

Large-spored *Alternaria* pathogens in section *Porri* disentangled

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Abstract: The omnipresent fungal genus *Alternaria* was recently divided into 24 sections based on molecular and morphological data. *Alternaria* sect. *Porri* is the largest section, containing almost all *Alternaria* species with medium to large conidia and long beaks, some of which are important plant pathogens (e.g. *Alternaria porri*, *A. solani* and *A. tomatophila*). We constructed a multi-gene phylogeny on parts of the ITS, GAPDH, RPB2, TEF1 and Alt 1 gene regions, which, supplemented with morphological and cultural studies, forms the basis for species recognition in sect. *Porri*. Our data reveal 63 species, of which 10 are newly described in sect. *Porri*, and 27 species names are synonymised. The three known *Alternaria* pathogens causing early blight on tomato all cluster in one clade, and are synonymised under the older name, *A. linariae*. *Alternaria protenta*, a species formerly only known as pathogen on *Helianthus annuus*, is also reported to cause early blight of potato, together with *A. solani* and *A. grandis*. Two clades with isolates causing purple blotch of onion are confirmed as *A. allii* and *A. porri*, but the two species cannot adequately be distinguished based on the number of beaks and branches as suggested previously. This is also found among the pathogens of *Passifloraceae*, which are reduced from four to three species. In addition to the known pathogen of sweet potato, *A. bataticola*, three more species are delineated of which two are newly described. A new *Alternaria* section is also described, comprising two large-spored *Alternaria* species with concatenate conidia.

Key words: *Alternaria*, Early blight of potato, Early blight of tomato, Leaf and stem blight of sweet potato, Multi-gene phylogeny, Purple blotch of onion.

Taxonomic novelties: New species: *Alternaria alternariacida* Woudenb. & Crous, *A. carthamicola* Woudenb. & Crous, *A. catananches* Woudenb. & Crous, *A. citrullicola* Woudenb. & Crous, *A. conidiophora* Woudenb. & Crous, *A. deserticola* Woudenb. & Crous, *A. ipomoeae* M. Truter, Woudenb. & Crous, *A. neoipomoeae* M. Truter, Woudenb. & Crous, *A. paralinicola* Woudenb. & Crous, *A. sennae* Woudenb. & Crous; **New section in *Alternaria*:** sect. *Euphorbiicola* Woudenb. & Crous; **Typifications (basionyms): Epitypifications:** *Alternaria bataticola* W. Yamam., *Cercospora crassa* Sacc., *Macrosporium porri* Ellis, *M. ricini* Yoshii, *Sporidesmium scorzonerae* Aderh.; **Neotypification:** *Sporidesmium exitiosum* var. *dauci* J.G. Kühn.

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INTRODUCTION

Alternaria is an important fungal genus with a worldwide distribution. This hyphomycetous ascomycete with phaeodictyospores includes saprophytic, endophytic and pathogenic species, which can be plant pathogens, post-harvest pathogens or human pathogens (Thomma 2003). The genus *Alternaria* was recently divided into 24 sections (Woudenberg *et al.* 2013) based on molecular and morphological data, which followed the recent initiative to divide *Alternaria* into sections (Lawrence *et al.* 2013). *Alternaria* sect. *Porri* is the largest section, containing almost all *Alternaria* species with medium to large conidia and long beaks. Among them are some important plant pathogens, such as *Alternaria bataticola*, *A. porri*, *A. solani* and *A. tomatophila*. *Alternaria bataticola* causes leaf petiole and stem blight of sweet potato in tropical and sub-tropical regions. The disease is most severe in East and Central Africa, with yield losses of over 70 % reported (Osiru *et al.* 2007). *Alternaria porri* causes purple blotch of onion, a very destructive disease of onions worldwide. The disease causes a significant reduction in seed and bulb yield, with seed losses of up to 100 % (Abo-Elyousr *et al.* 2014). *Alternaria solani* is the causative agent of early blight of potato. This very common disease, which can be found in most potato-

growing countries, can cause considerable defoliation. The disease typically reduces yields by ~20 %, but yield reductions of up to 80 % have been reported (Horsfield *et al.* 2010). *Alternaria tomatophila* is known for causing early blight of tomato, attacking the leaves, stems and fruit. This airborne pathogen has spread worldwide, mainly affecting field crops. When left untreated the damage can result in plant defoliation in excess of 60 % (Zitter & Drennan 2005).

The identification of these species has been problematic for many years, with every large-spored *Alternaria* found on *Solanaceae* commonly being identified as *A. solani*. This assumption changed with the treatment of *Alternaria* species on *Solanaceae*, in which Simmons (2000) distinguished 22 *Alternaria* and *Nimbya* species on solanaceous hosts on the basis of morphology. On potato, Simmons described the large-spored, long-beaked species *A. grandis* and *A. solani*, while on tomato he described *A. tomatophila*, *A. cretica* and *A. subcylindrica*. The distinction between potato and tomato pathogens was supported by subsequent molecular studies and chemotaxonomy (Andersen *et al.* 2008, Rodrigues *et al.* 2010, Brun *et al.* 2013, Gannibal *et al.* 2014).

The taxonomy of *Alternaria* species on *Allium* is also confused. *Macrosporium porri* was first described as pathogen of *Allium*

(Cooke & Ellis 1879), followed by *Alternaria allii* (Nolla 1927). Both species were later synonymised (Angell 1929) and the name changed to *Alternaria porri* (Cifferi 1930). The name *A. allii* was resurrected by Simmons in his identification manual (2007) where he described five large-spored, long-beaked species from *Allium*, which he could distinguish based on morphology. Large-spored *Alternaria* from sweet potato were mostly identified as *A. bataticola*, even if the isolates from some studies (Osiru *et al.* 2008, Narayanin *et al.* 2010) showed morphological differences compared with the description of Simmons (2007).

In the present study we aim to use a molecular approach to delineate the medium- to large-spored *Alternaria* species with long beaks in sect. *Porri*. A multi-locus analysis based on five partial gene regions, the internal transcribed spacer regions 1 and 2 and intervening 5.8S nrDNA (ITS), glyceraldehyde-3-phosphate dehydrogenase (GAPDH), RNA polymerase second largest subunit (RPB2), translation elongation factor 1-alpha (TEF1) and the *Alternaria* major allergen gene (Alt a 1), was performed. All available ex-type and representative isolates of medium to large-spored, long-beaked species described in Simmons (2007) were included in this study. The present multi-locus analysis supplemented with morphological and cultural data forms the basis for species recognition in sect. *Porri*.

MATERIALS AND METHODS

Isolates

One hundred eighty-three *Alternaria* strains including 116 ex-type or representative strains present at the Centraalbureau voor Schimmelcultures (CBS), Utrecht, the Netherlands were included in this study (Table 1). With “representative isolate” we refer to the strains used to describe the species based on morphology in Simmons (2007). Freeze-dried strains were revived in 2 mL malt/peptone (50 % / 50 %) and subsequently transferred to oatmeal agar (OA, Crous *et al.* 2009). Strains stored in the liquid nitrogen collection of the CBS were transferred to OA directly from the -80°C storage.

PCR and sequencing

DNA extraction was performed using the UltraClean Microbial DNA isolation kit (Mobio laboratories, Carlsbad, CA, USA), according to the manufacturer's instructions. The ITS region was amplified with the primers V9G (de Hoog & Gerrits van den Ende 1998) and ITS4 (White *et al.* 1990), the GAPDH region with gpd1 and gpd2 (Berbee *et al.* 1999) the RPB2 region with RPB2–5F2 (Sung *et al.* 2007) and fRPB2–7cR (Liu *et al.* 1999), the TEF1 gene with the primers EF1-728F and EF1-986R (Carbone & Kohn 1999) or EF2 (O'Donnell *et al.* 1998) and the Alt a 1 region with the primers Alt-for and Alt-rev (Hong *et al.* 2005). The ITS, GAPDH, RPB2 and TEF1 PCRs were performed as described in Woudenberg *et al.* (2013). The reaction mixture for the Alt a 1 PCR consisted of 1 μL genomic DNA, 1 \times NH_4 reaction buffer (Biolone, Luckenwalde, Germany), 3 mM MgCl_2 , 20 μM of each dNTP, 0.2 μM of each primer and 0.25 U BIOTAQ DNA polymerase (Biolone). Conditions for PCR

amplification consisted of an initial denaturation step of 5 min at 94°C followed by 40 cycles of 30 s at 94°C , 30 s at 55°C and 60 s at 72°C and a final elongation step of 7 min at 72°C . The PCR products were sequenced in both directions using the PCR primers and the BigDye Terminator v. 3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, CA, USA), and analysed with an ABI Prism 3730XL Sequencer (Applied Biosystems) according to the manufacturer's instructions. Consensus sequences were computed from forward and reverse sequences using the BioNumerics v. 4.61 software package (Applied Maths, St-Martens-Latem, Belgium). All newly generated sequences were deposited in GenBank (Table 1).

Phylogenetic analysis

Multiple sequence alignments were generated with MAFFT v. 7 (<http://mafft.cbrc.jp/alignment/server/index.html>), and adjusted by eye where necessary. Bayesian inference and Maximum Likelihood analyses were performed on both the individual sequence datasets as well as the concatenated datasets as described in Woudenberg *et al.* (2013), with the sample frequency set to 1000 instead of 100 in the Bayesian analysis. For the TEF1 partition an online tool (<http://www.hiv.lanl.gov/content/sequence/findmodel/findmodel.html>) suggested the K2P model with a gamma-rate variation as nucleotide substitution model, and for the remaining four partitions the TrN model with gamma-distributed rate variation. Sequences from the type species of the phylogenetically closest section, sect. *Gypsophilae*, *A. gypsophilae* (Woudenberg *et al.* 2013), were used as outgroup. The resulting trees were printed with TreeView v. 1.6.6 (Page 1996) and the alignments and trees deposited into TreeBASE (<http://www.treebase.org>).

Taxonomy

Cultures were incubated on potato carrot agar (PCA, Crous *et al.* 2009) and synthetic nutrient-poor agar (SNA, Nirenberg 1976) plates at moderate temperatures ($\sim 22^{\circ}\text{C}$) under CoolWhite fluorescent light with an 8 h photoperiod. After 7 d the growth rates were measured and the colony characters noted. Colony colours were rated according to Rayner (1970). Morphological descriptions were made for isolates grown on SNA with a small piece of autoclaved filter paper placed onto the agar surface to enhance sporulation. When sporulation occurred, the sellotape technique was used for making slide preparations (Schubert *et al.* 2007) with Titan Ultra Clear Tape (Conglom Inc., Toronto, Canada) and Shear's medium as mounting fluid. The 95 % confidence intervals were derived from measurements of 30 structures, with extremes given in parentheses. Photographs of characteristic structures were made with a Nikon Eclipse 80i microscope equipped with a Nikon digital sight DS-Fi1 high definition colour camera, using differential interference contrast (DIC) illumination and the Nikon software NIS-Elements D v. 3.00. Adobe Bridge CS5.1 and Adobe Photoshop CS5 Extended, v. 12.1, were used for the final editing and photographic preparation. Colonies which did not sporulate after 7 d were checked for sporulation up to 3 wk; after this period they were noted as sterile. Nomenclatural data were deposited in MycoBank (Crous *et al.* 2004).

Table 1. Isolates used in this study and their GenBank accession numbers. Bold accession numbers were generated in other studies.

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria acalyphicola</i>		CBS 541.94; E.G.S. 38.100; IMI 266969	T	<i>Acalypha indica</i>	Seychelles	KJ718097	KJ717952	KJ718617	KJ718446	KJ718271
<i>Alternaria agerati</i>		CBS 117221; E.G.S. 30.001; QM 9369	R	<i>Ageratum houstonianum</i>	USA, Illinois	KJ718098	KJ717953	KJ718618	KJ718447	KJ718272
<i>Alternaria agripestis</i>		CBS 577.94; E.G.S. 41.034	T	<i>Euphorbia esula</i> , stem lesion	Canada, Saskatchewan	KJ718099	JQ646356	KJ718619	KJ718448	KJ718273
<i>Alternaria allii</i>	<i>Alternaria porri</i>	CBS 107.28; E.G.S. 48.084	T	<i>Allium cepa</i> , leaf spot	Puerto Rico	KJ718100	KJ717954	KJ718620	KJ718449	KJ718274
	<i>Alternaria porri</i>	CBS 109.41; CBS 114.38		<i>Allium cepa</i> , seed	Denmark	KJ718101	KJ717955	KJ718621	KJ718450	KJ718275
	<i>Alternaria porri</i>	CBS 225.76		<i>Allium porrum</i> , leaf	Italy	KJ718102	KJ717956	KJ718622	KJ718451	KJ718276
		CBS 116701; E.G.S. 33.134	R	<i>Allium cepa</i> var. <i>viviparum</i> , floral bract	USA, Massachusetts	KJ718103	KJ717957	KJ718623	KJ718452	KJ718277
	<i>Alternaria vanuatuensis</i>	CBS 121345; E.G.S. 45.018	(T)	<i>Allium cepa</i> , leaf	Vanuatu	KJ718104	KJ717958	KJ718624	KJ718453	KJ718278
<i>Alternaria alternarioides</i> sp. nov.	<i>Alternaria solani</i>	CBS 105.51; ATCC 11078; IMI 46816; CECT 2997	T	<i>Solanum lycopersicum</i> , fruit	UK, England	KJ718105	KJ717959	KJ718625	KJ718454	KJ718279
<i>Alternaria anagallidis</i>		CBS 107.44		<i>Anagallis arvensis</i> , leaf spot	Denmark, Copenhagen	KJ718106	JQ646338	KJ718626	EU130544	KJ718280
		CBS 101004		<i>Anagallis arvensis</i> , leaf spot	New Zealand, Auckland	KJ718107	KJ717960	KJ718627	KJ718455	KJ718281
		CBS 117128; E.G.S. 42.074	R	<i>Anagallis arvensis</i> , leaf spot	New Zealand, Auckland	KJ718108	KJ717961	KJ718628	KJ718456	KJ718282
		CBS 117129; E.G.S. 50.091	R	<i>Anagallis arvensis</i> , leaf spot	New Zealand, Auckland	KJ718109	KJ717962	KJ718629	KJ718457	KJ718283
<i>Alternaria anodae</i>		PPRI 12376		<i>Anoda cristata</i> , leaf	South Africa, Gauteng	KJ718110	KJ717963	KJ718630	KJ718458	KJ718284
<i>Alternaria aragakii</i>		CBS 594.93; E.G.S. 29.016; QM 9046	T	<i>Passiflora edulis</i>	USA, Hawaii	KJ718111	KJ717964	KJ718631	KJ718459	KJ718285
<i>Alternaria argyroxiphii</i>		CBS 117222; E.G.S. 35.122	T	<i>Argyroxiphium</i> sp.	USA, Hawaii	KJ718112	JQ646350	KJ718632	KJ718460	KJ718286
		PPRI 11848		<i>Ipomoea batatas</i> , stem lesion	South Africa, Gauteng	KJ718113	KJ717965	KJ718633	KJ718461	KJ718287
		PPRI 11971		<i>Ipomoea batatas</i> , leaf and stem lesion	South Africa, Mpumalanga	KJ718114	KJ717966	KJ718634	KJ718462	KJ718288
<i>Alternaria azadirachtae</i>		CBS 116444; E.G.S. 46.195; BRIP 25386(ss1)	T	<i>Azadirachta indica</i> , leaf spot	Australia, Queensland	KJ718115	KJ717967	KJ718635	KJ718463	KJ718289
		CBS 116445; E.G.S. 46.196; BRIP 25386(ss2)	R	<i>Azadirachta indica</i> , leaf spot	Australia, Queensland	KJ718116	KJ717968	KJ718636	KJ718464	KJ718290

(continued on next page)

Table 1. (Continued).

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria bataticola</i>		CBS 531.63; IFO 6187; MUCL 28916 CBS 532.63	T	<i>Ipomoea batatas</i>	Japan	KJ718117	JQ646349	JQ646433	KJ718465	KJ718291
				<i>Ipomoea batatas</i>	Japan, Tokyo	KJ718118	KJ717969	KJ718637	KJ718466	KJ718292
		CBS 117095; E.G.S. 42.157; IMI 350492; BRIP 19470a	R	<i>Ipomoea batatas</i> , leaf spot	Australia, Queensland	KJ718119	KJ717970	KJ718638	KJ718467	KJ718293
		CBS 117096; E.G.S. 42.158; BRIP 19470b	R	<i>Ipomoea batatas</i> , leaf spot	Australia, Queensland	KJ718120	KJ717971	KJ718639	KJ718468	KJ718294
		PPRI 10502		<i>Ipomoea batatas</i> , leaf and stem lesion	South Africa, Gauteng	KJ718121	KJ717972	KJ718640	KJ718469	KJ718295
		PPRI 11930		<i>Ipomoea batatas</i> , leaf lesion	South Africa, Kwazulu-Natal	KJ718122	KJ717973	KJ718641	KJ718470	KJ718296
		PPRI 11931		<i>Ipomoea batatas</i> , leaf lesion	South Africa, Kwazulu-Natal	KJ718123	KJ717974	KJ718642	KJ718471	KJ718297
		PPRI 11934		<i>Ipomoea batatas</i> , leaf lesion	South Africa, Gauteng	KJ718124	KJ717975	KJ718643	KJ718472	KJ718298
<i>Alternaria blumeae</i>	<i>Alternaria brasiliensis</i>	CBS 117215; E.G.S. 39.116	(R)	<i>Phaseolus vulgaris</i> , leaf spot	Brazil, Esperito Santo	KJ718125	KJ717976	KJ718644	KJ718473	KJ718299
		CBS 117364; E.G.S. 40.149; ATCC 201357	T	<i>Blumea aurita</i>	Thailand, Yala Province	KJ718126	AY562405	AY563291	KJ718474	KJ718300
<i>Alternaria calendulae</i>		CBS 224.76; ATCC 38903; DSM 63161; IMI 205077 CBS 101498	T	<i>Calendula officinalis</i> , leaf spot	Germany	KJ718127	KJ717977	KJ718648	KJ718475	KJ718301
				<i>Calendula officinalis</i> , leaf	New Zealand, Auckland	KJ718128	KJ717978	KJ718645	KJ718476	KJ718302
	<i>Alternaria rosifolii</i>	CBS 116439; E.G.S. 42.197	(T)	<i>Rosa</i> sp., leaf spot	New Zealand, Auckland	KJ718129	KJ717979	KJ718646	KJ718477	KJ718303
		CBS 116650; E.G.S. 30.142; QM 9561	R	<i>Calendula officinalis</i> , leaf spot	Japan, Tokyo	KJ718130	KJ717980	KJ718647	KJ718478	KJ718304
<i>Alternaria carthami</i>		CBS 635.80		<i>Carthamus tinctorius</i> , leaf	Italy, Perugia	KJ718131	KJ717981	KJ718649	KJ718479	KJ718305
	<i>Alternaria heliophytonis</i>	CBS 116440; E.G.S. 43.143; IMI 366164	(T)	<i>Helianthus annuus</i> , leaf	Canada, Saskatchewan	KJ718132	KJ717982	KJ718650	KJ718480	KJ718306
		CBS 117091; E.G.S. 31.037	R	<i>Carthamus tinctorius</i> , leaf spot	USA, Montana	KJ718133	KJ717983	KJ718651	KJ718481	KJ718307
<i>Alternaria carthamicola</i>	<i>Alternaria carthami</i>	CBS 117092; E.G.S. 37.057; IMI 276943	(R)T	<i>Carthamus tinctorius</i>	Iraq	KJ718134	KJ717984	KJ718652	KJ718482	KJ718308
<i>Alternaria cassiae</i>		CBS 478.81; E.G.S. 33.147	R	<i>Senna obtusifolia</i> , diseased seedling	USA, Mississippi	KJ718135	KJ717985	KJ718653	KJ718483	KJ718309
	<i>Alternaria sauropodis</i>	CBS 116119; E.G.S. 47.112; IMI 286317; IMI 392448	(T)	<i>Sauropus androgynus</i>	Malaysia, Sarawak	KJ718136	KJ717986	KJ718654	KJ718484	KJ718310
		CBS 117224; E.G.S. 40.121	R	<i>Senna obtusifolia</i> , leaf spot	Brazil, Federal District	KJ718137	KJ717987	KJ718655	KJ718485	KJ718311
	<i>Alternaria hibiscificiens</i>	CBS 117369; E.G.S. 50.166	(T)	<i>Hibiscus sabdariffa</i> , leaf	Fiji	KJ718138	KJ717988	KJ718656	KJ718486	KJ718312
<i>Alternaria catananches</i> sp. nov.		CBS 137456; PD 013/05703936	T	<i>Catananche caerulea</i>	Netherlands	KJ718139	KJ717989	KJ718657	KJ718487	KJ718313

Table 1. (Continued).

