

A new species of the genus *Penicillium* isolated from the soil of the Chaco dry forest in Argentina

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Abstract: Studies related to the diversity of species of genus *Penicillium* present in Argentina soils focus on evaluating the functionality and importance of fungi in ecosystems, but little attention has been focused on the search for new species. The Chaco dry forest in Argentina is a semiarid region belonging to the subregion of Neotropical dry forests, characterized by the presence of the plant of the genus *Schinopsis* Engl. *Penicillium* is a genus that belongs to the phylum Ascomycota, species of this are ubiquitous and present in a wide range of environmental conditions. The aim of this work is to describe a new species of *Penicillium*, *Penicillium schinopsum* sp. nov. This species separates phylogenetically into a new clade that made identification to the species level feasible and allows the assignment to a possible new section and series. The strain is a novel species of genus *Penicillium* ser. and sect. *Schinopsiorum* sect. nov., we propose the name *Penicillium schinopsum* sp. nov. This new proposal could be part of the subgenus *Aspergilloides* and it is phylogenetically related to sections *Aspergilloides*, *Sclerotium*, *Charlesia*, and *Eremophila*. The morphology and growth of the colony support phylogenetic separation. The main morphological characteristic that it showed was the fast growth rates of the colonies on all culture media tested except on CYA at 37 °C, the green colour of the colony, the monoverticillate conidiophore with a long stipe, smooth-walled globose conidia and absence of sclerotia. We considered it necessary to continue advancing in the characterization to assess its biotechnological potential.

Keywords: Fungi, Taxonomy, Neotropical Dry Forest, Soil.

Resumen: Los estudios relacionados con la diversidad de especies del género *Penicillium* presentes en suelos de Argentina se centran en evaluar la funcionalidad e importancia de los hongos en los ecosistemas, pero se ha dado poca atención en la búsqueda de nuevas especies. El bosque seco chaqueño en Argentina es una región semiárida perteneciente a la subregión de los Bosques Secos Neotropicales, caracterizada por la presencia de plantas del género *Schinopsis* Engl. *Penicillium* es un género que pertenece al filo Ascomycota, las especies son ubicuas y están en un amplio rango de condiciones ambientales. El objetivo del trabajo es describir una nueva especie: *Penicillium schinopsum* sp. nov. Ésta se separa filogenéticamente en un nuevo clado que hizo factible la identificación a nivel de especie y la asignación de una posible nueva sección y serie. La cepa es una especie nueva del género *Penicillium*, ser., sect. *Schinopsiorum* sect. nov. Esta especie podría formar parte del subgénero *Aspergilloides* y está relacionada filogenéticamente con las secciones *Aspergilloides*, *Sclerotium*, *Charlesia* y *Eremophila*. La morfología y el crecimiento de la colonia apoyan la separación filogenética. Las principales características morfológicas que mostraron fueron las rápidas tasas de crecimiento de las colonias en todos los medios de cultivo probados excepto en CYA (37 °C), el color verde de la colonia, el conidióforo monoverticilado con un estípito largo, conidios globosos de paredes lisas y ausencia de esclerocios. Consideramos necesario seguir avanzando en la caracterización para evaluar su potencial biotecnológico.

Palabras claves: Hongos, Taxonomía, Neotropical Dry Forest, Soil.

INTRODUCTION

Penicillium is a genus of fungi that belongs to the phylum Ascomycota. The species of this genus are ubiquitous and present in a wide range of environmental conditions. The ability to grow in diverse substrates such as vegetation, soil, house samples, and food enables its wide distribution. The isolates of this genus have been obtained from a wide variety of soils such as forest, desert, agricultural, and saline soils (Visagie *et al.*, 2014 a,b; Houbraken *et al.*, 2020). The Chaco dry forest in Argentina is a semiarid region belonging to the subregion of Neotropical dry forests, characterized by the presence of the *Schinopsis* Engl. “Quebrachos”, closed canopy, subtropical climate with a long dry season and the presence of a period of rainfall (Merlos *et al.*, 2018). Research has been focused on the fragmentation and deforestation of this tree species due to the expansion of the agricultural frontier (Bonino & Araujo, 2005; Gasparri & Grau, 2009; Vallejos *et al.*, 2015). However, while diversity studies are mainly focused on amphibians, birds, insects, mammals, plants, and reptiles, studies on soil fungal communities are scarce (Godeas, 1972; Kacoliris *et al.*, 2006; Montecchia *et al.*, 2011; Banda *et al.*, 2016; Diodato & Fuster, 2016; Merlos *et al.*, 2018). Even though the *Penicillium* species of soils in Neotropical forests are numerous, only the high diversity of Caatinga and Atlantic forests is known (Cruz *et al.*, 2013; Barbosa do Nascimento *et al.*, 2020). Few studies have been carried out to evaluate fungal species in the Chaco dry forest in Argentina (Godeas, 1972; Montecchia *et al.* 2011), therefore the aim of this work is to describe a new species of *Penicillium*, *Penicillium schinopsium* sp. nov. and to promote future work in this area.

MATERIALS AND METHODS

Isolates and morphology

The soil samples were obtained from the Chaco dry forest (26°93'11" S; 61°62'49" W) and washed according to Cabello & Arambarri (2002). The soil particles were placed into Petri dishes containing Potato Dextrose Agar with (PDA 2%) amended with chloramphenicol to suppress bacterial growth. For macroscopic and morphological identification, *Penicillium* colonies were subcultured in Petri dishes with PDA, Czapek's Agar (Cz), Yeast Extract Sucrose Agar (YES), Oatmeal Agar (OA), Czapek Yeast Autolysate Agar (CYA), Czapek Yeast Autolysate

agar with 5% NaCl (CYAS), Malt Extract Agar (MEA), and Synthetic Nutrient-poor Agar (SNA) (Raper & Thom, 1968; Samson & Frisvad, 2004; Visagie *et al.*, 2014b). All Petri dishes were incubated for 7 days at 25 °C, with additional CYA plates incubated at 30 and 37 °C. Mounts were made from 7 days old colony grown on MEA, according to the description shown in Visagie *et al.* (2014b). Observations of microscope characteristics were made using binocular optical microscope Olympus CX31. Colony and morphological structures photographs were captured using a KODAK digital camera (Easyhare Z-712). Also, the structures of the fungal isolates were examined by scanning electron microscope (JSM-6390LV). The cultures were preserved and maintained on CyA agar and stored for short term at 4 °C and for the long-term at -80 °C in 15% glycerol. The type species, metabolically inactive as holotype, was deposited in the culture collection of the Instituto Spegazzini, UNLP, La Plata, Argentina (LPSC (type specie) and LPS (holotype)).

