



Mycelium of *Agrocybe praecox*, a fungus studied for its pollutant-degrading abilities.

Publication Analysis 1999-2010

Fungal Research

Photo: Grit Kabiersch, University of Helsinki

When it comes to the study of fungi, Germany is head and shoulders above the rest. Surprisingly, it is followed not by its eternal rival in the battle of the citation crown, England, but The Netherlands.

A world without fungi would be totally boring, said Hauke Harms, Head of the Department of Environmental Microbiology at the Helmholtz Centre for Environmental Research in Leipzig, Germany, to *Lab Times* last year. Not only boring but maybe even unthinkable, we might add, considering the fact that fungi have many precious talents. They decompose organic matter, are vital symbiosis partners as well as the source of antibiotics and play leading roles in the production of staple foods like bread and, for some people more importantly, beer.

But there's also a dark side to them. Fungi are responsible for many horrors in their sister kingdoms: A fungus by the name of *Batrachochytrium dendrobatidis* has come to worldwide fame as the "frog killer", driving hundreds of amphibian species to the brink of extinction. And pictures of the "mind control fungus" *Ophiocordyceps unilateralis*, growing out of an ant's thorax, have probably also etched into the minds of many. Not to mention all the crop plants succumbing to pathogenic fungi.

As limitless as their abilities are their numbers. Latest estimates speak of 5.1 million species encompassing yeasts, moulds, smuts and our beloved mushrooms, who have taken residence in a diverse range of partly rather unusual habitats. Recently, researchers from the University of Florence, for example, discovered that *Saccharomyces cerevisiae* 'overwinters' in the gut of queens of social wasps. However, from the five million species only a few have found their way into modern labs.

Out of the shadows?

What constitutes a "fungal researcher" was the main question we had to answer for this publication analysis. Does the fungus take centre stage in his or her research or does he or she use it only as a means to a cell biological end – to learn, for example, more about basic features of eukaryotes in general? What about the clinicians trying to understand and find treatment options for fungal infections? After a short debate, we decided to include all

– phylogeneticists, medical mycologists as well as those interested in fungal genomics and cell biology. As long as fungi were involved one way or another, it counted.

This, however, led to the fact that "real mycologists" who are anyway not often granted a place under the research sun, are once again, condemned to a shadowy existence. Ironically, this fits perfectly to their study subjects.

After having agreed on the publication analysis participants, we again encountered the same methodological constraints that already impeded earlier analyses. As we previously stated, in order to compare performance of individual European countries in fungal research (as shown in the "blue" Table on p. 33), we had to restrict the study to explicit "fungi journals" selected from the category "Mycology" of Thomson Reuters' database *Web of Science*, which we used for this analysis. Even though we are aware of the fact that many "top papers" are published in multidisciplinary journals like *Nature*, *Science* or *PNAS*, we had no choice but to omit these journals at least from this part of the analysis. The main reason for this omission is because *Web of Science* does not provide any reliable tools to automatically extract relevant fungal research articles from those multidisciplinary journals. Only the fungi expert journals were therefore consulted in the hope to avoid assigning too many "false positives" to individual countries. We still believe, however, that such a "trimmed" survey provides sufficiently valid indicators for the countries' overall productivity in fungal research. The rankings of the most-cited researchers and papers (see Tables on p. 34) were not subject to any analytical constraints. They could be analysed from publications in all journals.

The Netherlands oust England

Without any further explanations, let's have a look at the individual countries' performance in fungal research. Clear winner in this discipline is Germany; surprisingly followed by The Neth-

erlands. England, who, in most rankings had a monopoly for the top two spots, this time only made it to third place.

The Netherlands most likely owe their excellent result to the scientific output of the CBS-KNAW Fungal Biodiversity Centre in Utrecht, which besides doing research on fungal taxonomy, evolution, biology and ecology “maintains a world-renowned collection of living filamentous fungi, yeasts and bacteria”. Only the centre’s director, Pedro W. Crous, however, managed to enter the most-cited authors’ ranking (7th place) but it shouldn’t go unmentioned that some of his colleagues, namely Teun Boekhout and G. Sybren de Hoog, missed the top 30 only by a few citations.