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria centaureae</i>		CBS 116446; E.G.S. 47.119	T	<i>Centaurea solstitialis</i> , leaf spot	USA, California	KJ718140	KJ717990	KJ718658	KJ718488	KJ718314
<i>Alternaria cichorii</i>		CBS 102.33; E.G.S. 07.017; QM 1760	T	<i>Cichorium intybus</i> , leaf spot	Cyprus	KJ718141	KJ717991	KJ718659	KJ718489	KJ718315
		CBS 117218; E.G.S. 52.046; IMI 225641	R	<i>Cichorium endivia</i>	Greece	KJ718142	KJ717992	KJ718660	KJ718490	KJ718316
<i>Alternaria cirsinoxia</i>		CBS 113261; E.G.S. 41.136	T	<i>Cirsium arvense</i> , stem lesion	Canada, Saskatchewan	KJ718143	KJ717993	KJ718661	KJ718491	KJ718317
<i>Alternaria citrullicola</i> sp. nov.	<i>Alternaria cucumerina</i>	CBS 103.32; VKM F-1881; Natrass No. 190	T	<i>Citrullus vulgaris</i> , fruit	Cyprus	KJ718144	KJ717994	KJ718662	KJ718492	KJ718318
<i>Alternaria conidiophora</i> sp. nov.		CBS 137457	T	–	Netherlands	KJ718145	KJ717995	KJ718663	KJ718493	–
<i>Alternaria crassa</i>		CBS 103.18		<i>Datura</i> sp., leaf spot	USA, Wisconsin	KJ718146	KJ717996	KJ718664	KJ718494	KJ718319
		CBS 110.38	T	<i>Datura stramonium</i> , leaf spot	Cyprus	KJ718147	KJ717997	KJ718665	KJ718495	KJ718320
	<i>Alternaria capsici</i>	CBS 109160; E.G.S. 45.075; IMI 262408; IMI 381021	(T)	<i>Capsicum annuum</i>	Australia	KJ718148	AY562408	AY563298	KJ718496	KJ718321
		CBS 109162; E.G.S. 46.014		<i>Nicandra physalodes</i>	USA, Indiana	KJ718149	GQ180073	GQ180089	KJ718497	KJ718322
		CBS 116647; E.G.S. 46.013	R	<i>Datura stramonium</i> , leaf spot	USA, Indiana	KJ718150	KJ717998	KJ718666	KJ718498	KJ718323
		CBS 116648; E.G.S. 50.180	R	<i>Datura stramonium</i> , leaf spot	New Zealand, Auckland	KJ718151	KJ717999	KJ718667	KJ718499	KJ718324
		CBS 122590; E.G.S. 44.071	R	<i>Datura stramonium</i> , leaf spot	USA, Indiana	KJ718152	GQ180072	GQ180088	KJ718500	KJ718325
<i>Alternaria cucumerina</i>	<i>Alternaria loofahae</i>	CBS 116114; E.G.S. 35.123	(T)	<i>Luffa acutangula</i>	USA, Hawaii	KJ718153	KJ718000	KJ718668	KJ718501	KJ718326
		CBS 117225; E.G.S. 41.127	R	<i>Cucumis melo</i> , leaf spot	USA, Indiana	KJ718154	KJ718001	KJ718669	KJ718502	KJ718327
		CBS 117226; E.G.S. 44.197; BRIP 23060	R	<i>Cucumis melo</i> , leaf spot	Australia, Queensland	KJ718155	KJ718002	KJ718670	KJ718503	KJ718328
<i>Alternaria cyamopsidis</i>		CBS 364.67; E.G.S. 17.065; QM 8575	R	<i>Cyamopsis tetragonoloba</i> , leaf spot	USA, Maryland	KJ718156	KJ718003	KJ718671	KJ718504	KJ718329
		CBS 117219; E.G.S. 13.120; QM 8000	R	<i>Cyamopsis tetragonoloba</i> , leaf spot	USA, Georgia	KJ718157	KJ718004	KJ718672	KJ718505	KJ718330
<i>Alternaria dauci</i>		CBS 111.38	T	<i>Daucus carota</i> , seed	Italy	KJ718158	KJ718005	KJ718673	KJ718506	KJ718331
		CBS 106.48		<i>Daucus carota</i> , seed	–	KJ718159	KJ718006	KJ718674	KJ718507	KJ718332
		CBS 345.79; LEV 14814		<i>Daucus carota</i> , leaf spot	New Zealand, Ohakune	KJ718160	KJ718007	KJ718675	KJ718508	KJ718333
	<i>Alternaria cichorii</i>	CBS 477.83; CBS 721.79; PD 79/954		<i>Cichorium intybus</i> var. <i>foliosum</i> , leaf spot	Netherlands, Limburg	KJ718161	KJ718008	KJ718676	KJ718509	KJ718334
		CBS 101592		<i>Daucus carota</i> , seed	Netherlands	KJ718162	KJ718009	KJ718677	KJ718510	KJ718335
		CBS 117097; E.G.S. 46.006	R	<i>Daucus carota</i> , commercial seed	USA, California	KC584192	KC584111	KJ718678	KC584651	KC584392
		CBS 117098; E.G.S. 46.152	R	<i>Daucus carota</i> , leaf spot	New Zealand	KJ718163	KJ718010	HE796726	KJ718511	KJ718336
		CBS 117099; E.G.S. 47.131	R	<i>Daucus carota</i> , seed	USA, California	KJ718164	KJ718011	KJ718679	KJ718512	KJ718337
	<i>Alternaria poonensis</i>	CBS 117100; E.G.S. 47.138	(R)	<i>Coriandrum sativum</i> , seedling	Puerto Rico	KJ718165	JQ646348	KJ718680	KJ718513	KJ718338

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Table 1. (Continued).

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria deserticola</i> sp. nov.	<i>Alternaria acalyphicola</i>	CBS 110799	T	desert soil	Namibia	KJ718249	KJ718077	KJ718755	KJ718595	KJ718424
<i>Alternaria dichondrae</i>		CBS 199.74; E.G.S. 38.007	T	<i>Dichondra repens</i> , leaf spot	Italy	KJ718166	JQ646357	JQ646441	KJ718514	KJ718339
		CBS 200.74; E.G.S. 38.008	T	<i>Dichondra repens</i> , leaf spot	Italy	KJ718167	KJ718012	KJ718681	KJ718515	KJ718340
		CBS 346.79		<i>Dichondra repens</i> , leaf spot	New Zealand	KJ718168	KJ718013	KJ718682	KJ718516	KJ718341
		CBS 117127; E.G.S. 40.057	R	<i>Dichondra</i> sp., leaf	New Zealand, Auckland	KJ718169	KJ718014	KJ718683	KJ718517	KJ718342
<i>Alternaria echinaceae</i>		CBS 116117; E.G.S. 46.081	T	<i>Echinacea</i> sp., leaf lesion	New Zealand, Gisborne	KJ718170	KJ718015	KJ718684	KJ718518	KJ718343
		CBS 116118; E.G.S. 46.082	R	<i>Echinacea</i> sp., leaf lesion	New Zealand, Gisborne	KJ718171	KJ718016	KJ718685	KJ718519	KJ718344
<i>Alternaria grandis</i>		CBS 109158; E.G.S. 44.106	T	<i>Solanum tuberosum</i> , leaf spot	USA, Pennsylvania	KJ718239	JQ646341	JQ646425	EU130547	KJ718414
		CBS 116695; E.G.S. 44.108	R	<i>Solanum tuberosum</i> , leaf spot	USA, Pennsylvania	KJ718241	KJ718070	KJ718748	KJ718587	KJ718416
<i>Alternaria euphorbiicola</i>		CBS 198.86; E.G.S. 38.082		<i>Euphorbia pulcherrima</i>	USA, Florida	KJ718172	KJ718017	KJ718686	KJ718520	KJ718345
		CBS 119410; E.G.S. 41.029	R	<i>Euphorbia pulcherrima</i>	USA, Hawaii	KJ718173	KJ718018	–	KJ718521	KJ718346
		CBS 133874; E.G.S. 38.191		<i>Euphorbia hyssopifolia</i>	USA, Louisiana	KJ718174	KJ718019	KJ718687	KJ718522	KJ718347
<i>Alternaria gypsophilae</i>		CBS 107.41; E.G.S. 07.025; IMI 264349	T	<i>Gypsophila elegans</i> , seed	Netherlands	KC584199	KC584118	KJ718688	KC584660	KC584401
<i>Alternaria ipomoeae</i> sp. nov.	<i>Alternaria cucumerina</i>	CBS 219.79	T	<i>Ipomoea batatas</i> , stem and petiole	Ethiopia	KJ718175	KJ718020	KJ718689	KJ718523	KJ718348
		PPRI 8988		<i>Ipomoea batatas</i> , stem	South Africa, Gauteng	KJ718176	KJ718021	KJ718690	KJ718524	KJ718349
<i>Alternaria jesenskiae</i>		CBS 133855; CCM 8361	T	<i>Fumana procumbens</i> , seed	Slovakia	KJ718177	KJ718022	KJ718691	KJ718525	KJ718350
<i>Alternaria limicola</i>		CBS 483.90; E.G.S. 39.070	T	<i>Citrus aurantiifolia</i> , leaf spot	Mexico, Colima	KJ718178	JQ646329	JQ646413	KJ718526	KJ718351
		CBS 117360; E.G.S. 43.009	R	<i>Citrus</i> sp.	Mexico, Jalisco	KJ718179	KJ718023	–	KJ718527	KJ718352
<i>Alternaria linariae</i>		CBS 105.41; E.G.S. 07.016	T	<i>Linaria maroccana</i> , seedling	Denmark	KJ718180	KJ718024	KJ718692	KJ718528	KJ718353
	<i>Alternaria solani</i>	CBS 108.53		–	–	KJ718181	KJ718025	KJ718693	KJ718529	KJ718354
	<i>Alternaria solani</i>	CBS 107.61		–	Belgium	KJ718182	KJ718026	KJ718694	KJ718530	KJ718355
	<i>Alternaria tomatophila</i>	CBS 109156; E.G.S. 42.156	(T)	<i>Solanum lycopersicum</i> , leaf spot	USA, Indiana	KJ718183	JQ646347	GQ180101	KJ718531	KJ718356
	<i>Alternaria subcylindrica</i>	CBS 109161; E.G.S. 45.113	(T)	<i>Solanum lycopersicum</i> var. <i>cerasiforme</i> , leaf spot	USA, Louisiana	KJ718184	JQ646345	JQ646429	KJ718532	KJ718357
	<i>Alternaria cretica</i>	CBS 109164; E.G.S. 46.188	(T)	<i>Solanum lycopersicum</i> , leaf spot	Greece, Crete	KJ718185	JQ646342	JQ646426	EU130545	KJ718358
	<i>Alternaria cucumericola</i>	CBS 116438; E.G.S. 41.057	(T)	<i>Cucumis sativus</i> , leaf spot	New Zealand	KJ718186	KJ718027	KJ718695	KJ718533	KJ718359
	<i>Alternaria tabasco</i>	CBS 116441; E.G.S. 45.108	(T)	<i>Capsicum frutescens</i> , leaf spot	USA, Louisiana	KJ718187	KJ718028	KJ718696	KJ718534	KJ718360
	<i>Alternaria tomatophila</i>	CBS 116704; E.G.S. 44.074	(R)	<i>Solanum lycopersicum</i> , leaf spot	USA, Indiana	KJ718188	KJ718029	KJ718697	KJ718535	KJ718361
		CPC 21620		<i>Solanum lycopersicum</i> , leaf spot	Thailand, Chiang Mai	KJ718189	KJ718030	KJ718698	KJ718536	KJ718362

Table 1. (Continued).

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria macrospora</i>	<i>Alternaria porri</i>	CBS 106.29		<i>Gossypium</i> sp.	Nigeria	KJ718193	KJ718032	KJ718701	KJ718540	KJ718366
		CBS 117228; E.G.S. 50.190; ATCC 58172	T	<i>Gossypium barbadense</i>	USA, Arizona	KC584204	KC584124	KJ718702	KC584668	KC584410
<i>Alternaria montanica</i>		CBS 121343; E.G.S. 44.112; IMI 257563	T	<i>Cirsium arvense</i>	USA, Montana	KJ718194	KJ718033	KJ718703	KJ718541	KJ718367
<i>Alternaria multirostrata</i>		CBS 712.68; ATCC 18515; IMI 135454; MUCL 11722; QM 8820; VKM F-2997	T	<i>Richardia scabra</i> , floral bract	USA, Georgia	KJ718195	JQ646362	KJ718704	EU130546	KJ718368
		CBS 713.68; ATCC 18517; IMI 135455; MUCL 11715; QM 8821	R	<i>Richardia scabra</i> , floral bract	USA, Georgia	KJ718196	KJ718034	KJ718705	KJ718542	KJ718369
<i>Alternaria neoipomoeae</i> sp. nov.		PPRI 8990		<i>Ipomoea batatas</i>	South Africa, North West	KJ718197	KJ718035	KJ718706	KJ718543	KJ718370
		PPRI 11845	T	<i>Ipomoea batatas</i> , stem	South Africa, Gauteng	KJ718198	KJ718036	KJ718707	KJ718544	KJ718371
		PPRI 11847		<i>Ipomoea batatas</i>	South Africa, Mpumalanga	KJ718199	KJ718037	KJ718708	KJ718545	KJ718372
		PPRI 13903		<i>Ipomoea batatas</i> , leaf lesion	South Africa, Gauteng	KJ718200	KJ718038	KJ718709	KJ718546	KJ718373
<i>Alternaria nitrimali</i>		CBS 109163; E.G.S. 46.151	T	<i>Solanum viarum</i> , leaf spot	Puerto Rico	KJ718201	JQ646358	KJ718710	KJ718547	KJ718374
<i>Alternaria novae-guineensis</i>		CBS 116120; E.G.S. 47.198	T	<i>Citrus</i> sp., dry leaf	Papua New Guinea	KJ718202	KJ718039	KJ718711	KJ718548	KJ718375
		PPRI 12171		<i>Galinsoga parviflora</i> , leaf	South Africa, Gauteng	KJ718203	KJ718040	KJ718712	KJ718549	KJ718376
<i>Alternaria obtecta</i>		CBS 117367; E.G.S. 42.063	R	<i>Euphorbia pulcherrima</i> , leaf	USA, California	KJ718204	KJ718041	KJ718713	KJ718550	KJ718377
		CBS 134278; E.G.S. 42.064		<i>Euphorbia pulcherrima</i>	USA, California	KJ718205	KJ718042	KJ718714	KJ718551	KJ718378
<i>Alternaria paralinicola</i> sp. nov.	<i>Alternaria linicola</i>	CBS 116652; E.G.S. 47.157; DAOM 225747	(R)T	<i>Linum usitatissimum</i> , seed	Canada, Manitoba	KJ718206	KJ718043	KJ718715	KJ718552	KJ718379
<i>Alternaria passiflorae</i>		CBS 113.38		<i>Passiflora edulis</i>	Australia, South Queensland	KJ718207	JQ646353	JQ646437	KJ718553	KJ718380
	<i>Alternaria solani</i>	CBS 166.77		<i>Capsicum frutescens</i> , leaf	New Zealand, Waitakere	KJ718208	KJ718044	KJ718716	KJ718554	KJ718381
		CBS 629.93; E.G.S. 16.150; QM 8458	R	<i>Passiflora edulis</i> , fruit	New Zealand	KJ718209	KJ718045	KJ718717	KJ718555	KJ718382
	<i>Alternaria hawaiiensis</i>	CBS 630.93; E.G.S. 29.020; QM 9050	(T)	<i>Passiflora edulis</i>	USA, Hawaii	KJ718210	JQ646352	KJ718718	KJ718556	KJ718383
	<i>Alternaria gaurae</i>	CBS 116333; E.G.S. 50.121	(T)	<i>Gaura lindheimeri</i> , leaf	New Zealand, Auckland	KJ718211	KJ718046	KJ718719	KJ718557	KJ718384
		CBS 117102; E.G.S. 51.165	R	<i>Passiflora ligularis</i> , fruit spot	New Zealand, Auckland	KJ718212	KJ718047	KJ718720	KJ718558	KJ718385
		CBS 117103; E.G.S. 52.032	R	<i>Passiflora caerulea</i> , leaf spot	New Zealand, Auckland	KJ718213	KJ718048	KJ718721	KJ718559	KJ718386
<i>Alternaria pipionipisi</i>		CBS 116115; E.G.S. 40.096; IMI 340950	T	<i>Cajanus cajan</i> , seed	India	KJ718214	KJ718049	KJ718722	KJ718560	KJ718387
	<i>Alternaria obtecta</i>	CBS 117365; E.G.S. 42.048	(R)	<i>Euphorbia pulcherrima</i> , leaf	USA, California	KJ718215	KJ718050	KJ718723	KJ718561	KJ718388
	<i>Alternaria obtecta</i>	CBS 134265; E.G.S. 42.047		<i>Euphorbia pulcherrima</i>	USA, California	KJ718216	KJ718051	KJ718724	KJ718562	KJ718389

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Table 1. (Continued).

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria porri</i>	<i>Alternaria allii</i>	CBS 116649; E.G.S. 17.082; QM 8613	(R)	<i>Allium cepa</i> , leaf	USA, Nebraska	KJ718217	KJ718052	KJ718725	KJ718563	KJ718390
		CBS 116698; E.G.S. 48.147	R	<i>Allium cepa</i> , leaf spot	USA, New York	DQ323700	KC584132	KJ718726	KC584679	KC584421
		CBS 116699; E.G.S. 48.152	R,T	<i>Allium cepa</i> , leaf spot	USA, New York	KJ718218	KJ718053	KJ718727	KJ718564	KJ718391
<i>Alternaria protenta</i>	<i>Alternaria solani</i>	CBS 347.79; E.G.S. 44.091; LEV 14726; ATCC 38569		<i>Solanum lycopersicum</i> , fruit rot	New Zealand, Levin	KJ718219	KJ718054	KJ718728	KJ718565	KJ718392
		CBS 116437; E.G.S. 32.076	(T)	<i>Hordeum vulgare</i> , seed	New Zealand	KJ718220	KJ718055	KJ718729	KJ718566	KJ718393
	<i>Alternaria solani</i>	CBS 116651; E.G.S. 45.020	(R)	<i>Solanum tuberosum</i> , tuber	USA, California	KC584217	KC584139	GQ180097	KC584688	KC584430
		CBS 116696; E.G.S. 45.023; IMI 372955	R	<i>Helianthus annuus</i> , leaf spot	Israel	KJ718221	JQ646335	JQ646419	KJ718567	KJ718394
	<i>Alternaria pulcherrimae</i>	CBS 116697; E.G.S. 45.024; IMI 372957	R	<i>Helianthus annuus</i> , leaf spot	Israel	KJ718222	KJ718056	KJ718730	KJ718568	KJ718395
		CBS 121342; E.G.S. 42.122; IMI 310506	(R)	<i>Euphorbia pulcherrima</i>	Australia, Queensland	KJ718223	KJ718057	KJ718731	KJ718569	KJ718396
	<i>Alternaria solani</i>	CBS 135189; E.G.S. 45.053	(R)	<i>Solanum tuberosum</i>	New Zealand, Hastings	KJ718224	GQ180082	GQ180098	KJ718570	KJ718397
<i>Alternaria pseudorostrata</i>		CBS 119411; E.G.S. 42.060	T	<i>Euphorbia pulcherrima</i>	USA, California	JN383483	AY562406	AY563295	KC584680	KC584422
<i>Alternaria ranunculi</i>		CBS 116330; E.G.S. 38.039; IMI 285697	T	<i>Ranunculus asiaticus</i> , seed	Israel	KJ718225	KJ718058	KJ718732	KJ718571	KJ718398
<i>Alternaria ricini</i>		CBS 215.31	T	<i>Ricinus communis</i>	Japan	KJ718226	KJ718059	KJ718733	KJ718572	KJ718399
		CBS 353.86		<i>Ricinus communis</i>	Italy, Sardinia	KJ718227	JQ646331	KJ718734	KJ718573	KJ718400
		CBS 117361; E.G.S. 06.181	R	<i>Ricinus communis</i>	USA, Virginia	KJ718228	KJ718060	KJ718735	KJ718574	KJ718401
<i>Alternaria rostellata</i>		CBS 117366; E.G.S. 42.061	T	<i>Euphorbia pulcherrima</i> , leaf	USA, California	KJ718229	JQ646332	KJ718736	KJ718575	KJ718402
<i>Alternaria scorzonerae</i>	<i>Alternaria linicola</i>	CBS 103.46; Elliot No. 45-190C		<i>Linum usitatissimum</i>	UK, Scotland	KJ718190	JQ646363	JQ646447	KJ718537	KJ718363
		CBS 478.83; E.G.S. 38.011	R,T	<i>Scorzonera hispanica</i> , leaf spot	Netherlands, Reusel	KJ718191	JQ646334	KJ718699	KJ718538	KJ718364
	<i>Alternaria linicola</i>	CBS 116703; E.G.S. 36.110; IMI 274549	(R)	<i>Linum usitatissimum</i> , seed	UK, Derbyshire	KJ718192	KJ718031	KJ718700	KJ718539	KJ718365
<i>Alternaria sennae</i> sp. nov.	<i>Alternaria cassiae</i>	CBS 477.81; E.G.S. 34.030; IMI 257253	(R)T	<i>Senna corymbosa</i> , leaf	India, Uttar Pradesh	KJ718230	JQ646344	JQ646428	EU130543	KJ718403
<i>Alternaria sesami</i>		CBS 240.73		<i>Sesamum indicum</i>	Egypt	KJ718231	JQ646343	KJ718737	KJ718576	KJ718404
		CBS 115264; CBS 117214; E.G.S. 13.027	R	<i>Sesamum indicum</i> , seedling	India	JF780939	KJ718061	KJ718738	KJ718577	KJ718405
<i>Alternaria sidae</i>		CBS 117730; E.G.S. 12.129	T	<i>Sida fallax</i> , leaf spot	Kiribati, Phoenix Islands	KJ718232	KJ718062	KJ718739	KJ718578	KJ718406
<i>Alternaria silybi</i>		CBS 134092; VKM F-4109	T	<i>Silybum marianum</i> , leaf	Russia, Vladivostok	KJ718233	KJ718063	KJ718740	KJ718579	KJ718407
		CBS 134093; VKM F-4117		<i>Silybum marianum</i> , leaf	Russia, Vladivostok	KJ718234	KJ718064	KJ718741	KJ718580	KJ718408
		CBS 134094; VKM F-4118		<i>Silybum marianum</i> , leaf	Russia, Vladivostok	KJ718235	KJ718065	KJ718742	KJ718581	KJ718409

Table 1. (Continued).