DNA extractions, PCR, DNA sequencing and phylogenetic analysis

The species identified morphologically was cultured as monospore isolated in Petri dishes with 2% PDA for 7 days at 25 °C under 12-h light/dark conditions. The DNA was extracted using the cetyl trimethyl ammonium bromide (CTAB) protocol described by Stenglein and Balatti (2006). The DNA quality was examined by electrophoresis in 0.8% (w/v) agarose gels containing Gel Red TM (Biotium) at 80 V in 1X Trisborate-EDTA buffer for 3 h at room temperature. The DNA was visualized under UV light. DNA concentrations were calculated using a fluorometer (Qubit TM-Invitrogen). The Bt₂a/ Bt₂b (Partial β -tubulin gene; Glass & Donaldson, 1995), ITS1/ITS4 (Internal Transcriber spacer; White *et al.*, 1990), CMD5/CMD6 (Calmoduline gene; Hong *et al.*, 2006), and 5F/7CR (RNA polymerase II second largest subunit; Liu *et al.*, 1999) were amplified through polymerase chain reaction (PCR) (XP Thermal Cycler). Those fragments amplified by PCR were analyzed by electrophoresis agarose gels (1.5% w/v) containing Gel Red TM (Biotium) in 1 X Trisborate-EDTA buffer, at 80 V for 1 h at room temperature. The fragments were purified by AccuPrep® Gel Purification Kit (Bioneer Corporation). DNA sequencing was carried out using Big Dye Terminator version 3.1 Cycle Sequencing Ready Reaction Kit (Applied Biosystems) in an Applied Biosystems Sequencer

(ABI/Hitachi Genetic Analyzer 3130). The sequences were compared with the NCBI database using BLAST (Altschul et al., 1990).

To determine the phylogenetic relationship of our isolate, a combined of ITS-*BenA*-*CaM*-*RPB2* using representative species from 20 sections was built to distinguish among other species of *Penicillium* belonging to sections *Alfrediorum*, *Aspergilloides*, *Charlesia*, *Cinnamopurpurea*, *Citrina*, *Crypta*, *Eremophila*, *Exilicaulis*, *Gracilentia*, *Griseola*, *Inusitata*, *Lanata-Divaricata*, *Lasseniorum*, *Ochrosalmonea*, *Paradoxa*, *Ramigena*, *Sclerotiorum*, *Stolkia*, *Torulomyces* and *Thysanophora* (Table 1, Fig. 1). The species *Aspergillus glaucus* CBS 516.65 and *Hamigera avellanea* CBS 295.48 were selected as outgroups. The sequence alignments and the maximum-likelihood (ML) and Bayesian-inference (BI) phylogenetic analyses were performed as described by Valenzuela-Lopez et al. (2018).

RESULTS

Taxonomy

Morphological analysis

Penicillium schinopsium L.B. Silvestro, Rodriguez-Andrade, Pelizza, Stchigel, Merlos, and M.V. Moreno sp. nov.

The ex-type strain is LPSc1424^T. Holotype LPS 49247 (dried specimen in metabolically inactive state). Index Fungorum number: IF558048. *Etymology*. From Latin *Schinopsidis*, of main species of tree native *Schinopsis* sp. from Chaco Dry Forest.

Type. Argentina, Chaco Province, “Tres Estacas” (26°55'27" S; 61°37'36" W) in Charata (district Chaco - Argentina), from soil samples, isolated by CSM, January 2013.

Description. The fungus colonies showed pale green coloration with concentric rings on all culture media after 7 days of incubation (Fig. 2). Colonies on all culture media after 7 days of incubation (Fig. 1) tended to be pale green (26D4) with concentric rings. The species showed good growth on MEA, YES, SNA, OA, Czapek, APG, CyAS, CREA at 25 °C, CYA at 25 °C and CYA at 30 °C and did not grow on CYA at 37 °C. The colony diameter was on APG: 34–42 mm, CYA at 25 °C: 41–46 mm, CYA at 30 °C: 30–33 mm, CyAS: 28–30 mm, CREA: 28–31 mm, Czapek: 34–41 mm, MEA: 42–45 mm, SNA: 30–32 mm, OA: 34–36 mm and YES: 40–42 mm. Colonies

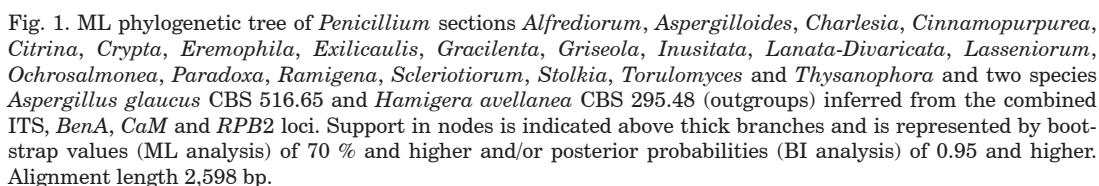
morphology, on all culture media, showed circular margin, entire, white floccose mycelia without production of sclerotia and exudates. Sporulation is abundant, pale green towards the centre (26D4). Colonies on YES produced conidia greenish grey towards the edges (25E2) and turning white towards the centre. The bottom view under CYA 30 °C, OA, and CYAS was white in colour; on APG, CYA 25 °C, MEA, YES pale and yellowish, and on CZAPEK reddish. Under CREA medium a yellow halo was formed around the colonies which revealed a good capacity to acid production (Fig. 1). Conidiophores were monoverticillate, smooth, unbranched, vesiculated with vesicles (3–6 µm), stipes (20–100 µm), phialides ampulliform 6–8 (7.5–10 µm) and globose smooth walled conidia (2–3 µm, n = 50) (Fig. 3 and Fig. 4).

DNA sequencing and phylogenetic analysis

The sequences generated were deposited in the NCBI/GeneBank database under the accession number: ITS (MN627761), *BenA* (MN627762), *CaM* (MN627760), and *RPB2* (MN627763).