The Netherlands’ good result was not the only surprise. Portugal did very well (13th place) compared to previous rankings, while Israel must have their research foci anywhere but on fungal research – they didn’t make the top 20 this time. Regarding mean citation rates, Scotland again came off as one of the winners, followed by Ireland – who were short of a few total citations to be included in the top 20 – and The Netherlands.

A look to the left and right of our continent revealed overwhelming fungal research supremacy. European researchers have published more than twice as many articles on fungi than their US colleagues and ten times as many as their Japanese and Chinese peers. Their overall citation number dwarfs those of several other countries. Europe’s reign, however, does not span all parameters. When it comes to citations per article, European papers clearly lose against the USA, Canada and Australia.

Infections dominate

As wide as the fields of fungal activity are the topics our top 30 researchers study. Crudely, they can be divided into four categories: fungal pathogenesis and infections, physiology, phylogeny/taxonomy and industrial exploitation. Researchers interested in the two former categories are the most numerous, taking up 26 of the 30 available spots including the top two spots. Thus, champion and vice champion, David W. Denning and Olivier Lortholary, outpaced all other “contestants” with their publications on aspergillosis, a fungally inflicted condition affecting a patient’s lungs, and candidosis or thrush, courtesy of *Candida albicans*.

Other top 30 researchers are more interested in the inner workings of a fungal cell. Johan Thevelein (10th), for example, wants to understand how yeasts sense nutrients and how different nutrients influence cellular activities like stress and growth. Ida van der Klei (27th) and Marten Veenhuis (22nd) are after peroxisomes, eukaryotic organelles involved in, amongst others, the degradation of very long chain fatty acids. Fungi, especially Ascomycota or sac fungi, are a good model system to study these organelles because of their peroxisome-derived “Woronin bodies”.

That fungi are especially well-suited for biotechnological approaches has been known for some time. Bärbel Hahn-Hägerdal (9th) recognised this too. In her long career, she has worked on improving the fermenting abilities of industrial yeast strains. Optimising industrially-used fungal strains is also Christian Kubicek’s (26th) line of research. His lab pets, however, are representatives of the genus *Trichoderma*, soil fungi employed as bio-control agents in plants.

Fungi can thus provide answers to very different scientific questions. And with the knowledge that thousands, if not millions of species are still out there waiting to be discovered and analysed, this field of research is surely good for a few more revealing insights about our world.

KATHLEEN GRANSALKE

Europe...

Country	Citations	Articles	Cit./Art.
1. Germany	20,558	1,982	10.4
2. Netherlands	15,134	983	15.4
3. England	12,295	1,025	12
4. France	11,846	1,168	10.1
5. Spain	10,858	1,363	8.0
6. Italy	6,382	757	8.4
7. Sweden	6,143	504	12.2
8. Scotland	5,278	277	19.1
9. Austria	5,236	492	10.6
10. Denmark	4,598	322	14.3
11. Switzerland	4,225	355	11.9
12. Belgium	3,486	391	8.9
13. Portugal	2,941	253	11.6
14. Norway	2,898	262	11.1
15. Finland	1,990	181	11.0
16. Turkey	1,954	326	6.0
17. Poland	1,825	279	6.5
18. Wales	1,763	99	17.8
19. Hungary	1,626	147	11.1
20. Czech Rep.	1,561	297	5.3

Articles appearing between 1999 and 2010 in ‘fungi research journals’ as listed by *SCImago* and Thomson Reuters’ *Web of Science*. The citation numbers are accurate as of July 2012. A country’s figures are derived from articles, where at least one author working in the respective European nation is included in the authors’ list. Israel is included because it is a member of many European research organisations and programmes (EMBO, FP7 of the EU...).

... and the World

	Citations	Articles	Cit./Art.
Europe	95,953	10,223	9.4
USA	53,530	4,084	13.1
Japan	10,376	1,088	9.5
Canada	10,033	741	13.5
Australia	9,177	694	13.2
China	8,192	1,167	7.0
Brazil	6,937	973	7.1



Publication Analysis 1999-2010 – Fungal Research

Most Cited Authors...