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria solani</i>		CBS 106.21		–	–	KJ718236	KJ718066	KJ718743	KJ718582	KJ718410
		CBS 111.41		<i>Solanum aviculare</i> , leaf spot	–	KJ718237	KJ718067	KJ718744	KJ718583	KJ718411
	<i>Alternaria danida</i>	CBS 111.44; E.G.S. 07.029; QM 1772	(T)	<i>Ageratum houstonianum</i> , seed	Italy	Y17070	KJ718068	KJ718745	KJ718584	KJ718412
		CBS 109157; E.G.S. 44.098	R	<i>Solanum tuberosum</i> , leaf spot	USA, Washington	KJ718238	GQ180080	KJ718746	KJ718585	KJ718413
	<i>Alternaria viciae-fabae</i>	CBS 116442; E.G.S. 46.162; ICMP 10242	(T)	<i>Vicia faba</i>	New Zealand	KJ718240	KJ718069	KJ718747	KJ718586	KJ718415
<i>Alternaria solani-nigri</i>	<i>Alternaria cyphomandrae</i>	CBS 109155; E.G.S. 40.058	(T)	<i>Cyphomandra betacea</i> , fruit	New Zealand, New Plymouth	KJ718242	JQ646360	JQ646444	KJ718588	KJ718417
		CBS 113403; E.G.S. 51.106; CPC 10620	R	<i>Solanum nigrum</i> , leaf spot	New Zealand, Waikato	KJ718243	KJ718071	KJ718749	KJ718589	KJ718418
	<i>Alternaria herbiculiniae</i>	CBS 116332; E.G.S. 49.180	(T)	<i>Petroselinum crispum</i> , stunted plant	New Zealand, Taranaki	KJ718244	KJ718072	KJ718750	KJ718590	KJ718419
	<i>Alternaria glyceriae</i>	CBS 116334; E.G.S. 51.107	(T)	<i>Glyceria maxima</i> , leaf spot	New Zealand, Waikato	KJ718245	KJ718073	KJ718751	KJ718591	KJ718420
	<i>Alternaria beticola</i>	CBS 116447; E.G.S. 47.196	(T)	<i>Beta vulgaris</i> , leaf spot	New Zealand, Canterbury	KJ718246	KJ718074	KJ718752	KJ718592	KJ718421
		CBS 117101; E.G.S. 51.032	R	<i>Solanum nigrum</i> , leaf spot	New Zealand, Waikato	KJ718247	KJ718075	KJ718753	KJ718593	KJ718422
	<i>Alternaria ascaloniae</i>	CBS 121347; E.G.S. 46.052	(T)	<i>Allium ascalonicum</i> , leaf spot	New Zealand, Hastings	KJ718248	KJ718076	KJ718754	KJ718594	KJ718423
<i>Alternaria steviae</i>		CBS 631.88; IFO 31212		<i>Stevia rebaudiana</i> , leaf spot	Japan, Kagawa	KJ718250	KJ718078	KJ718756	KJ718596	KJ718425
		CBS 632.88; IFO 31183		<i>Stevia rebaudiana</i> , leaf spot	Japan, Kagawa	KJ718251	JQ646339	KJ718757	KJ718597	KJ718426
		CBS 117362; E.G.S. 37.019; IFO 31182	T	<i>Stevia rebaudiana</i> , leaf spot	Japan, Kagawa	KJ718252	KJ718079	KJ718758	KJ718598	KJ718427
<i>Alternaria tagetica</i>		CBS 297.79; GST AM2		<i>Tagetes</i> sp., seed	UK	KJ718253	KJ718080	KJ718759	KJ718599	KJ718428
		CBS 298.79; GST AM3		<i>Tagetes</i> sp., seed	UK	KJ718254	KJ718081	KJ718760	KJ718600	KJ718429
		CBS 479.81; E.G.S. 33.081; GST 556	R	<i>Tagetes erecta</i> , seed	UK, England	KC584221	KC584143	KJ718761	KC584692	KC584434
		CBS 480.81; E.G.S. 33.184	R	<i>Tagetes</i> sp., seed	USA, South Carolina	KJ718255	KJ718082	KJ718762	KJ718601	KJ718430
		CBS 117217; E.G.S. 44.045	R	<i>Tagetes</i> sp., leaf spot	USA, Ohio	KJ718256	KJ718083	KJ718763	KJ718602	KJ718431
<i>Alternaria thunbergiae</i>		CBS 116331; E.G.S. 41.073; BRIP 14963	T	<i>Thunbergia alata</i> , leaf spot	Australia, Queensland	KJ718257	KJ718084	KJ718764	KJ718603	KJ718432
	<i>Alternaria iranica</i>	CBS 120986; E.G.S. 51.075	(T)	<i>Allium cepa</i> , leaf	Iran, Miandoab	KJ718258	KJ718085	KJ718765	KJ718604	KJ718433
		CBS 122597		<i>Thunbergia alata</i>	New Zealand, Auckland	KJ718259	KJ718086	KJ718766	KJ718605	KJ718434
<i>Alternaria tillandsiae</i>		CBS 116116; E.G.S. 43.074	T	<i>Tillandsia usneoides</i>	New Zealand	KJ718260	KJ718087	KJ718767	KJ718606	KJ718435
<i>Alternaria tropica</i>		CBS 631.93; E.G.S. 39.126	T	<i>Passiflora edulis</i> , fruit	USA, Florida	KJ718261	KJ718088	KJ718768	KJ718607	KJ718436
		CBS 117216; E.G.S. 39.125	R	<i>Passiflora edulis</i> , fruit	USA, Florida	KJ718262	KJ718089	KJ718769	KJ718608	KJ718437

(continued on next page)

Table 1. (Continued).

Name	Old name	Strain number ¹	Status ²	Host / Substrate	Locality	GenBank accession numbers				
						ITS	GAPDH	Alt a 1	TEF1	RPB2
<i>Alternaria venezuelensis</i>		CBS 116121; E.G.S. 48.065	T	<i>Phaseolus vulgaris</i> , leaf spot	Venezuela, Maracay	KJ718263	KJ718090	KJ718770	KJ718609	KJ718438
<i>Alternaria zinniae</i>		CBS 118.44		<i>Callistephus chinensis</i> , seed	Hungary	KJ718264	JQ646361	KJ718771	KJ718610	KJ718439
		CBS 107.48		<i>Zinnia</i> sp., leaf	Netherlands	KJ718265	KJ718091	KJ718772	KJ718611	KJ718440
		CBS 117.59		<i>Zinnia elegans</i>	Italy, Sardinia	KJ718266	KJ718092	KJ718773	KJ718612	KJ718441
		CBS 108.61		<i>Zinnia elegans</i>	–	KJ718267	KJ718093	KJ718774	KJ718613	KJ718442
		CBS 299.79		<i>Zinnia</i> sp., seed	UK	KJ718268	KJ718094	KJ718775	KJ718614	KJ718443
		CBS 300.79		<i>Zinnia</i> sp., seed	UK	KJ718269	KJ718095	KJ718776	KJ718615	KJ718444
		CBS 117223; E.G.S. 44.035	R	<i>Zinnia elegans</i> , leaf spot	New Zealand, Auckland	KJ718270	KJ718096	KJ718777	KJ718616	KJ718445

¹ ATCC: American Type Culture Collection, Manassas, VA, USA; BRIP: Queensland Plant Pathology Herbarium, Queensland, Australia; CBS: Culture collection of the Centraalbureau voor Schimmelcultures, Fungal Biodiversity Centre, Utrecht, Netherlands; CCM: Czech Collection of Microorganisms, Brno, Czech Republic; CECT: Spanish Type Culture Collection, Valencia, Spain; CPC: Personal collection of P.W. Crous, Utrecht, Netherlands; DAOM: Canadian Collection of Fungal Cultures, Ottawa, Canada; DSM: German Collection of Microorganisms and Cell Cultures, Leibniz Institute, Braunschweig, Germany; E.G.S.: Personal collection of Dr. E.G. Simmons; Elliott: Personal collection of M.E. Elliott; GST: Personal collection of G.S. Taylor; ICMP: International Collection of Micro-organisms from Plants, Auckland, New Zealand; IFO: Institute for Fermentation Culture Collection, Osaka, Japan; IMI: Culture collection of CABI Europe UK Centre, Egham UK; LEV: Plant Health and Diagnostic Station, Levin, New Zealand; MUCL: (Agro)Industrial Fungi and Yeast Collection of the Belgian Co-ordinated Collections of Micro-organisms (BCCM), Louvain-la Neuve, Belgium; Nattrass: Personal collection of R.M. Nattrass; PD: Plant Protection Service, Wageningen, Netherlands; PPR: ARC-Plant Protection Research Institute, Roodeplaat, South Africa; QM: Quarter Master Culture Collection, Amherst, MA, USA; VKM: All-Russian Collection of Microorganisms, Moscow, Russia.

² T: ex-type strain; R: representative strain; Letters between parentheses refer to synonymised species names; Bold letters are designated in this study.

RESULTS

Phylogeny

Because the amplification/sequencing of the RPB2 region of CBS 137457 and the Alt a 1 region of CBS 119410 and CBS 117360 failed, these genes were included as missing data in the combined analysis of these isolates. The topologies of the trees obtained from the RAxML and Bayesian analyses were overall congruent, resulting in identical species-clades. The phylogenies of the single-gene trees were congruent with one exception, CBS 137456, which swapped between clusters with the different genes used, resulting in a somewhat distorted picture in the combined analysis. The aligned sequences of the ITS (538 characters), GAPDH (581 characters), RPB2 (772 characters), TEF1 (355 characters) and Alt a 1 (476 characters) gene regions of the 183 included *Alternaria* strains had a total length of 2722 characters, with respectively 77, 111, 134, 141 and 131 unique site patterns. After discarding the burn-in phase trees, the Bayesian analysis resulted in 7 502 trees from which the 50 % majority rule consensus tree and posterior probabilities were calculated. The multi-gene phylogeny of section *Porri* (Fig. 1) divided the isolates in 62 species (clades) and one new *Alternaria* section. The species *A. euphorbicola* and *A. limicola*, previously assigned to sect. *Porri* (Lawrence et al. 2013, Woudenberg et al. 2013), form a sister-clade to sect. *Porri*, here described as *Alternaria* sect. *Euphorbicola* sect. nov. A Bayesian phylogeny based on the GAPDH, RPB2 and TEF1 sequences of representative isolates of the closely related sections in *Alternaria* (sequences obtained from Woudenberg et al. 2013) was constructed for comparison, with *A. brassicicola* CBS 118699 from sect. *Brassicicola*, as outgroup (Fig. 2).

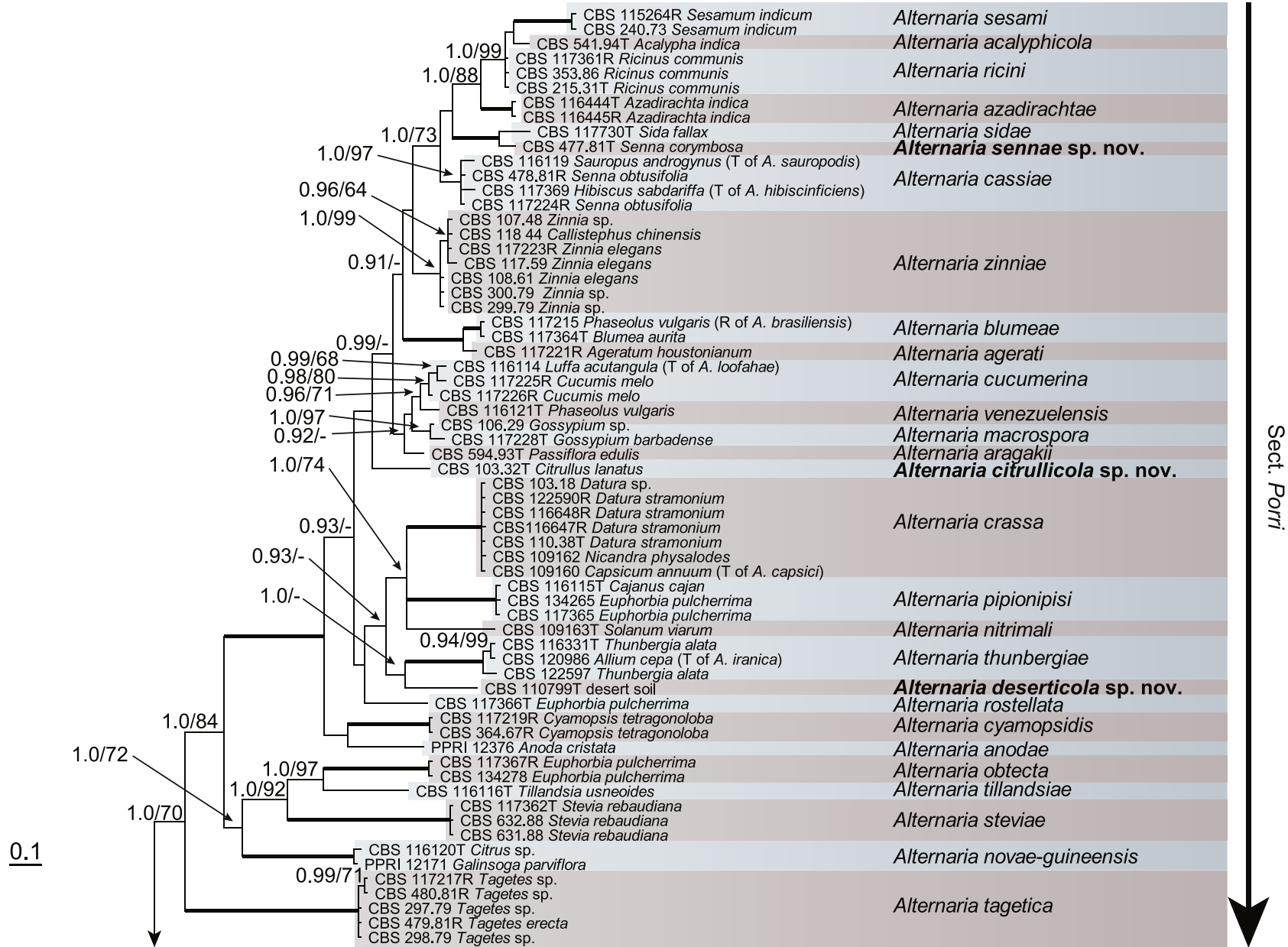


Fig. 1. Bayesian 50% majority rule consensus tree based on the ITS, GAPDH, RPB2, TEF1 and Alt 1 sequences of 183 *Alternaria* strains. The Bayesian posterior probabilities > 0.75 (PP) and RAxML bootstrap support values > 65 (ML) are given at the nodes (PP/ML). Thickened lines indicate a PP of 1.0 and ML of 100. Species names between parentheses represent synonymised species names. Ex-type strains are indicated with T and representative strains with R. Novel species names are printed in bold face. The tree was rooted to *A. gypsophilae* (CBS 107.41).

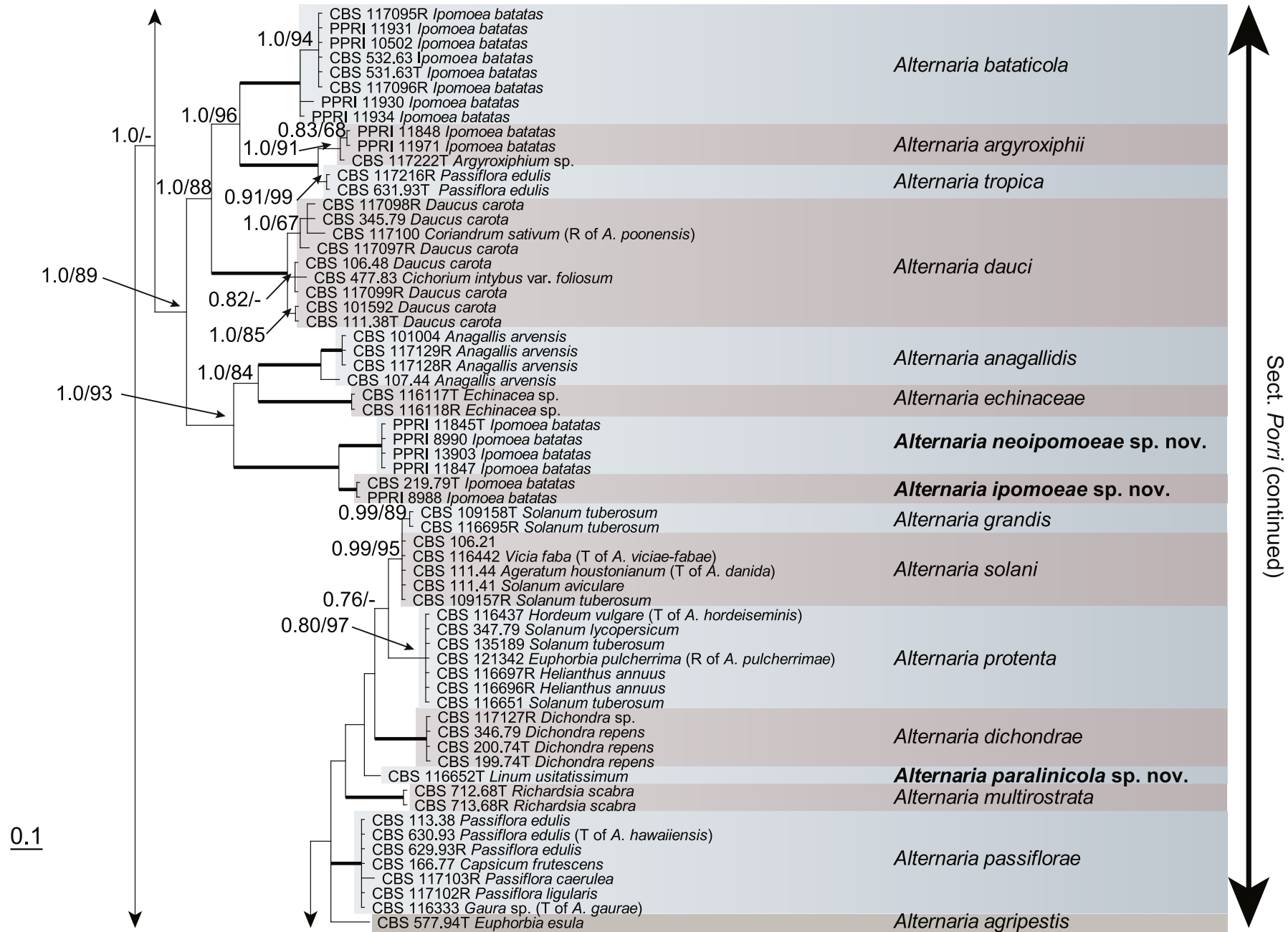


Fig. 1. (continued).

Sect. Porri

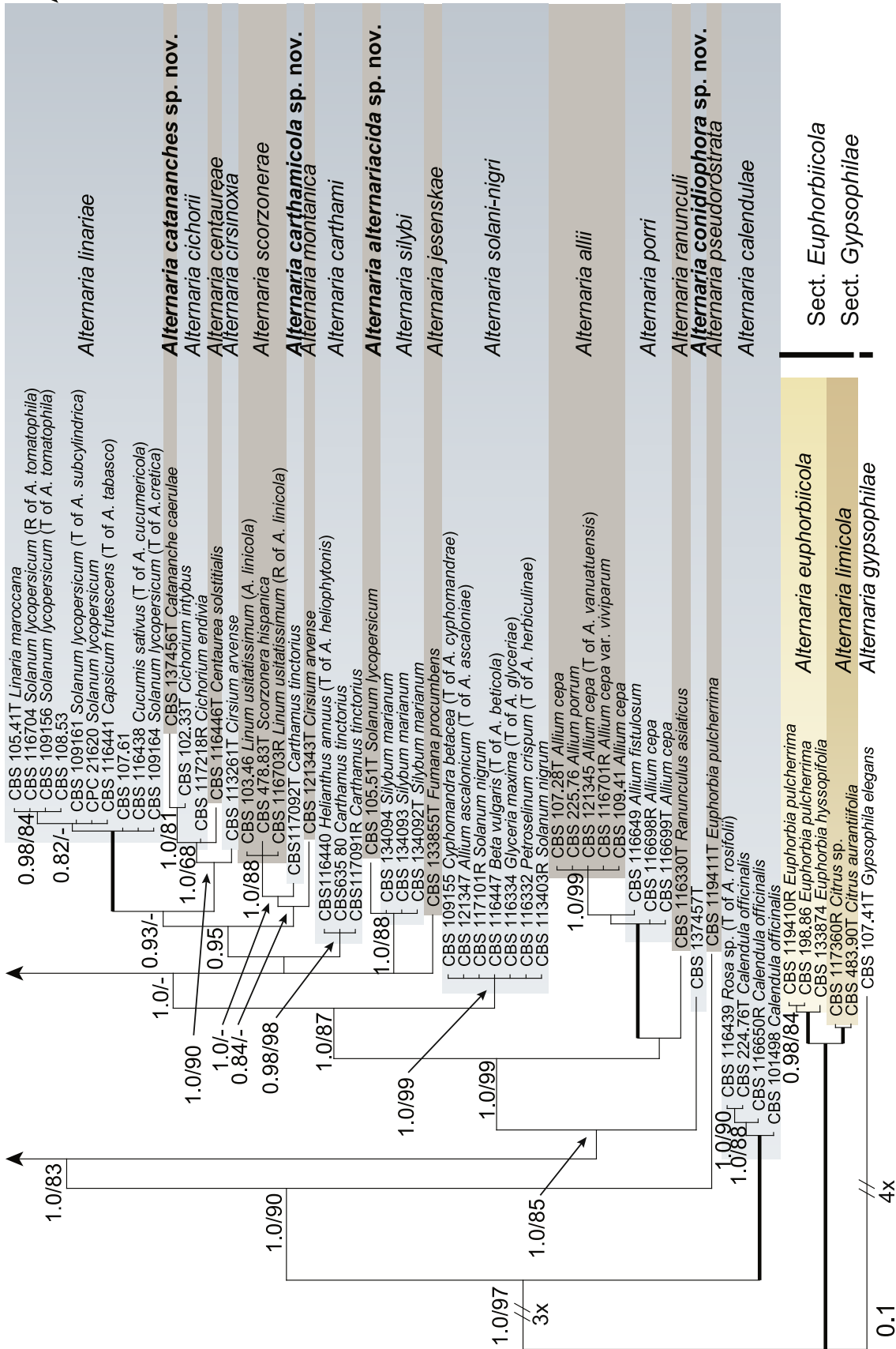


Fig. 1. (continued).

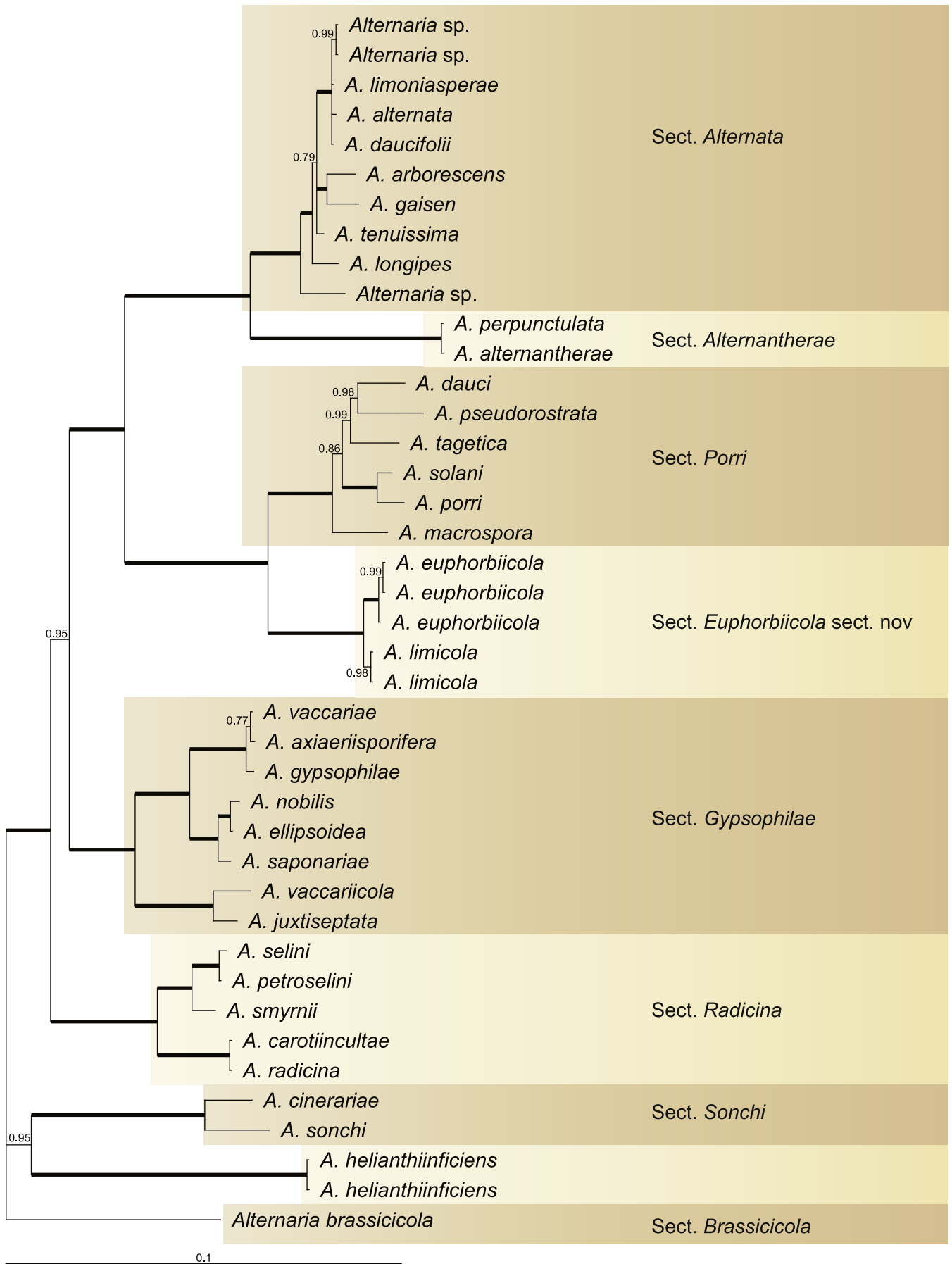


Fig. 2. Bayesian 50 % majority rule consensus tree based on the GAPDH, RPB2 and TEF1 sequences of 41 *Alternaria* strains. The Bayesian posterior probabilities (PP) are given at the nodes. Thickened lines indicate a PP of 1.0. The tree was rooted to *A. brassicicola* (CBS 118699).