Based on a megablast search of NCBI's GenBank nucleotide database, the closest hit using the ITS sequence is with the ex-type strain of *Penicillium wisconsinense* (CBS 128279, GenBank NR153225; Identities = 494/515 (96 %), gaps 12/515 (2 %)), using the *BenA* sequence is with the strain of *Penicillium griseolum* (DTO 216-D2, GenBank MF974920; Identities = 237/293 (81 %), gaps 23/293 (7 %)), using the *CaM* sequence is with the strain of *Penicillium magnielliptisporum* (CMV00711, GenBank MK451665; Identities = 397/398 (99 %), gaps 1/398 (0 %)), and using *RPB2* sequence is with *Penicillium fortuitum* (DTO 313-A3, GenBank MN969206; Identities = 853/1004 (85 %), gaps 4/1004 (0 %)).

We carried out individual and combined analyses with ITS, *BenA*, *CaM* and *RPB2* loci to resolve the taxonomical position of our strain with species of *Penicillium* sections *Alfrediorum*, *Aspergilloides*, *Charlesia*, *Cinnamopurpurea*, *Citrina*, *Crypta*, *Eremophila*, *Exilicaulis*, *Gracilentia*, *Griseola*, *Inusitata*, *Lanata-Divaricata*, *Lasseniorum*, *Ochrosalmonea*, *Paradoxa*, *Ramigena*, *Sclerotiorum*, *Stolkia*, *Torulomyces*, and *Thysanophora*, including type strains of the accepted species (TREEBASE ID: 27313). A concatenated dataset obtained contained 109 sequences with a total of 2,598 characters including gaps (606 of them for ITS, 461



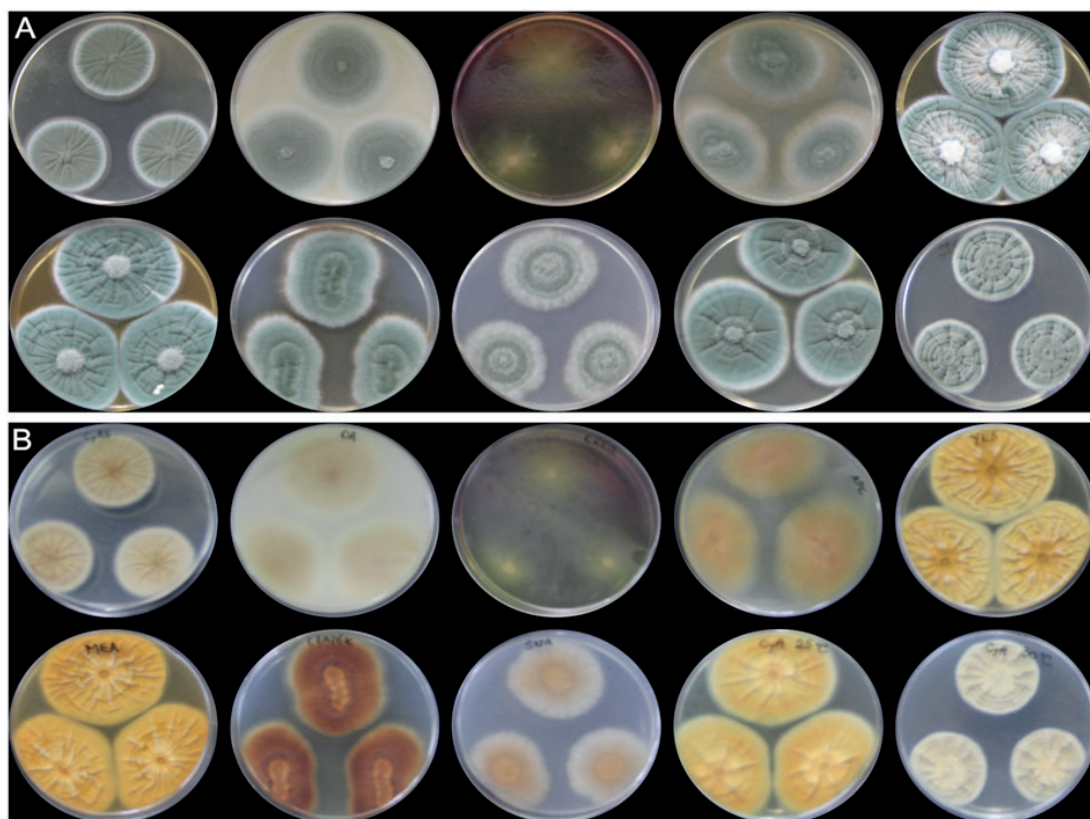


Fig. 2. *Penicillium schinopsum*. A. Top view of the colonies, left to right, CYAS, OA, CREA, APG, YES, MEA, CZAPEK, SNA, CYA 25 °C and CYA 30 °C. B. Bottom view of colony, left to right: CYAS, OA, CREA, APG, YES, MEA, CZAPEK, SNA, CYA 25 °C and CYA 30 °C.

for *BenA*, 642 for *CaM* and 889 for *RPB2*), of which 1402 were parsimony informative (237 for ITS, 309 for *BenA*, 423 for *CaM* and 433 for *RPB2*). The sequence datasets did not show conflict in the tree topologies for the 70 % reciprocal bootstrap trees, which allowed to combine the four genes for the multi-locus analysis. The ML analysis showed a similar tree topology and was congruent with that obtained in the Bayesian analysis. Phylogenetic analysis resolved 21 main clades, 19 of them define all sections of subgenus *Aspergilloides*: *Aspergilloides* (99/0.97), *Sclerotiorum* (97/0.95), *Charlesia*, *Eremophila*, *Ramigena* (73/-), *Ochrosalmonea* (99/0.97), *Thysanophora* (99/0.98), *Griseola*, *Gracilentia* (85/-), *Stolkia* (99/1), *Lanata-Divariata* (92/0.95), *Exicaulis* (84/0.95), *Crypta* (99/1), *Alfrediorum*, *Lasseniorum*, *Torulomyces* (99/0.98), *Inusitata*, *Cinnamopurpurea* (98/0.97), and *Citrina* (98/0.95), moreover, a well-defined clade belonged to the section of subgenus *Penicillium*: *Paradoxa* (99/1). Within these sec-

tions, 63 series have been classified and these are observed in different subclades. Finally, one clade includes *Penicillium schinopsum* sp. nov. does not belong to any series or section and phylogenetically is related to sections *Aspergilloides*, *Sclerotiorum*, *Charlesia*, and *Eremophila* (Fig. 1).