	Cit-ations	Art-icles
1. David W. Denning , Univ. Manchester	11,487	146
2. Olivier Lortholary , Univ. René Descartes Paris	8,081	194
3. Stephen G. Oliver , Univ. Manchester	6,592	132
4. Jens Nielsen , Chalmers Univ. Technol. Gothenburg	6,264	200
5. Jean-Paul Latge , Inst. Pasteur Paris	5,513	110
6. J. J. (Sef) Heijnen , Delft Univ. Technol.	5,418	160
7. Pedro W. Crous , CBS-KNAW Fungal Biodiv. Ctr. Utrecht	5,278	255
8. Frank C. Odds (emer.), Univ. Aberdeen	5,060	104
9. Bärbel Hahn-Hägerdal (emer.), Lund Univ.	4,937	100
10. Johan M. Thevelein , Kathol. Univ. Leuven	4,867	114
11. Neil A. R. Gow , Univ. Aberdeen	4,615	110
12. Claude Gaillardin , AgroParisTech	4,447	91
13. Frans M. Klis , Univ. Amsterdam	4,046	70
14. Paul E. Verweij , Univ. Hosp. Nijmegen	4,001	137
15. Alistair J. P. Brown , Univ. Aberdeen	3,940	88
16. Jack Pronk , Delft Univ. Technol.	3,912	108
17. Juan-Luis Rodriguez-Tudela , Complutense Univ. Madrid	3,795	137
18. Ulrich Güldener , Helmholtz Ctr. Munich	3,700	19
19. Manuel Cuenca-Estrella , Inst. Salud Carlos III, Madrid	3,503	133
20. Oliver A. Cornely , Univ. Cologne	3,397	101
21. Peter W. Piper , Univ. Sheffield	3,354	58
22. Marten Veenhuis , Univ. Groningen	3,309	124
23. Josep Guarro , Univ. Rovira i Virgili	3,300	255
24. Bernhard Hube , Hans Knöll Inst. Jena	3,196	80
25. Nick D. Read , Univ. Edinburgh	3,025	51
26. Christian P. Kubicek , Vienna Univ. Technol.	2,978	115
27. Ida J. van der Klei , Univ. Groningen	2,974	99
28. Paola Bonfante , Univ. Turin	2,851	114
29. Françoise Dromer , Inst. Pasteur Paris	2,841	89
30. Hans-Christian Korting , LMU Munich († 2012)	2,836	133



Citations of articles published between 1999 and 2010 were recorded up until July 2012 using the Web of Science database from Thomson Reuters. The "most-cited papers" had correspondence addresses in Europe or Israel.

... and Papers

	Citations
1. Herbrecht, R; Denning, DW; Patterson, TF; [...] Schlamm, HT; Troke, PF; de Pauw, B Voriconazole versus amphotericin B for primary therapy of invasive aspergillosis. <i>NEW ENGLAND JOURNAL OF MEDICINE</i> 347(6): 408-415 AUG 8 2002	1,318
2. Latge, JP <i>Aspergillus fumigatus</i> and aspergillosis. <i>CLINICAL MICROBIOLOGY REVIEWS</i> 12(2): 310-50 APR 1999	875
3. Wood, V; Gwilliam, R; Rajandream, MA; [...] Ussery, D; Barrell, BG; Nurse, P The genome sequence of <i>Schizosaccharomyces pombe</i> . <i>NATURE</i> 415(6874): 871-80 FEB 21 2002	746
4. Dujon, B; Sherman, D; Fischer, G; [...] Weissenbach, J; Wincker, P; Souciet, JL Genome evolution in yeasts. <i>NATURE</i> 430(6995): 35-44 JUL 1 2004	606
5. Hohmann S Osmotic stress signaling and osmoadaptation in yeasts. <i>MICROBIOLOGY AND MOLECULAR BIOLOGY REVIEWS</i> 66(2): 300-72 JUN 2002	604