Taxonomy

At the onset of this study, *Alternaria* sect. *Porri* contained 82 *Alternaria* species. After extensive phylogenetic analyses and morphological examination we now recognise 63 species in this section (Table 2), of which 10 are newly described. Twenty-seven species names are reduced to synonymy (Table 2). All isolates where taxonomic changes were found based on the multi-gene phylogeny were studied morphologically; photo plates of these species are included. Type details are only listed when typification is proposed.

Section *Porri* D.P. Lawr., Gannibal, Peever & B.M. Pryor, *Mycologia* 105: 541. 2013

Type species: Alternaria porri (Ellis) Cif.

Section *Porri* is characterised by broadly ovoid, obclavate, ellipsoid, subcylindrical or obovoid, medium to large conidia, disto- and euseptate, solitary or in short chains, with a simple or branched, long to filamentous beak. Conidia contain multiple transverse and longitudinal septa and are slightly constricted near some transverse septa. Secondary conidiophores can be formed apically and/or laterally.

Species in sect. *Porri*

Alternaria acalyphicola E.G. Simmons, *Mycotaxon* 50: 260. 1994.

Material examined: Seychelles, from *Acalypha indica* (Euphorbiaceae), before Apr. 1982, C. Kingsland, culture **ex-type** of *A. acalyphicola* CBS 541.94 = E.G.S. 38.100 = IMI 266969.

Notes: *Alternaria acalyphicola* is closely related to *A. ricini*, with only 1 nt difference in three out of the five genes sequenced; RPB2, TEF1 and GAPDH. Based on this single isolate, the data is inconclusive to support the synonymy of these two species.

Alternaria agerati E.G. Simmons, *Mycotaxon* 65: 63. 1997.

= *Alternaria agerati* Sawada, Rep. Dept. Agric. Gov. Res. Inst. Formosa 86: 165. 1943. (nom. inval., Art. 36.1)

Material examined: USA, Illinois, Springfield, from *Ageratum houstonianum* (Asteraceae) in a commercial greenhouse, Nov. 1968, J.L. Forsberg, representative isolate of *A. agerati* CBS 117221 = E.G.S. 30.001 = QM 9369.

Alternaria agripestis E.G. Simmons & K. Mort., *Mycotaxon* 50: 255. 1994.

Material examined: Canada, Saskatchewan, Maxim, from infected stem of *Euphorbia esula* (Euphorbiaceae), 9 Jul. 1992, P. Harris, culture **ex-type** of *A. agripestis* CBS 577.94 = E.G.S. 41.034.

Alternaria allii Nolla, *Phytopathology* 17: 118. 1927. Fig. 3.

= *Alternaria vanuatuensis* E.G. Simmons & C.F. Hill, CBS Biodiversity Ser. (Utrecht) 6: 260. 2007.

Materials examined: Denmark, from seed of *Allium cepa* (Amaryllidaceae), 1937, P. Neergaard, CBS 109.41 = CBS 114.38. Italy, from leaf of *Allium porrum* (Amaryllidaceae), 1974, H. Nirenberg, CBS 225.76. Puerto Rico, from

leaf of *Allium cepa*, before 1928, J.A.B. Nolla, culture **ex-type** of *A. allii* CBS 107.28 = E.G.S. 48.084. USA, Massachusetts, Hadley, from floral bract of *Allium cepa* var. *viviparum*, 13 Jul. 1980, E.G. Simmons, representative of *A. allii* CBS 116701 = E.G.S. 33.134. Vanuatu, from leaves of *Allium cepa*, 1996, C.F. Hill, culture **ex-type** of *A. vanuatuensis* CBS 121345 = E.G.S. 45.018.

Notes: Simmons (2007) designated the lectotype of *A. allii* as Nolla (1927), *loc. cit.*, Pl. III, fig. 11–19, based on the absence of original Nolla specimens. In our study, however, we managed to uncover an original specimen, CBS 107.28, which was deposited in the CBS by J.A.B. Nolla in December 1927 as his "*A. allii* sp. nov.", just after he published the new species description. We therefore recognise this isolate as the **ex-type** strain of *A. allii*. Isolate CBS 116701 did not sporulate after 3 wk of cultivation on SNA.

Alternaria alternariacida Woudenb. & Crous, **sp. nov.** MycoBank MB808990. Fig. 4.

Etymology: Named after its ability to produce high amounts of alternaric acid.

Alternaria alternariacida differs from the **ex-type** isolate of its closest phylogenetic neighbour *A. silybi* (CBS 134092) based on alleles in three loci (positions derived from respective alignments of the separate loci deposited in TreeBASE): ITS position 386 (T), 497 (T), 498 (T); TEF1 position 3 (T), 18 (T); Alt a 1 position 205 (C), 336 (T), 339 (A), 350 (C), 404 (T), 408 (G).

Sporulation is atypical. *Primary conidiophores* solitary, simple, straight to slightly curved, septate, pale brown with a subhyaline tip, (52–)73–93(–155) × (4–)5–6(–7) μm, bearing a single, darkened, apical conidiogenous locus. *Conidia* solitary or in unbranched chains of 2(–3) conidia, conidium body pale olive-brown, smooth-walled, narrowly ovoid, solitary, non-catenulate, and secondary conidia (33–)44–49(–56) × (5–)7–8(–9) μm, with (3–)5–6(–8) transverse eusepta and no longitudinal septa; primary conidia in total (85–)99–111(–121) × (6–)7–8(–10) μm. The conidial body can be slightly constricted near the septa. The conidium body gradually tapers into mostly an aseptate, single, unbranched beak, but branched beaks do occur; apical and multiple lateral *secondary conidiophores* can also occur. *Beaks* (47–)129–257(–610) μm long, ca. 2 μm wide throughout their length. *Sexual morph* not observed.

Culture characteristics: After 7 d cultures on SNA flat, fimbriate, white; aerial mycelium sparse, white, colonies reaching 25–30 mm diam; cultures on PCA flat, entire, olivaceous in the centre with three olivaceous concentric circles and a buff to white margin; aerial mycelium fine, felty, white, colonies reaching 50 mm diam; reverse with four olivaceous concentric circles.

Material examined: UK, England, from fruit of *Solanum lycopersicum* (Solanaceae), 1946, P.W. Brian (**holotype** CBS H-21734, culture **ex-type** CBS 105.51 = ATCC 11078 = IMI 46816 = CECT 2997 = IBPG 14 = BRL408).

Note: The atypical sporulation of the single isolate of *A. alternariacida*, which is over 60 yr old, resulted in our decision to include sequence data in the species description.

Table 2. Current species within *Alternaria* sect. *Porri* and their host / substrate.

Species name	Synonymised names (this study)	Host / Substrate
<i>Alternaria acalyphicola</i>		Euphorbiaceae (<i>Acalypha indica</i>)
<i>Alternaria agerati</i>		Asteraceae (<i>Ageratum houstonianum</i>)
<i>Alternaria agripestis</i>		Euphorbiaceae (<i>Euphorbia esula</i>)
<i>Alternaria allii</i>	<i>Alternaria vanuatuensis</i>	Amaryllidaceae (<i>Allium cepa</i> , <i>A. porrum</i>)
<i>Alternaria alternariacida</i>		Solanaceae (<i>Solanum lycopersicum</i>)
<i>Alternaria anagallidis</i>		Primulaceae (<i>Anagallis arvensis</i>)
<i>Alternaria anodae</i>		Malvaceae (<i>Anoda cristata</i>)
<i>Alternaria aragakii</i>		Passifloraceae (<i>Passiflora edulis</i>)
<i>Alternaria argyroxiphii</i>		Asteraceae (<i>Argyroxiphium</i> sp.), Convolvulaceae (<i>Ipomoea batatas</i>)
<i>Alternaria azadirachtae</i>		Meliaceae (<i>Azadirachta indica</i>)
<i>Alternaria bataticola</i>		Convolvulaceae (<i>Ipomoea batatas</i>)
<i>Alternaria blumeae</i>	<i>Alternaria brasiliensis</i>	Asteraceae (<i>Blumea aurita</i>), Fabaceae (<i>Phaseolus vulgaris</i>)
<i>Alternaria calendulae</i>	<i>Alternaria rosifolii</i>	Asteraceae (<i>Calendula officinalis</i>), Rosaceae (<i>Rosa</i> sp.)
<i>Alternaria carthami</i>	<i>Alternaria heliophytonis</i>	Asteraceae (<i>Carthamus tinctorius</i> , <i>Helianthus annuus</i>)
<i>Alternaria carthamicola</i>		Asteraceae (<i>Carthamus tinctorius</i>)
<i>Alternaria cassiae</i>	<i>Alternaria hibiscificiens</i> <i>Alternaria sauropodis</i>	Fabaceae (<i>Senna obtusifolia</i>), Malvaceae (<i>Hibiscus sabdariffa</i>), Phyllanthaceae (<i>Sauropus androgynus</i>)
<i>Alternaria catananches</i>		Asteraceae (<i>Catananche caerulea</i>)
<i>Alternaria centaureae</i>		Asteraceae (<i>Centaurea solstitialis</i>)
<i>Alternaria cichorii</i>		Asteraceae (<i>Cichorium endivia</i> , <i>C. intybus</i>)
<i>Alternaria cirsinoxia</i>		Asteraceae (<i>Cirsium arvense</i>)
<i>Alternaria citrullicola</i>		Cucurbitaceae (<i>Citrullus lanatus</i>)
<i>Alternaria conidiophora</i>		Unknown
<i>Alternaria crassa</i>	<i>Alternaria capsici</i>	Solanaceae (<i>Capsicum annuum</i> , <i>Datura stramonium</i> , <i>Nicandra physalodes</i>)
<i>Alternaria cucumerina</i>	<i>Alternaria loofahae</i>	Cucurbitaceae (<i>Cucumis melo</i> , <i>Luffa acutangula</i>)
<i>Alternaria cyamopsidis</i>		Fabaceae (<i>Cyamopsis tetragonoloba</i>)
<i>Alternaria dauci</i>	<i>Alternaria poonensis</i>	Apiaceae (<i>Daucus carota</i> , <i>Coriandrum sativum</i>), Asteraceae (<i>Cichorium intybus</i>)
<i>Alternaria deserticola</i>		Soil
<i>Alternaria dichondrae</i>		Convolvulaceae (<i>Dichondra</i> sp., <i>D. repens</i>)
<i>Alternaria echinaceae</i>		Asteraceae (<i>Echinacea</i> sp.)
<i>Alternaria grandis</i>		Solanaceae (<i>Solanum tuberosum</i>)
<i>Alternaria ipomoeae</i>		Convolvulaceae (<i>Ipomoea batatas</i>)
<i>Alternaria jesenskae</i>		Cistaceae (<i>Fumana procumbens</i>)
<i>Alternaria linariae</i>	<i>Alternaria cretica</i> <i>Alternaria cucumericola</i> <i>Alternaria subcylindrica</i> <i>Alternaria tabasco</i> <i>Alternaria tomatophila</i>	Cucurbitaceae (<i>Cucumis sativus</i>), Scrophulariaceae (<i>Linaria maroccana</i>), Solanaceae (<i>Capsicum frutescens</i> , <i>Solanum lycopersicum</i>)
<i>Alternaria macrospora</i>		Malvaceae (<i>Gossypium</i> sp., <i>G. barbadense</i>)
<i>Alternaria montanica</i>		Asteraceae (<i>Cirsium arvense</i>)
<i>Alternaria multirostrata</i>		Rubiaceae (<i>Richardia scabra</i>)
<i>Alternaria neoipomoeae</i>		Convolvulaceae (<i>Ipomoea batatas</i>)
<i>Alternaria nitrimali</i>		Solanaceae (<i>Solanum viarum</i>)
<i>Alternaria novae-guineensis</i>		Asteraceae (<i>Galinsoga parviflora</i>), Rutaceae (<i>Citrus</i> sp.)
<i>Alternaria obtecta</i>		Euphorbiaceae (<i>Euphorbia pulcherrima</i>)
<i>Alternaria paralinicola</i>		Linaceae (<i>Linum usitatissimum</i>)
<i>Alternaria passiflorae</i>	<i>Alternaria gaurae</i> <i>Alternaria hawaiiensis</i>	Onagraceae (<i>Gaura lindheimeri</i>), Passifloraceae (<i>Passiflora edulis</i> , <i>P. caerulea</i> , <i>P. ligularis</i>), Solanaceae (<i>Capsicum frutescens</i>)
<i>Alternaria pipionipisi</i>		Euphorbiaceae (<i>Euphorbia pulcherrima</i>), Fabaceae (<i>Cajanus cajan</i>)
<i>Alternaria porri</i>		Amaryllidaceae (<i>Allium cepa</i> , <i>A. porrum</i>)

Table 2. (Continued).

Species name	Synonymised names (this study)	Host / Substrate
<i>Alternaria protenta</i>	<i>Alternaria hordeiseminis</i> <i>Alternaria pulcherrimae</i>	Asteraceae (<i>Helianthus annuus</i>), Euphorbiaceae (<i>Euphorbia pulcherrima</i>), Gramineae (<i>Hordeum vulgare</i>), Solanaceae (<i>Solanum lycopersicum</i> , <i>S. tuberosum</i>)
<i>Alternaria pseudorostrata</i>		Euphorbiaceae (<i>Euphorbia pulcherrima</i>)
<i>Alternaria ranunculi</i>		Ranunculaceae (<i>Ranunculus asiaticus</i>)
<i>Alternaria ricini</i>		Euphorbiaceae (<i>Ricinus communis</i>)
<i>Alternaria rostellata</i>		Euphorbiaceae (<i>Euphorbia pulcherrima</i>)
<i>Alternaria scorzonerae</i>	<i>Alternaria linicola</i>	Asteraceae (<i>Sorzonerae hispanica</i>), Linaceae (<i>Linum usitatissimum</i>)
<i>Alternaria sennae</i>		Fabaceae (<i>Senna corymbosa</i>)
<i>Alternaria sesami</i>		Pedaliaceae (<i>Sesamum indica</i>)
<i>Alternaria sidae</i>		Malvaceae (<i>Sida fallax</i>)
<i>Alternaria silybi</i>		Asteraceae (<i>Silybum marianum</i>)
<i>Alternaria solani</i>	<i>Alternaria danida</i> <i>Alternaria viciae-fabae</i>	Asteraceae (<i>Ageratum houstonianum</i>), Fabaceae (<i>Vicia faba</i>), Solanaceae (<i>Solanum aviculare</i> , <i>S. tuberosum</i>)
<i>Alternaria solani-nigri</i>	<i>Alternaria ascaloniae</i> <i>Alternaria beticola</i> <i>Alternaria cyphomandrae</i> <i>Alternaria glyceriae</i> <i>Alternaria herbiculiniae</i>	Amaryllidaceae (<i>Allium ascalonicum</i>), Apiaceae (<i>Petroselinum crispum</i>), Chenopodiaceae (<i>Beta vulgaris</i>), Gramineae (<i>Glyceria maxima</i>), Solanaceae (<i>Cyphomandra betacea</i> , <i>Solanum nigrum</i>)
<i>Alternaria steviae</i>		Asteraceae (<i>Stevia rebaudiana</i>)
<i>Alternaria tagetica</i>		Asteraceae (<i>Tagetes</i> sp., <i>T. erecta</i>)
<i>Alternaria thunbergiae</i>	<i>Alternaria iranica</i>	Acanthaceae (<i>Thunbergia alata</i>), Amaryllidaceae (<i>Allium cepa</i>)
<i>Alternaria tillandsiae</i>		Bromeliaceae (<i>Tillandsia usneoides</i>)
<i>Alternaria tropica</i>		Passifloraceae (<i>Passiflora edulis</i>)
<i>Alternaria venezuelensis</i>		Fabaceae (<i>Phaseolus vulgaris</i>)
<i>Alternaria zinniae</i>		Asteraceae (<i>Callistephus chinensis</i> , <i>Zinnia</i> sp., <i>Z. elegans</i>)

Alternaria anagallidis A. Raabe, Hedwigia 78: 87. 1939.

Materials examined: Denmark, Copenhagen, from *Anagallis arvensis* (Primulaceae), before Mar. 1944, P. Neergaard, CBS 107.44. **New Zealand**, Auckland, Lynfield, from *Anagallis arvensis*, 4 May 1998, C.F. Hill, CBS 101004; Auckland, Lynfield, from *Anagallis arvensis*, 28 Jun. 1995, C.F. Hill, representative isolate of *A. anagallidis* CBS 117128 = E.G.S. 42.074; Auckland, from leaf spot of *Anagallis arvensis*, Jan. 2002, C.F. Hill, representative isolate of *A. anagallidis* CBS 117129 = E.G.S. 50.091.

Notes: Isolate CBS 107.44 differs on 6 nt positions in its RPB2 sequence from the other three *A. anagallidis* isolates included in this study. Because CBS 107.44 still clusters closest to the other *A. anagallidis* isolates, and since these isolates, from a single host species, form a distinct clade from all other *Alternaria* spp., we retained the name *A. anagallidis* for this isolate.

Alternaria anodae E.G. Simmons, Mycotaxon 88: 198. 2003.

Material examined: South Africa, Gauteng Province, Pretoria, ARC-Roodeplaat VOPI, from leaves of *Anoda cristata* (Malvaceae), 12 Jan. 2012, A. Thompson, PPRI 12376.

Alternaria aragakii E.G. Simmons, Mycotaxon 46: 181. 1993.

Material examined: USA, Hawaii, from *Passiflora edulis* (Passifloraceae), before Oct. 1968, M. Aragaki, culture **ex-type** of *A. aragakii* CBS 594.93 = E.G.S. 29.016 = QM 9046.

Alternaria argyroxiphii E.G. Simmons & Aragaki, Mycotaxon 65: 40. 1997.

Materials examined: South Africa, Gauteng Province, Pretoria, ARC-Roodeplaat VOPI, from stem lesion of *Ipomoea batatas* (Convolvulaceae), 20 Apr. 2005, A. Thompson, PPRI 11848; Mpumalanga Province, Marble Hall, from stem and leaf lesion of *Ipomoea batatas*, 22 Nov. 2011, A. Thompson, PPRI 11971. **USA**, Hawaii, Maui, Haleakala, from *Argyroxiphium* sp. (Asteraceae), 1969, M. Aragaki, culture **ex-type** of *A. argyroxiphii* CBS 117222 = E.G.S. 35.122.

Note: The host range of *A. argyroxiphii* is not restricted to *Argyroxiphium*, but has been broadened with the inclusion of two isolates from *Ipomoea batatas* (Convolvulaceae).

Alternaria azadirachtae E.G. Simmons & Alcorn, CBS Biodiversity Ser. (Utrecht) 6: 218. 2007.

Materials examined: Australia, Queensland, Tewantin, from *Azadirachta indica* (Meliaceae), 20 Jul. 1998, A. Bradley, culture **ex-type** of *A. azadirachtae* CBS 116444 = E.G.S. 46.195 = BRIP 25386 (ss1); additional strain from the same source, CBS 116445 = E.G.S. 46.196 = BRIP25386 (ss2).

Alternaria bataticola W. Yamam., Trans. Mycol. Soc. Japan 2(5): 89. 1960.

= *Macrosporium bataticola* Ikata, Agric. Hort. (Tokyo) 22: 241. 1947 (nom. inval., Art. 36.1).

Type: (Lectotype, designated in Simmons 2007) S. Ikata, Agric. & Hort. 22: 241. fig. 1. 1947.