DISCUSSION

Studies related to the diversity of fungi present in Argentina soils focus on evaluating the functionality and importance of fungi in ecosystems, but little attention has been focused on the search for new species. The discovery and characterization of species on different substrates offer the possibility to use these species as potential agents of biocontrol of pathogens, bioremediation, biotransformation, and production of enzymes. Soils have been the source of many new species of interest to the scientific community. The identification of new species of *Penicillium*

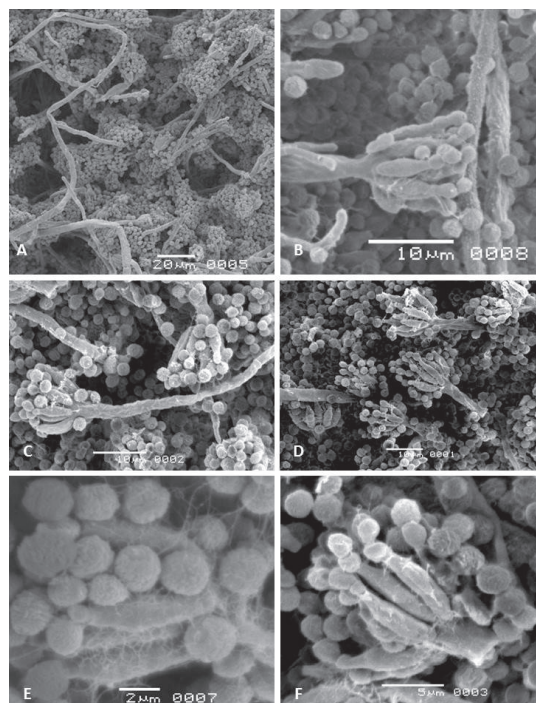


Fig. 3. *Penicillium schinopsum*. A-D, F. Conidiophores. E. Conidia. Scales: A-D, F= 2,5 µm; E= 1µm.

from soils in Argentina is scarce. There is only one record in the Tierra del Fuego Province that mentions two new species of the genus (Ramírez, 1985); therefore, it is crucial to consider that the dry forest of Chaco is a good place to find species that have not been described yet. Our work shows that *Penicillium schinopsum* separates into a branch that allows assigning it to a new series and a new section, different from those characterized in Houbraken *et al.* (2020) using the same markers (ITS, *BenA*, *CaM*, and *RPB2*) that made feasible identification to the specie level and phylogenetic classification. Furthermore, the morphology and growth of the colony support phylogenetic separation and could belong to a new section and series (*Schinopsiorum*). This new proposal could be part of the subgenus *Aspergilloides* and it is phylogenetically related to sections *Aspergilloides*, *Sclerotiorum*, *Charlesia* and *Eremophila*. *Penicillium schinopsum* sp. nov. have morphological differences compared to the species in the sect. *Aspergilloides*, *Sclerotiorum*, *Charlesia* and *Eremophila*. The main characteristic in culture that allowed to distinguished new section and series was fast growth rates of the colonies on all culture media tested except on CYA at 37 °C, and the green color of the colony.

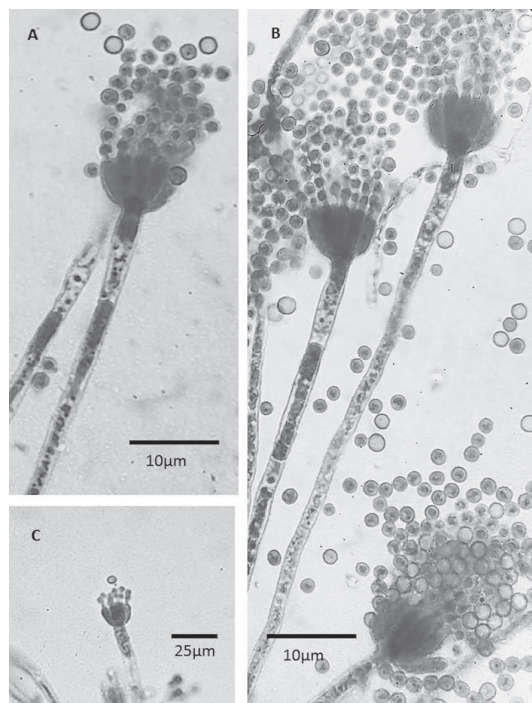


Fig. 4. Detail of the conidiophores and conidia of *Penicillium schinopsum*. Conidiophore and conidia. Scales: A-B= 10 µm; C= 25µm.

The morphological characteristics that define the species and section are the monoverticillate conidiophore with a smooth long stipe, smooth-walled globose conidia and absence of sclerotia. The species in sections *Charlesia* grow restricted on Czapek yeast agar; in section *Aspergilloides* rate of growing is moderately to fast on CYA and/or MEA; in section *Sclerotiorum* colonies grow is restricted or moderated (and strains have vivid orange to red colony colours, with colorful sclerotia); and in section *Eremophila* (which include xerophilic species) the asexual morph is not known and colonies do not grow on high water activity media (Rivera & Seifert, 2011; Houbraken *et al.*, 2014; Houbraken *et al.*, 2020; Sun *et al.*, 2021). The morphological similarities among all sections of subgenus *Aspergilloides* are the monoverticillate conidiophore with a vesiculate apex or swelling (Houbraken *et al.*, 2020). The proposal of a new series and section was informally introduced here and it is important to be considered in the next works. For this, we considered it necessary to continue advancing in the phylogenetic and physiological characterization to assess its biotechnological, taxonomic and biochemical potential.

