

University of Dundee

## The second International Symposium on Fungal Stress

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# **The Second International Symposium on Fungal Stress: ISFUS**

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64

## 65 **Abstract**

66 The topic of ‘fungal stress’ is central to many important disciplines, including medical  
67 mycology, chronobiology, plant and insect pathology, industrial microbiology, material sciences,  
68 and astrobiology. The International Symposium on Fungal Stress (ISFUS) brought together  
69 researchers, who study fungal stress in a variety of fields. The second ISFUS was held in May  
70 2017 in Goiania, Goiás, Brazil and hosted by the Instituto de Patologia Tropical e Saúde Pública  
71 at the Universidade Federal de Goiás. It was supported by grants from CAPES and FAPEG.  
72 Twenty-seven speakers from 15 countries presented their research related to fungal stress  
73 biology. The Symposium was divided into seven general topics: 1. Fungal biology in extreme  
74 environments; 2. Stress mechanisms and responses in fungi: molecular biology, biochemistry,  
75 biophysics, and cellular biology; 3. Fungal photobiology in the context of stress; 4. Role of stress  
76 in fungal pathogenesis; 5. Fungal stress and bioremediation; 6. Fungal stress in agriculture and  
77 forestry; and 7. Fungal stress in industrial applications. This article provides an overview of the  
78 science presented and discussed at ISFUS-2017.

79

80 **Keywords:** agricultural mycology; forest mycology; industrial mycology; medical mycology;  
81 fungal stress mechanisms and responses.

82

## 83 **Introduction**

84 Research into fungal biology and fungal stress can help solve many issues related to  
85 human health, climate change, food security, environmental impacts, etc. (Rangel et al., 2015a;  
86 Rangel et al., 2015b). Fungi can be used for bioremediation (Gadd, 2016); to replace synthetic  
87 pesticides (Li et al., 2010; Rangel and Correia, 2003; Santi et al., 2011); to produce biofuels

88 (Alper et al., 2006; Lam et al., 2014), novel antibiotics (Mygind et al., 2005), enzymes  
89 (Maheshwari et al., 2000), and useful chemicals (Hagedorn and Kaphammer, 1994). Soil-  
90 dwelling fungi may enhance plant health and crop production of in arid environments (Gal-  
91 Hemed et al., 2011; Molina-Montenegro et al., 2016), and fungi can help degrade and valorize  
92 organic waste materials (Hultberg and Bodin, 2017). Understanding fungal metabolism at  
93 biophysical extremes for life can enable effective preservation of foods, documents, and artefacts  
94 and has implications for astrobiology in relation to habitability of hostile environments and  
95 preventing contamination of other planetary bodies during space exploration (Stevenson et al.,  
96 2015a; Stevenson et al., 2015b; Stevenson et al., 2017). On the other hand, fungal pathogens  
97 represent a serious threat to crops, animals, and humans (Rangel et al., 2015a). Fungi are also  
98 used as models for basic research on the biology of eukaryotic cells (Rangel et al., 2015a). Thus,  
99 understanding how fungi deal with stress during growth or while infecting a host will help  
100 optimize the use of fungi in biotechnological applications, improve the environment, and fight  
101 fungal diseases.

102         Like all living organisms, fungi must cope with a variety of stresses to survive, including  
103 ionizing radiation (Dadachova and Casadevall, 2008; Zhdanova et al., 2000); water activity  
104 (Stevenson et al., 2015a); acidic and alkaline environments (Rangel et al., 2015c; Steiman et al.,  
105 2004); hypoxic or anoxic stress (Bonaccorsi et al., 2006; Camilo et al., 2008; Hillmann et al.,  
106 2015; Rangel et al., 2015c); chaotropicity (Hallsworth et al., 2003); hydrophobicity (Bhaganna et  
107 al., 2010); poisons and toxic chemicals (Pennisi, 2004; Pointing, 2001); solar UV radiation  
108 (Braga et al., 2001; Braga et al., 2015; Braga et al., 2002); agricultural and industrial pollutants  
109 (Pennisi, 2004; Rangel et al., 2010a ); biotic stress (Druzhinina et al., 2011; Saxena et al., 2015);  
110 nutritive stress (Ferreira et al., 2017; Rangel et al., 2006a); oxidative stress (reactive oxygen

111 species, ROS) (Azevedo et al., 2014; Eleutherio et al., 2015; Huarte-Bonnet et al., 2015; Rangel,  
112 2011); heat stress (Rangel et al., 2005; Rangel et al., 2010b; Souza et al., 2014); cold activity  
113 (Santos et al., 2011); and extreme cold (Chin et al., 2010; Selbmann et al., 2015).

114         The International Symposium on Fungal Stress (ISFUS) is a unique meeting which brings  
115 together mycology community under the common umbrella of "stress", be it environmental or  
116 host-related, and promotes unique interaction between researchers and cross-pollination of ideas.  
117 Before ISFUS, there had never been a scientific meeting specifically dedicated to the study of  
118 fungal stress.

119         The first ISFUS was held in 2014 in São José dos Campos, in the state of São Paulo,  
120 Brazil featured presentations from 33 researchers from 10 countries, including students and  
121 young, mid-career, and senior researchers. A good number of discussions, collaborations, and  
122 new friendships were also initiated. (Rangel et al., 2015a; Rangel et al., 2015b). Researchers,  
123 who had been studying fungal stress for years and knew each other through journal articles were  
124 given the opportunity to finally meet. Young scientists were able to connect with more  
125 experienced researchers. From the first ISFUS, over 33 collaborative articles have been  
126 published, which included those published in a special issue of *Current Genetics* that was  
127 devoted to ISFUS 2014 (Rangel et al., 2015a; Rangel et al., 2015b). The first ISFUS was  
128 supported by a generous grant from FAPESP (São Paulo Research Foundation).

129         The first ISFUS was such a success that the organizers decided to host another ISFUS.  
130 The second ISFUS occurred in May 2017 in Goiania, Goiás, Brazil. Drauzio E.N. Rangel  
131 conceived and was the primary organizer of both symposia. Alene Alder-Rangel, Gilberto U. L.  
132 Braga, John E. Hallsworth, and Luis M. Corrochano helped bring the symposia to fruition.

133           The second ISFUS was supported by grants from CAPES and FAPEG. The Instituto de  
134 Patologia Tropical e Saúde Pública at the Universidade Federal de Goiás (UFG) acted as the host  
135 institution. Corporate sponsors included Elsevier (Amsterdam, Netherlands - which provided the  
136 students awards), Biocontrol (Sertãozinho, SP, Brazil), Koppert Biological Systems (Piracicaba,  
137 SP, Brazil), and Alder’s English Services (Goiânia, GO, Brazil). The logo of the 2017  
138 symposium (Figure 1) features one of the most-studied ascomycetes, *Aspergillus nidulans*, and  
139 illustrates several key stress parameters that fungi cope with to survive. Twenty-seven speakers  
140 from 15 countries (Figures 2 and 3) presented talks about their cutting-edge research related to  
141 fungal stress. In addition, there were 42 poster presentations. One hundred participants attended  
142 ISFUS-2017, with about a third from the UFG, and the rest from other Brazilian and  
143 international universities.

144           The ISFUS-2017 Abstracts Book, which feature abstracts from the presentations and  
145 posters, is available in the Electronic Supplementary Material 1 of this article. Articles  
146 highlighting the contributions to the conference are published in this *Fungal Biology* special  
147 issue entitled “Biology of Fungal Systems under Stress”, which focuses on cellular biology,  
148 ecology, environment, agriculture, medical mycology, and biotechnology in the context of fungal  
149 stress biology (Chen et al., 2017; Ferreira et al., 2017; Huarte-Bonnet et al., 2017b; Keyhani,  
150 2017; Malo et al., 2017; Muniz et al., 2017; Tonani et al., 2017).

151           By design, the second ISFUS facilitated interactions between researchers from Brazil and  
152 other countries. Researchers were provided platforms to discuss their work in-depth with the  
153 diverse yet intimate group. Long lunch breaks and social activities provided many opportunities  
154 for all the delegates to interact, share ideas, and promote lasting contacts and collaborations.  
155 Assembling active researchers for the purpose of interdisciplinary exchange will inevitably



156 stimulate ideas for new lines of research across international borders. Several such new  
157 international collaborations are already underway due to this ISFUS.

### 158 **ISFUS 2017: a brief synopsis**

159 The ISFUS-2017 began Monday morning with a welcome talk by Drauzio E. N. Rangel.  
160 He encouraged everyone to follow their intuition as inspired by Albert Einstein: “The intellect  
161 has little to do on the road to discovery. There comes a leap in consciousness, call it Intuition or  
162 what you will, the solution comes to you and you don't know how or why.” Drauzio said:  
163 “Intuition comes when you have an open and clear heart like a child to follow where your  
164 curiosity leads you, in science and in life.”

165 Flávia Aparecida de Oliveira (Figure 4), the Director of the Instituto de Patologia  
166 Tropical e Saúde Pública (the host institution), welcomed researchers. The president of the  
167 Foundation for Research Support of Goiás (FAPEG), Maria Zaira Turchi (Figure 5), praised the  
168 work of the organizers of the Symposium saying, “Times are difficult; despite the little financial  
169 incentive in Brazil, the determination of faculty professors to make things happen is very  
170 beautiful.” Also participating in the opening ceremony were Dr. João Teodoro Pádua (Figure 5),  
171 Chief of Staff of the University presidency; Dr. Luis M. Corrochano, Universidad de Sevilla  
172 (Figure 5); Dr. John E. Hallsworth, Queen’s University Belfast (Figure 5); and Alene Alder-  
173 Rangel, the co-chair (Figure 5).

174 The Symposium was organized around seven general topics related to fungal stress  
175 accordingly to the program found in the Electronic Supplementary Material 2:

#### 176 **1. Fungal biology in extreme environments**

177 The microbial biosphere is limited by thermodynamic and biophysical parameters such as  
178 temperature, water activity, chaotropicity, salinity, and ionizing radiation. Fungi survive and, in

179 the case of extremophiles, retain metabolic activity and grow at the thermodynamic fringes for  
180 life on Earth. Therefore, elucidating cellular stress mechanisms and responses and adaptations in  
181 fungi are imperative to understand life in the context of the various constraints for Earth  
182 ecosystems (Runner and Brewster, 2003; Stevenson et al., 2017; Yakimov et al., 2015).

183 Ekaterina Dadachova talked about the resistance of melanized fungi to both sparsely and  
184 densely ionizing radiation (Casadevall et al., 2017; Pacelli et al., 2017a; Shuryak et al., 2015).  
185 Two melanized fungi - a fast-growing *Cryptococcus neoformans* and a slow-growing *Cryomyces*  
186 *antarcticus* - were subjected to densely ionizing deuterons. Melanin protected both fungi;  
187 however, *Cryomyces antarcticus* was more resistant to deuterons than *Cryptococcus neoformans*.  
188 The irradiated cells were analyzed by a panel of metabolic assays – XTT (2,3-bis(2-methoxy-4-  
189 nitro-5-sulfophenyl)-5-[(phenylamino)carbonyl]-2H-tetrazolium hydroxide), MTT (2-(4,5-  
190 dimethyl-2-thiazolyl)-3,5-diphenyl-2H-tetrazolium bromide), and ATP (adenosine triphosphate).  
191 XTT showed increased activity in melanized strains of both species, while the activity in non-  
192 melanized cells either remained stable or decreased. In a follow-up study performed with only *C.*  
193 *neoformans* cells, transmission electron microscopy (TEM) demonstrated the removal of  
194 polysaccharide capsules by radiation, in both melanized and non-melanized cells, and  
195 considerable damage to the cell wall and organelles was observed in the non-melanized cells.