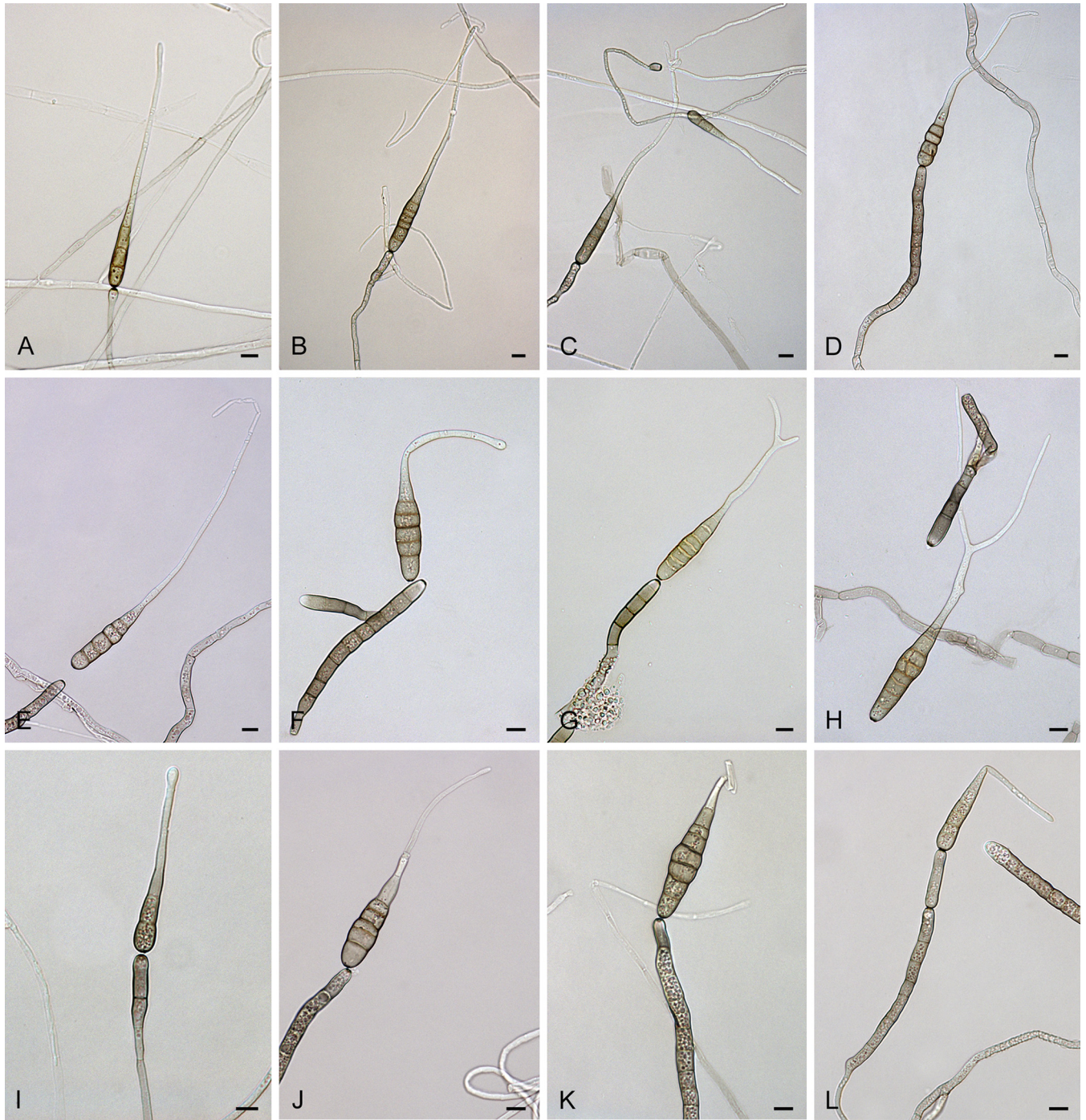


Fig. 3. *Alternaria allii*: conidia and conidiophores. A–C. CBS 107.28. D–E. CBS 109.41. F–H. CBS 225.76. I–L. CBS 121345. Scale bars = 10 µm.

Materials examined: **Australia**, Queensland, Walkamin, from leaf spot of *Ipomoea batatas* (Convolvulaceae), 5 Jul. 1991, collector unknown, representative isolate of *A. bataticola* CBS 117095 = E.G.S. 42.157 = IMI 350492 = BRIP 19470a; additional strain from the same source CBS 117096 = E.G.S. 42.158 = BRIP 19470b. **Japan**, Tokyo, from *Ipomoea batatas*, before Nov. 1963, collector unknown, CBS 532.63; from *Ipomoea batatas*, before Nov. 1963, collector unknown (**epitype designated here** CBS H-21743, MBT178114, culture **ex-epitype** CBS 531.63 = IFO 6187 = MUCL 28916). **South Africa**, Gauteng Province, Pretoria, ARC-Rooideplaar VOPI, from leaf and stem lesion of *Ipomoea batatas*, 16 Jun. 2010, M. Truter, PPRI 10502; Kwazulu-Natal Province, Empangeni, from leaf lesion of *Ipomoea batatas*, 4 Jul. 2011, A. Thompson, PPRI 11930; Kwazulu-Natal Province, Empangeni, from leaf lesion of *Ipomoea batatas*, 4 Jul. 2011, A. Thompson, PPRI 11931; Gauteng Province, Pretoria, ARC-Rooideplaar VOPI, from leaf lesion of *Ipomoea batatas*, 12 Jan. 2012, A. Thompson, PPRI 11934.

Alternaria blumeae E.G. Simmons & Sontirat, Mycotaxon 65: 81. 1997. Fig. 5.

= *Alternaria brasiliensis* F.M. Queiroz, M.F.S. Muniz & M. Menezes, Mycopathologia 150: 63. 2001.

Materials examined: **Brazil**, Espírito Santo, from leaf spot of *Phaseolus vulgaris* (Fabaceae), 1989, F.M. Queiroz, representative isolate of *A. brasiliensis* CBS 117215 = E.G.S. 39.116. **Thailand**, Yala Province, Amphoe Muang, from *Blumea aurita* (Asteraceae), 18 Jan. 1992, P. Sontirat, culture **ex-type** of *A. blumeae* CBS 117364 = E.G.S. 40.149 = ATCC 201357.

Notes: By synonymising *A. brasiliensis* with *A. blumeae*, the host range of this taxon has expanded to include *Phaseolus vulgaris*. The five sequenced genes are 100 % identical between the two examined specimens.

Alternaria calendulae Ondřej, Čas. Slez. Mus., Ser. A, Hist. Nat. 23: 150. 1974. Fig. 6.



Fig. 4. *Alternaria alternariacida* sp. nov. CBS 105.51: A–H. Conidia and conidiophores. Scale bars = 10 µm.

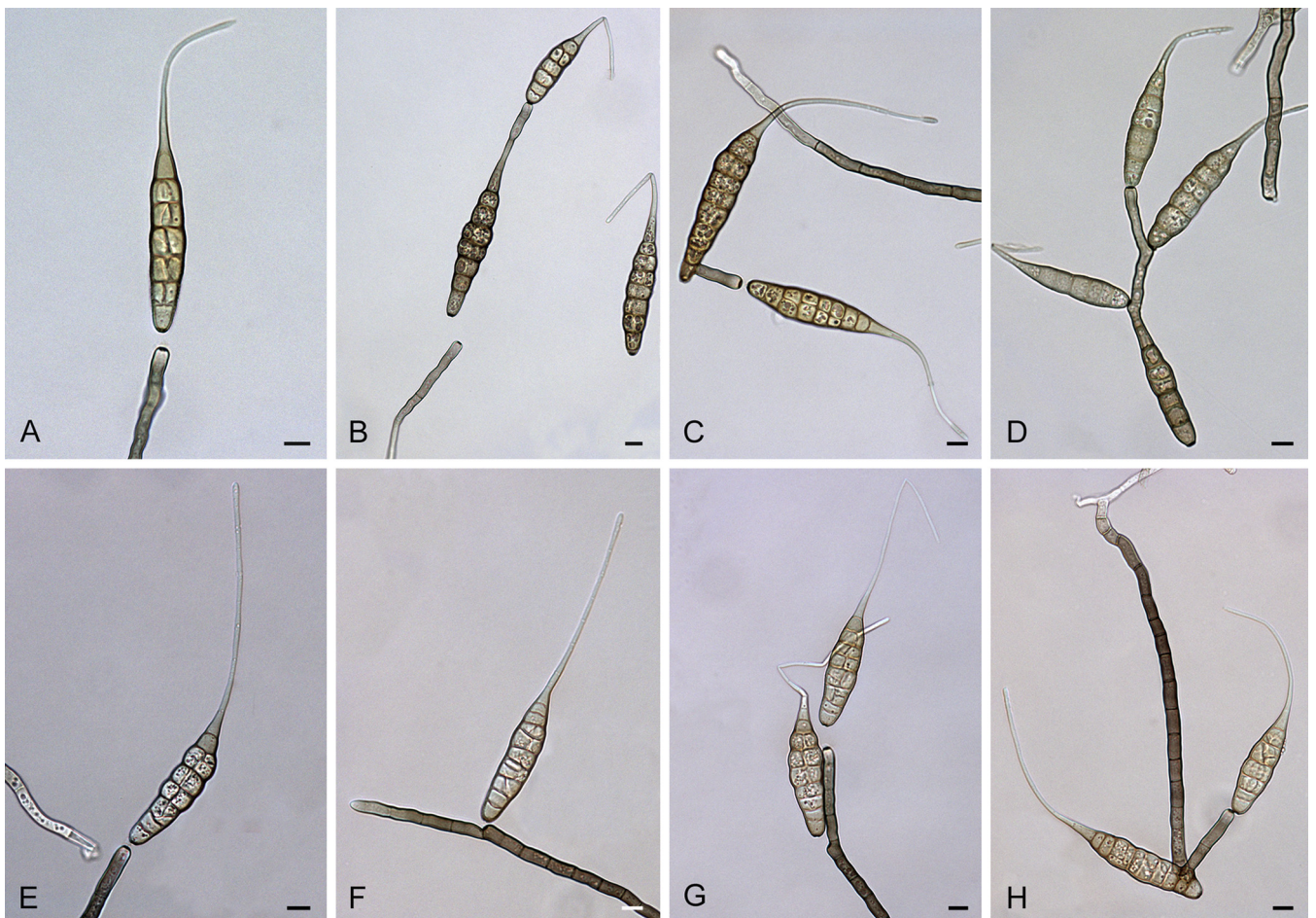


Fig. 5. *Alternaria blumeae*: conidia and conidiophores. A–D. CBS 117364. E–H. CBS 117215. Scale bars = 10 µm.

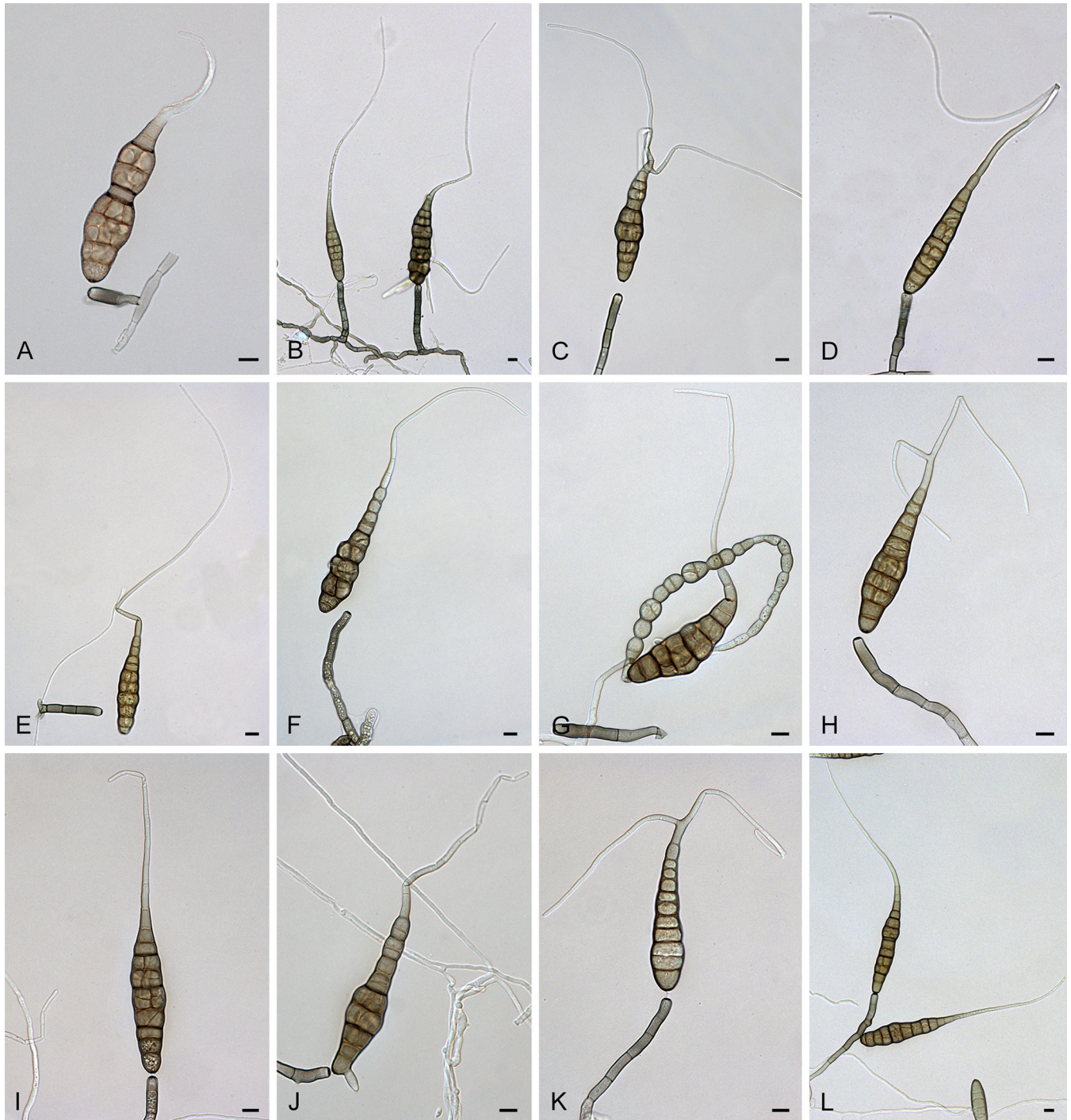


Fig. 6. *Alternaria calendulae*: conidia and conidiophores. A–C. CBS 224.76. D–E. CBS 101498. F–H. CBS 116650. I–L. CBS 116439. Scale bars = 10 µm.

= *Alternaria calendulae* W. Yamam. 1939 (nom. nud.).
 = *Macrosporium calendulae* Nelen, Bull. Centr. Bot. Gard. (Moscow) 35: 90. 1959 (nom. inval., Art. 36.1).
 = *Macrosporium calendulae* Nelen, Bot. Mater. Otd. Sporov. Rast. Bot. Inst. Akad. Nauk S.S.S.R. 15: 144. 1962.
 = *Alternaria calendulae* Nirenberg, Phytopathol. Z. 88: 108. 1977 (nom. illegit., Art. 53.1).
 = *Alternaria rosifolii* E.G. Simmons & C.F. Hill, CBS Biodiversity Ser. (Utrecht) 6: 192. 2007.

Materials examined: **Germany**, former West-Germany, from leaf spot of *Calendula officinalis* (Asteraceae), 1974, H. Nirenberg, culture **ex-type** of *A. calendulae* Nirenberg CBS 224.76 = ATCC 38903 = IMI 205077 = DSM 63161. **Japan**, Tokyo, from leaf spot of *Calendula officinalis*, before 1964, representative isolate of *A. calendulae* CBS 116650 = E.G.S. 30.142 = QM 9561. **New Zealand**, Auckland, Kumeu, from leaf spot of *Calendula officinalis*, Oct. 1998, C.F. Hill, CBS 101498; Auckland, Mount Albert, from leaf of *Rosa* sp.

(Rosaceae), before Feb. 1995, C.F. Hill, culture **ex-type** of *A. rosifolii* CBS 116439 = E.G.S. 42.197.

Note: By synonymising *A. rosifolii* with *A. calendulae*, the host range of this taxon has expanded to include *Rosa*.

Alternaria carthami S. Chowdhury, J. Indian Bot. Soc. 23: 65. 1944. Fig. 7.

= *Macrosporium anatolicum* A. Săvul., Bull. Sect. Sci. Acad. Roumaine 26: 709. 1944.

= *Alternaria heliophytonis* E.G. Simmons, CBS Biodiversity Ser. (Utrecht) 6: 206. 2007.

Materials examined: **Canada**, Saskatchewan, Saskatoon, from leaf of *Helianthus annuus* (Asteraceae), 26 Aug. 1993, C. Jaslavich, culture **ex-type** of *A. heliophytonis* CBS 116440 = IMI 366164 = E.G.S. 43.143. **Italy**, Perugia, from leaf

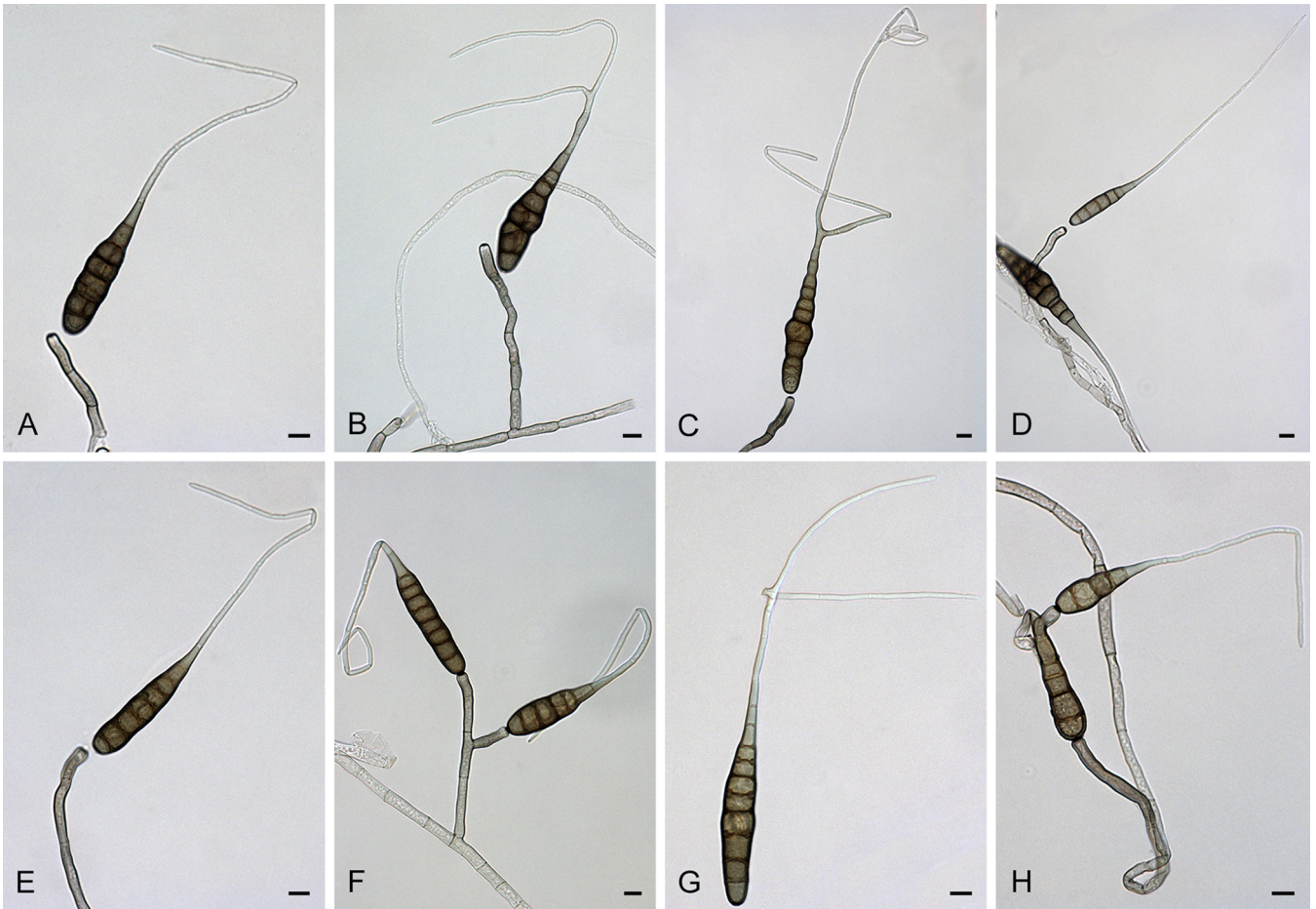


Fig. 7. *Alternaria carthami*: conidia and conidiophores. A–D. CBS 117091. E–H. CBS 116440. Scale bars = 10 μ m.

of *Carthamus tinctorius* (Asteraceae), before Nov. 1980, A. Zizzerini, CBS 635.80. USA, Montana, Sidney, from leaf spot of *Carthamus tinctorius*, 11 Jul. 1973, E.E. Burns, representative isolate of *A. carthami* CBS 117091 = E.G.S. 31.037.

Notes: Isolate CBS 635.80 did not sporulate after 3 wk cultivation on SNA. By synonymising *A. heliophytonis* with *A. carthami*, the host range of this taxon has expanded to include *Helianthus annuus* (Asteraceae).

Alternaria carthamicola Woudenberg & Crous, **sp. nov.** MycoBank MB808991. Fig. 8.

Etymology: Named after the host genus from which it was collected, *Carthamus*.

Primary conidiophores solitary or in small groups, simple, straight to slightly curved, septate, pale to dark brown with a subhyaline tip, (33–)55–71(–108) \times 5–6(–7) μ m, bearing a single, darkened, apical conidiogenous locus, but may produce geniculate conidiogenous extensions. **Conidia** solitary, rarely in chains of two conidia, conidium body pale olive-brown, mostly smooth-walled but sometimes ornamented at the base, ovoid, (39–)58–64(–82) \times (13–)15–16(–17) μ m; with (5–)6–7(–9) transverse and (1–)3(–4) longitudinal septa. Dark coloured eusepta can be formed during development; the conidial body is slightly constricted near the transverse septa. Conidia mostly have a septate, single to double filamentous beak, triple beaks are observed but not common, apical **secondary conidiophores** can be formed. **Beaks** (40–)158–186(–219) μ m long, ca. 2 μ m

diam throughout their length and 4 μ m at the base. **Sexual morph** not observed.

Culture characteristics: After 7 d cultures on SNA flat, rhizoid, white to opaque; aerial mycelium sparse, white, floccose, colonies reaching 55–60 mm diam; cultures on PCA flat, entire, olivaceous with three clear concentric circles; aerial mycelium fine, felty, olivaceous to olivaceous-grey, colonies reaching 65–70 mm diam; reverse shows four olivaceous concentric circles with an buff edge.

Material examined: Iraq, from *Carthamus tinctorius* (Asteraceae), 10 Apr. 1983, M.M. Elshookie (**holotype** CBS H-21735, culture **ex-type** CBS 117092 = IMI 276943 = E.G.S. 37.057).

Notes: The new species *A. carthamicola*, originally identified as *A. carthami*, differs only on 9 nt positions in its RPB2 sequence from the other two *A. carthami* strains studied. Based on its RPB2 sequence it clusters with *A. linicola*.

Alternaria cassiae Jurair & A. Khan, Pakistan J. Sci. Industr. Res. 3: 72. 1960. Fig. 9.

= *Alternaria hibiscificiens* E.G. Simmons & C.F. Hill, Mycotaxon 88: 205. 2003.

= *Alternaria sauropodis* E.G. Simmons, CBS Biodiversity Ser. (Utrecht) 6: 340. 2007.

Materials examined: Brazil, Federal District, from leaf spot of *Senna obtusifolia* (Fabaceae), May 1990, G. Figueiredo, representative isolate of *A. cassiae* CBS 117224 = E.G.S. 40.121. Fiji, from leaf of *Hibiscus sabdariffa* (Malvaceae), Jun.



Fig. 8. *Alternaria carthamicola* sp. nov. CBS 117092: A–L. Conidia and conidiophores. Scale bars = 10 μ m.