Table 1. *Penicillium* EMBL/GenBank codes used in this study

Species name	Section	Serie	Strain no.	GenBank accession nr.	BenA	CaM	rpb2
<i>Penicillium schinopsum</i> sp. nov.	-	-	LPSc1424 (T)	ITS	BenA	CaM	rpb2
<i>Penicillium alfredii</i>	Alfrediorum	Alfrediorum	DTO 269A4 (T)	MN627761	MN627762	MN627760	MN627763
<i>Penicillium fortuitum</i>	Aspergilloides	Fortuita	DTO 313-A3 = DAOMC 251497 (T)	KJ775684	KJ775177	KJ775411	KJ834520
<i>Penicillium glabrum</i>	Aspergilloides	Glabra	CBS 125543 = IBT 22658 = IMI 91944 (T)	MF803942	MF803936	MF803932	MN969206
<i>Penicillium pulvis</i>	Aspergilloides	Glabra	CBS 138482 = DTO 180-B7 (T)	GU981567	GU981619	KM089152	JF417447
<i>Penicillium hoeksii</i>	Aspergilloides	Hoeksiorum	CBS 137776 = DTO 192-H4 (T)	KM189632	KM088876	KM089263	KM089650
<i>Penicillium zhuangii</i>	Aspergilloides	Hoeksiorum	CBS 137464 = NRRL 62806 = AS 3.15341 (T)	KM189707	KM088954	KM089341	KM089728
<i>Penicillium improvisum</i>	Aspergilloides	Improvisa	DAOMC 250547 = CBS 140994 = DTO 410-D9 = KAS 2386 = W 156 (T)	KF769435	KF769411	KF769422	MN969145
<i>Penicillium kamaense</i>	Aspergilloides	Kiamaensia	CBS 137947 = FRR 6087 = DTO 056-I6 (T)	KT887867	KT887828	KT887789	MN969169
<i>Penicillium lividum</i>	Aspergilloides	Livida	CBS 347.48 = ATCC 10102 = CCRC	KM189506	KM088743	KM089128	KM089515
<i>Penicillium odoratum</i>	Aspergilloides	Livida	31286 = DSM1180 = IFO 6102 = IMI 039736 = NRRL 754 = QM 1930 = VKMF-303 (T)	KM189582	KM088825	KM089211	KM089598
<i>Penicillium longicatenum</i>	Aspergilloides	Longicatenata	CBS 294.62 = CBS 296.62 = ATCC 14769 = DSM2419 = IFO 7741 = IMI 094208H = NRRL 3007 = WSF2000 (T)	KC411730	KJ834478	KM089363	JN406583
<i>Penicillium vagum</i>	Aspergilloides	Longicatenata	CBS 137728 = DTO 180-G3 = CV 25 = DAOM 241357 (T)	KM189636	KM088880	KM089267	KM089654
<i>Penicillium fuscum</i>	Aspergilloides	Pinetorum	CBS 295.62 = ATCC 14770 = CCRC	KM189642	KM088886	KM089273	KM089660
<i>Penicillium montanense</i>	Aspergilloides	Pinetorum	31517 = DSM2438 = IFO 7743 = IMI 094209 = MUCL 31196 = NRRL 3008 = WSF15c (T)	AF033411	GQ367513	GQ367539	JN121483
<i>Penicillium quercetorum</i>	Aspergilloides	Quercetorum	CBS 310.63 = ATCC 14941 = FRR 3407 = IFO 7740 = IHEM 4375 = IMI 099468 = MUCL 31326 = NRRL 3407 (T)	KM189551	KM088789	KM089174	KM089561
<i>Penicillium saturniforme</i>	Aspergilloides	Saturniformia	CBS 417.69 = NRRL 3758 = ATCC 48727 = CCRC 31668 = FRR 516 = IFO 31749 = IMI 140342 = MUCL 31203 = VKMF-1074 (T)	KM189556	KM088795	KM089180	KM089567
<i>Penicillium spinulosum</i>	Aspergilloides	Spinulosa	CBS 374.48 = ATCC 10498 = FRR 1750 = IMI 024316 = LSHEAd 29 = MUCL 13910 = MUCL 13911 = NCTC 591 = NRRL 1750 = QM 7654 (T)	EU644081	EU644080	EU644062	JN121439
<i>Penicillium trzebinskii</i>	Aspergilloides	Spinulosa	CBS 382.48 = ATCC 10507 = FRR 731 = IFO 6110 = IMI 039749 = MUCL 29102 = NRRL 731 = QM 7678 (T)	AF033410	KJ834493	GQ367524	JN406558
<i>Penicillium sublectatum</i>	Aspergilloides	Sublectatica	CBS 122276 = AS 3.6886 (T)	KM089784	KM089034	KM089421	KM089808
<i>Penicillium malmesburieense</i>	Aspergilloides	Sublectatica	CBS 137744 = DTO 182-H5 = CV 1180 = DAOM 241144 (T)	KM189761	KM089010	KM089397	KM089784
<i>Penicillium thiersii</i>	Aspergilloides	Thiersiorum	CBS 117503 = IBT 27050 = NRRL 28162 (T)	KM189676	KM088921	KM089308	KM089695
<i>Penicillium thomii</i>	Aspergilloides	Thomiorum	CBS 225.81 = IMI 189694 = NRRL 2077 (T)	AF125936	KJ834497	AY741726	JN121434
<i>Penicillium cartierense</i>	Aspergilloides	Thomiorum	CBS 137956 = DTO 092-H9 (T)	KM189560	KM088799	KM089184	KM089571
<i>Penicillium verhagenii</i>	Aspergilloides	Verhageniorum	CBS 137959 = DTO 193-A1 (T)	KM189564	KM088804	KM089189	KM089576
<i>Penicillium ranomafanense</i>	Aspergilloides	Verhageniorum	CBS 137953 = DTO 085-A5 (T)	KM189708	KM088955	KM089342	KM089729
				KM189541	KM088779	KM089164	KM089551