196 Laura Selbmann also discussed the resistance of the Antarctic cryptoendolithic fungus  
197 *Cryomyces antarcticus* to radiation. This organism is a perfect model for astrobiological studies  
198 because it lives in the closest Mars analogue on Earth, the McMurdo Dry Valleys in Antarctica  
199 (Selbmann et al., 2015). This fungus has been selected for a number of astrobiological projects:  
200 STARLIFE (Moeller et al., 2017); and two funded by the European Space Agency (ESA) and  
201 Italian Space Agency (ASI): LIFE and BIOlogy and Mars Experiment, (Onofri et al., 2012;

202 Onofri et al., 2015); and Lichens and Fungi Experiment, BIOMEX (de Vera et al., 2012). Its  
203 resistance was tested in terms of survival and DNA damage in response to different types of  
204 space-relevant radiation (i.e. UV) and sparsely (up to 117 kGy) and densely ionizing radiation  
205 (up to 1000 Gy). The fungus showed considerable resistance to all the conditions tested,  
206 remaining viable up to 55.81 kGy (Pacelli et al., 2017b).

207 John E. Hallsworth's talk, 'A story of glycerol', detailed the interventions that this polyol  
208 can make in the cellular biology and ecology of microbes, such as enhancement of biological  
209 control and reduction of temperature and water-activity minima for growth (Hallsworth and  
210 Magan, 1995); mechanisms by which glycerol exerts these activities including its ability to  
211 enhance macromolecular flexibility (entropically increased disorder) at high concentrations; a  
212 method to quantify this entropic activity of solutes (chaotropicity) (Cray et al., 2013); and a long-  
213 term research endeavor to try to demonstrate that microbes can retain metabolic activity and  
214 maintain growth below the limit for life recognized since the 1960s (i.e. 0.605 water activity)  
215 (Stevenson et al., 2015a ). This culminated in the discovery that glycerol can facilitate  
216 differentiation and germination of xerophilic fungi, most notably *Aspergillus penicillioides*,  
217 down to 0.585 water activity (Stevenson et al., 2017). He finished the talk by posing a series of  
218 intriguing questions e.g.: 1) does glycerol determine the extent of and failure points for the  
219 functional biosphere, and 2) does abiotic glycerol influence habitability of hostile environments  
220 (both terrestrial & extraterrestrial)?

## 221 **2. Stress mechanisms and responses in fungi: molecular biology, biochemistry, biophysics,** 222 **and cellular biology**

223 Certain fungal species such as *Saccharomyces cerevisiae*, *A. nidulans*, and *Neurospora*  
224 *crassa* have been used by the scientific community for decades as effective eukaryotic models.

225 Many genetic, molecular, cell biology, biochemical, and biophysical research tools and  
226 techniques have been developed and perfected using these model systems. The value of the tools  
227 and techniques is evidenced by research that addresses questions about the fundamental  
228 processes which drive fungal stress and responses including the perception of the stress, signal  
229 transduction, and cellular responses to fungal stresses (Brown and Goldman, 2016; de Nadal and  
230 Posas, 2015; Ho and Gasch, 2015; Rangel et al., 2015b).

231 Gustavo H. Goldman presented studies about regulation of *Aspergillus nidulans* CreA-  
232 mediated catabolite repression by Fbx23 and Fbx47, which are F-box subunits of the Skp, Cullin,  
233 F-box containing (SCF) ubiquitin ligase complex. Carbon catabolite repression (CCR) is a  
234 process that selects the energetically most-favorable carbon source in an environment, by  
235 suppressing the use of less-favorable carbon sources when a better one is available (Brown et al.,  
236 2014). Glucose is the preferential carbon source for most microorganisms because it is rapidly  
237 metabolized, generating quick energy for growth. In the filamentous fungus *Aspergillus*  
238 *nidulans*, CCR is mediated by the transcription factor CreA, a C<sub>2</sub>H<sub>2</sub> finger domain DNA-  
239 binding protein (Ries et al., 2016). The aim of his work was to investigate the regulation of  
240 CreA. CreA depends in part on *de novo* protein synthesis and is regulated in part by  
241 ubiquitination. CreC, the scaffold protein in the CreB-CreC deubiquitination (DUB) complex, is  
242 essential for CreA function and stability. Goldman's research group screened a collection of null  
243 mutations for F-box encoding genes and identified two of them as important for carbon  
244 catabolite repression and derepression. Immunoprecipitation of one of them revealed several  
245 potential targets involved in CreA regulation.

246 Maria Celia Bertolini focused on the *Neurospora crassa* RUV-1 protein, which is identified  
247 as a protein involved in heat stress response (Freitas et al., 2008). This protein, together with its

248 paralogue RUV-2, belongs to the AAA+ ATPase protein family and is annotated as an ATP-  
249 dependent DNA helicase. The proteins have been identified as components of several  
250 macromolecular complexes, implicated in many cellular processes in different organisms. In *N.*  
251 *crassa*, the *ruv-1* transcript and RUV-1 protein are up-regulated under heat stress; however, *ruv-*  
252 *2* transcript is not regulated under the same condition. In addition, cellular localization analyses  
253 showed that both proteins move to the nucleus under heat stress.

### 254 **3. Fungal photobiology in the context of stress**

255       The entire second day of the Symposium focused on fungal photobiology. Fungi respond to  
256 light as environmental signals that modulate several aspects of their biology, including  
257 development and metabolism. However, excess light causes biological stress and most fungi  
258 respond by synthesizing protective pigments and enzymes for repairing UV-induced DNA  
259 damage (Braga et al., 2015; Braga et al., 2006; Fischer et al., 2016; Idnurm et al., 2010; Rangel  
260 et al., 2006b; Rangel et al., 2011).

261       Luis M. Corrochano began the morning explaining how light is the ultimate source of  
262 energy for life. However, light is both a signal from the environment and a damaging agent for  
263 all organisms. Most fungi respond to light by regulating gene transcription, and a key response to  
264 light is the activation of genes for repairing UV-induced DNA damage. In *Phycomyces*, a  
265 cryptochrome seems to act as a blue-light regulated DNA repair enzyme (Tagua et al., 2015).

266       Gerhard Braus stated that light represents a stress signal in fungi and induces different  
267 reactions. *A. nidulans* develops in the soil in the absence of light, primarily in closed sexual  
268 fruiting bodies linked to a specific secondary metabolism as overwintering structures. In contrast,  
269 light promotes and accelerates the formation of conidiophores, which release asexual spores into  
270 the air. Various control layers coordinate fungal development, virulence, and secondary

271 metabolism. They include the control of transcription and histone modification, signal perception  
272 and transduction as well as protein localization and stability (Bayram and Braus, 2012; Sarikaya-  
273 Bayram et al., 2014; Sarikaya-Bayram et al., 2015).

274 Monika Schmoll's presentation was about *Trichoderma reesei*, an important producer of  
275 plant cell-wall degrading enzymes and heterologous proteins. Therefore, it is of utmost  
276 importance to understand the factors influencing the regulation cascade that lead to high  
277 efficiency production of enzymes - particularly the previously unconsidered effect of light  
278 (Stappler et al., 2016). Regulation of cellulase gene expression is connected with regulation of  
279 secondary metabolism in *T. reesei* with differences in light and darkness (Monroy et al., 2017).  
280 Screening for cellulose-sensing receptors permitted identification of two G-protein coupled  
281 receptors (GPCRs). These GPCRs are essential for chemotropical sensing of the building block  
282 glucose and morphological changes on natural substrate surfaces. Additionally, these receptors  
283 act as checkpoints for posttranscriptional up-regulation of secreted cellulose degrading enzymes  
284 on cellulose and lactose (Stappler et al., 2017). Analysis of the photoreceptor ENV1 revealed an  
285 evolutionarily conserved mechanism to integrate stress responses with light response in the  
286 Hypocreales (Lokhandwala et al., 2015). This finding highlights the importance of stress  
287 responses in diverse interconnected regulatory processes in *T. reesei*, such as light-dependent  
288 regulation, enzyme expression, metabolite production, and chemical communication in nature.

289 Luis Larrondo showed how circadian clocks are molecular devices that allow organisms to  
290 anticipate daily cyclic challenges by temporally modulating different processes. Using clock-null  
291 mutants of *Botrytis cinerea*, Larrondo's group found that interaction between this  
292 phytopathogenic fungus and its host varies with the time of day (Canessa et al., 2013; Hevia et  
293 al., 2016; Hevia et al., 2015). In *Neurospora*, the FREQUENCY protein (FRQ) is the main

294 component of the circadian oscillator (Ruoff et al., 2005), a role that is also conserved for the  
295 *Botrytis* ortholog BcFRQ1. This protein also appears to play a critical function in asexual/sexual  
296 decisions. Nevertheless, developmental phenotypes triggered by the absence of FRQ can be  
297 reversed by nutritional cues.

298 Kevin Fuller explained that for the saprophyte and opportunistic pathogen *Aspergillus*  
299 *fumigatus*, visible light leads to conspicuous effects on colonial growth, e.g. the induction of  
300 mycelial pigments or asexual spores, as well as an induction of genes involved in DNA repair  
301 (Fuller et al., 2016; Fuller et al., 2013). Transcriptome analysis revealed that in *A. fumigatus*  
302 most regulated genes are repressed by light, including those involved in oxidative  
303 phosphorylation, ergosterol biosynthesis, and metal ion homeostasis. The biological significance  
304 of these light-repressed categories is more difficult to discern, but likely reflects a difference  
305 between metabolic conditions the fungus faces at the soil surface and deeper in the soil/compost.  
306 Interestingly, there is a correspondence between genes that are induced under hypoxia (Barker et  
307 al., 2012) and those repressed by light, and so the current model is proposed: at the sub-surface  
308 (dark), the fungus experiences low-oxygen concentrations and genes involved in hypoxia  
309 adaptation are up-regulated by the conserved regulator SrbA (Willger et al., 2008); at the soil  
310 surface, where oxygen levels are ambient, photoreceptors (LreA, FphA) down-regulate those  
311 hypoxia-adaptive pathways, including ergosterol metabolism and iron homeostasis. As the  
312 surface is also a site for optimal dispersal (i.e. open air) and exposure to ultraviolet radiation,  
313 genes involved in sporulation and resistance to genotoxic damage are induced by light. Fuller  
314 and colleagues are currently dissecting the interplay between canonical light and hypoxia-  
315 regulatory pathways as well as probing the conservation of ergosterol biosynthesis and drug  
316 sensitivity by light in other fungal pathogens.

317 Gilberto U. L. Braga explained that antimicrobial photodynamic treatment (APDT) is a  
318 promising alternative to conventional antifungal agents that can be used to kill fungi, which  
319 cause diseases in animals or plants (de Menezes et al., 2014; Gonzales et al., 2017). APDT, using  
320 phenothiazinium photosensitizers, efficiently kills planktonic cells of *Candida* species and  
321 conidia of several pathogenic fungi, damages the fungal plasma membrane increasing its  
322 permeability and greatly impacting their proteomes (Brancini et al., 2016).

323 Drauzio E. N. Rangel completed the day by discussing how fungi illuminated during  
324 mycelial growth produce conidia with increased stress tolerance. Light is an important stimulus  
325 for many fungi and it has been shown to induce production of *Metarhizium robertsii* conidia with  
326 increased stress tolerance (Rangel et al., 2015c; Rangel et al., 2011). White light, as well as blue  
327 light during mycelial growth, induces higher conidial stress tolerance, higher germination rates,  
328 and higher virulence in *Metarhizium robertsii*, but nutritional stress always produces conidia  
329 with more intense stress tolerance and virulence than conidia produced under white or blue light  
330 (Rangel, 2011; Rangel et al., 2008; Rangel et al., 2006a; Rangel et al., 2012).

#### 331 **4. Role of stress in fungal pathogenesis**

332 Fungal pathogens have evolved numerous mechanisms to escape host defenses such as  
333 thermotolerance, toxin production, masking or modulating pathogen-associated molecular  
334 patterns (PAMPs) and pattern recognition receptors (PRRs), and overcoming oxidative defenses  
335 (Sales-Campos et al., 2013; Stappers and Brown, 2017). Research on fungal pathogenesis is a  
336 wide field that encompasses basic research on host-pathogen interactions, cell and molecular  
337 biology, and development and aging, as well as applied research in crop protection, food  
338 security, public health, and medicine.



