPDAIL QFAASGGHDL SVDAERTRYA
 LTLSEHSCG ANTLAPSA GED-SMDGLF DFD----- ---F
 LAQMQQSEEW SSPVMGRLEF ARG-QEQDAI SLAD----- ---LQ
 --LSGRAIET SEASEAARQL TDS-EVNILE FIFEKVHKT SGIERGRGAG
 ---LNTG SDNAHSQPSL FGD-DSFDLS QFFQ----- ---S
 ---QSTAQET PTNGGSCNQA SQL-SLEDDM FLQ----- ---L
 ATISQTLAW PESTTDASAF FASFGPEAFA DLLP----- ---AD
 ----- ---APLEFA FFMD----- ---
 -----DSSSFCPPS FNN-EPFDLA RLE----- ---LA
 HAIGAAITDW PSAPEIASQM AMGLSTESAR DMFV----- ---A
 --ANPAGFAS NNGSSDSAL SNG-EPIDLH NFSE----- ---
 TLLNQATISV PNELRRA SVN GKW-TFDASK MLEG----- ---AGDEWF

 ASIPAHLPST LSHSQQCGFC QMPFV----- ---DPNMQSFE
 LRIDGTMLRR DSVMKARMA PPPSA----- ---
 TRSNMEEAHR RLFQSYVSP MTACL----- ---
 LNLGLRSAG TDTPTSSEA STDGN----- ---GSSVVTNPL
 QSLPTLGSFP SSSTPREKDI VTPPS----- ---R VADANSPEDF
 SAPDAANGSS SDFDFSGLD LPFCF----- ---SPKQL
 STQNSGPSAS TSTQTSFGSS TPRSL----- ---
 STTFSSSSSS SSSISTPGEQ YTPGW----- ---WMNCDLVVS
 TSVPTHMPSI MTFPQHGFL EVPLF----- ---QVHTQELG
 VDSYPHNIAF TQVAQSTYHE GQPCDLRID MFDIDRLFQL LEAENYQYA
 ADPKAQAQPE IHVPVHVDIG PDTSF----- ---

 AAAPAHLPST SPPASQPPQ LPTED----- ---
 IEVDPAMDIS EDAKPVMLVS VPIPS----- ---
 --VGSHPAP ASYAPYQOTS PQQPV----- ---P TASTTPVVNA
 VKLDVPTPST SSSSPSSVAS PQTPS----- ---

 EIEQDLDDM TDIQEFLLGD IFASSLPGSQ QSNCG---V GSADANVQGS
 -----P LTTQSYPLPL
 -----PPYSSLS
 ---FDFSL QCL-YINQIM VANLATFEEP EDCT-----G TSKSISHHLP
 ---AFTDF AEL-GLDRSF AEIRKSYRVA DEEAKMYSIS EVEDEEGGGA
 GLPLAFDFAR QAFSDVEAEM YASYSSCEMS GSDT-----D GDAEVELHGT
 ---FNFDF DNL-GLEDAM TYNNESIG--- ---Q QINSIDLHAM
 QTPPSTLEN GSVPNVDYL SFPGESDECK QAIAE-----E MDFNLASLGI
 ETEKPLDMDL DDIQSLDSN IFASSLPSQ QSNGGIA---P QNSSAQGCNA
 QGDLYALNF DSGDLVQSI DSTNENDSGF DSQP-----N LQIRIFRLAS


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---SFAAGL ESWAACPTSL EHVIEQWKGF -----V PSATPEELAS
-----A
---TNLDIEM TDIQSLFDRD LFDASSLP-- -----G SQQSNAGDGA
-----GIL VKNGSSSG-----A IQLTPESFAS
NAFLDFEVEV ADLDDLSSSF VQPAPV---- -----A PTAAAEVVGAG
RDLFNFDLES LQMHDIVQAN IKTYDCT--- -----Y NESTPTPTPT

NGGASIGEGI LHMDFDPYSN SFSLA----- -----
SARWNHDAIA PNVLTWDLNR GISSTLVP-- -----
QGYVAPSTQS FEPMNITSPS LMECSH---- -----
LETMAANESS FVAMATARD TMHC----- -----
TSGWETGPEE MKGRGTRRSS SGTIISERHT SSETSSGPWA IPARFVDLHG
TDRRAAKATA ATSPSIQGPV ATSVAF---- -----
EELLKYEPLT TDMLGLIFSP PASASPIANV DTASLTLN-----
NEAWEENRKM MAMTMSMAPP FFHGLPSDQT QMVEVEMTDG GFW-----
GTGAEMGEGV FQMNFDLDSN SFGYV----- -----
LSLLEFHPAT LSSRDVLRNF SFPSPFIDS HDTLPSIYIY TRHIPAPHV-
SSAMDIDDSQ MNELGELRRH SEQALFYEES QQPMLLA--- -----
LGLPSSTDVQ MHAN----- -----
LQGNAAAEAQ FCMNFDMSN AFSMV----- -----
LESWTHDASS LEYI----- -----
VQVTQQQPAE FYLNFDLSPD MFRAA----- -----
AHQFCDAAKE PCQLSGLKPE DDDISMEISS Q-----