Species name	Section	Serie	Strain no.	GenBank accession nr.
<i>Penicillium costaricense</i>	Charlesia	Costaricensia	DAOMC 250520 = CBS 140998 = DTO 410-E3 = KAS 2597 = 01-RGTHC-294 (T)	MN431396 KT887834 KT887795 MN969173
<i>Penicillium fellutanum</i>	Charlesia	Fellutana	CBS 229.81 = CBS 326.48 = ATCC 10443 = FRR 746 = IFO 5761 = IMI 039734 = IMI 039734iii = NRRL 746 = QM 7554 (T)	AF033399 KJ834450 AY741753 JN121460
<i>Penicillium charlesii</i>	Charlesia	Fellutana	CBS 304.48 = ATCC 8730 = CBS 342.51 = CECT 2277 = FRR 778 = IMI 040232 = LSHBB127 = LSHBP 146 = NRRL 1887 = NRRL 778 = QM 6338 = QM 6838 (T)	AF033400 JX091508 AY741727 JN121486
<i>Penicillium chermesinum</i>	Charlesia	Indica	CBS 231.81 = FRR 2048 = IFO 31745 = IMI 191730 = NRRL 2048 (T)	AY742693 KJ834441 AY741728 MN969111
<i>Penicillium indicum</i>	Charlesia	Indica	CBS H-7476 (isotype). Ex-type: CBS 115.63 = NRRL 3387 = ATCC 18324 = FRR 3387 = IFO 31744 = IMI 166620 (T)	EU427263 AY741744 JN406640
<i>Penicillium coffeae</i>	Charlesia	Phoenicea	CBS 119387 = IBT 27866 = NRRL 35363 (T)	AY742702 KJ834443 AY741747 JN121436
<i>Penicillium phoeniceum</i>	Charlesia	Phoenicea	CBS 249.82 = ATCC 10481 = LFM 5122 = IMI 040585 = NRRL 2070 = QM 7608 = VKMF-321 (T)	KC411711 KJ834483 AY741729 JN406597
<i>Penicillium cinnamomipureum</i>	Cinnamomipurea	Cinnamomipurea	CBS 429.65 = CBS 847.68 = NRRL 162 = ATCC 18489 = CSIR 936 = FAT 362 = IAM 7016 EF626950 = IFO 6032 = NHL 6359 = QM 7888 (T)	EF626948 EF626949 JN406553
<i>Penicillium parvulum</i>	Cinnamomipurea	Cinnamomipurea	CBS 132825 = NRRL 35504 (T)	EF422845 EF506225 MN969131
<i>Penicillium idahoense</i>	Cinnamomipurea	Idahoensia	CBS 341.68 = NRRL 5274 = ATCC 22055 = FRR 881 = IMI 148393 (T)	KC411747 EF626953 EF626954 JN121499
<i>Penicillium colei</i>	Cinnamomipurea	Idahoensia	NRRL 13013 = IBT 29696 (T)	KF932958 KF932926 KF932942 KF932996
<i>Penicillium pusillum</i>	Cinnamomipurea	Jiangxiensia	CBS 312.63 = FRR 1541 = IMI 089286 = LSHBB147 = NRRL 2498 (T)	KF932951 EF626951 KF932941 KF932995
<i>Penicillium jiangxiense</i>	Cinnamomipurea	Jiangxiensia	AS 3.6521 = DTO 309-A7 (T)	KJ890411 KJ890409 KJ890407 MN969122
<i>Penicillium incoloratum</i>	Cinnamomipurea	Nodula	CBS 101753 = AS 3.4672 (T)	KJ834508 KJ834457 KJ866984 JN406651
<i>Penicillium nodulum</i>	Cinnamomipurea	Nodula	CBS 227.89 (T)	KC411703 KJ834475 KJ867003 JN406603
<i>Penicillium citrinum</i>	Citrina	Citrina	CBS 139.45 = DTO 022-F3 = ATCC 1109 = ATCC 36382 = CECT 2269 = FRR 1841 = IMI 091961 = IMI 092196 = LSHBAad 95 = LSHBP 25 = LSHBP 6 = MUCIL 29781 = NRRL 1841 = NRRL 1842 (T)	GU944545 MN969245 JF417416
<i>Penicillium hetheringtonii</i>	Citrina	Citrina	CBS 122392 = DTO 005-H9 = IBT 29057 (T)	GU944558 GU944538 MN969263 JN606606
<i>Penicillium copiticolum</i>	Citrina	Copiticolum	CBS 127355 = IBT 30771 (T)	JN617685 JN606817 JN606553 JN606599
<i>Penicillium dokdoense</i>	Citrina	Copiticolum	CNUFC-DDS11-1 (T)	MG906868 MH243037 MH243031 -
<i>Penicillium euglaucum</i>	Citrina	Euglaucum	CBS 323.71 = IBT 30767 (T)	JN617699 JN606856 JN606564 JN606594
<i>Penicillium argentinense</i>	Citrina	Euglaucum	CBS 130371 = IBT 30761 (T)	JN831361 JN606815 JN606549 MN969105
<i>Penicillium gallaicum</i>	Citrina	Gallaica	CBS 167.81 = ATCC 42232 = LFM 5597 (T)	JN617690 JN606837 JN606548 JN606609
<i>Penicillium paxillium</i>	Citrina	Paxillorum	CBS 360.48 = ATCC 10480 = FRR 2008 = IMI 040226 = NRRL 2008 = QM 725 (T)	GU944577 JN606844 JN606566 JN606610
<i>Penicillium sanguifluum</i>	Citrina	Roseopurpurea	CBS 127082 = IBT 29041 = DTO 020-B7 (T)	JN617681 JN606819 JN606555 MN969135
<i>Penicillium roseopurpureum</i>	Citrina	Roseopurpurea	CBS 226.29 = ATCC 10492 = ATHUM2895 = FRR 2064 = IMI 040573 = MUCIL 28654 = MUCIL 29237 = NRRL 2064 = NRRL 2064A (T)	GU944605 JN606838 JN606556 JN606613
<i>Penicillium shearii</i>	Citrina	Sheariorum	CBS 290.48 = ATCC 10410 = IFO 6088 = IMI 039739 = IMI 039739iv = NRRL 715 = QM 1870 (T)	GU944606 JN606840 EU644068 JN121482
<i>Penicillium sumatraense</i>	Citrina	Sumatraensia	CBS 281.36. Ex-type: CBS 281.36 = DTO 022-F1 = NRRL 779 = FRR 779 (T)	GU944578 JN606639 MN968301 EF198541
<i>Penicillium wellingtonense</i>	Citrina	Westlingorum	CBS 130375 = DTO 076-C6 = IBT 23557 = DTO 76C6 (T)	JN617713 JN606670 MN968311 JN606616