339 Jon Y. Takemoto addressed global challenges for crop production and food security and the  
340 critical roles for research into fungal stress and biology (Fisher et al., 2012). He described  
341 strategies behind the recent discovery of a new generation of aminoglycoside fungicides aimed  
342 to help counter the critical shortage of effective, safe, and environmentally friendly fungicides  
343 against crop diseases. K20 is a new membrane-targeting amphiphilic aminoglycoside that is not  
344 toxic and a broad-spectrum antifungal, which can be produced at scalable, kilogram levels  
345 (Chang and Takemoto, 2014). K20 by itself, or in combination with current crop fungicides  
346 (employed at lower than recommended rates), shows promise in combating several crop diseases  
347 including the devastating wheat disease, Fusarium Head Blight.

348 Célia M. A. Soares discussed metabolic changes in *Paracoccidioides* spp. during human  
349 host infection. Members of the *Paracoccidioides* complex, the etiologic agents of  
350 paracoccidioidomycosis, cause disease in healthy and immunocompromised patients in Latin  
351 America. Her team developed a method to harvest *Paracoccidioides brasiliensis* yeast cells from  
352 infected murine lung to facilitate *in vivo* transcriptional and proteomic profiling (Lacerda Pigosso  
353 et al., 2017). They compared the *in vivo* to *in vitro* and *ex vivo* responses of *Paracoccidioides*  
354 spp., as obtained by proteomic analysis (Lima et al., 2014; Parente-Rocha et al., 2015).

355 Iran Malavazi described the contribution of the cell wall integrity pathway to virulence in  
356 *Aspergillus fumigatus*. He showed that besides its role in cell wall reinforcement and remodeling,  
357 the cell wall integrity pathway (Rocha et al., 2015) is an important hub for production of fungal  
358 secondary metabolites. The fumiquinazoline (Fq) production is regulated by the transcription  
359 factor RlmA and the MAP kinase MpkA. In fact, the RlmA transcription factor binds to the  
360 promoter region of most of the genes of the Fq cluster genes. The results indicate an

361 unprecedented connection of the CWI pathway with the biosynthesis of a conidia-born secondary  
362 metabolite.

363 Marcia R. von Zeska Kress related her research about antimicrobial photodynamic  
364 inactivation and photodynamic therapy. *Neoscytalidium* spp. and *Fusarium* spp. are filamentous  
365 fungi widely distributed in nature that cause non-dermatophyte onychomycosis that have  
366 significant resistance to commercial antifungal therapy. APDT with the phenothiazinium  
367 photosensitizers methylene blue, toluidine blue, new methylene blue, and the pentacyclic  
368 phenothiazinium S137 were able to kill both quiescent and germinated arthroconidia and  
369 microconidia of *Neoscytalidium* spp. and *Fusarium* spp., respectively. The photodynamic  
370 therapy with phenothiazinium photosensitizers on *Fusarium moniliforme* infection of *Galleria*  
371 *mellonella*, the model for fungal virulence and susceptibility testing, showed that this therapy is a  
372 promising alternative to antifungal treatment against this filamentous fungus (de Menezes et al.,  
373 2016; Tonani et al., 2017).

374 Alexandre M. Bailão explained that the black fungi *Fonsecaea pedrosoi* and  
375 *Cladophialophora carrionii* are the most common agents of Chromoblastomycosis, a  
376 subcutaneous mycosis frequently diagnosed in tropical regions. The virulence strategies used by  
377 these fungi are poorly understood. As iron is an essential element, pathogenic fungi have  
378 developed molecular mechanisms to obtain the metal during infection. *F. pedrosoi* and *C.*  
379 *carrionii* have genes encoding for reductive and siderophore-mediated iron-uptake systems, and  
380 the transcriptional levels of those genes are induced upon iron limitation. Moreover, these  
381 pathogens produce ferricrocin as intra- and extracellular siderophores (Silva-Bailão et al., 2017).

## 382 **5. Fungal stress and bioremediation**

383 Fungi are ubiquitous in polluted habitats, and they exhibit remarkable tolerance to organic

384 and inorganic contaminants. Some fungi synthesize specific metal-binding peptides or  
385 metallothioneins in response to metal pollutants. Fungi also exhibit morphological differentiation  
386 in response to toxic stress, such as the formation of hyphal aggregates and cords, melanized cell  
387 forms as well as thigmotropism and chemotropism to locate a favorable microenvironment.  
388 Metabolic versatility underpins enzyme expression, carbon metabolism, pollutant transport, and  
389 production and excretion of metabolites that immobilize oxalates, oxides, phosphates, and  
390 carbonates (Gadd, 2007, 2010; Gadd, 2016). The morphological and metabolic versatility of  
391 fungi provides several advantages for bioremediation approaches, not the least their capacity to  
392 combat and overcome stress in adverse environments.

393 Rosane M. Peralta was the only speaker about using fungi for bioremediation. The  
394 capability of white rot fungi to biodegrade several recalcitrant pollutants has generated a  
395 considerable research interest in this area of industrial/environmental microbiology. The ability  
396 of white rot fungi to degrade pollutants appears to be related to the capability of producing  
397 extracellular non-specific lignin-degrading enzymes, especially peroxidases and laccases, as well  
398 as to produce intracellular oxidases generating of H<sub>2</sub>O<sub>2</sub> and cytochrome P450 (Coelho-Moreira et  
399 al., 2013; Maciel et al., 2013). WRF can be an alternative to reduce the ecological problems  
400 caused by the accumulation of these products in nature.

## 401 **6. Fungal stress in agriculture and forestry**

402 Stress conditions, particularly UV radiation and heat from sunlight are important regulators  
403 of fungal communities in agriculture and forest (Bidochka et al., 2001; Ferreira et al., 2017;  
404 Wang and Wang, 2017). Many fungi have been developed into commercial biological control  
405 agents and are being mass produced to be used in agriculture and forestry (Li et al., 2010) to  
406 promote plant growth (Vega et al., 2009), promote plant defense responses (Vega et al., 2009);

407 and to control plant diseases (Costa et al., 2013; Druzhinina et al., 2011), plant parasitic  
408 nematodes (Siddiqui and Mahmood, 1996), aquatic weeds (Cother and Gilbert, 1994), terrestrial  
409 weeds (Moraes et al., 2014), and insects (Alston et al., 2005; Faria and Wraight, 2007; Keyser et  
410 al., 2017). Different abiotic environmental factors cause stress and consequently harm these  
411 important fungi in agricultural systems, highlighting the need to study stress tolerance of fungi  
412 used in agriculture and forestry.

413 Elias Hakalehto's presentation was about competitive interactions between fungi and other  
414 microbes in stressed ecosystems. In mixed cultures, fast-growing Gram-positive bacteria play a  
415 dominant role. For example, the fungi that pioneer in soil do not compete with bacteria as much  
416 for the degradation products as they spread their influence on novel sources of organic raw  
417 materials. The bacterial strains, in turn, receive an advantage of the biodegradation by fungi.  
418 Therefore, the instances of confrontation between fungi and bacteria are limited to specific  
419 conditions only. The effects of the industrially upgraded fungal enzymes have been tested in  
420 biorefinery trials for producing carbon and energy sources for undefined mixed cultures fortified  
421 with some industrial bacterial strains under controllable gas flow (den Boer et al., 2016; Schwede  
422 et al., 2017). The fungi colonize hostile or poor environments with the help of their aerial  
423 mycelium; transport nutrients along the growing hyphae; change the surroundings by enzymatic  
424 activities; and mobilize nutrients from various sources and niches. Fungi also produce sexual and  
425 asexual spores to conquer new areas, and nutrient sources (fungal spores fill the atmosphere).  
426 There is evidence about the relatively even distribution of the spores in the layers of the  
427 atmosphere detected from samples collected by a jet at altitudes of 300-1000 m (Hakalehto,  
428 2015).

429 Roger D. Finlay discussed ways in which root-associated fungi mediate stress responses of

430 plants. Symbiotic mycorrhizal fungi play important roles in reducing abiotic and biotic stress to  
431 plants in forestry and agriculture, and can minimize negative effects of soil acidification, Al-  
432 toxicity, and base cation leaching (Finlay, 2008). High-throughput DNA sequencing and stable  
433 isotope-based studies suggest that ectomycorrhizal fungi may play an important role in  
434 fractionation of Mg isotopes and uptake of base cations through weathering of minerals (Fahad et  
435 al., 2016). These fungi also influence patterns of stable carbon storage in humified material and  
436 secondary minerals. Moreover, these fungi may have global impacts on sequestration or release  
437 of atmospheric CO<sub>2</sub> (Clemmensen et al., 2013; Finlay and Clemmensen, 2017).

438 Chengshu Wang elucidated the cause-effect relationships between oxidative stress and  
439 fungal culture degeneration. Filamentous fungi undergo frequent culture degeneration during  
440 successive maintenance on artificial media by showing fluffy mycelium growth and colony  
441 sectorization (Butt et al., 2006). The degenerate fungal cultures show the loss or reduced abilities  
442 to sporulate, perform sexual cycle, fruit, and/or produce secondary metabolites. Molecular and  
443 biochemical characterizations reveal that fungal culture degeneration is a sign of cell aging  
444 (Wang et al., 2005), and the occurrence of spontaneous oxidative stress, i.e., cellular  
445 accumulation of reactive oxygen species, is connected with mitochondrial dysfunction and  
446 thereby fungal culture degeneration (Li et al., 2014; Li et al., 2008; Xiong et al., 2013).

447 Octavio Loera explained how sublethal oxidant states improve production and quality of  
448 conidia in entomopathogenic fungi (EF). EF conidia control insect plagues in crop fields where  
449 abiotic factors weaken conidia. During production of conidia by *Metarhizium*, *Beauveria*, and  
450 *Isaria*, controlled oxidant stress improves the conidial yields, and production of stronger and  
451 more infective conidia is possible (Muñiz-Paredes et al., 2017). This implies metabolic  
452 adjustments leading to cross protection mechanisms, which could be feasible in large-scale

453 processes (Miranda-Hernández et al., 2016).

454 Nicolás Pedrini studies molecular interactions between EF and insects. During insect-  
455 cuticle degradation as well as during invasion and proliferation throughout their host, EF secrete  
456 a suite of enzymes and secondary metabolites that help them cope with the stressful situation  
457 they have to endure to finally achieve a successful infection (Huarte-Bonnet et al., 2017a;  
458 Pedrini, 2017; Wang and Wang, 2017). Moreover, insects trigger innate immune reactions to  
459 prevent microbial proliferation. By analysis of available transcriptomic and metabolomic data,  
460 several components and mechanisms involved in this fungi-insect interaction were reviewed.

461 Everton K. K. Fernandes presented a study about stress tolerance of EF conidia and  
462 blastospores. The study compared the tolerance to heat (45 °C) and UV-B radiation between  
463 conidia and blastospores of *Metarhizium* spp. and *Beauveria bassiana* s.l. He discussed the  
464 principles for this comparison concerning their use for biological control of arthropods.

## 465 **7: Fungal stress in industry**

466 Many industrial processes essential for meeting societal needs use fungi that play central  
467 roles in those processes. Examples are industrial ethanol production using yeast strains and the  
468 brewery industry utilizing *Saccharomyces pastorianus*. Research into the biology of fungi within  
469 industrial systems have catalyzed research into other areas such as eukaryotic responses to  
470 oxidative stress and effects on aging (Wei et al., 2007; Zhao and Bai, 2009).

471 Elis C. A. Eleutherio explained how fungi can be used as models to study oxidative stress  
472 (da Silva et al., 2012; Fernandes et al., 2007). Evidence shows that oxidative stress is connected  
473 to life span (Mannarino et al., 2008). Throughout the world, leading causes of death are age-  
474 related diseases, such as cancer and neurodegenerative diseases. Her presentation highlighted the

475 value of the yeast *S. cerevisiae* as a model to investigate the oxidative stress response and its  
476 potential impact on aging and age-related diseases (Brasil et al., 2013; França et al., 2017).