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Figure S2 Alignment of bW (HD2) protein sequences. The bW protein sequence from *Ustilago maydis* (UMAG_00578) was used as a reference sequence to determine orthologs in all 16 Ustilaginomycotina genomes. Then, all orthologous sequences were used for the alignment using the MUSCLE algorithm performed in MEGA-X. Species abbreviations are as follows: Acain, *Acaromyces ingoldii*; Cergu, *Ceraceosorus guamensis*; Exova, *Exobasidium vaccinii*; Jamro, *Jaminaea rosea*; Malgl, *Malassezia globosa*; Malsy, *Malassezia sympodialis*; Meimi, *Meira miltonrushii*; Psean, *Pseudozyma antarctica*; Psehu, *Pseudozyma hubeiensis*; Psegl, *Pseudomicrostroma glucosiphilum*; Spore, *Sporisorium reilianum*; Tescy, *Testicularia cyperi*; Tilan, *Tilletiaria anomala*; Tilwa, *Tilletiopsis washingtonensis*; Ustma, *Ustilago maydis*; Viopa, *Violaceomyces palustris*.

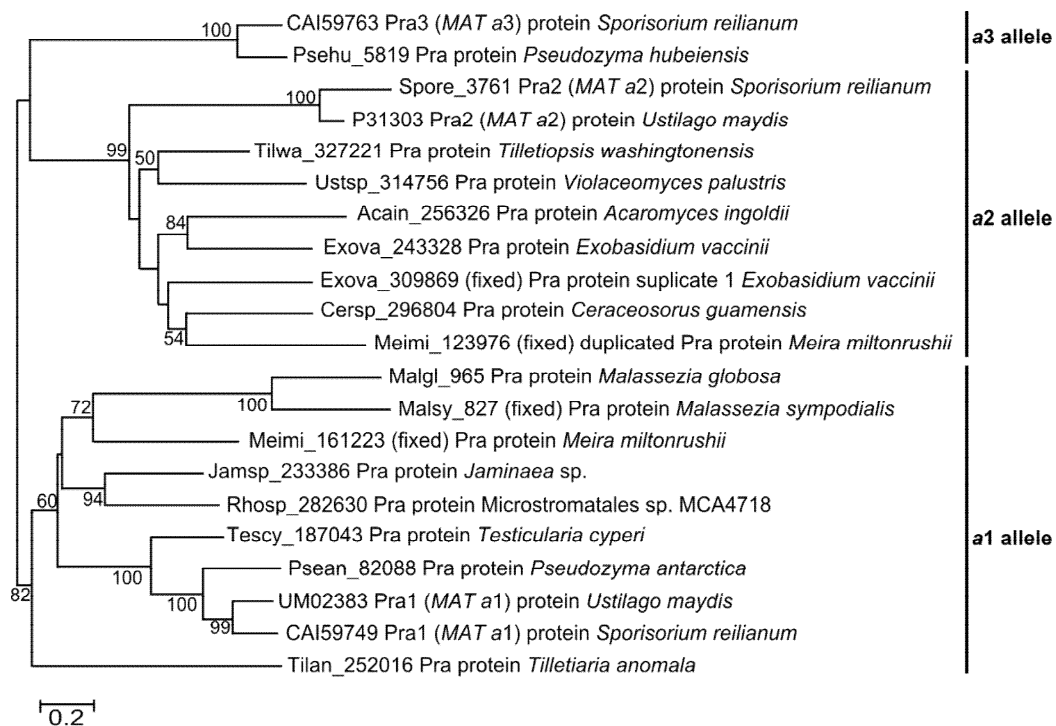


Figure S3 Gene phylogeny of pheromone receptors Pra1. The pheromone receptor protein sequence from *Ustilago maydis* (UMAG_02383) was used as a reference sequence to determine orthologs in all 16 Ustilaginomycotina genomes. All orthologous sequences, plus the ones from each *MAT a* allele in *Ustilago maydis* and *Sporisorium reilianum*, were retrieved for the analyses. The protein sequences were aligned using the MUSCLE algorithm, and then used for phylogenetic reconstruction through the Neighbor-joining method with JTT as a substitution model and a gamma distribution as a rate heterogeneity among sites. The 1000 replicates of bootstrapping were used as an indicator for node supports. Allele types of pheromone receptors are classified based on monophyletic relationships with reference sequences from *U. maydis* and *S. reilianum*: UMAG_02383 for the *a1* allele in *U. maydis*, CAI59749 for the *a1* allele in *S. reilianum*, P31303 for the *a2* allele in *U. maydis*, Spore_3761 for the *a2* allele in *S. reilianum*, and CAI59763 for the *a3* allele in *S. reilianum*. Species abbreviations are as follows: Acain, *Acaromyces ingoldii*; Cersp, *Ceraceosorus guamensis*; Exova, *Exobasidium vaccinii*; Jamsp, *Jaminaea rosea*; Malgl, *Malassezia globosa*; Malsy, *Malassezia sympodialis*; Meimi, *Meira miltonrushii*; Psean, *Pseudozyma antarctica*; Psehu, *Pseudozyma hubeiensis*; Rhodsp, *Pseudomicrostroma glucosiphilum*; Spore, *Sporisorium reilianum*; Tescy, *Testicularia cyperi*; Tilan, *Tilletiaria anomala*; Tilwa, *Tilletiopsis washingtonensis*; Ustma, *Ustilago maydis*; Viopa, *Violaecomyces palustris*. Bar: 0.2 substitution/site.