2002, C.F. Hill, culture **ex-type** of *A. hibiscificiens* CBS 177369 = E.G.S. 50.166. **Malaysia**, Sarawak, Kuching, from *Sauropus androgynus* (*Phyllanthaceae*), 25 Apr. 1984, T.K. Kieh, culture **ex-type** of *A. sauropodis* CBS 116119 = IMI 286317 = IMI 392448 = E.G.S. 47.112. **USA**, Mississippi, Stoneville, from diseased seedling of *Senna obtusifolia*, before Oct. 1980, H.L. Walker, representative isolate of *A. cassiae* CBS 478.81 = E.G.S. 33.147.

Notes: Isolate CBS 478.81 did not sporulate after 3 wk incubation on SNA. By synonymising *A. hibiscificiens* and *A. sauropodis* with *A. cassiae*, the host range of this taxon has expanded to include *Sauropus androgynus* (*Euphorbiaceae*) and *Hibiscus sabdariffa* (*Malvaceae*).

Alternaria catananches Woudenb. & Crous, **sp. nov.**
Mycobank MB808992. Fig. 10.

Etymology: Named after its host genus from which it was isolated, *Catananche*.

Primary conidiophores solitary, simple, straight to curved, septate, pale brown, (31–)54–67(–94) \times (5–)6(–7) μ m, bearing a single, darkened, apical conidiogenous locus, but may produce geniculate conidiogenous extensions. **Conidia** solitary, conidium body pale olive-brown, ornamented in lower half of the conidium, narrowly ovoid, (26–)37–43(–57) \times (7–)8–9(–11) μ m, with (2–)4(–6) transverse septa and no longitudinal septa. Some darker coloured eusepta can be formed during development. The conidium body gradually tapers into a single, septate, unbranched beak; basal lateral **secondary conidiophores** can be formed. **Beaks** (77–)

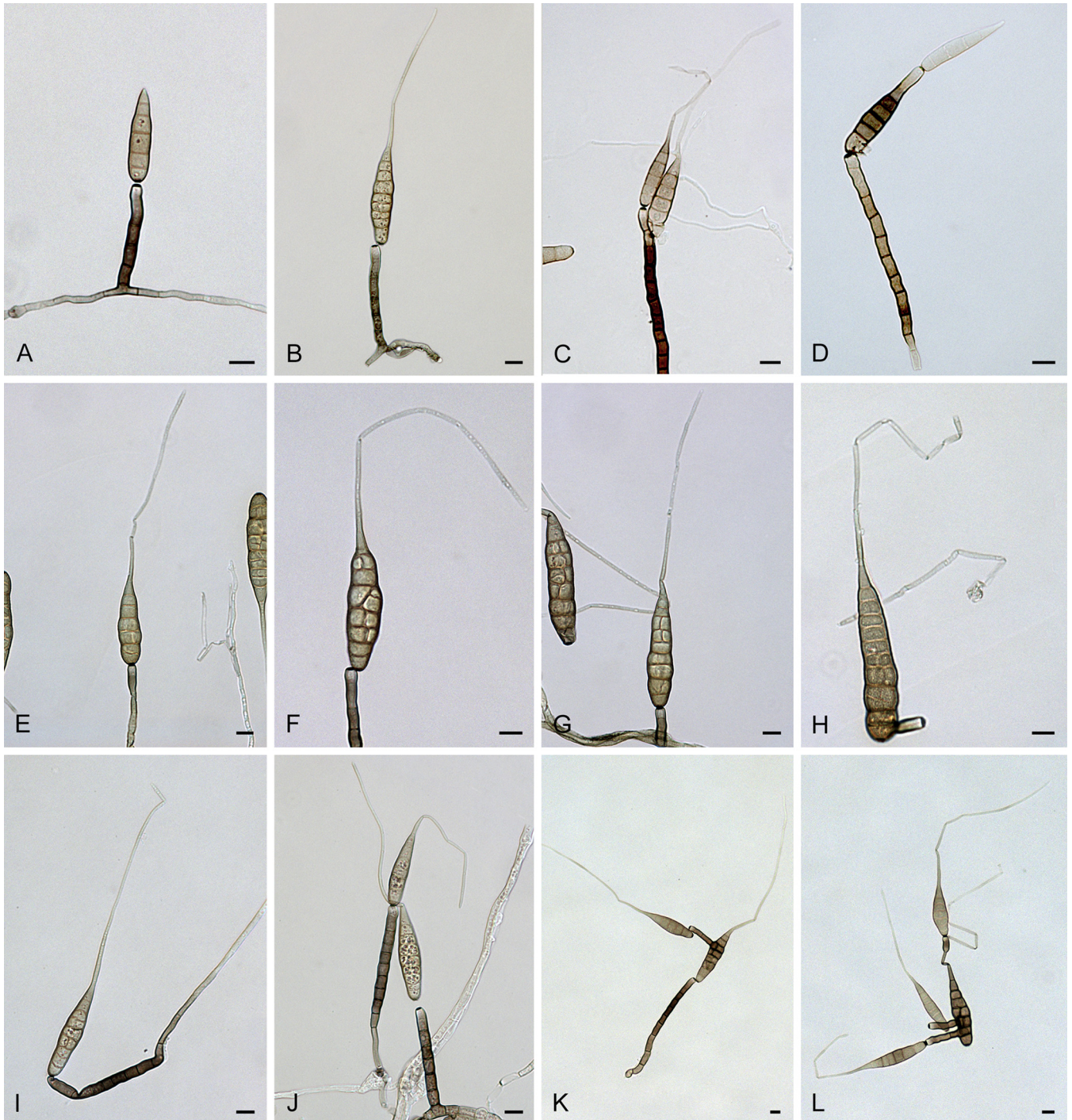


Fig. 9. *Alternaria cassiae*: conidia and conidiophores. A–D. CBS 116119. E–H. CBS 117224. I–L. CBS 117369. Scale bars = 10 μ m.

126–160(–260) μ m long, ca. 2 μ m diam throughout their length. Sexual morph not observed.

Culture characteristics: After 7 d cultures on SNA flat, entire/fimbriate, olivaceous around agar plug, white; aerial mycelium felty, white to olivaceous, colonies reaching 10–15 mm diam; cultures on PCA flat, erose, grey-olivaceous; aerial mycelium fine felty, olivaceous-grey; colonies reaching 25 mm diam; reverse identical.

Material examined: Netherlands, from *Catananche caerulea* (Asteraceae), 11 Dec. 2013, N. Troost-Riksen (holotype CBS H-21736, culture ex-type CBS 137456 = PD 013/05703936).

Notes: *Alternaria catananches* seems closely related to the *A. cichorii* isolates in the multi-gene phylogeny, but this is probably caused by long-branch attraction and incongruency between the different gene trees. Based on the ITS sequence it is identical to *A. jesenskae*, with RPB2 it is identical to *A. cirsinoxia*, with TEF1 it clusters with *A. cichorii*/*A. cirsinoxia*/*A. carthami* and with Alt a 1 it is identical to *A. cichorii* CBS 102.33, *A. alternariacida* and *A. scorzonerae*. Only its GAPDH sequences make it distinct from all other *Alternaria* species. Although the multi-gene tree does not provide strong support for separating it from the *A. cichorii* isolates, based on the individual gene sequences it is described here as a new *Alternaria* species.



Fig. 10. *Alternaria catananches* sp. nov. A–B. Disease symptoms on *Catananche caerulea* (photo's K.-H. Nugteren, Florensis B.V., Netherlands). C–L. CBS 137456: conidia and conidiophores. Scale bars = 10 µm.

Alternaria centaureae E.G. Simmons, CBS Biodiversity Ser. (Utrecht) 6: 236. 2007.

Specimen examined: USA, California, Sacramento, from *Centaurea solstitialis* (Asteraceae), Feb. 1999, D. Fogle, culture **ex-type** of *A. centaureae* CBS 116446 = E.G.S. 47.119.

Alternaria cichorii Nattrass, First List of Cyprus Fungi: 29. 1937.

- ≡ *Alternaria porri* f. sp. *cichorii* (Nattrass) T. Schmidt, Pflanzenschutzberichte 32: 181. 1965.
- ≡ *Macrosporium cichorii* (Nattrass) Gordenko, Mikol. Fitopatol. 9: 241. 1975.

Materials examined: **Cyprus**, from leaf spot of *Cichorium intybus* (Asteraceae), 1933, R.M. Nattrass (**holotype** IMI 1007, culture **ex-type** CBS 102.33 = E.G.S. 07.017 = QM 1760). **Greece**, Attica, from *Cichorium endivia* (Asteraceae), 24 Feb. 1978, S.D. Demetriades, representative isolate of *A. cichorii* CBS 117218 = E.G.S. 52.046 = IMI 225641.

Notes: Strain CBS 102.33 was deposited in Aug. 1933 in the CBS by R.M. Nattrass as *A. cichorii* sp. nov., with the remark that the description of the new species was in preparation. The holotype was subsequently deposited in IMI (IMI 1007) which consists of a dried herbarium specimen. In the present study we link CBS 102.33 as ex-type of *A. cichorii* to IMI 1007. The two isolates used in this study, CBS 102.33 and CBS 117218, differ only on 7 nt positions in their Alt 1 sequence. Unfortunately CBS 102.33 is sterile, which does not provide additional

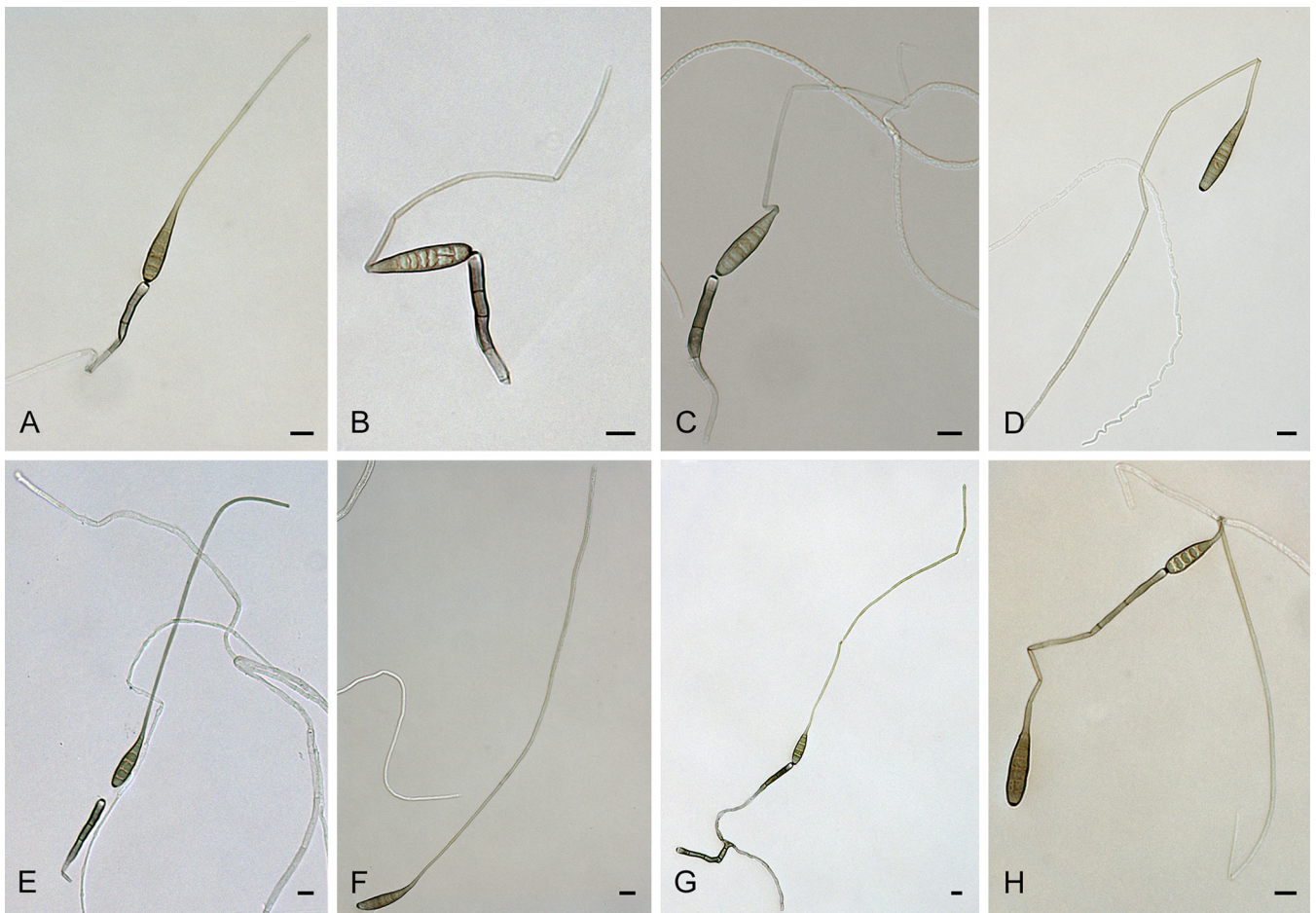


Fig. 11. *Alternaria citrullicola* sp. nov. CBS 103.32: A–H. Conidia and conidiophores. Scale bars = 10 μ m.

information to support them as being two different species. Furthermore, the time difference of 45 yr between isolation of the two strains led to the decision to retain them as one species for now, pending fresh collections.

Alternaria cirsinoxia E.G. Simmons & K. Mort., Mycotaxon 65: 72. 1997.

Material examined: Canada, Saskatchewan, Watrous, from stem lesion and top dieback of *Cirsium arvense* (Asteraceae), 5 Aug. 1993, K. Mortensen, culture *ex-type* of *A. cirsinoxia* CBS 113261 = E.G.S. 41.136.

Alternaria citrullicola Woudenb. & Crous, sp. nov. MycoBank MB808993. Fig. 11.

Etymology: Named after the host genus from which it was collected, *Citrullus*.

Primary conidiophores solitary, simple, straight or sometimes curved, septate, pale brown with a subhyaline tip, (28–)35–52(–73) \times (3–)4(–5) μ m, bearing a single, darkened, apical conidiogenous locus. *Conidia* mostly solitary but chains of two conidia can occur, conidium body pale olive-brown, smooth-walled, narrowly ovoid, (28–)35–41(–56) \times (6–)8(–10) μ m; with (3–)5–6(–9) transverse distosepta and 0–1(–2) longitudinal septa. Conidia have a single, aseptate, unbranched filamentous beak; apical *secondary conidiophores* can be formed. *Beaks* (72–)178–232(–324) μ m long, ca. 2 μ m diam throughout their length. *Sexual morph* not observed.

Culture characteristics: After 7 d cultures on SNA flat, fimbriate, white to opaque with primrose sections near the edge; aerial mycelium sparse, fine felty, colonies reaching 45–50 mm diam; cultures on PCA flat, entire, olivaceous with three unclear concentric circles; aerial mycelium is sparse, pale olivaceous-grey, colonies reaching 50–55 mm diam; reverse shows olivaceous-buff to olivaceous rings.

Material examined: Cyprus, from fruit of *Citrullus lanatus* (Cucurbitaceae), before Jul. 1932, R.M. Nattrass (*holotype* CBS H-21742, culture *ex-type* CBS 103.32 = VKM F-1881).

Alternaria conidiophora Woudenb. & Crous, sp. nov. MycoBank MB808995. Fig. 12.

Etymology: Named after its characteristically long, thick, conidiophores.

Primary conidiophores solitary, simple, mostly straight but sometimes curved, septate, dark brown with a subhyaline tip, (46–)89–105(–152) \times (6–)7(–8) μ m, bearing a single to multiple, darkened, long geniculate conidiogenous loci. *Conidia* solitary, conidium body olive-brown, smooth-walled, narrowly ovoid, (30–)45–52(–66) \times (10–)12–13(–18) μ m, with (2–)6–7(–9) transverse septa and (0–)1–2(–4) longitudinal septa. Darker coloured eusepta are formed during development. The conidial body is slightly constricted near the transverse septa. Conidia have a single, septate, unbranched, filamentous beak; basal, lateral *secondary conidiophores* can be formed. *Beaks*

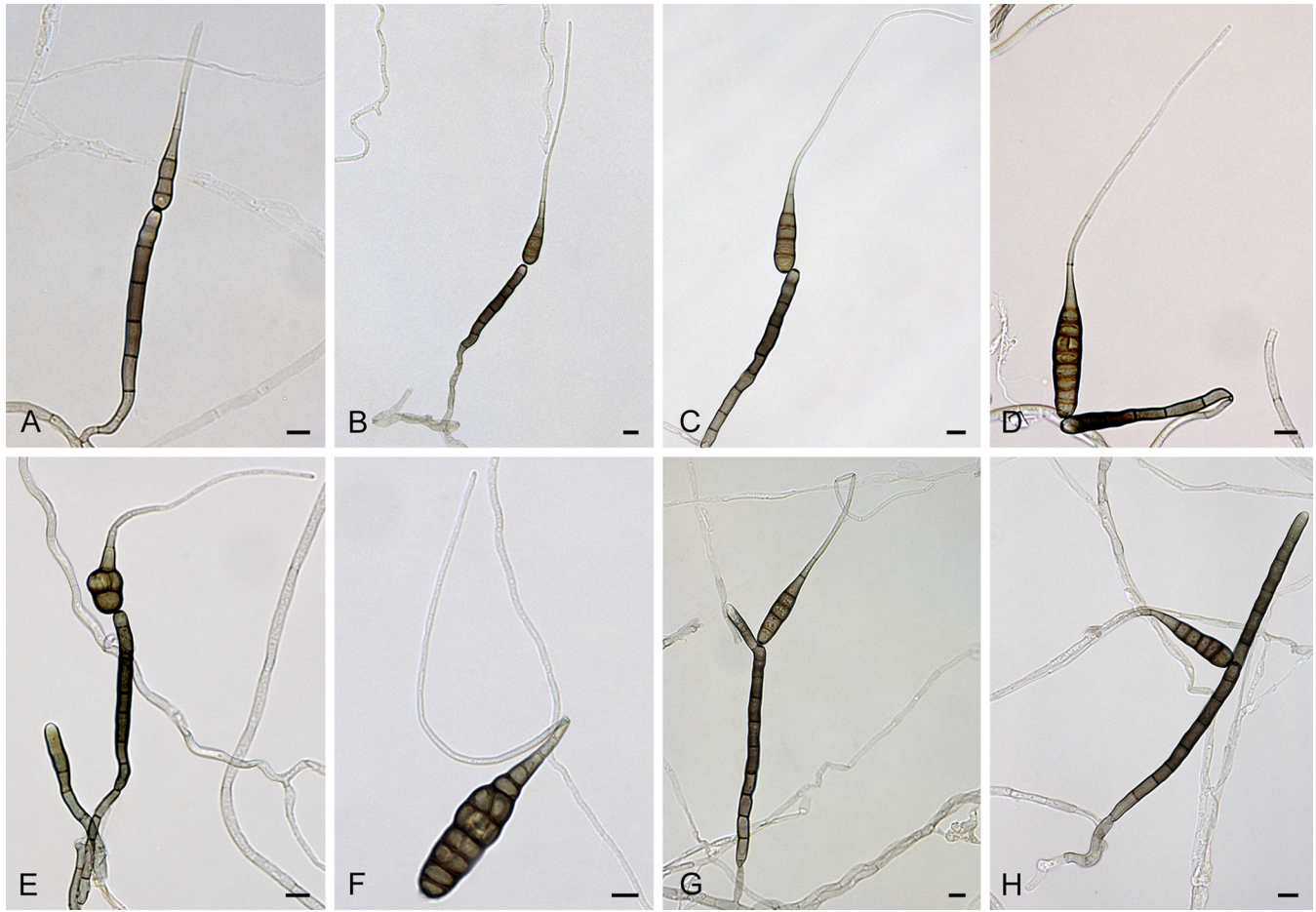


Fig. 12. *Alternaria conidiophora* sp. nov. CBS 137457: A–H. Conidia and conidiophores. Scale bars = 10 µm.

(49–)117–138(–186) µm long; ca. 2 µm diam throughout their length. *Sexual morph* not observed.

Culture characteristics: After 7 d cultures on SNA flat, fimbriate to rhizoid, white to opaque; aerial mycelium felty, white, colonies reaching 55–60 mm diam; cultures on PCA flat, entire, grey-olivaceous with two concentric circles; aerial mycelium wooly, pale olivaceous-grey, colonies reaching 55–60 mm diam; reverse identical.

Material examined: **Netherlands**, from unidentified host, Jul. 2011, U. Damm (holotype CBS H-21737, culture **ex-type** CBS 137457).

***Alternaria crassa* (Sacc.) Rands, Phytopathology 7: 337. 1917. Fig. 13.**

Basionym: *Cercospora crassa* Sacc., *Michelia* 1(no. 1): 88. 1877.
 = *Macrosporium solani* Cooke, *Grevillea* 12: 32. 1883. (non *M. solani* Ellis & Martin, 1882)
 = *Cercospora daturae* Peck, *Rep. New York State Mus. Nat. Hist.* 35: 140. 1884.
 = *Macrosporium cookei* Sacc., *Syll. Fungorum* 4: 530. 1886. (nom. nov. in Saccardo for *M. solani* Cooke, 1883, non *M. solani* Ellis & Martin, 1882)
 ≡ *Alternaria cookei* (Sacc.) Bremer, Ismen, Karel, Özkan & M. Özkan, *Istanbul Üniv. Fak. Mecm.*, B. 13: 42. 1948.
 = *Macrosporium daturae* Fautrey, *Rev. Mycol. (Toulouse)* 16: 76. 1894.
 ≡ *Alternaria daturae* (Fautrey) Bubák & Ranoj., *Fungi Imperf. Exsicc. Fasc.* 14: 694. 1911.
 = *Alternaria capsici* E.G. Simmons, *Mycotaxon* 75: 84. 2000.

Type: (Lectotype, designated in Simmons 2000) PAD, *Cercospora crassa*, *Datura stramonium*, S. [elva] '76. 10.

Materials examined: **Australia**, from *Capsicum annuum* (*Solanaceae*), May 1981, D. Trimboli, culture **ex-type** of *A. capsici* CBS 109160 = IMI 262408 = IMI 381021 = E.G.S. 45.075. **Cyprus**, Famagusta, from leaves of *Datura stramonium* (*Solanaceae*), Jan. 1936, R.M. Nattrass (**epitype designated here** CBS H-21744, MBT178115, culture **ex-epitype** CBS 110.38). **New Zealand**, Auckland, from leaf spot of *Datura stramonium*, 2002, C.F. Hill, representative isolate of *A. crassa* CBS 116448 = E.G.S. 50.180. **USA**, Indiana, Montgomery County, *Nicandra physalodes* (*Solanaceae*), 5 Sep. 1997, E.G. Simmons, CBS 109162 = E.G.S. 46.014; Indiana, from leaf spot of *Datura stramonium*, 5 Sep. 1997, E.G. Simmons, representative isolate of *A. crassa* CBS 116447 = E.G.S. 46.013; Indiana, Montgomery County, from leaf spot of *Datura stramonium*, 1 Aug. 1996, E.G. Simmons, representative isolate of *A. crassa* CBS 122590 = E.G.S. 44.071; Wisconsin, Madison, from leaf spot of *Datura* sp., before Apr. 1918, R.D. Rands, CBS 103.18.