477 Diego Bonatto's topic was the delicate balance between hybrid genomes and brewery  
478 stresses in lager yeasts. *Saccharomyces pastorianus* has been employed in the brewery industry  
479 for the fermentation of lager beers, a product consumed worldwide. Despite its industrial  
480 importance, little is known about how *S. pastorianus* deals with brewery stress. His group has  
481 evaluated the major stress-associated biological mechanisms using transcriptome and systems  
482 biology analyses. [ref](#)

483 Anderson Ferreira da Cunha finished the Symposium with his study of thermotolerance and  
484 ethanol-resistance in *Saccharomyces cerevisiae* strains. Several stress factors are involved in the  
485 efficiency of production during ethanol fermentation. High ethanol concentrations and high  
486 temperatures are the most relevant ones. A good industrial strain must be sufficiently robust to  
487 respond well to this environmental stress, without altering its fermentative characteristics during  
488 the whole crop season. Since 2010, his group has been sampling different fermentation tanks  
489 trying to find yeasts able to grow at temperatures above 40 °C and at concentrations of ethanol  
490 above 12%. They have isolated four different thermotolerant and two ethanol-tolerant strains,  
491 which produced superior ethanol yield than strains currently used in ethanol plants. These strains  
492 showed a high potential of direct application for ethanol production.

493

#### 494 **Elsevier Student Competition Awards**

495 Elsevier sponsored awards to recognize excellent work by graduate students in the area of  
496 fungal stress. For the award competitions, students submitted original research articles formatted  
497 for journal publication. Two of these articles are featured in this special issue (Huarte-Bonnet et

498 al., 2017b; Muniz et al., 2017). The award winners also gave oral presentations at ISFUS. The  
499 articles were read and judged by several of the international speakers following the evaluation  
500 criteria found in the website <https://isfus.wordpress.com/>.

501 Four doctoral students received silver Elsevier awards: Mariane Paludetti Zubieta (PhD  
502 student in Functional and Molecular Biology at the Universidade Estadual de Campinas). Her  
503 article was titled: “Understanding the production of recombinant proteins in *Aspergillus nidulans*  
504 by global proteome profiling” (Figure 6). Ronaldo A. Pereira-Junior (PhD student in Tropical  
505 Medicine and Public Health, Universidade Federal de Goiás), and his article was titled:  
506 “Riboflavin: A supplement that increases the tolerance of *Metarhizium* species against UV-B  
507 radiation by over-expressing photolyase, laccase, and polyketide synthase genes” (Figure 7 and  
508 10). Carla Huarte-Bonnet (PhD student in Biotechnology and Molecular Biology, Universidad  
509 Nacional de La Plata) from Argentina was the only non-Brazilian award winner. Her article was  
510 titled: “Alkane-grown *Beauveria bassiana*: mycelial pellets formation, oxidative stress induction,  
511 and cell surface alterations” (Figure 8 and 10) (Huarte-Bonnet et al., 2017b). Elen Regozino  
512 Muniz (PhD student in Tropical Medicine and Public Health at the Universidade Federal de  
513 Goiás). Her article was titled: “Impact of short-term temperature challenges on the larvicidal  
514 activities of the entomopathogenic water mold *Leptolegnia chapmanii* against *Aedes aegyptii*, and  
515 development on infected dead larvae” (Figure 9 and 10) (Muniz et al., 2017).

516 The weekend after the ISFUS-2017 about half of the international speakers, several  
517 Brazilian speakers, and a few international participants took an excursion to Pirenópolis, in the  
518 state of Goiás. This historic town, about 130 km from Goiânia, attracts many tourists due to its  
519 richly preserved history and surrounding mountains. On a guided tour to Pireneus State Park, we  
520 experienced the beautiful waterfalls and then hiked up a hill to view the magnificent sunset over



521 the Pico dos Pireneus. The following day was spent at Vagafogo Wildlife Sanctuary, walking  
522 through the riparian forest and tasting a large variety of local foods for brunch. We also enjoyed  
523 the history and cuisine of Pirenópolis. The excursion was an excellent opportunity to see more of  
524 Brazil and become better acquainted with our colleagues.

## 525 **Conclusion**

526 This special issue of *Fungal Biology* was inspired by the International Symposium on  
527 Fungal Stress. Most of the articles were written by speakers or participants of ISFUS-2017.  
528 Individuals who find the subject of fungal stress fascinating and attractive are invited to consider  
529 attending the next ISFUS, tentatively planned for 2019.

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## 541 **References**

542 Alper, H., Moxley, J., Nevoigt, E., Fink, G.R., Stephanopoulos, G., 2006. Engineering yeast  
543 transcription machinery for improved ethanol tolerance and production. *Science* 314, 1565-1568,  
544 10.1126/science.1131969.

545 Alston, D.G., Rangel, D.E.N., Lacey, L.A., Golez, H.G., Kim, J.J., Roberts, D.W., 2005.  
546 Evaluation of novel fungal and nematode isolates for control of *Conotrachelus nenuphar*  
547 (Coleoptera: Curculionidae) larvae. *Biological Control* 35, 163-171,

548 Azevedo, R.F.F., Souza, R.K.F., Braga, G.U.L., Rangel, D.E.N., 2014. Responsiveness of  
549 entomopathogenic fungi to menadione-induced oxidative stress. *Fungal Biology* 118, 990-995,  
550 10.1016/j.funbio.2014.09.003.

551 Barker, B.M., Kroll, K., Vödisch, M., Mazurie, A., Kniemeyer, O., Cramer, R.A., 2012.  
552 Transcriptomic and proteomic analyses of the *Aspergillus fumigatus* hypoxia response using an  
553 oxygen-controlled fermenter. *BMC Genomics* 13, 62-62, 10.1186/1471-2164-13-62.

554 Bayram, Ö., Braus, G.H., 2012. Coordination of secondary metabolism and development in  
555 fungi: the velvet family of regulatory proteins. *FEMS Microbiology Reviews* 36, 1-24,  
556 10.1111/j.1574-6976.2011.00285.x.

557 Bhaganna, P., Volkers, R.J.M., Bell, A.N.W., Kluge, K., Timson, D.J., McGrath, J.W.,  
558 Ruijsenaars, H.J., Hallsworth, J.E., 2010. Hydrophobic substances induce water stress in  
559 microbial cells. *Microbial Biotechnology* 3, 701-716, 10.1111/j.1751-7915.2010.00203.x.

560 Bidochka, M.J., Kamp, A.M., Lavender, T.M., Dekoning, J., De Croos, J.N., 2001. Habitat  
561 association in two genetic groups of the insect-pathogenic fungus *Metarhizium anisopliae*:  
562 uncovering cryptic species? *Appl. Environ. Microbiol.* 67, 1335-1342,

563 Bonaccorsi, E.D., Ferreira, A.J.S., Chambergo, F.S., Ramos, A.S.P., Mantovani, M.C., Farah,  
564 J.P.S., Sorio, C.S., Gombert, A.K., Tonso, A., El-Dorry, H., 2006. Transcriptional response of  
565 the obligatory aerobe *Trichoderma reesei* to hypoxia and transient anoxia: Implications for  
566 energy production and survival in the absence of oxygen. *Biochemistry* 45, 3912-3924,  
567 10.1021/bi052045o.

568 Braga, G.U.L., Flint, S.D., Miller, C.D., Anderson, A.J., Roberts, D.W., 2001. Variability in  
569 response to UV-B among species and strains of *Metarhizium anisopliae* isolates from sites at  
570 latitudes from 61°N to 54°S. *Journal of Invertebrate Pathology* 78, 98-108,

571 Braga, G.U.L., Rangel, D.E.N., Fernandes, É.K.K., Flint, S.D., Roberts, D.W., 2015. Molecular  
572 and physiological effects of environmental UV radiation on fungal conidia. *Current Genetics* 61,  
573 405-425, 10.1007/s00294-015-0483-0.

574 Braga, G.U.L., Rangel, D.E.N., Flint, S.D., Anderson, A.J., Roberts, D.W., 2006. Conidial  
575 pigmentation is important to tolerance against solar-simulated radiation in the entomopathogenic  
576 fungus *Metarhizium anisopliae*. *Photochemistry and Photobiology* 82, 418-422,

577 Braga, G.U.L., Rangel, D.E.N., Flint, S.D., Miller, C.D., Anderson, A.J., Roberts, D.W., 2002.  
578 Damage and recovery from UV-B exposure in conidia of the entomopathogens *Verticillium*  
579 *lecanii* and *Aphanocladium album*. *Mycologia* 94, 912-920,

580 Brancini, G.T.P., Rodrigues, G.B., Rambaldi, M.d.S.L., Izumi, C., Yatsuda, A.P., Wainwright,  
581 M., Rosa, J.C., Braga, G.U.L., 2016. The effects of photodynamic treatment with new methylene

582 blue N on the *Candida albicans* proteome. Photochemical & Photobiological Sciences 15, 1503-  
583 1513, 10.1039/c6pp00257a.

584 Brasil, A.A., Belati, A., Mannarino, S.C., Panek, A.D., Eleutherio, E.C.A., Pereira, M.D., 2013.  
585 The involvement of GSH in the activation of human Sod1 linked to FALS in chronologically  
586 aged yeast cells. FEMS Yeast Research 13, 433-440, 10.1111/1567-1364.12045.

587 Brown, N.A., Goldman, G.H., 2016. The contribution of *Aspergillus fumigatus* stress responses  
588 to virulence and antifungal resistance. Journal of Microbiology 54, 243-253, 10.1007/s12275-  
589 016-5510-4.

590 Brown, N.A., Ries, L.N.A., Goldman, G.H., 2014. How nutritional status signalling coordinates  
591 metabolism and lignocellulolytic enzyme secretion. Fungal Genetics and Biology 72, 48-63,  
592 10.1016/j.fgb.2014.06.012.

593 Butt, T.M., Wang, C., Shah, F.A., Hall, R., 2006. Degeneration of entomopathogenous fungi, in:  
594 Eilenberg, J., Hokkanen, H.M.T. (Eds.), An Ecological and Societal Approach to Biological  
595 Control. Springer Netherlands, Dordrecht, pp. 213-226.

596 Camilo, C., El-Dorry, H., Gomes, S., 2008. Transcriptional response to hypoxia and transient  
597 anoxia in the aquatic fungus *Blastocladiella emersonii*. Febs Journal 275, 282-282,

598 Canessa, P., Schumacher, J., Hevia, M.A., Tudzynski, P., Larrondo, L.F., 2013. Assessing the  
599 effects of light on differentiation and virulence of the plant pathogen *Botrytis cinerea*:  
600 characterization of the white collar complex. PLoS One 8, 10.1371/journal.pone.0084223.

601 Casadevall, A., Cordero, R.J.B., Bryan, R., Nosanchuk, J., Dadachova, E., 2017. Melanin,  
602 Radiation, and Energy Transduction in Fungi. Microbiol Spectr 5,  
603 10.1128/microbiolspec.FUNK-0037-2016.

604 Chang, C.W., Takemoto, J.Y., 2014. Antifungal Amphiphilic Aminoglycosides. Medicinal  
605 Chemical Communications 5, 1048-1057, 10.1039/C4MD00078A.

606 Chen, Y., Cen, K., Lu, Y., Zhang, S., Shang, Y., Wang, C., 2017. Nitrogen-starvation triggers  
607 cellular accumulation of triacylglycerol in *Metarhizium robertsii*. Fungal Biology,  
608 <https://doi.org/10.1016/j.funbio.2017.07.001>.

609 Chin, J.P., Megaw, J., Magill, C.L., Nowotarski, K., Williams, J.P., Bhaganna, P., Linton, M.,  
610 Patterson, M.F., Underwood, G.J.C., Mswaka, A.Y., Hallsworth, J.E., 2010. Solutes determine  
611 the temperature windows for microbial survival and growth. Proceedings of the National  
612 Academy of Sciences of the United States of America 107, 7835-7840, DOI  
613 10.1073/pnas.1000557107.