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<i>Penicillium vancoverense</i>	Citrina	Westlingiorum	CBS 126323 = DTO 082-B8 = IBT 20700 (T)	JN617675 MN969307 MN969143
<i>Penicillium cryptum</i>	Crypta	Crypta	CBS 271.89 = DTO 122C9 = ATCC 60138 = IMI 296794 = NRRL 13460 (T)	KF303608 KF303628 JN121478
<i>Penicillium sexuale</i>	Crypta	Crypta	FMR 17380 = CBS 146939 (T)	LR655199 LR655203 LR655207
<i>Penicillium eremophilum</i>	Eremophila	Eremophila	IMI 313774 = CBS 123361 = ATCC 62925 (T)	KY709170 KY611931 KY611970
<i>Penicillium alutaceum</i>	Exlicaulis	Alutacea	CBS 317.67 = ATCC 18542 = FRR 1158 = IFO 31728 = IMI 136243 (T)	AF033454 KP016768 JN121489
<i>Penicillium decumbens</i>	Exlicaulis	Alutacea	CBS 230.81 = FRR 741 = IMI 190875 = MUCL 29107 = NRRL 741 (T)	AY157490 KP016782 JN406601
<i>Penicillium citreogrum</i>	Exlicaulis	Citreonigra	CBS 258.29 = ATCC 48736 = FRR 761 = IMI 092209 = LSHBP 20 = LSHBP 98 = MUCL 28048 = MUCL 29062 = MUCL 29116 = NRRL 761 (T)	EF198621 EF198628 JN121474
<i>Penicillium cherascens</i>	Exlicaulis	Citreonigra	DTO 189-A9 = NRRL 748 = ATCC 48693 = BIOURGE 90 = FRR 748 = IMI 92234 = QM 7555 = Thom 4733.34 (T)	JX141041 JX157405 MN969112
<i>Penicillium corylophilum</i>	Exlicaulis	Corylophila	CBS 312.48 = TCC9784 = ATHUM2890 = CECT 2270 = FRR 802 = IMI 039754 = MUCL 28671 = MUCL 29073 = MUCL 29131 = NRRL 802 = QM 7510 (T)	JX141042 KP016780 KP064631
<i>Penicillium cravenianum</i>	Exlicaulis	Corylophila	CBS 139138 = DAOMC 241082 = DTO 180-15 = CV 92 (T)	JX141076 JX157418 KP064636
<i>Penicillium erubescens</i>	Exlicaulis	Erubescencia	CBS 318.67 = ATCC 18544 = CSIR 1040 = FRR 814 = IFO 31734 = IMI 136204 = NRRL 6223 (T)	AF033464 AF033466 JN121490
<i>Penicillium vinaceum</i>	Exlicaulis	Erubescencia	CBS 389.48 = ATCC 10514 = FRR 739 = IMI 029189 = NRRL 739 = QM 6746 (T)	AF033461 HQ646575 HQ646586 JN406555
<i>Penicillium lapidosum</i>	Exlicaulis	Lapidoso	CBS 343.48 = ATCC 10462 = CCT4477 = IFO 6100 = IMI 039743 = NRRL 718 = QM 1928 (T)	KJ834465 FJ530984 JN121500
<i>Penicillium burgense</i>	Exlicaulis	Lapidoso	CBS 325.89 (T)	KC411736 KJ834437 KP016772 JN406572
<i>Penicillium restrictum</i>	Exlicaulis	Restricta	CBS 367.48 = ATCC 11257 = FRR 1748 = IMI 040228 = NRRL 1748 = QM 1962 (T)	AF033457 KJ834486 KP016803 JN121506
<i>Penicillium chalabudae</i>	Exlicaulis	Restricta	CBS 219.66 = ATCC 18322 = ATCC 18329 = FRR 3393 = VKM F-1037 (T)	KP016811 KP016748 KP064572
<i>Penicillium angustiporcatum</i>	Gracienta	Angustiporcata	CBS 202.84 (T)	KC411690 KJ834431 MN969235 JN406617
<i>Penicillium estinogenum</i>	Gracienta	Estinogena	CBS 329.59 = DTO 360-C8 = ATCC 18310 = CCRC 31557 = FAT1196 = FRR 3428 = IFO 6230 = IMI 068241 = QM 8149 = VKMF-274 (T)	MN969381 MN969255 -
<i>Penicillium gracilentum</i>	Gracienta	Gracienta	CBS 599.73 = ATCC 28047 = ATCC 48268 = FRR 1557 = IMI 216900 = NHL 6452 = DTO 095-D8 (T)	KJ834453 MN969260 JN121537
<i>Penicillium macrosclerotiorum</i>	Gracienta	Macrosclerotiorum	CBS 116871 = AS 3.6581 (T)	KJ834469 DQ911123 JN121432
<i>Penicillium apinei</i>	Gracienta	Macrosclerotiorum	CBS 142502 = URM 7591 (T)	MF278310 LT854641 LT882717 LT854650
<i>Penicillium griseolum</i>	Griseola	Griseola	CBS 277.58 = ATCC 18239 = FRR 2671 = IFO 8175 = IMI 071626 = LSHBB323 = NRRL 2671 = QM 7523 (T)	EF422848 EF506232 JN121480
<i>Penicillium inusitatum</i>	Inusitata	Inusitata	CBS 351.67 = ATCC 18622 = CSIR 1096 = FRR 1163 = IMI 136214 = NRRL 5810 (T)	KJ834458 MN969265 JN121503
<i>Penicillium daleae</i>	Lanata-Divariata	Dalearum	CBS 211.28 = DTO 105-F2 = ATCC 10435 = DSM 2449 = FRR 2025 = IFO 6087 = IFO 9072 = IMI 034910 = MUCL 29234 = NRRL 2025(T)	GU981583 MN969251 KF296427
<i>Penicillium rubriannulatum</i>	Lanata-Divariata	Dalearum	CGMCC 3.18804 = NN072456 = CBS 144641 (T)	KY495029 MN969336 KY495080
<i>Penicillium janthinellum</i>	Lanata-Divariata	Janthinella	CBS 340.48 = DTO 095-C3 = ATCC 10455 = IMI 040238 = NRRL 2016 = QM 6865 (T)	GU981585 MN969268 JN121497
<i>Penicillium ludwigii</i>	Lanata-Divariata	Janthinella	CBS 417.68 = DTO 094-D8 = DTO 264-19 = FRR 559 (T)	KF296409 MN969273 KF296435
<i>Penicillium oxalicum</i>	Lanata-Divariata	Oxalica	CBS 219.30 = ATCC 1126 = FRR 787 = IMI 192332 = MUCL 29047 = NRRL 787 = QM 7606 (T)	KF296462 MN969283 JN121456