Notes: Isolates CBS 110.38 and CBS 116647 did not sporulate after 3 wk incubation on SNA. By synonymising *A. capsici* with *A. crassa*, the host range of this taxon expanded to include *Capsicum annuum*, which also belongs to the *Solanaceae*.

***Alternaria cucumerina* (Ellis & Everh.) J.A. Elliott, Amer. J. Bot. 4: 472. 1917. Fig. 14.**

Basionym: *Macrosporium cucumerinum* Ellis & Everh., *Proc. Acad. Nat. Sci. Philadelphia* 47: 440. 1895.
 = *Alternaria loofahae* E.G. Simmons & Aragaki, *CBS Biodiversity Ser. (Utrecht)* 6: 316. 2007.

Materials examined: **Australia**, Queensland, from leaf spot of *Cucumis melo* (*Cucurbitaceae*), Oct. 1996, R. O'Brien, representative isolate of *A. cucumerina* CBS 117226 = E.G.S. 44.197 = BRIP 23060. **USA**, Hawaii, Oahu, Waialua, from *Luffa acutangula* (*Cucurbitaceae*), 1971, M. Aragaki, culture **ex-type** of *A. loofahae* CBS 116114 = E.G.S. 35.123; Indiana, Knox County, from leaf spot of *Cucumis melo*, 1993, R.X. Latin, representative isolate of *A. cucumerina* CBS 117225 = E.G.S. 41.127.

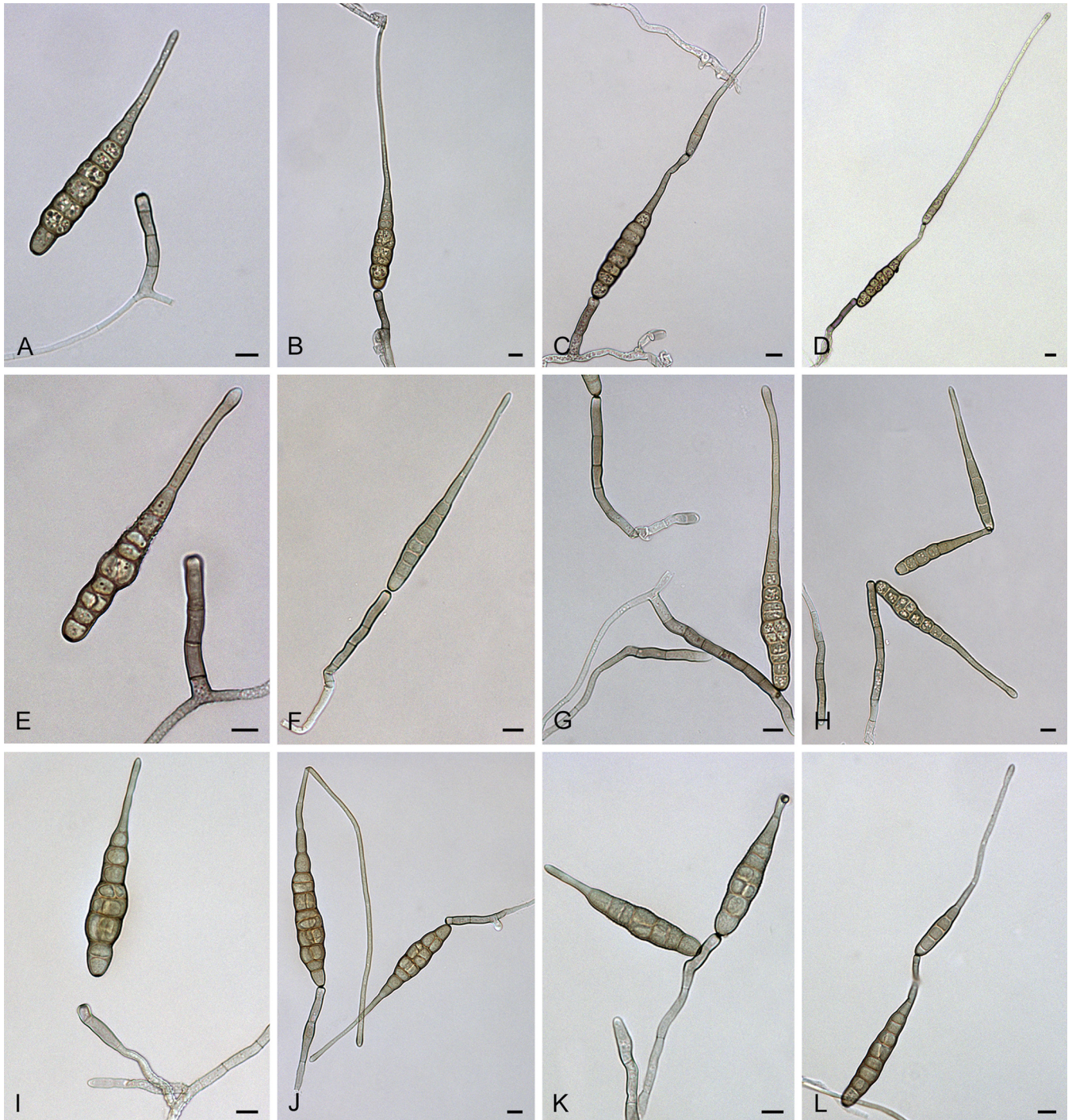


Fig. 13. *Alternaria crassa*: conidia and conidiophores. A–D. CBS 109162. E–H. CBS 116648. I–L. CBS 119160. Scale bars = 10 μ m.

Notes: The species clade for *A. cucumerina* does not have a clear support in the multi-gene phylogeny. CBS 117225 and CBS 117226 differ only on 2 nt in their RPB2 sequence, while the ex-type of *A. loofahae* (CBS 116114) differs on 1 nt from both *A. cucumerina* isolates in RPB2 and on 1 nt in Alt a 1. This internal variation in the two *A. cucumerina* isolates and the identical host family, *Cucurbitaceae*, with *A. loofahae*, supported the synonymy of *A. loofahae*. By synonymising *A. loofahae* with *A. cucumerina*, the host range of this taxon expanded to include *Luffa acutangula*.

Alternaria cyamopsidis Rangaswami & A.V. Rao, Indian Phytopathol. 10: 23. 1957.

≡ *Alternaria cucumerina* var. *cyamopsidis* (Rangaswami & A.V. Rao) E.G. Simmons, Mycopathol. Mycol. Appl. 29: 131. 1966.

Materials examined: USA, Georgia, from leaf spot of *Cyamopsis tetragonoloba* (*Fabaceae*), Jul. 1961, G. Sowell, representative isolate of *A. cyamopsidis* CBS 117219 = E.G.S. 13.120 = QM 8000; Maryland, Beltsville, from leaf spot of *Cyamopsis tetragonoloba*, 1964, R.G. Orellana, representative isolate of *A. cyamopsidis* CBS 364.67 = E.G.S. 17.065 = QM 8575.

Alternaria dauci (J.G. Kühn) J.W. Groves & Skolko, Canad. J. Res., Sect. C, Bot. Sci. 22: 222. 1944. Fig. 15. **Basionym:** *Sporidesmium exitiosum* var. *dauci* J.G. Kühn, Hedwigia 1: 91. 1855.

≡ *Polydesmus exitiosus* var. *dauci* (J.G. Kühn) J.G. Kühn, Die Krankheiten der Kulturgewächse, ihre Ursachen und ihre Verhütung: 165. 1858.

≡ *Macrosporium dauci* (J.G. Kühn) Rostr., Tidsskr. Landoekon. ser. 5, 7: 385. 1888.

≡ *Alternaria brassicae* var. *dauci* (J.G. Kühn) Lindau, Rabenhorst's Kryptog.-Fl., Edn 2 (Leipzig) 1(9): 260. 1908.

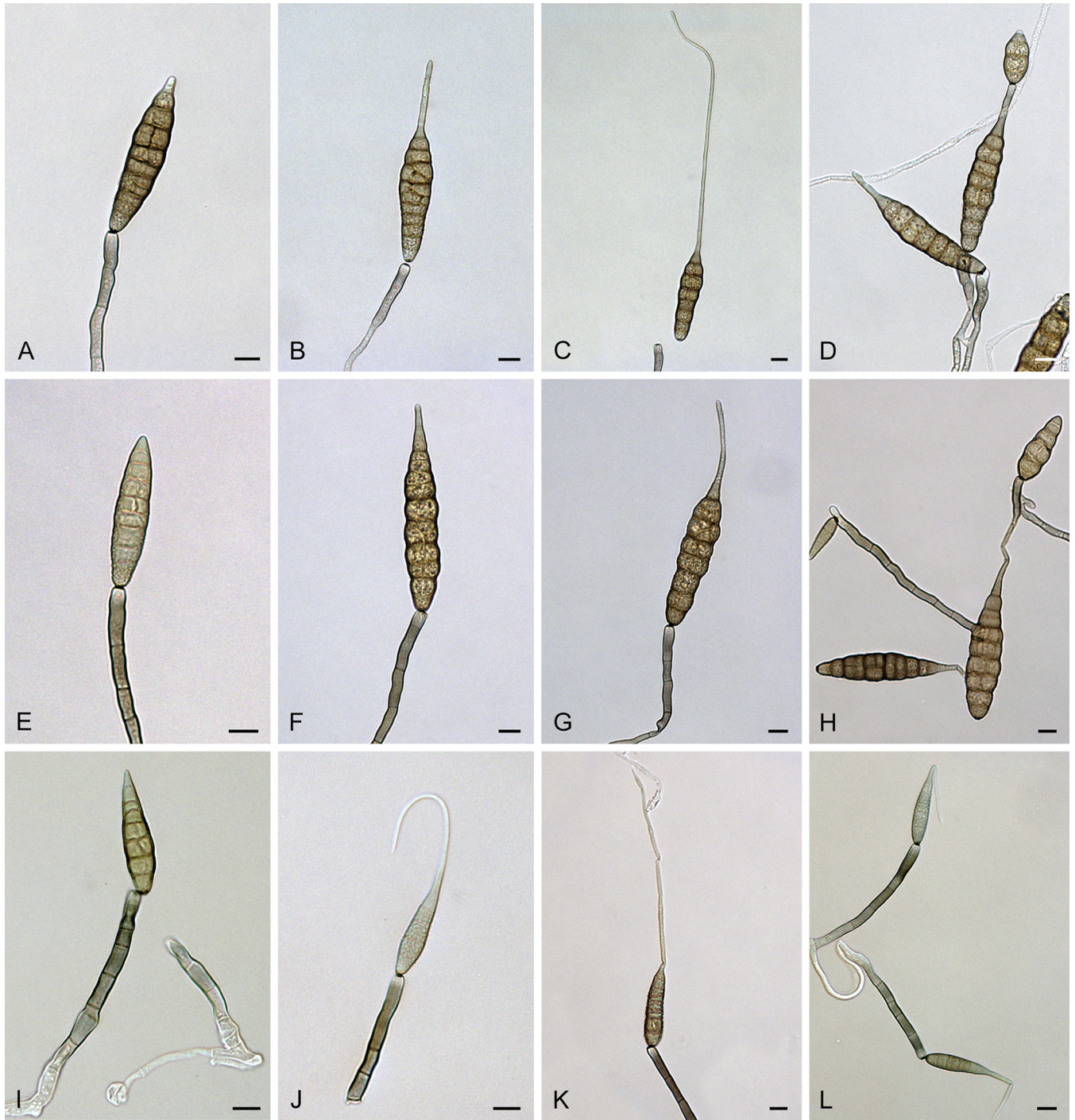


Fig. 14. *Alternaria cucumerina*: conidia and conidiophores. A–D. CBS 117225. E–H. CBS 117226. I–L. CBS 116114. Scale bars = 10 µm.

- ≡ *Alternaria porri* f. sp. *dauci* (J.G. Kühn) Neerg, Danish species of *Alternaria* & *Stemphylium*: 252. 1945.
- = *Macrosporium carotae* Ellis & Langl., J. Mycol. 6: 36. 1890.
- ≡ *Alternaria carotae* (Ellis & Langl.) J.A. Stev. & Wellman, J. Wash. Acad. Sci. 34: 263. 1944.
- = *Alternaria poonensis* Ragnath, Mycopathol. Mycol. Appl. 21: 315. 1963.

Type: (Lectotype, designated in Simmons 1995) B, ms. spec. *Sporidesmium exitiosum* var. *dauci* Kühn, Leg. Gross Krausche p. Bunzlau, Jul. Kühn.

Materials examined: **Italy**, from seed of *Daucus carota* (*Apiaceae*), Sept. 1937, P. Neergaard (neotype designated here CBS H-21745, MBT178116, culture ex-neotype CBS 111.38). **Netherlands**, Limburg, Horst, from leaf spot in *Cichorium intybus* var. *foliosum* (*Asteraceae*), 1979, W.M. Loerakker, CBS 477.83 = CBS 721.79 = PD 79/954; from seed of *Daucus carota*, 1993, S&G Seeds, CBS

101592. **New Zealand**, from leaf spot of *Daucus carota*, Mar. 1998, C.F. Hill, representative isolate of *A. dauci* CBS 117098 = E.G.S. 46.152; Ohakune, from leaf spot of *Daucus carota*, before Jul. 1979, G.F. Laundon, CBS 345.79 = LEV 14814. **Puerto Rico**, from seedling of *Coriandrum sativum* (*Apiaceae*), 1999, W. Almodovar, representative isolate of *A. poonensis* CBS 117100 = E.G.S. 47.138. **Unknown**, from seed of *Daucus carota*, Jan. 1948, J.W. Groves, CBS 106.48. **USA**, California, from commercial seed of *Daucus carota*, Nov. 1994, B.M. Pryor, representative isolate of *A. dauci* CBS 117097 = E.G.S. 46.006; California, Kern County, from seed of *Daucus carota*, 1999, D. Fogle, representative isolate of *A. dauci* CBS 117099 = E.G.S. 47.131.

Notes: The indicated lectotype cannot be traced in B, and appears to be lost. We therefore designate CBS 111.38 as neotype. The isolates CBS 111.38, CBS 345.79 and CBS 101592 did not sporulate after 3 wk incubation on SNA.

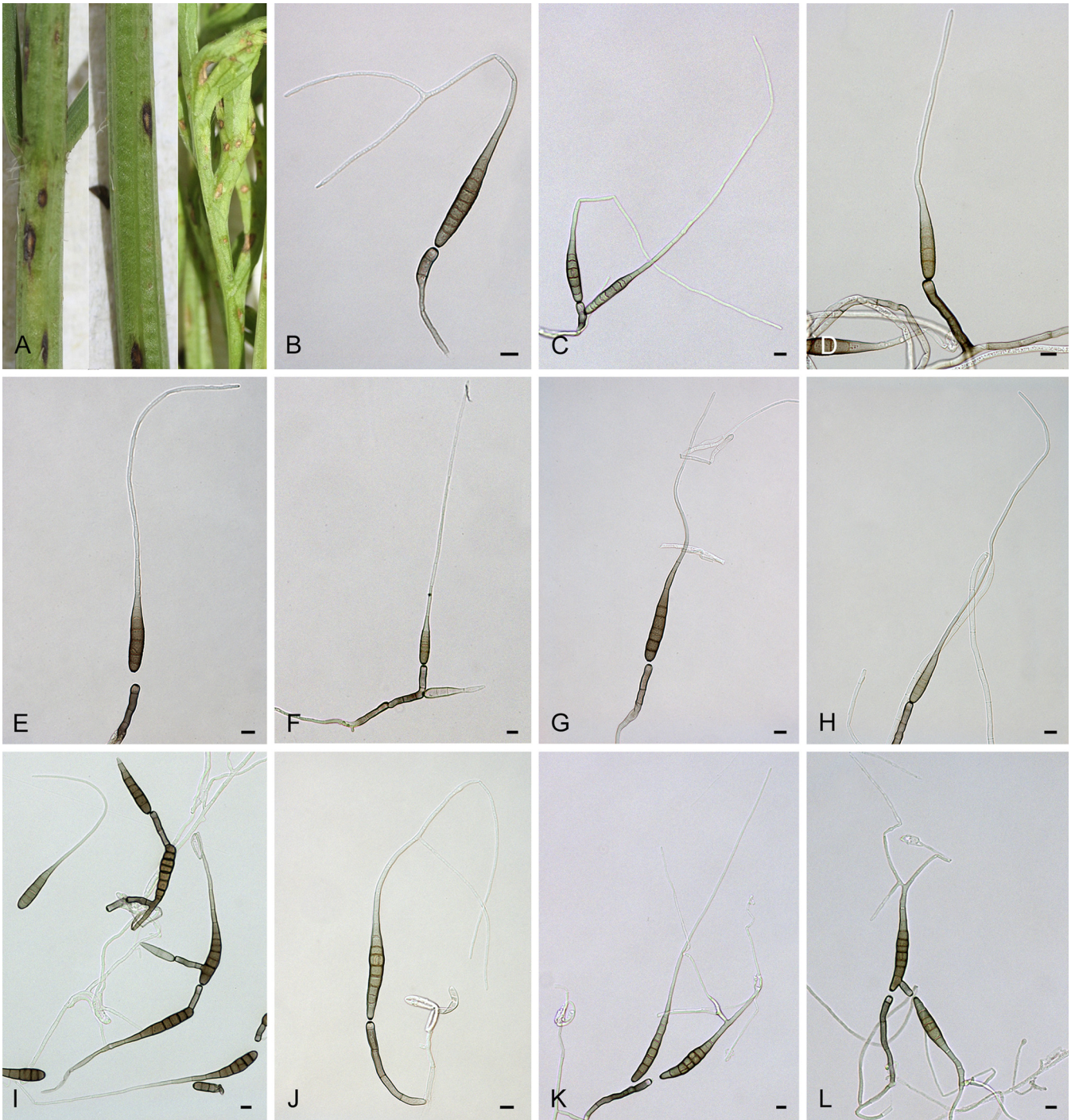


Fig. 15. *Alternaria dauci*. A. Disease symptoms on *Daucus carota*. B–L. Conidia and conidiophores. B–C. CBS 117097. D–F. CBS 117098. G–I. CBS 117099. J–L. CBS 117100. Scale bars = 10 µm.

Alternaria deserticola Woudenb. & Crous, **sp. nov.**
MycoBank MB808996.

Etymology: Named after the substrate from which it was isolated, namely desert soil.

Culture sterile

Alternaria deserticola differs from the ex-type strain of its closest phylogenetic neighbour *A. thunbergiae* (CBS 116331) based on alleles in all five loci (positions derived from respective alignments of the separate loci deposited in

TreeBASE): ITS position 165 (–), 373 (T), 381 (C), 383 (C), 488 (A); GAPDH position 484 (T); RPB2 position 76 (C), 88 (T), 91 (T), 139 (C), 211 (T), 316 (T), 490 (C), 496 (A), 646 (T), 670 (C), 671 (T), 673 (A), 760 (G); TEF1 position 37 (C), 49 (G), 197 (A), 223 (A), 274 (T), 277(–), 311(T); Alt a 1 position 10 (C), 209 (A), 210 (T), 220 (G), 322 (T), 452 (G).

Culture characteristics: After 7 d cultures on SNA flat, rhizoid, olivaceous-buff; aerial mycelium absent, colonies reaching 55 mm diam; cultures on PCA flat, entire, five grey-olivaceous concentric circles; aerial mycelium sparse, colonies reaching 75–80 mm diam; reverse shows five olivaceous-grey rings.

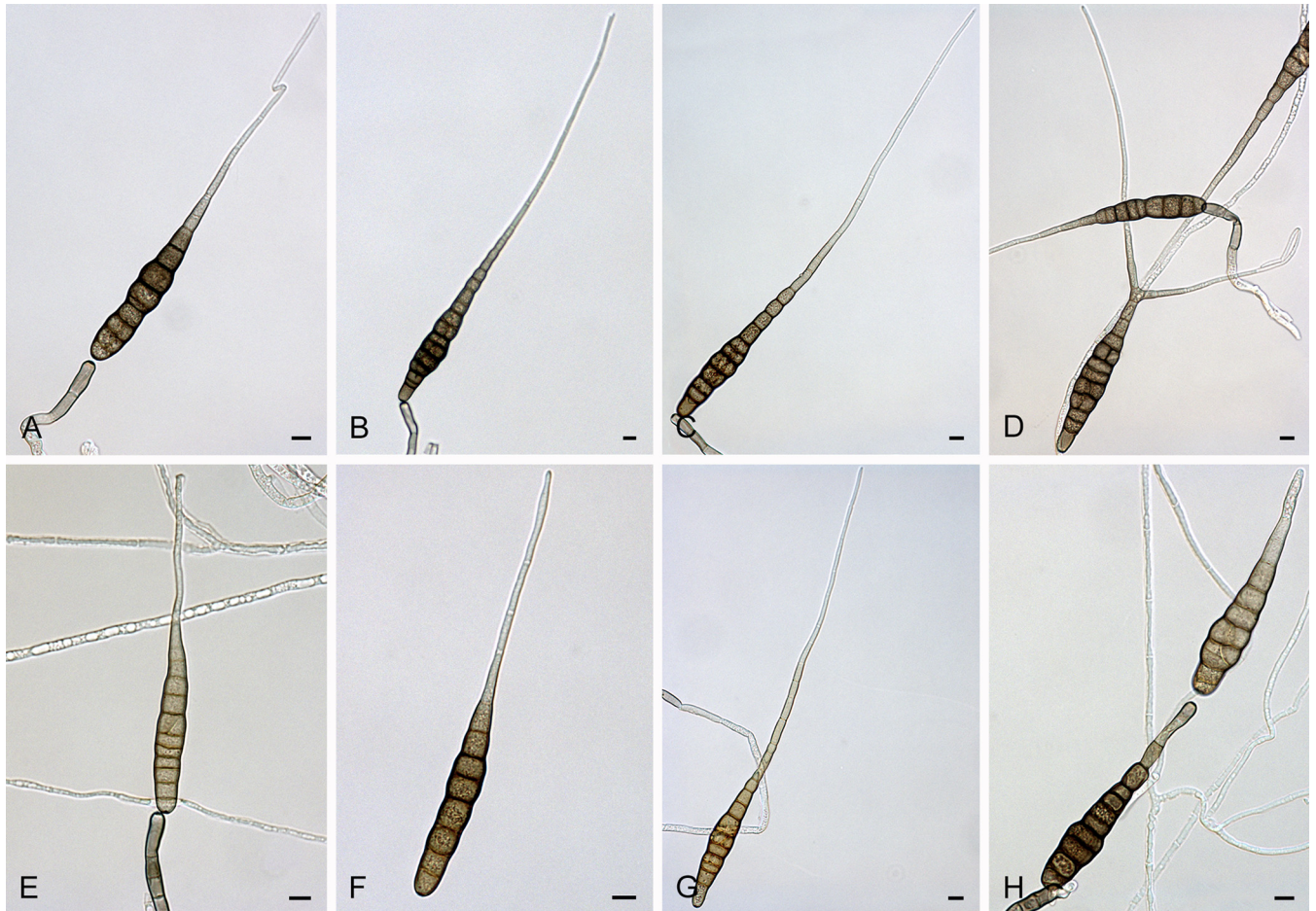


Fig. 16. *Alternaria grandis*: conidia and conidiophores. A–D. CBS 109158. E–H. CBS 116695. Scale bars = 10 μ m.