614 Clemmensen, K.E., Bahr, A., Ovaskainen, O., Dahlberg, A., Ekblad, A., Wallander, H., Stenlid,  
615 J., Finlay, R.D., Wardle, D.A., Lindahl, B.D., 2013. Roots and associated fungi drive long-term  
616 carbon sequestration in boreal forest. Science 339, 1615-1618, 10.1126/science.1231923.

617 Coelho-Moreira, J.S., Bracht, A., Souza, A.C.S., Oliveira, R.F., Sá-Nakanishi, A.B., C.G.M., S.,  
618 Peralta, R.M., 2013. Degradation of diuron by *Phanerochaete chrysosporium*: role of ligninolytic  
619 enzymes and cytochrome P450. *Biomed Res Int* 2013, 251354, 10.1155/2013/251354.

620 Costa, L.B., Rangel, D.E.N., Morandi, M.A.B., Bettiol, W., 2013. Effects of UV-B radiation on  
621 the antagonistic ability of *Clonostachys rosea* to *Botrytis cinerea* on strawberry leaves.  
622 *Biological Control* 65, 95–100, 10.1016/j.biocontrol.2012.12.007.

623 Cother, E.J., Gilbert, R.L., 1994. Pathogenicity of *Rhynchosporium alismatis* and its potential as  
624 a mycoherbicide on several weed species in the Alismataceae. *Australian Journal of*  
625 *Experimental Agriculture* 34, 1039-1042, 10.1071/ea9941039.

626 Cray, J.A., Russell, J.T., Timson, D.J., Singhal, R.S., Hallsworth, J.E., 2013. A universal  
627 measure of chaotropicity and kosmotropicity. *Environmental Microbiology* 15, 287-296,  
628 10.1111/1462-2920.12018.

629 da Silva, C.G., Carvalho, C.D.F., Hamerski, L., Castro, F.A.V., Alves, R.J.V., Kaiser, C.R.,  
630 Eleutherio, E.C.A., de Rezende, C.M., 2012. Protective effects of flavonoids and extract from  
631 *Vellozia kolbekii* Alves against oxidative stress induced by hydrogen peroxide in yeast. *Journal*  
632 *of Natural Medicines* 66, 367-372, 10.1007/s11418-011-0585-z.

633 Dadachova, E., Casadevall, A., 2008. Ionizing radiation: how fungi cope, adapt, and exploit with  
634 the help of melanin. *Current Opinion in Microbiology* 11, 525-531, 10.1016/j.mib.2008.09.013.

635 de Menezes, H.D., Rodrigues, G.B., Teixeira, S.d.P., Massola, N.S., Bachmann, L., Wainwright,  
636 M., Braga, G.U.L., 2014. *In vitro* photodynamic inactivation of plant-pathogenic fungi  
637 *Colletotrichum acutatum* and *Colletotrichum gloeosporioides* with novel phenothiazinium  
638 photosensitizers. *Applied and Environmental Microbiology* 80, 1623-1632, 10.1128/aem.02788-  
639 13.

640 de Menezes, H.D., Tonani, L., Bachmann, L., Wainwright, M., Braga, G.Ú.L., von Zeska Kress,  
641 M.R., 2016. Photodynamic treatment with phenothiazinium photosensitizers kills both  
642 ungerminated and germinated microconidia of the pathogenic fungi *Fusarium oxysporum*,  
643 *Fusarium moniliforme* and *Fusarium solani*. *Journal of Photochemistry and Photobiology B:*  
644 *Biology* 164, 1-12, 10.1016/j.jphotobiol.2016.09.008.

645 de Nadal, E., Posas, F., 2015. Osmostress-induced gene expression – a model to understand how  
646 stress-activated protein kinases (SAPKs) regulate transcription. *The Febs Journal* 282, 3275-  
647 3285, 10.1111/febs.13323.

648 de Vera, J.P., Boettger, U., de la Torre Noetzel, R., Sánchez, F.J., Grunow, D., Schmitz, N.,  
649 Lange, C., Hübers, H.W., Baqué, M., Rettberg, P., Rabbow, E., Reit, G., Berger, T., Möller, R.,  
650 Bohmeier, M., Horneck, G., Westall, F., Jänchen, J., Fritzt, J., Meyer, C., Onofri, S., Selbmann,  
651 L., Zucconi, L., Kozyrovska, N., Leyal, T., Foing, B., Demets, D., Cockell, C., Bryce, C.,  
652 Wagner, D., Serrano, P., Edwards, H.G.M., Joshi, J., Huwe, B., Ehrenfreund, P., Elsaesser, A.,  
653 Ott, S., Messen, J., Feyh, N., Szewzyk, U., Jaumann, R., and Spohn, T., 2012. Supporting Mars  
654 exploration: BIOMEX in Low Earth Orbit and further astrobiological studies on the Moon using  
655 Raman and PanCam technology. *Planet Space Sci* 74,

656 den Boer, E., Łukaszewska, A., Kluczkiwicz, W., Lewandowska, D., King, K., Reijonen, T.,  
657 Kuhmonen, T., Suhonen, A., Jääskeläinen, A., Heitto, A., Laatikainen, R., Hakalehto, E., 2016.  
658 Volatile fatty acids as an added value from biowaste. *Waste Management* 58, 62-69,  
659 10.1016/j.wasman.2016.08.006.

660 Druzhinina, I.S., Seidl-Seiboth, V., Herrera-Estrella, A., Horwitz, B.A., Kenerley, C.M., Monte,  
661 E., Mukherjee, P.K., Zeilinger, S., Grigoriev, I.V., Kubicek, C.P., 2011. *Trichoderma*: the  
662 genomics of opportunistic success. *Nat Rev Micro* 9, 749-759,

663 Eleutherio, E., Panek, A., De Mesquita, J.F., Trevisol, E., Magalhães, R., 2015. Revisiting yeast  
664 trehalose metabolism. *Current Genetics* 61, 263-274, 10.1007/s00294-014-0450-1.

665 Fahad, Z.A., Bolou-Bi, E.B., Köhler, S.J., Finlay, R.D., Mahmood, S., 2016. Fractionation and  
666 assimilation of Mg isotopes by fungi is species dependent. *Environmental Microbiology Reports*  
667 8, 956-965, 10.1111/1758-2229.12459.

668 Faria, M.R., Wraight, S.P., 2007. Mycoinsecticides and mycoacaricides: A comprehensive list  
669 with worldwide coverage and international classification of formulation types. *Biological*  
670 *Control* 43, 237-256,

671 Fernandes, P.N., Mannarino, S.C., Silva, C.G., Pereira, M.D., Panek, A.D., Eleutherio, E.C.A.,  
672 2007. Oxidative stress response in eukaryotes: effect of glutathione, superoxide dismutase and  
673 catalase on adaptation to peroxide and menadione stresses in *Saccharomyces cerevisiae*. *Redox*  
674 *Report* 12, 236-244, 10.1179/135100007x200344.

675 Ferreira, P.C., Pupin, B., Rangel, D.E.N., 2017. Stress tolerance of soil fungal communities from  
676 native Atlantic forests, reforestations, and a sand mining degraded area. *Fungal Biology*,  
677 10.1016/j.funbio.2017.07.002.

678 Finlay, R.D., 2008. Ecological aspects of mycorrhizal symbiosis: with special emphasis on the  
679 functional diversity of interactions involving the extraradical mycelium. *J Exp Bot* 59, 1115-  
680 1126, 10.1093/jxb/ern059.

681 Finlay, R.D., Clemmensen, K.E., 2017. Immobilization of Carbon in Mycorrhizal Mycelial  
682 Biomass and Secretions. In: *Mycorrhizal Mediation of Soil: Fertility, Structure and Carbon*  
683 *Storage*, in: Johnson, N.C., Gehring, K., Jansa, J. (Eds.). Elsevier, Amsterdam, pp. 413-440.

684 Fischer, R., Aguirre, J., Herrera-Estrella, A., Corrochano, L.M., 2016. The complexity of fungal  
685 vision. *Microbiol Spectr* 4, 10.1128/microbiolspec.FUNK-0020-2016.

686 Fisher, M.C., Henk, D.A., Briggs, C.J., Brownstein, J.S., Madoff, L.C., McCraw, S.L., Gurr, S.J.,  
687 2012. Emerging fungal threats to animal, plant and ecosystem health. *Nature* 484, 186-194,  
688 10.1038/nature10947.

689 França, M.B., Lima, K.C., Eleutherio, E.C.A., 2017. Oxidative stress and amyloid toxicity:  
690 Insights from yeast. *Journal of Cellular Biochemistry* 118, 1442-1452, 10.1002/jcb.25803.

691 Freitas, F.Z., Chapeaurouge, A., Perales, J., Bertolini, M.C., 2008. A systematic approach to  
692 identify STRE-binding proteins of the *gsn* glycogen synthase gene promoter in *Neurospora*  
693 *crassa*. *Proteomics* 8, 2052-2061, 10.1002/pmic.200700921.

694 Fuller, K.K., Cramer, R.A., Zegans, M.E., Dunlap, J.C., Loros, J.J., 2016. *Aspergillus fumigatus*  
695 photobiology illuminates the marked heterogeneity between isolates. *MBio* 7,  
696 10.1128/mBio.01517-16.

697 Fuller, K.K., Ringelberg, C.S., Loros, J.J., Dunlap, J.C., 2013. The fungal pathogen *Aspergillus*  
698 *fumigatus* regulates growth, metabolism, and stress resistance in response to light. *MBio* 4,  
699 10.1128/mBio.00142-13.

700 Gadd, G.M., 2007. Geomycology: biogeochemical transformations of rocks, minerals, metals  
701 and radionuclides by fungi, bioweathering and bioremediation. *Mycological Research* 111, 3-49,  
702 10.1016/j.mycres.2006.12.001.

703 Gadd, G.M., 2010. Metals, minerals and microbes: geomicrobiology and bioremediation.  
704 *Microbiology* 156, 609-643, 10.1099/mic.0.037143-0.

705 Gadd, G.M., 2016. Geomycology, in: Purchase, D. (Ed.), *Fungal Applications in Sustainable*  
706 *Environmental Biotechnology*. Springer International Publishing, Switzerland.

707 Gal-Hemed, I., Atanasova, L., Komon-Zelazowska, M., Druzhinina, I.S., Viterbo, A., Yarden,  
708 O., 2011. Marine isolates of *Trichoderma* spp. as potential halotolerant agents of biological  
709 control for arid-zone agriculture. *Appl Environ Microbiol* 77, 5100-5109, 10.1128/AEM.00541-  
710 11.

711 Gonzales, J.C., Brancini, G.T.P., Rodrigues, G.B., Silva-Junior, G.J., Bachmann, L.,  
712 Wainwright, M., Braga, G.Ú.L., 2017. Photodynamic inactivation of conidia of the fungus  
713 *Colletotrichum abscissum* on *Citrus sinensis* plants with methylene blue under solar radiation.  
714 *Journal of Photochemistry and Photobiology B: Biology* 176, 54-61,  
715 <https://doi.org/10.1016/j.jphotobiol.2017.09.008>.

716 Hagedorn, S., Kaphammer, B., 1994. Microbial biocatalysis in the generation of flavor and  
717 fragrance chemicals. *Annu Rev Microbiol* 48, 773-800, 10.1146/annurev.mi.48.100194.004013.

718 Hakalehto, E., 2015. Bacteriological Indications of Human Activities in the Ecosystems, in:  
719 Armon, R.H., Hänninen, O. (Eds.), *Environmental Indicators*. Springer Netherlands, Dordrecht,  
720 pp. 579-611.

721 Hallsworth, J.E., Heim, S., Timmis, K.N., 2003. Chaotropic solutes cause water stress in  
722 *Pseudomonas putida*. *Environmental Microbiology* 5, 1270-1280, 10.1046/j.1462-  
723 2920.2003.00478.x.