Table S1 A list of known fungal dimorphism genes from *Ustilago maydis* literature

Categories	Gene name	Function	References
Receptors	<i>Pra1</i>	Pheromone receptor	[1]
	<i>Msb2</i>	Transmembrane mucin, multicopy suppressor of a budding defect	[2]
	<i>Sho1</i>	Osmosensor transmembrane protein	[2]
	<i>Ump2</i>	Ammonium transporter	[3]
cAMP/PKA pathway	<i>Gpa3</i>	G protein alpha subunit	[4]
	<i>Bpp1</i>	G protein beta subunit	[5]
	<i>Uac1</i>	Adenylate cyclase	[6]
	<i>Ubc1</i>	Regulatory subunit of cAMP-dependent protein kinase A	[6,7]
	<i>Adr1</i>	Catalytic subunit of cAMP-dependent protein kinase A	[8]
	<i>Uka1</i>	cAMP-dependent protein kinase A	[8]
	<i>Umpde1/2</i>	Phosphodiesterases	[9]
MAPK pathway	<i>Ucn1</i>	Antagonist phosphatase of PKA	[10]
	<i>Ubc2</i>	Pheromone-responsive SH3 domain protein	[11,12]
	<i>Kpp2/Ubc3</i>	MAP kinase	[13,14]
	<i>Kpp4/Ubc4</i>	MAP kinase kinase kinase	[15,16]
	<i>Kpp6</i>	MAP kinase	[17]
	<i>Fuz7/Ubc5</i>	MAP kinase kinase	[16,18]
	<i>Rok1</i>	Dual specificity protein phosphatase	[19]
GTPase-mediated signaling	<i>Crk1</i>	MAP kinase	[20]
	<i>Ras1, Ras2</i>	<i>Ras</i> family GTPase	[21,22]
	<i>Sql2</i>	Cdc25-like guanyl nucleotide exchange factor	[22]
	<i>Rho1</i>	<i>Rho</i> family GTPase	[23]
	<i>Pdc1</i>	14-3-3 homolog	[24]
	<i>Cla4</i>	PAK family kinase	[25]
Transcriptional regulator	<i>Rac1</i>	<i>Rho</i> family GTPase	[26]
	<i>Biz1</i>	<i>b</i> locus-dependent Zn finger transcription factor	[27]
	<i>Hap2</i>	CCAAT-box binding protein	[28]
	<i>Rop1</i>	High-mobility-group (HMG) domain transcription factor	[29]
	<i>Prf1</i>	Pheromone response factor functioning as a transcription factor	[30,31]
	<i>Rbf1</i>	<i>b</i> locus-dependent Zn finger transcription factor	[32]
	<i>Cib1</i>	<i>b</i> locus-dependent Zn finger transcription factor	[33]
	<i>Gcn5</i>	Histone acetyltransferase	[34]
	<i>Hos2</i>	Histone deacetylase	[35]
	<i>Tup1</i>	General transcriptional repressor	[36]
	<i>Pac2</i>	WOPR family transcriptional repressor	[36]
	<i>Ros1</i>	WOPR family transcriptional regulator	[37]
	<i>Nit2</i>	GATA transcription factor responsive to low nitrogen	[38]

	<i>Med1</i>	Transcription factor	[39]
Other downstream molecular players	<i>Hgl1</i>	Putative regulatory protein	[40]
	<i>Rak1</i>	Seven-WD40 repeat motif protein	[41]
	<i>Myo5</i>	Class V myosin	[42]
	<i>Kin1, Kin3</i>	Kinesin-1 and 3 required for hyphal growth	[43]
	<i>Rrm4, Khd4</i>	RNA-binding protein for filamentous growth	[44,45]
	<i>Clb2</i>	B-type cyclin 2	[46]
	<i>Chs5</i>	Chitin synthase V	[47]
	<i>Chs7</i>	Chitin synthase	[47]
	<i>Mcs1</i>	Myosin chitin synthase 1	[47]
	<i>Clp1</i>	Function in nuclei distribution during cell division in dikaryon	[33]
	<i>Yup1</i>	<i>t</i> -SNARE protein for vesicular cycling	[48]
	<i>Sep3</i>	Septin 3 as an effector of cAMP/PKA pathway	[49]
	<i>Tea1, Tea4</i>	Cell end markers	[50,51]

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