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

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, ctitinins, cyclopiazonic acids, fumagillins, gliotoxins, griseofulvins, kjoj acids, mycophenolic acid, 3-nitropropionic acid, ochratoxins, patulin, pavilins, penicillic acid, penicillins, penigequinolones, penitrems, pseurotine, 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, CH2Cl2, 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, 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, ascobic acid and gluconic acid, whereas Terrei species produced itaconic acid, terrein, and terreic acid, Flavi species kjoj acid, Circumdati species penicillic acids and aspyrones, Fumigati species epoxysuccinic acids and fumigatins, Creemi 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, acetylarylanol in Terrei, aspirochlorine in Flavi, emetrin in Nidulantes; territrems in Terrei versus pyripyropens in Fumigati; novofumigatine in Fumigati versus terretons in Terrei and austins in Nidulantes and Versicolores; in some sections optical antipodes were produced: (-)-versicollamide in Versicolores and (+)-versicollamide in Circumdati 1; azsonalenins are produced in Flavipedes etc., but apparently both azsonalenins and epi-azsonalenins are produced in Fumigati2,3. There were, however, examples of the same SM being produced by species in different sections (Fig. 1, Fig. 2). Aspergillus acids and ochratoxins have been found in Flavi and Circumdati, pseurotins have been found in Fumigati and Clavati , kjoj 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 Creemi, 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

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