724 Hallsworth, J.E., Magan, N., 1995. Manipulation of intracellular glycerol and erythritol enhances  
725 germination of conidia at low water availability. *Microbiology* 141, 1109-1115,

726 Hevia, M.A., Canessa, P., Larrondo, L.F., 2016. Circadian clocks and the regulation of virulence  
727 in fungi: Getting up to speed. *Seminars in Cell & Developmental Biology* 57, 147-155,  
728 10.1016/j.semcdb.2016.03.021.

729 Hevia, M.A., Canessa, P., Muller-Esparza, H., Larrondo, L.F., 2015. A circadian oscillator in the  
730 fungus *Botrytis cinerea* regulates virulence when infecting *Arabidopsis thaliana*. *Proceedings of*  
731 *the National Academy of Sciences of the United States of America* 112, 8744-8749,  
732 10.1073/pnas.1508432112.

733 Hillmann, F., Shekhova, E., Kniemeyer, O., 2015. Insights into the cellular responses to hypoxia  
734 in filamentous fungi. *Current Genetics* 61, 441-455, 10.1007/s00294-015-0487-9.

735 Ho, Y.-H., Gasch, A.P., 2015. Exploiting the yeast stress-activated signaling network to inform  
736 on stress biology and disease signaling. *Current Genetics* 61, 503-511, 10.1007/s00294-015-  
737 0491-0.

738 Huarte-Bonnet, C., Juarez, M.P., Pedrini, N., 2015. Oxidative stress in entomopathogenic fungi  
739 grown on insect-like hydrocarbons. *Current Genetics* 61, 289-297, 10.1007/s00294-014-0452-z.

740 Huarte-Bonnet, C., Kumar, S., Saparrat, M.C.N., Girotti, J.R., Santana, M., Hallsworth, J.E.,  
741 Pedrini, N., 2017a. Insights into hydrocarbon assimilation by eurotial and hypocrealean  
742 fungi: Roles for CYP52 and CYP53 clans of cytochrome P450 genes. *Applied Biochemistry and*  
743 *Biotechnology*, 10.1007/s12010-017-2608-z.

744 Huarte-Bonnet, C., Paixão, F.R.S., Ponce, J.C., Santana, M., Prieto, E.D., Pedrini, N., 2017b.  
745 Alkane-grown *Beauveria bassiana* produce mycelial pellets displaying peroxisome proliferation,  
746 oxidative stress, and cell surface alterations. *Fungal Biology*, 10.1016/j.funbio.2017.09.003.

747 Hultberg, M., Bodin, H., 2017. Fungi-based treatment of brewery wastewater-biomass  
748 production and nutrient reduction. *Appl Microbiol Biotechnol* 101, 4791-4798, 10.1007/s00253-  
749 017-8185-9.

750 Idnurm, A., Verma, S., Corrochano, L.M., 2010. A glimpse into the basis of vision in the  
751 kingdom Mycota. *Fungal Genetics and Biology* 47, 881-892, 10.1016/j.fgb.2010.04.009.

752 Keyhani, N.O., 2017. Lipid biology in fungal stress and virulence: Entomopathogenic fungi.  
753 *Fungal Biology*, <https://doi.org/10.1016/j.funbio.2017.07.003>.

754 Keyser, C.A., Fernandes, É.K.K., Rangel, D.E.N., Foster, R.N., Jech, L.E., Reuter, K.C., Black,  
755 L.R., Jaronski, S., Flake, D.D., Evans, E.W., Roberts, D.W., 2017. Laboratory bioassays and  
756 field-cage trials of *Metarhizium* spp. isolates with field-collected Mormon crickets (*Anabrus*  
757 *simplex*). *Biocontrol*, 1-12, 10.1007/s10526-016-9782-8.

758 Lacerda Pigosso, L., Baeza, L.C., Vieira Tomazett, M., Batista Rodrigues Faleiro, M., Brianezi  
759 Dignani de Moura, V.M., Melo Bailão, A., Borges, C.L., Alves Parente Rocha, J., Rocha  
760 Fernandes, G., Gauthier, G.M., Soares, C.M.d.A., 2017. *Paracoccidioides brasiliensis* presents  
761 metabolic reprogramming and secretes a serine proteinase during murine infection. *Virulence*, 1-  
762 18, 10.1080/21505594.2017.1355660.

- 763 Lam, F.H., Ghaderi, A., Fink, G.R., Stephanopoulos, G., 2014. Biofuels. Engineering alcohol  
764 tolerance in yeast. *Science* 346, 71-75, 10.1126/science.1257859.
- 765 Li, L., Hu, X., Xia, Y., Xiao, G., Zheng, P., Wang, C., 2014. Linkage of oxidative stress and  
766 mitochondrial dysfunctions to spontaneous culture degeneration in *Aspergillus nidulans*.  
767 *Molecular & Cellular Proteomics* : MCP 13, 449-461, 10.1074/mcp.M113.028480.
- 768 Li, L., Pischetsrieder, M., St Leger, R.J., Wang, C., 2008. Associated links among mtDNA  
769 glycation, oxidative stress and colony sectorization in *Metarhizium anisopliae*. *Fungal Genetics*  
770 *and Biology* 45, 1300-1306, 10.1016/j.fgb.2008.06.003.
- 771 Li, Z.Z., Alves, S.B., Roberts, D.W., Fan, M.Z., Delalibera, I., Tang, J., Lopes, R.B., Faria, M.,  
772 Rangel, D.E.N., 2010. Biological control of insects in Brazil and China: history, current  
773 programs and reasons for their successes using entomopathogenic fungi. *Biocontrol Science and*  
774 *Technology* 20, 117-136, 10.1080/09583150903431665.
- 775 Lima, P.d.S., Casaletti, L., Bailão, A.M., Vasconcelos, A.T.R.d., Fernandes, G.d.R., Soares,  
776 C.M.d.A., 2014. Transcriptional and proteomic responses to carbon starvation in  
777 *Paracoccidioides*. *PLOS Neglected Tropical Diseases* 8, e2855,
- 778 Lokhandwala, J., Hopkins, H.C., Rodriguez-Iglesias, A., Dattenbock, C., Schmoll, M.,  
779 Zoltowski, B.D., 2015. Structural biochemistry of a fungal LOV domain photoreceptor reveals  
780 an evolutionarily conserved pathway integrating light and oxidative stress. *Structure* 23, 116-  
781 125, S0969-2126(14)00368-2 [pii]  
782 10.1016/j.str.2014.10.020.
- 783 Maciel, G.M., Inácio, F.D., Sá-Nakanishi, A.B., Haminiuk, C.W.I., Castoldi, R., Comar, J.F.,  
784 Bracht, A., Peralta, R.M., 2013. Response of *Ganoderma lucidum* and *Trametes* sp. to the  
785 herbicide picloram: tolerance, antioxidants and production of ligninolytic enzymes. *Pesticide*  
786 *Biochemistry and Physiology* 105, 84-92,
- 787 Maheshwari, R., Bharadwaj, G., Bhat, M.K., 2000. Thermophilic fungi: Their physiology and  
788 enzymes. *Microbiology and Molecular Biology Reviews* 64, 461-488,
- 789 Malo, M.E., Bryan, R.A., Shuryak, I., Dadachova, E., 2017. Morphological changes in  
790 melanized and non-melanized *Cryptococcus neoformans* cells post exposure to sparsely and  
791 densely ionizing radiation demonstrate protective effect of melanin. *Fungal Biology*,  
792 <https://doi.org/10.1016/j.funbio.2017.08.010>.
- 793 Mannarino, S.C., Amorim, M.A., Pereira, M.D., Moradas-Ferreira, P., Panek, A.D., Costa, V.,  
794 Eleutherio, E.C.A., 2008. Glutathione is necessary to ensure benefits of calorie restriction during  
795 ageing in *Saccharomyces cerevisiae*. *Mechanisms of Ageing and Development* 129, 700-705,  
796 <https://doi.org/10.1016/j.mad.2008.09.001>.
- 797 Miranda-Hernández, F., Garza-López, P.M., Loera, O., 2016. Cellular signaling in cross  
798 protection: An alternative to improve mycopesticides. *Biological Control* 103, 196-203,  
799 <https://doi.org/10.1016/j.biocontrol.2016.09.007>.



800 Moeller, R., Raguse, M., Leuko, S., Berger, T., Hellweg, C.E., Fujimori, A., Okayasu, R.,  
801 Horneck, G., Kawaguchi, Y., Yokobori, S.-I., Yamagishi, A., Rettberg, P., Verseux, C., Baqué,  
802 M., Cifariello, R., Fagliarone, C., Billi, D., Pacelli, C., Selbmann, L., Zucconi, L., Onofri, S.,  
803 Shuryak, I., Brandt, A., Backhaus, T., Meeßen, J., Ott, S., Jänicke, R.U., De La Torre, R., Miller,  
804 A.Z., Martín-Cerezo, M.L., Cubero, B., Böttger, U., De Vera, J.-P., Jönsson, K.I., Wojcik, A.,  
805 2017. STARLIFE-An international campaign to study the role of galactic cosmic radiation in  
806 astrobiological model systems. *Astrobiology* 17, 101-109,

807 Molina-Montenegro, M.A., Oses, R., Torres-Diaz, C., Atala, C., Zurita-Silva, A., Ruiz-Lara, S.,  
808 2016. Root-endophytes improve the ecophysiological performance and production of an  
809 agricultural species under drought condition. *AoB Plants* 8, 10.1093/aobpla/plw062.

810 Monroy, A.A., Stappler, E., Schuster, A., Sulyok, M., Schmoll, M., 2017. A CRE1- regulated  
811 cluster is responsible for light dependent production of dihydrotrichotetronin in *Trichoderma*  
812 *reesei*. *PLoS One* 12, e0182530, 10.1371/journal.pone.0182530.

813 Moraes, C., Monteiro, A.C., Machado, A.C.R., Barbosa, J.C., Mochi, D.A., 2014. Production of  
814 a bioherbicide agent in liquid and solid medium and in a biphasic cultivation system. *Planta*  
815 *Daninha* 32, 255-264,

816 Muñoz-Paredes, F., Miranda-Hernández, F., Loera, O., 2017. Production of conidia by  
817 entomopathogenic fungi: from inoculants to final quality tests. *World Journal of Microbiology*  
818 *and Biotechnology* 33, 57, 10.1007/s11274-017-2229-2.

819 Muniz, E.R., Catão, A.M.L., Rueda-Páramo, M.E., Rodrigues, J., López Lastra, C.C.J.J.G.,  
820 Fernandes, É.K.K., Luz, C., 2017. Impact of short-term temperature challenges on the larvicidal  
821 activities of the entomopathogenic water mold *Leptolegnia chapmanii* against *Aedes aegypti*, and  
822 development on infected dead larvae *Fungal Biol This issue*,

823 Mygind, P.H., Fischer, R.L., Schnorr, K.M., Hansen, M.T., Sonksen, C.P., Ludvigsen, S.,  
824 Raventos, D., Buskov, S., Christensen, B., De Maria, L., Taboureau, O., Yaver, D., Elvig-  
825 Jorgensen, S.G., Sorensen, M.V., Christensen, B.E., Kjaerulff, S., Frimodt-Moller, N., Lehrer,  
826 R.I., Zasloff, M., Kristensen, H.H., 2005. Plectasin is a peptide antibiotic with therapeutic  
827 potential from a saprophytic fungus. *Nature* 437, 975-980, 10.1038/nature04051.

828 Onofri, S., de la Torre, R., de Vera, J.P., Ott, S., Zucconi, L., Selbmann, L., Scalzi, G.,  
829 Venkateswaran, K.J., Rabbow, E., Sanchez Inigo, F.J., Horneck, G., 2012. Survival of rock-  
830 colonizing organisms after 1.5 years in outer space. *Astrobiology* 12, 508-516,  
831 10.1089/ast.2011.0736.

