Why are Aspergilli so different in their expression of secondary metabolites from section to section?

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Invited Lecture (abstract):

Why are Aspergilli so different in their expression of secondary metabolites from section to section?

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Introduction:

Aspergillus and *Penicillium* (*Eupenicillium*) species are often occupying the same ecological niches and have a large number of secondary metabolites in common. Known mycotoxins and other secondary metabolites (SMs) are in common including aflavinins, aspergamides, asperphenamates, austins, carolic acids, chrysogines, citreoviridins, citrinins, cyclopiazonic acids, fumagillins, gliotoxins, griseofulvins, kojic acids, mycophenolic acid, 3-nitropropionic acid, ochratoxins, patulin, paxillins, penicillic acid, penicillins, penigequinolones, penitrems, pseurotins, roquefortines, secalonic acids, terreins, viridicatins, viridicatumtoxins, viriditoxins, xanthocillins, and xanthomegnins. Few SM biosynthetic families have only been found in either *Aspergillus* or *Penicillium*. The issue is being further complicated by the fact that some of these SMs are also found in phylogenetically completely different species. We have SM profiled nearly all known species in the two important genera, and we tried to see if there are any patterns in the different sections of *Aspergillus*.

Methods

The fungi were grown on CYA and YES media for 7 days at 25° C in darkness. Small agar plugs were extracted with EtOAc, CH_2Cl_2, MeOH (3:2:1) with 1 % HCOOH and after re-dissolving in MeOH and filtering, analyzed by gradient HPLC-DAD-MS.

Results and discussion:

The sections of *Aspergillus* could be subdivided into *Aspergillus, Cremei, Nidulantes* + *Versicolores* + *Usti* + *Sparsi*, *Ochraceorosei*, *Flavipedes* + *Terrei* + *Cervini, Candidi, Fumigati, Clavati, Circumdati*, *Flavi, Nigri* & *Ornati*. Each of these groups had a large number of characteristic SMs, but only few were in common between sections or section groups. Sterigmatocystin was found in four of these section groups, but also in completely unrelated fungi for example *Bipolaris*, *Chaetomium, Humicola,* & *Podospora.* On the other hand SMs such as the ochratoxins have only been found in *Aspergillus* and *Penicillium* so far, and the aflatoxins have only been found in *Aspergillus*.

Within *Aspergillus*, which comprises 9 very different teleomorphs (*Eurotium, Chaetosartorya, Emericella, Fennellia, Neosartorya, Neocarpenteles, Neopetromyces, Petromyces* and *Sclerocleista*) there are also very large differences in actual SMs being produced in species in anyone section group. *Nigri* species produced citric acid, oxalic acid, ascorbic acid and gluconic acid, whereas *Terrei* species produced itaconic acid, terrein, and terreic acid, *Flavi* species kojic acid, *Circumdati* species penicillic acids and aspyrones, *Fumigati* species epoxysuccinic acids and fumigatins, *Cremei* species citraconic acids, *Clavati* species patulin. There were also analogous production of many other SMs, including fumifungins in *Fumigati* versus fumonisins in *Nigri;* gliotoxin in *Fumigati*, acetylaranotin in *Terrei*, aspirochlorine in *Flavi*, emestrin in *Nidulantes*; territrems in *Terrei* versus pyripyropens in *Fumigati*; novofumigatonin in *Fumigati* versus terretonins in *Terrei* and austins in *Nidulantes* and *Versicolores*; in some sections optical antipodes were produced: (-)-versicolamide in *Versicolores* and (+)-versicolamide in *Circumdati* [1]; aszonalenins are produced in *Flavipedes* etc., but apparently both aszonalenins and epi-aszonalenins are produced in *Fumigati*[2,3.]

There were, however, examples of the same SM being produced by species in different sections (Fig. 1, Fig. 2). Aspergillic acids and ochratoxins have been found in *Flavi* and *Circumdati*, pseurotins have been found in *Fumigati* and *Clavati ,* kojic acid + aflatoxins have been found in few *Nidulantes* but many *Flavi* species; cyclopiazonic acid has been found *Flavi* and *Fumigati*, physcion in section *Aspergillus* and *Cremei*, citrinin in *Terrei* and *Flavipedes*,

Conclusions:

There are remarkably few identical SMs being produced in different sections of *Aspergillus*.

- The same SM may occur in widely different fungi, so either the biosyntheses have been reinvented or occur due to horizontal gene cluster transfer (maybe guided by niche construction)
- Within closely related species, vertical gene cluster transfer seems very probable
- *Aspergillus* species in different sections produce analogous solutions to the same biological problems

References:

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