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<i>Penicillium diatomitis</i>	Lanata-Divariata	Oxalica	CCF 3904 = MH 53 = CBS 140107 = IBT 30728 (T)	FJ430748	HE651133 LT970912 LJ797560
<i>Penicillium rolfii</i>	Lanata-Divariata	Rolfiorum	CBS 368.48 = DTO 106-H8 = ATCC 10491 = FRR 1078 = IFO 7735 = IMI 040029 = MUCL 29229 = NRRL 1078 = QM 1961 (T)	JN617705	GU981667 MN969294 KF296455
<i>Penicillium camponotum</i>	Lanata-Divariata	Rolfiorum	DAOMC 250557 = CBS 140982 = NBBR-2-1 = W 471 = KAS 2177 (T)	KT887855	KT887816 KT887777 MN969179
<i>Penicillium simplicissimum</i>	Lanata-Divariata	Simplicissima	CBS 372.48 = DTO 014-H2 = ATCC 10495 = FRR 902 = IFO 5762 = IMI 039816 = QM 1939 (T)	GU981588	GU981632 MN969297 JN121507
<i>Penicillium tanzanicum</i>	Lanata-Divariata	Simplicissima	DAOMC 250514 = CBS 140968 = DTO 410-D3 = 50.118 = KAS 1946 (T)	KT887841	KT887802 KT887763 MN969183
<i>Penicillium lassenii</i>	Lasseniorum	Lasseniorum	CBS 277.70 = DTO 95D6 = NRRL 5272 = ATCC 22054 = FRR 858 = IMI 148395 (T)	KF303648	KF303629 JN121481
<i>Penicillium ochrosalmonea</i>	Ochrosalmonea	Ochrosalmonea	CBS 489.66 = ATCC 18338 = CSIR 145 = IMI 116248ii = NRRL 35499 (T)	EF626961	EF506212 EF506257 JN121524
<i>Penicillium isariforme</i>	Ochrosalmonea	Ochrosalmonea	CBS 247.56 = ATCC 18425 = CCRC 31699 = IFO 6393 = IHEM 4376 = IMI 060371 = LSHBBB308 = MUCL 31191 = MUCL 31323 = NRRL 2638 = QM 1897 (T)	AF454077	KJ834459 MN969266 JN121470
<i>Penicillium magneliptisporum</i>	Paradoxa	Atramentosa	CBS 138225 = DTO 128-H8 (T)	KJ775686	KJ775179 KJ775413 MN969124
<i>Penicillium mexicanum</i>	Paradoxa	Atramentosa		KJ775685	KJ775178 KJ775412 MN969127
<i>Penicillium georgiense</i>	Ramigena	Georgiense		EF422852	EF506223 EF506239 KM089734
<i>Penicillium capsulatum</i>	Ramigena	Ramigena	CBS 132826 = NRRL 35509 = DTO 194-D3 (T)	MN968375	KP735539 JN406582
<i>Penicillium ramusculum</i>	Ramigena	Ramigena	CBS 301.48 = ATCC 10420 = DSM2210 = FRR 2056 = LFM 5120 = IMI 040576 = NRRL 2056 = QM 4869 = VKMF-445 (T)	AF033429	EU427269 EU427278 JN121472
<i>Penicillium adamantzoides</i>	Sclerotium	Adametziorum	CBS 251.56 = ATCC 12292 = FRR 3459 = IMI 063546 = IMUR478 = LSHBBB324 = NRRL 3459 = QM 7057 (T)	EF433765	JN686433 JN799642 JN686387 JN406578
<i>Penicillium angulare</i>	Sclerotium	Adametziorum	CBS 313.59 = ATCC 18306 = FAT1302 = IFO 6055 = IMI 068227 = NRRL 3405 = QM 7312 (T)	JN686433	KC773779 KC773804 JN406554
<i>Penicillium herquei</i>	Sclerotium	Herqueorum	CBS 130293 = IBT 27051 = NRRL 28157 (T)	AF125937	KC773779 KC773804 JN406554
<i>Penicillium verrucisporum</i>	Sclerotium	Herqueorum	CBS 336.48 = NRRL 1040 = ATCC 10118 = BIOURGE 452 = FRR 1040 = IFO 31747 = IMI 28809 = MUCL 29213 = NCTC 1721 = QM 1926 = Thom 4640.447 (T)	JN626101	JN625970 JN626013 JN121494
<i>Penicillium sclerotium</i>	Sclerotium	Sclerotium	CGMCC 3.18415 (T)	KX885069	KX885049 KX885059 KX885040
<i>Penicillium vanoranjei</i>	Sclerotium	Sclerotium	CBS 287.36 = ATCC 10494 = IFO 6105 = IMI 040569 = NRRL 2074 = QM 1938 = VKMF-353 (T)	JN626132	JN626001 JN626044 JN406585
<i>Penicillium stolkiae</i>	Stolkia	Stolkia	CBS 134406 (T)	KC695696	KC695686 KC695691 -
<i>Penicillium subarcticum</i>	Stolkia	Stolkia	CBS 315.67 = ATCC 18546 = CSIR 1041 = FRR 534 = IMI 136210 = NRRL 5816 (T)	AF033444	JN617717 AF481135 JN121488
<i>Penicillium taxi</i>	Thysanophora	Thysanophora	CBS 111719 = NRRL 31108 = UAMH 3897 (T)	AF481120	JN617716 AF481141 MN969139
<i>Penicillium hennebertii</i>	Thysanophora	Thysanophora	CBS 206.57 = ATCC 18484 = BBA 7480 = MUCL 11402 = QM 8153 (T)	KJ834517	KJ834495 MN969302 JN121454
<i>Penicillium aeris</i>	Torulomyces	Torulomyces	CBS 334.68 = ATCC 18741 = IMI 137644 = MUCL 21216 = VKMF-2999 (T)	KJ834507	KJ834454 MN969262 JN121493
<i>Penicillium wisconsinense</i>	Torulomyces	Torulomyces	CBS 135697 = DTO 207D4 (T)	KF303654	KF303614 KF303627 KF303681
<i>Aspergillus glaucus</i>	-	-	CBS 128279 = DTO 198-H7 = WSF 3132 (T)	KF303670	KF303624 KF303641 KF303706
<i>Hamigera avellanea</i>	-	-	CBS 516.65 = NRRL 116 = ATCC 16469 = IMI 211383 = LCP 64.1859 = Thom 5629.C = WB 116 (T)	EF652052	EF651887 EF651989 EF651934
			CBS 295.48 = ATCC 10414 = CECT 2265 = DSM 2208 = IMI 040230 = NRRL 1938 (T)	AF454075	EU021664 EU021682 EU021627

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