832 Onofri, S., de Vera, J.P., Zucconi, L., Selbmann, L., Scalzi, G., Venkateswaran, K.J., Rabbow,  
833 E., de la Torre, R., Horneck, G., 2015. Survival of Antarctic cryptoendolithic fungi in simulated  
834 martian conditions on board the International Space Station. *Astrobiology* 15, 1052-1059,  
835 10.1089/ast.2015.1324.

836 Pacelli, C., Bryan, R.A., Onofri, S., Selbmann, L., Shuryak, I., Dadachova, E., 2017a. Melanin is  
837 effective in protecting fast and slow growing fungi from various types of ionizing radiation.  
838 *Environmental Microbiology* 19, 1612-1624, 10.1111/1462-2920.13681.

839 Pacelli, C., Selbmann, L., Zucconi, L., Raguse, M., Moeller, R., Shuryak, I., Onofri, S., 2017b.  
840 Survival, DNA integrity, and ultrastructural damage in antarctic cryptoendolithic eukaryotic  
841 microorganisms exposed to ionizing radiation. *Astrobiology* 17, 126-135,  
842 10.1089/ast.2015.1456.

843 Parente-Rocha, J.A., Parente, A.F.A., Baeza, L.C., Bonfim, S.M.R.C., Hernandez, O., McEwen,  
844 J.G., Bailão, A.M., Taborda, C.P., Borges, C.L., Soares, C.M.d.A., 2015. Macrophage interaction  
845 with *Paracoccidioides brasiliensis* yeast cells modulates fungal metabolism and generates a  
846 response to oxidative stress. *PLoS One* 10, e0137619,

847 Pedrini, N., 2017. Molecular interactions between entomopathogenic fungi and their insect host:  
848 perspectives from stressful cuticle and hemolymph battlefields. *Fungal Biol This issue*,

849 Pennisi, E., 2004. The secret life of fungi. *Science* 304, 1620-1622,  
850 10.1126/science.304.5677.1620.

851 Pointing, S.B., 2001. Feasibility of bioremediation by white-rot fungi. *Applied Microbiology and*  
852 *Biotechnology* 57, 20-33,

853 Rangel, D.E.N., 2011. Stress induced cross-protection against environmental challenges on  
854 prokaryotic and eukaryotic microbes. *World Journal of Microbiology & Biotechnology* 27,  
855 1281-1296, 10.1007/s11274-010-0584-3.

856 Rangel, D.E.N., Alder-Rangel, A., Dadachova, E., Finlay, R.D., Dijksterhuis, J., Braga, G.U.L.,  
857 Corrochano, L.M., Hallsworth, J.E., 2015a. The International Symposium on Fungal Stress:  
858 ISFUS. *Current Genetics* 61, 479-487, 10.1007/s00294-015-0501-2.

859 Rangel, D.E.N., Alder-Rangel, A., Dadachova, E., Finlay, R.D., Kupiec, M., Dijksterhuis, J.,  
860 Braga, G.U.L., Corrochano, L.M., Hallsworth, J.E., 2015b. Fungal stress biology: a preface to  
861 the Fungal Stress Responses special edition. *Current Genetics* 61, 231-238, 10.1007/s00294-015-  
862 0500-3.

863 Rangel, D.E.N., Alston, D.G., Roberts, D.W., 2008. Effects of physical and nutritional stress  
864 conditions during mycelial growth on conidial germination speed, adhesion to host cuticle, and  
865 virulence of *Metarhizium anisopliae*, an entomopathogenic fungus. *Mycological Research* 112,  
866 1355-1361,

867 Rangel, D.E.N., Anderson, A.J., Roberts, D.W., 2006a. Growth of *Metarhizium anisopliae* on  
868 non-preferred carbon sources yields conidia with increased UV-B tolerance. *Journal of*  
869 *Invertebrate Pathology* 93, 127-134,

870 Rangel, D.E.N., Braga, G.U.L., Anderson, A.J., Roberts, D.W., 2005. Variability in conidial  
871 thermotolerance of *Metarhizium anisopliae* isolates from different geographic origins. *Journal of*  
872 *Invertebrate Pathology* 88, 116-125,

873 Rangel, D.E.N., Braga, G.U.L., Fernandes, É.K.K., Keyser, C.A., Hallsworth, J.E., Roberts,  
874 D.W., 2015c. Stress tolerance and virulence of insect-pathogenic fungi are determined by

875 environmental conditions during conidial formation. *Current Genetics* 61, 383-404,  
876 10.1007/s00294-015-0477-y.

877 Rangel, D.E.N., Butler, M.J., Torabinejad, J., Anderson, A.J., Braga, G.U.L., Day, A.W.,  
878 Roberts, D.W., 2006b. Mutants and isolates of *Metarhizium anisopliae* are diverse in their  
879 relationships between conidial pigmentation and stress tolerance. *Journal of Invertebrate*  
880 *Pathology* 93, 170-182,

881 Rangel, D.E.N., Correia, A.d.C.B., 2003. Virulencia de *Aphanocladium album* (Preuss) Gams e  
882 *Verticillium lecanii* (Zimm.) Viégas (Deuteromycotina: Hyphomycetes) para o percevejo-de-  
883 renda da seringueira, *Leptopharsa heveae* (Drake & Poor) (Hemiptera: Tingidae). *Ciência e*  
884 *Agrotecnologia Edição Especial*, 1636-1642,

885 Rangel, D.E.N., Dettenmaier, S.J., Fernandes, E.K.K., Roberts, D.W., 2010a. Susceptibility of  
886 *Metarhizium* spp. and other entomopathogenic fungi to dodine-based selective media. *Biocontrol*  
887 *Science and Technology* 20, 375-389,

888 Rangel, D.E.N., Fernandes, E.K.K., Anderson, A.J., Roberts, D.W., 2012. Culture of  
889 *Metarhizium robertsii* on salicylic-acid supplemented medium induces increased conidial  
890 thermotolerance. *Fungal Biology* 116, 438-442,

891 Rangel, D.E.N., Fernandes, E.K.K., Braga, G.U.L., Roberts, D.W., 2011. Visible light during  
892 mycelial growth and conidiation of *Metarhizium robertsii* produces conidia with increased stress  
893 tolerance. *Fems Microbiology Letters* 315, 81-86, 10.1111/j.1574-6968.2010.02168.x.

894 Rangel, D.E.N., Fernandes, E.K.K., Dettenmaier, S.J., Roberts, D.W., 2010b. Thermotolerance  
895 of germlings and mycelium of the insect-pathogenic fungus *Metarhizium* spp. and mycelial  
896 recovery after heat stress. *Journal of Basic Microbiology* 50, 344–350,

897 Ries, L.N.A., Beattie, S.R., Espeso, E.A., Cramer, R.A., Goldman, G.H., 2016. Diverse  
898 regulation of the CreA carbon catabolite repressor in *Aspergillus nidulans*. *Genetics*,  
899 10.1534/genetics.116.187872.

900 Rocha, M.C., Godoy, K.F.d., de Castro, P.A., Hori, J.I., Bom, V.L.P., Brown, N.A., Cunha,  
901 A.F.d., Goldman, G.H., Malavazi, I., 2015. The *Aspergillus fumigatus* pkcAG579R mutant is  
902 defective in the activation of the cell wall integrity pathway but is dispensable for virulence in a  
903 neutropenic mouse infection model. *PLoS One* 10, e0135195,

904 Runner, V.M., Brewster, J.L., 2003. A genetic screen for yeast genes induced by sustained  
905 osmotic stress. *Yeast* 20, 913-920,

906 Ruoff, P., Loros, J.J., Dunlap, J.C., 2005. The relationship between FRQ-protein stability and  
907 temperature compensation in the *Neurospora* circadian clock. *Proceedings of the National*  
908 *Academy of Sciences of the United States of America* 102, 17681-17686,  
909 10.1073/pnas.0505137102.

910 Sales-Campos, H., Tonani, T., Cardoso, C.R.B., von Zeska Kress, M.R., 2013. The immune  
911 interplay between the host and the pathogen in *Aspergillus fumigatus* lung infection. BioMed  
912 Research International 2013, Article ID 693023, 693014 pages, 10.1155/2013/693023.

913 Santi, L., Silva, L.A.D.E., da Silva, W.O.B., Correa, A.P.F., Rangel, D.E.N., Carlini, C.R.,  
914 Schrank, A., Vainstein, M.H., 2011. Virulence of the entomopathogenic fungus *Metarhizium*  
915 *anisopliae* using soybean oil formulation for control of the cotton stainer bug, *Dysdercus*  
916 *peruvianus*. World Journal of Microbiology & Biotechnology 27, 2297-2303, 10.1007/s11274-  
917 011-0695-5.

918 Santos, M.P., Dias, L.P., Ferreira, P.C., Pasin, L.A., Rangel, D.E.N., 2011. Cold activity and  
919 tolerance of the entomopathogenic fungus *Tolypocladium* spp. to UV-B irradiation and heat.  
920 Journal of Invertebrate Pathology 108, 209-213, 10.1016/j.jip.2011.09.001.

921 Sarikaya-Bayram, Ö., Bayram, Ö., Feussner, K., Kim, J.-H., Kim, H.-S., Kaefer, A., Feussner, I.,  
922 Chae, K.-S., Han, D.-M., Han, K.-H., Braus, G.H., 2014. Membrane-bound methyltransferase  
923 complex VapA-VipC-VapB guides epigenetic control of fungal development. Developmental  
924 Cell 29, 406-420, 10.1016/j.devcel.2014.03.020.

925 Sarikaya-Bayram, Ö., Palmer, J.M., Keller, N., Braus, G.H., Bayram, Ö., 2015. One Juliet and  
926 four Romeos: VeA and its methyltransferases. Front Microbiol 6, 1, 10.3389/fmicb.2015.00001.

927 Saxena, A., Raghuwanshi, R., Singh, H.B., 2015. *Trichoderma* species mediated differential  
928 tolerance against biotic stress of phytopathogens in *Cicer arietinum* L. J Basic Microbiol 55,  
929 195-206, 10.1002/jobm.201400317.

930 Schwede, S., Thorin, E., Lindmark, J., Klintenberg, P., Jääskeläinen, A., Suhonen, A.,  
931 Laatikainen, R., Hakalehto, E., 2017. Using slaughterhouse waste in a biochemical-based  
932 biorefinery – results from pilot scale tests. Environmental Technology 38, 1275-1284,  
933 10.1080/09593330.2016.1225128.

934 Selbmann, L., Zucconi, L., Isola, D., Onofri, S., 2015. Rock black fungi: excellence in the  
935 extremes, from the Antarctic to space. Current Genetics, 1-11, 10.1007/s00294-014-0457-7.

936 Shuryak, I., Bryan, R.A., Broitman, J., Marino, S.A., Morgenstern, A., Apostolidis, C.,  
937 Dadachova, E., 2015. Effects of radiation type and delivery mode on a radioresistant eukaryote  
938 *Cryptococcus neoformans*. Nucl Med Biol 42, 515-523, 10.1016/j.nucmedbio.2015.02.006.

939 Siddiqui, Z.A., Mahmood, I., 1996. Biological control of plant parasitic nematodes by fungi: A  
940 review. Bioresource Technology 58, 229-239, 10.1016/s0960-8524(96)00122-8.

941 Silva-Bailão, M.G., dos Anjos, L.R.B., da Silva, K.L.P., Lima, P.S., Teixeira, M.M., Soares,  
942 C.M.A., Bailão, A.M., 2017. Mechanisms of copper and zinc homeostasis in pathogenic black  
943 fungi. Fungal Biol, in press.,

944 Souza, R.K.F., Azevedo, R.F.F., Lobo, A.O., Rangel, D.E.N., 2014. Conidial water affinity is an  
945 important characteristic for thermotolerance in entomopathogenic fungi. Biocontrol Science and  
946 Technology 24, 448–461, 10.1080/09583157.2013.871223.

- 947 Stappers, M.H.T., Brown, G.D., 2017. Host Immune Response During Infections with *Candida*  
948 *albicans*. In: *Candida albicans: Cellular and Molecular Biology*. Springer Nature.
- 949 Stappler, E., Dattenbock, C., Tisch, D., Schmoll, M., 2017. Analysis of light- and carbon-specific  
950 transcriptomes implicates a class of G-protein-coupled receptors in cellulose sensing. *mSphere* 2,  
951 10.1128/mSphere.00089-17.
- 952 Stappler, E., Rodriguez-Iglesias, A., Bazafkan, H., Li, G., Schmoll, M., 2016. Relevance of  
953 Signal Transduction Pathways for Efficient Gene Expression in Fungi, in: Schmoll, M.,  
954 Dattenböck, C. (Eds.), *Gene expression systems in fungi: Advancements and applications*. .  
955 Springer International Publishing, Heidelberg, pp. 309-334.
- 956 Steiman, R., Ford, L., Ducros, V., Lafond, J.L., Guiraud, P., 2004. First survey of fungi in  
957 hypersaline soil and water of Mono Lake area (California). *Antonie Van Leeuwenhoek* 85, 69-  
958 83, 10.1023/B:ANTO.0000020150.91058.4d.
- 959 Stevenson, A., Burkhardt, J., Cockell, C.S., Cray, J.A., Dijksterhuis, J., Fox-Powell, M., Kee,  
960 T.P., Kminek, G., McGenity, T.J., Timmis, K.N., Timson, D.J., Voytek, M.A., Westall, F.,  
961 Yakimov, M.M., Hallsworth, J.E., 2015a. Multiplication of microbes below 0.690 water activity:  
962 implications for terrestrial and extraterrestrial life. *Environmental Microbiology* 17, 257-277,  
963 10.1111/1462-2920.12598.
- 964 Stevenson, A., Cray, J.A., Williams, J.P., Santos, R., Sahay, R., Neuenkirchen, N., McClure,  
965 C.D., Grant, I.R., Houghton, J.D.R., Quinn, J.P., Timson, D.J., Patil, S.V., Singhal, R.S., Anton,  
966 J., Dijksterhuis, J., Hocking, A.D., Lievens, B., Rangel, D.E.N., Voytek, M.A., Gunde-  
967 Cimerman, N., Oren, A., Timmis, K.N., McGenity, T.J., Hallsworth, J.E., 2015b. Is there a  
968 common water-activity limit for the three domains of life? *ISME J* 9, 1333–1351,  
969 10.1038/ismej.2014.219.
- 970 Stevenson, A., Hamill, P.G., O'Kane, C.J., Kminek, G., Rummel, J.D., Voytek, M.A.,  
971 Dijksterhuis, J., Hallsworth, J.E., 2017. *Aspergillus penicillioides* differentiation and cell  
972 division at 0.585 water activity. *Environ Microbiol* 19, 687-697, 10.1111/1462-2920.13597.
- 973 Tagua, V.G., Pausch, M., Eckel, M., Gutierrez, G., Miralles-Duran, A., Sanz, C., Eslava, A.P.,  
974 Pokorny, R., Corrochano, L.M., Batschauer, A., 2015. Fungal cryptochrome with DNA repair  
975 activity reveals an early stage in cryptochrome evolution. *Proc Natl Acad Sci U S A* 112, 15130-  
976 15135, 10.1073/pnas.1514637112.
- 977 Tonani, L., Morosini, N.S., de Menezes, H.D., Bonifácio da Silva, M.E.N., Wainwright, M.,  
978 Braga, G.Ú.L., von Zeska Kress, M.R., 2017. In vitro susceptibilities of *Neoscytalidium* spp.  
979 sequence types to antifungal agents and antimicrobial photodynamic treatment with  
980 phenothiazinium photosensitizers. *Fungal Biology*, 10.1016/j.funbio.2017.08.009.
- 981 Vega, F.E., Goettel, M.S., Blackwell, M., Chandler, D., Jackson, M.A., Keller, S., Koike, M.,  
982 Maniania, N.K., Monzon, A., Ownley, B.H., Pell, J.K., Rangel, D.E.N., Roy, H.E., 2009. Fungal  
983 entomopathogens: new insights on their ecology. *Fungal Ecology* 2, 149-159,

- 984 Wang, C., Butt, T.M., St. Leger, R.J., 2005. Colony sectorization of *Metarhizium anisopliae* is a  
985 sign of ageing. *Microbiology* 151, 3223-3236,
- 986 Wang, C.S., Wang, S.B., 2017. Insect pathogenic fungi: genomics, molecular interactions, and  
987 genetic improvements. *Annual Review of Entomology* 62, 73-90, doi:10.1146/annurev-ento-  
988 031616-035509.
- 989 Wei, P., Li, Z., Lin, Y., He, P., Jiang, N., 2007. Improvement of the multiple-stress tolerance of  
990 an ethanologenic *Saccharomyces cerevisiae* strain by freeze-thaw treatment. *Biotechnol Lett* 29,  
991 1501-1508, 10.1007/s10529-007-9419-1.
- 992 Willger, S.D., Puttikamonkul, S., Kim, K.-H., Burritt, J.B., Grahl, N., Metzler, L.J., Barbuch, R.,  
993 Bard, M., Lawrence, C.B., Cramer, R.A., 2008. A sterol-regulatory element binding protein Is  
994 required for cell polarity, hypoxia adaptation, azole drug resistance, and virulence in *Aspergillus*  
995 *fumigatus*. *Plos Pathogens* 4, e1000200, 10.1371/journal.ppat.1000200.
- 996 Xiong, C.H., Xia, Y.L., Zheng, P., Wang, C.S., 2013. Increasing oxidative stress tolerance and  
997 subculturing stability of *Cordyceps militaris* by overexpression of a glutathione peroxidase gene.  
998 *Applied Microbiology and Biotechnology* 97, 2009-2015, 10.1007/s00253-012-4286-7.
- 999 Yakimov, M.M., La Cono, V., Spada, G.L., Bortoluzzi, G., Messina, E., Smedile, F., Arcadi, E.,  
1000 Borghini, M., Ferrer, M., Schmitt-Kopplin, P., Hertkorn, N., Cray, J.A., Hallsworth, J.E.,  
1001 Golyshin, P.N., Giuliano, L., 2015. Microbial community of the deep-sea brine Lake Kryos  
1002 seawater–brine interface is active below the chaotricity limit of life as revealed by recovery of  
1003 mRNA. *Environmental Microbiology* 17, 364-382, 10.1111/1462-2920.12587.
- 1004 Zhao, X.Q., Bai, F.W., 2009. Mechanisms of yeast stress tolerance and its manipulation for  
1005 efficient fuel ethanol production. *Journal of Biotechnology* 144, 23-30,  
1006 10.1016/j.jbiotec.2009.05.001.
- 1007 Zhdanova, N.N., Zakharchenko, V.A., Vember, V.V., Nakonechnaya, L.T., 2000. Fungi from  
1008 Chernobyl: mycobiota of the inner regions of the containment structures of the damaged nuclear  
1009 reactor. *Mycol. Res.* 104, 1421-1426.  
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1012 FIGURE LEGENDS

1013 Figure 1. Logo of the second International Symposium on Fungal Stress (ISFUS-2017) that was  
1014 hosted at the Universidade Federal de Goiás in Goiânia, GO, Brazil. This figure shows the some  
1015 of the stress parameters that fungi are subjected to such as ionizing radiation, acidic and alkaline  
1016 environments, hypoxic or anoxic conditions, poisons in general such as genotoxic and oxidative  
1017 products, UV radiation from Sun, pollution from industry and agriculture, salt stress, nutritive  
1018 stress, and heat from solar radiation and other sources.  
1019

1020 Figure 2. Speakers of the second International Symposium on Fungal Stress – ISFUS-2017.  
1021 Standing from left to right: Elias Hakalehto (Finland), Jon Y. Takemoto (USA), Maria Celia  
1022 Bertolini (Brazil), John E. Hallsworth (UK), Kevin K. Fuller (USA), Rosane M. Peralta (Brazil),  
1023 Luis M. Corrochano (Spain), Luis Larrondo (Chile), Roger D. Finlay (Sweden), Laura  
1024 Selbmann (Italy), Monika Schmoll (Austria), Célia M. A. Soares (Brazil), Elis Eleutherio  
1025 (Brazil), Ekaterina Dadachova (Canada), Gerhard Braus (Germany), Iran Malavazi (Brazil),  
1026 Gustavo Goldman (Brazil), Diego Bonatto (Brazil), Anderson F. da Cunha (Brazil), and  
1027 Chengshu Wang (China). Standing from left to right: Drauzio E. N. Rangel (Brazil), Amanda  
1028 Rangel (daughter of the organizers), Alene Alder-Rangel (Brazil), Gilberto U. L. Braga (Brazil),  
1029 Octavio Loera (Mexico), Alexandre M. Bailão (Brazil), and Marcia R. Z. Kress (Brazil).  
1030

1031 Figure 3. Speakers of the second International Symposium on Fungal Stress – ISFUS. From left  
1032 to right in the top row: Kevin Fuller (USA), Gustavo Goldman (Brazil), Chengshu Wang  
1033 (China), Gerhard Braus (Germany), Rosane M. Peralta (Brazil), Iran Malavazi in the back  
1034 (Brazil), Elis Eleutherio (Brazil), Célia M. A. Soares in the back (Brazil), Jon Y. Takemoto  
1035 (USA), Maria Celia Bertolini (Brazil), Marcia R. Z. Kress in the back, not visible (Brazil).  
1036 Monika Schmoll (Austria), John E. Hallsworth in the back (UK), Elias Hakalehto in the back  
1037 (Finland), Luis Larrondo (Chile), Luis M. Corrochano (Spain), Roger Finlay (Sweden), Laura  
1038 Selbmann (Italy), Anderson F. da Cunha in the back (Brazil), Ekaterina Dadachova (Canada),  
1039 Diego Bonatto (Brazil), and Alexandre M. Bailão (Brazil). From left to right in the lower row:  
1040 Drauzio E. N. Rangel (Brazil), Gilberto U. L. Braga (Brazil), and Octavio Loera (Mexico).  
1041

1042 Figure 4. Opening Ceremony: Flávia Aparecida de Oliveira, the director of IPTSP (the host  
1043 institution) welcoming researchers and students.  
1044

1045 Figure 5. Opening Ceremony: Alene Alder-Rangel, John E. Hallsworth, Luis M. Corrochano,  
1046 Maria Zaira Turchi, João Teodoro Pádua, Flávia Aparecida de Oliveira, and Drauzio E. N.  
1047 Rangel.  
1048

1049 Figure 6. Elsevier Award given to Mariane Paludetti Zubieta, presented by Drauzio E. N. Rangel  
1050 (left) and Luis M. Corrochano (right).  
1051

1052 Figure 7. Elsevier Award given to Ronaldo A. Pereira-Junior, presented by Drauzio E. N. Rangel  
1053 (left) and Luis M. Corrochano (right).  
1054

1055 Figure 8. Elsevier Award given to Carla Huarte-Bonnet, presented by Drauzio E. N. Rangel (left)  
1056 and Luis M. Corrochano (right).

1057  
1058 Figure 9. Elsevier Award given to Elen Regozino Muniz, presented by Drauzio E.N. Rangel  
1059 (left) and Luis M. Corrochano (right).

1060  
1061 Figure 10. Elsevier Award winners Ronaldo A. Pereira-Junior, Carla Huarte-Bonnet, and Elen  
1062 Regozino Muniz. From left to right: Alene Alder-Rangel, Dr. João Teodoro Pádua ( from the  
1063 office of the University President), Flávia Aparecida de Oliveira (Director of IPTSP  
1064 Universidade Federal de Goiás), Elen Regozino Muniz (PhD student), Drauzio E. N. Rangel  
1065 (professor Universidade Federal de Goiás), Carla Huarte-Bonnet (PhD student), Luis M.  
1066 Corrochano (professor Universidad de Sevilla), and Ronaldo A. Pereira-Junior (PhD student).