Material examined: Namibia, from desert soil, 2001, M. Christensen (holotype CBS H-21738, culture **ex-type** CBS 110799).

Note: The clear phylogenetic distinction of the sterile culture of *A. deserticola* from all other strains included in this study, resulted in our decision to describe this species based on sequence data only.

Alternaria dichondrae Gambogi, Vannacci & Triolo, *Trans. Brit. Mycol. Soc.* 65(2): 323. 1975.

Materials examined: Italy, Pisa, from leaf spot of *Dichondra repens* (Convolvulaceae), Mar. 1974, P. Gambogi, **ex-isotype** of *A. dichondrae* CBS 199.74 = E.G.S. 38.007; Pisa, from leaf spot of *Dichondra repens*, Mar. 1974, P. Gambogi, **living lectotype** of *A. dichondrae* CBS 200.74 = E.G.S. 38.008. **New Zealand**, from leaf spot of *Dichondra repens*, before 1979, G.F. Laundon, CBS 346.79; Auckland, Lynfield, from leaf of *Dichondra* sp., Apr. 1991, C.F. Hill, representative isolate of *A. dichondrae* CBS 117127 = E.G.S. 40.057.

Note: Simmons (2007) designated a lectotype with ex-lectotype strain (CBS 200.74), as he found the ex-isotype strain (CBS 199.74) to be sterile.

Alternaria echinaceae E.G. Simmons & C.F. Hill, *CBS Biodiversity Ser. (Utrecht)* 6: 318. 2007.

Materials examined: **New Zealand**, Gisborne, Makaraka, from leaf of *Echinacea* sp. (Asteraceae), Jan. 1998, C.F. Hill, culture **ex-type** of *A. echinaceae* CBS 116117 = E.G.S. 46.081; Gisborne, Makaraka, from leaf of *Echinacea* sp., Jan. 1998, C.F. Hill, representative isolate of *A. echinaceae* CBS 116118 = E.G.S. 46.082.

Alternaria grandis E.G. Simmons, *Mycotaxon* 75: 96. 2000. Fig. 16.

Materials examined: **USA**, Pennsylvania, Centre County, from leaf lesion of *Solanum tuberosum* (Solanaceae), Sep. 1966, B.J. Christ, culture **ex-type** of *A. grandis* CBS 109158 = E.G.S. 44.106; Pennsylvania, Clarion County, from leaf spot of *Solanum tuberosum*, Sep. 1966, B.J. Christ, representative isolate of *A. grandis* CBS 116695 = E.G.S. 44.108.

Notes: Although *A. grandis* differs by only 1 nt in its GAPDH sequence from *A. solani*, we retain it as a distinct species. Conidia of *A. grandis* are substantially larger than those of *A. solani*, and a recently published study could separate *A. solani* (CBS 109157) and *A. grandis* (CBS 109158) based on partial calmodulin gene sequence data (Gannibal *et al.* 2014).

Alternaria ipomoeae M. Truter, Woudenb. & Crous, **sp. nov.** MycoBank MB808997. Fig. 17.

Etymology: Named after the host genus on which it occurs, *Ipomoea*.

Primary conidiophores simple to branched, straight to slightly curved, septate, pale brown, (10–)51–73(–145) \times (4–)5 μ m, bearing a single to multiple, darkened, geniculate conidiogenous loci. **Conidia** mostly solitary but chains of two conidia can occur, conidium body olive-brown, smooth-walled with ornamented base, long ellipsoid to obclavate, (53–)60–65(–76) \times (9–)12(–15) μ m, with (6–)8–9(–12) transverse septa and (0–)2(–3) longitudinal septa. Up to four dark coloured eusepta can be

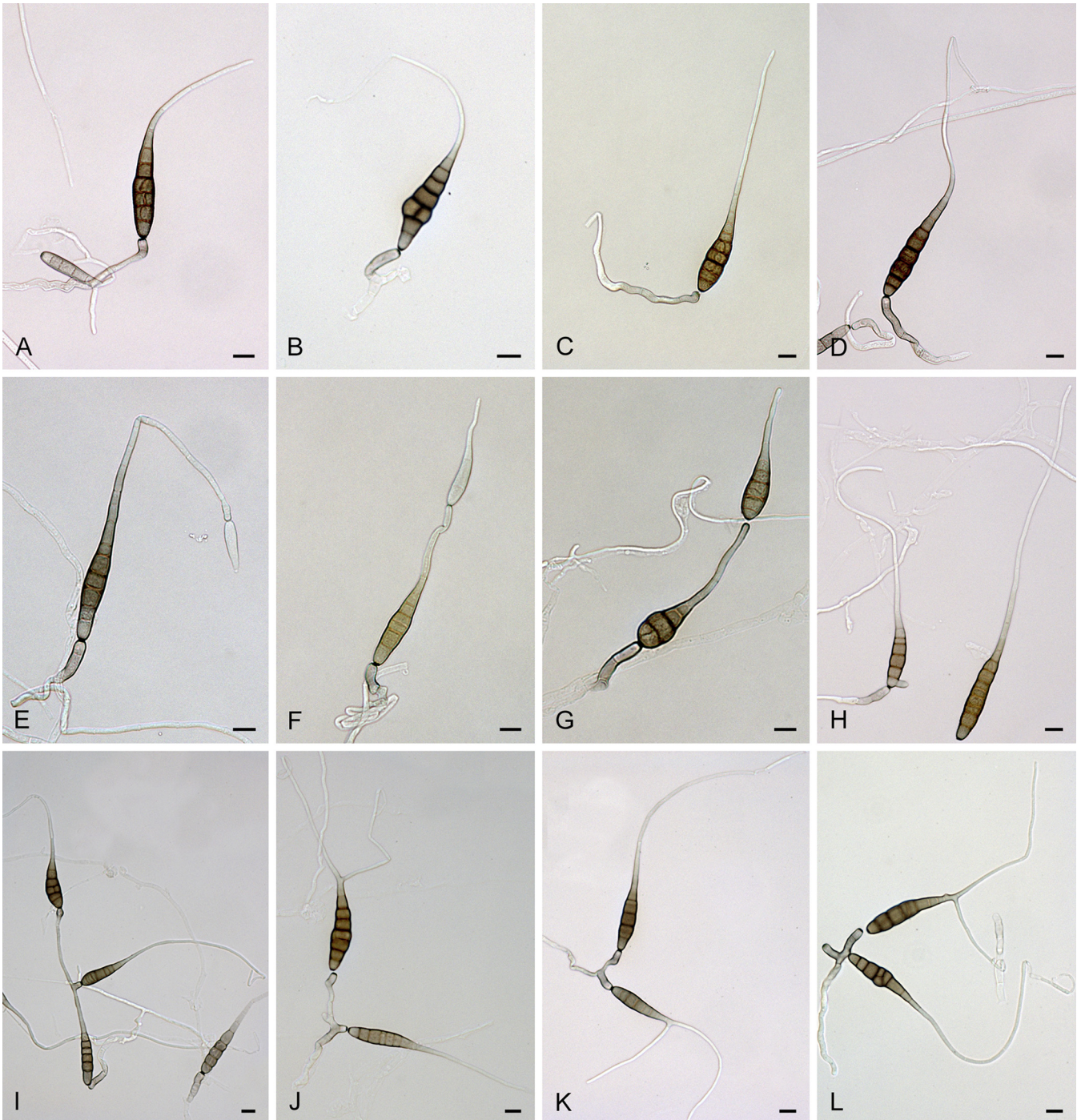


Fig. 17. *Alternaria ipomoeae* sp. nov. CBS 219.79: A–L. Conidia and conidiophores. Scale bars = 10 μ m.

formed during development; the conidial body is constricted near these eusepta. Conidia have a septate, single to double, filamentous beak; apical and lateral *secondary conidiophores* can be formed. *Beaks* (47–)136–162(–221) μ m long, single beaks generally longer than multiple beaks, ca. 2 μ m diam throughout their length, and approx. 3 μ m diam at the base. *Sexual morph* not observed.

Culture characteristics: After 7 d cultures on SNA are flat, fimbriate, white; aerial mycelium sparse, felty, white, colonies reaching 50 mm diam; cultures on PCA flat, entire, grey-olivaceous with some darker sections; aerial mycelium fine felty, pale olivaceous-grey, colonies reaching 65–70 mm diam; reverse identical.

Materials examined: **Ethiopia**, from black lesions of *Ipomoea batatas* (*Convolvulaceae*), Jun. 1978, A.H.C. van Bruggen (**holotype** CBS H-21739, culture **ex-type** CBS 219.79). **South Africa**, Gauteng Province, Pretoria, ARC-Roodeplaat VOPI, from stem lesions of *Ipomoea batatas*, 16 Nov. 2006, C.D. Narayanan (**paratype** PREM 60979, culture **ex-paratype** PPRI 8988).

Alternaria jesenskae Labuda, P. Eliáš & Sterfl., *Microbiol. Res.* 163: 209. 2008.

Material examined: **Slovakia**, district of the village Muzla, Podunajská nizina lowland, from seeds of *Fumana procumbens* (*Cistaceae*), Aug. 1999, P. Eliáš jr., culture **ex-type** of *A. jesenskae* CBS 133855 = CCM 8361.

Alternaria linariae (Neerg.) E.G. Simmons, *CBS Biodiversity Ser. (Utrecht)* 6: 677. 2007. [Fig. 18.](#)



Fig. 18. *Alternaria linariae*. A. Disease symptoms on *Solanum lycopersicum*. B–P. Conidia and conidiophores. B–C. CBS 105.41. D–F. CBS 109161. G–H. CBS 107.61. I–J. CBS 109156. K–L. CBS 109164. M–N. CBS 116438. O–P. CBS 116441. Scale bars = 10 μ m.

Basionym: *Alternaria anagallidis* var. *linariae* Neerg., Danish species of *Alternaria* & *Stemphylium*: 297. 1945.

- = *Alternaria cretica* E.G. Simmons & Vakal., Mycotaxon 75: 64. 2000.
- = *Alternaria subcylindrica* E.G. Simmons & R.G. Roberts, Mycotaxon 75: 62. 2000.
- = *Alternaria tomatophila* E.G. Simmons, Mycotaxon 75: 53. 2000.
- = *Alternaria cucumericola* E.G. Simmons & C.F. Hill, CBS Biodiversity Ser. (Utrecht) 6: 210. 2007.
- = *Alternaria tabasco* E.G. Simmons & R.G. Roberts, CBS Biodiversity Ser. (Utrecht) 6: 158. 2007.

Materials examined: **Belgium**, host unknown, before Mar. 1961, R. Sys, CBS 107.61. **Denmark**, from seedling of *Linaria maroccana* (*Scrophulariaceae*), 13 Nov. 1940, P. Neergaard, culture **ex-type** of *A. linariae* CBS 105.41 = E.G.S. 07.016. **Greece**, Crete, Heraklio, from leaf spot of *Solanum lycopersicum* (*Solanaceae*), 1997, D.J. Vakilounakis, culture **ex-type** of *A. cretica*, CBS 109164 = E.G.S. 46.188. **New Zealand**, Northland, Kerikeri, from leaf spot of *Cucumis sativus* (*Cucurbitaceae*), Mar. 1993, C.F. Hill, culture **ex-type** of *A. cucumericola* CBS 116438 = E.G.S. 41.057. **Thailand**, Chiang Mai, Royal project, from leaf spot of *Solanum lycopersicum*, 5 Nov. 2012, P.W. Crous, CPC 21620. **Unknown**, host unknown, before Apr. 1953, P.W. Brian, CBS 108.53 = No. 408P. **USA**, Indiana, Montgomery County, from leaf spot of *Solanum lycopersicum*, 23 Aug. 1995, E.G. Simmons, culture **ex-type** of *A. tomatophila* CBS 109156 = E.G.S. 42.156; Indiana, from leaf lesion of *Solanum lycopersicum*, Aug. 1996, E.G. Simmons, representative isolate of *A. tomatophila* CBS 116704 = E.G.S. 44.074; Louisiana, Baton Rouge, Louisiana State University Burden Research Plantation, from leaf lesion of *Solanum lycopersicum* var. *cerasiforme*, 2 Jul. 1997, R.G. Roberts, culture **ex-type** of *A. subcylindrica* CBS 109161 = E.G.S. 45.113; Louisiana, Avery Island, from leaf spot of *Capsicum frutescens* (*Solanaceae*), 1 Jul. 1997, R.G. Roberts, culture **ex-type** of *A. tabasco* CBS 116441 = E.G.S. 45.108 = R.G.R. 97-52.

Notes: By synonymising *A. cretica*, *A. cucumericola*, *A. subcylindrica*, *A. tabasco* and *A. tomatophila* with *A. linariae*, the broad host range of this taxon now consists of *Solanaceae*, *Cucurbitaceae* and *Scrophulariaceae* species. The isolates CBS 108.53 and CBS 116704 did not sporulate on SNA after 3 wk of incubation.

Alternaria macrospora Zimm., Ber. Land-Forstw. Deutsch-Ostafrika 2: 24. 1904.

- ≡ *Macrosporium macrosporum* (Zimm.) Nishikado & Oshima, Agric. Res. (Kurashiki) 36: 391. 1944.
- = *Sporidesmium longipedicellatum* Reichert, Bot. Jahrb. Syst. 56: 723. 1921.
- ≡ *Alternaria longipedicellata* (Reichert) Snowden, Rep. Dept. Agric. Uganda: 31. 1927 [1926].

Materials examined: **Nigeria**, from *Gossypium* sp. (*Malvaceae*), May 1929, Jones, CBS 106.29. **USA**, Arizona, from *Gossypium barbadense* (*Malvaceae*), before 1984, P.J. Cotty, culture **epitype** of *A. macrospora* CBS 117228 = E.G.S. 50.190 = ATCC 58172.

Notes: Isolate CBS 106.29 was preserved in the CBS collection as *A. porri*, but did not sporulate since 1978. Based on our molecular data this isolate belongs to *A. macrospora*, which, based on the same host, seems plausible.

Alternaria montanica E.G. Simmons & Robeson, CBS Biodiversity Ser. (Utrecht) 6: 178. 2007.

Material examined: **USA**, Montana, from *Cirsium arvense* (*Asteraceae*), before Apr. 1981, D.J. Robeson, culture **ex-type** of *A. montanica* CBS 121343 = E.G.S. 44.112 = IMI 257563.

Alternaria multirostrata E.G. Simmons & C.R. Jacks., Phytopathology 58: 1139. 1968.

Materials examined: **USA**, Georgia, Tifton, from floral bract of *Richardia scabra* (*Rubiaceae*), 1967, C.R. Jackson, culture **ex-type** of *A. multirostrata* CBS 712.68 = ATCC 18515 = IMI 135454 = MUCL 11722 = QM 8820 = VKM-F2997; Georgia, Tifton, from floral bract of *Richardia scabra*, 1967, C.R. Jackson, representative isolate of *A. multirostrata* CBS 713.68 = ATCC 18517 = IMI 135455 = MUCL 11715 = QM 8821.

Alternaria neoipomoeae M. Truter, Woudenb. & Crous, **sp. nov.** MycoBank MB808998. Fig. 19.

Etymology: Named after its close phylogenetic relationship to *A. ipomoeae*.

Primary conidiophores solitary, simple, straight to slightly curved, septate, pale brown, (10–)23–59(–111) × (4–)5 µm, bearing a single, darkened, apical conidiogenous locus, which may produce 1–2 geniculate conidiogenous extensions. **Conidia** are mostly solitary but chains of two conidia can occur, conidium body olive-brown, smooth-walled with ornamented base, long ellipsoid to obclavate, (52–)66–77(–93) × (12–)14–16(–18) µm, with (7–)9(–12) transverse and (2–)3–4(–5) longitudinal septa. Up to four dark coloured eusepta can be formed during development; the conidial body is constricted near these eusepta. Conidia mostly have a septate, single to double, filamentous beak, triple beaks are observed but not common; apical and lateral **secondary conidiophores** can be formed. **Beaks** (54–)104–136(–200) µm long, ca. 2 µm diam throughout their length, and approx. 3 µm diam at the base. **Sexual morph** not observed.

Culture characteristics: After 7 d cultures on SNA flat, fimbriate, white to opaque; aerial mycelium sparse, fine felty, white, colonies reaching 60–65 mm diam; cultures on PCA flat, entire, grey-olivaceous with 2 dark and one lighter concentric circles and a pale olivaceous edge; aerial mycelium fine felty, pale olivaceous-grey, colonies reaching 55–60 mm diam; reverse four olivaceous-grey rings.

Materials examined: **South Africa**, Gauteng Province, Pretoria, ARC-Roodeplaat VOPI, from stem lesion of *Ipomoea batatas* (*Convolvulaceae*), 8 Jun. 2011, A. Thompson (**holotype** PREM 60981, culture **ex-type** PPRI 11845); North-West Province, Brits, from *Ipomoea batatas*, 25 Oct. 2007, C.D. Narayanan (**paratype** PREM 60982, culture **ex-paratype** PPRI 8990); Mpumalanga Province, Kwamahlanga, from *Ipomoea batatas*, between 2006 and 2008, C.D. Narayanan (**paratype** PREM 60983, culture **ex-paratype** PPRI 11847); Gauteng Province, Pretoria, ARC-Roodeplaat VOPI, from leaf lesion of *Ipomoea batatas*, Oct. 2013, A. Thompson (**paratype** PREM 60984, culture **ex-paratype** PPRI 13903).

Alternaria nitrimali E.G. Simmons & M.E. Palm, Mycotaxon 75: 93. 2000.

Material examined: **Puerto Rico**, Luquillo, from leaf spot of *Solanum viarum* (*Solanaceae*), 26 Feb. 1998, USDA-APHIS, culture **ex-type** of *A. nitrimali* CBS 109163 = E.G.S. 46.151.

Alternaria novae-guineensis E.G. Simmons & C.F. Hill, CBS Biodiversity Ser. (Utrecht) 6: 350. 2007.

Materials examined: **Papua New Guinea**, from dried leaf of *Citrus* sp. (*Rutaceae*) imported to New Zealand, 1999, C.F. Hill, culture **ex-type** of *A. novae-guineensis* CBS 116120 = E.G.S. 47.198. **South Africa**, Gauteng, Pretoria, ARC-Roodeplaat VOPI, from leaves of *Galinsoga parviflora* (*Asteraceae*), 12 Jan. 2012, A. Thompson, PPRI 12171.

Alternaria obtecta E.G. Simmons, Mycotaxon 50: 250. 1994.



Fig. 19. *Alternaria neoipomoeae* sp. nov. A. Disease symptoms on *Ipomoeae batatas* (Photo A.H. Thompson, ARC, South Africa). B–L. PPRI 11845: conidia and conidiophores. Scale bars = 10 μ m.

Materials examined: USA, California, Encinitas, from leaf of *Euphorbia pulcherrima* (Euphorbiaceae), Nov. 1994, C.F. Hill, representative isolate of *A. oblecta* CBS 117367 = E.G.S. 42.063; California, Encinitas, from *Euphorbia pulcherrima* (Euphorbiaceae), Nov. 1994, C.F. Hill, CBS 134278 = E.G.S. 42.064.

Alternaria paralinicola Woudenb. & Crous, sp. nov.
Mycobank MB808999. Fig. 20.

Etymology: Named after its close phylogenetic relationship to *A. linicola*.

Primary conidiophores solitary, simple, straight to slightly curved, septate, pale brown, (39–)64–82(–133) \times (4–)5–6 μ m, bearing a

single, darkened, apical conidiogenous locus, but may produce geniculate conidiogenous extensions. *Conidia* are mostly solitary but chains of two conidia can occur, conidium body pale olive-brown, smooth-walled, narrowly ovoid, (31–)39–44(–58) \times (8–)10–11(–15) μ m, with (3–)5–6(–8) transverse septa and 0–1(–2) longitudinal septa. Dark coloured eusepta are formed during maturation. The conidial body is slightly constricted near the transverse septa. Some transverse blocks of cells can have a conspicuously different width in comparison with neighbouring segments, resulting in specific shape of the conidium body. Conidia mostly have a single, aseptate, unbranched, filamentous beak; double beaks are observed but not common; apical or lateral *secondary conidiophores* can be formed. *Beaks* (61–)



Fig. 20. *Alternaria paralinicola* sp. nov. CBS 116652: A–L. Conidia and conidiophores. Scale bars = 10 μ m.

114–135(–169) μ m long, ca. 2 μ m diam throughout their length. Sexual morph not observed.

Culture characteristics: After 7 d cultures on SNA flat, fimbriate, white to opaque; aerial mycelium sparse, white, colonies reaching 70–75 mm diam; cultures on PCA flat, entire, grey-olivaceous with four olivaceous clear concentric circles; aerial mycelium is fine felty, olivaceous, colonies reaching 70 mm diam; reverse shows five grey-olivaceous concentric circles.

Material examined: Canada, Manitoba, from seeds of cultivated *Linum usitatissimum* (Linaceae), 1996, M.E. Corlett (holotype CBS H-21740, culture ex-type CBS 116652 = E.G.S. 47.157 = DAOM 225747).

Note: *Alternaria paralinicola*, which was originally identified as *A. linicola*, differs on 16 nt positions in its RPB2 sequence from the other two *A. linicola* strains studied. Based on its RPB2 sequence it clusters with *A. passiflorae*.

Alternaria passiflorae J.H. Simmonds, Proc. Roy. Soc. Queensland. 49: 151. 1938. Fig. 21.

= *Alternaria hawaiiensis* E.G. Simmons, Mycotaxon 46: 184. 1993.

= *Alternaria gaurae* E.G. Simmons & C.F. Hill, CBS Biodiversity Ser. (Utrecht) 6: 188. 2007.

Materials examined: New Zealand, from fruit of *Passiflora edulis* (Passifloraceae), 6 Feb. 1963, F.J. Mortin, representative isolate of *A. passiflorae* CBS 629.93 = E.G.S. 16.150 = QM 8458; Auckland, from fruit spot of *Passiflora ligularis* (Passifloraceae), Apr. 2004, C.F. Hill, representative isolate of *A. passiflorae* CBS 117102 = E.G.S. 51.165; Auckland, from leaf spot of

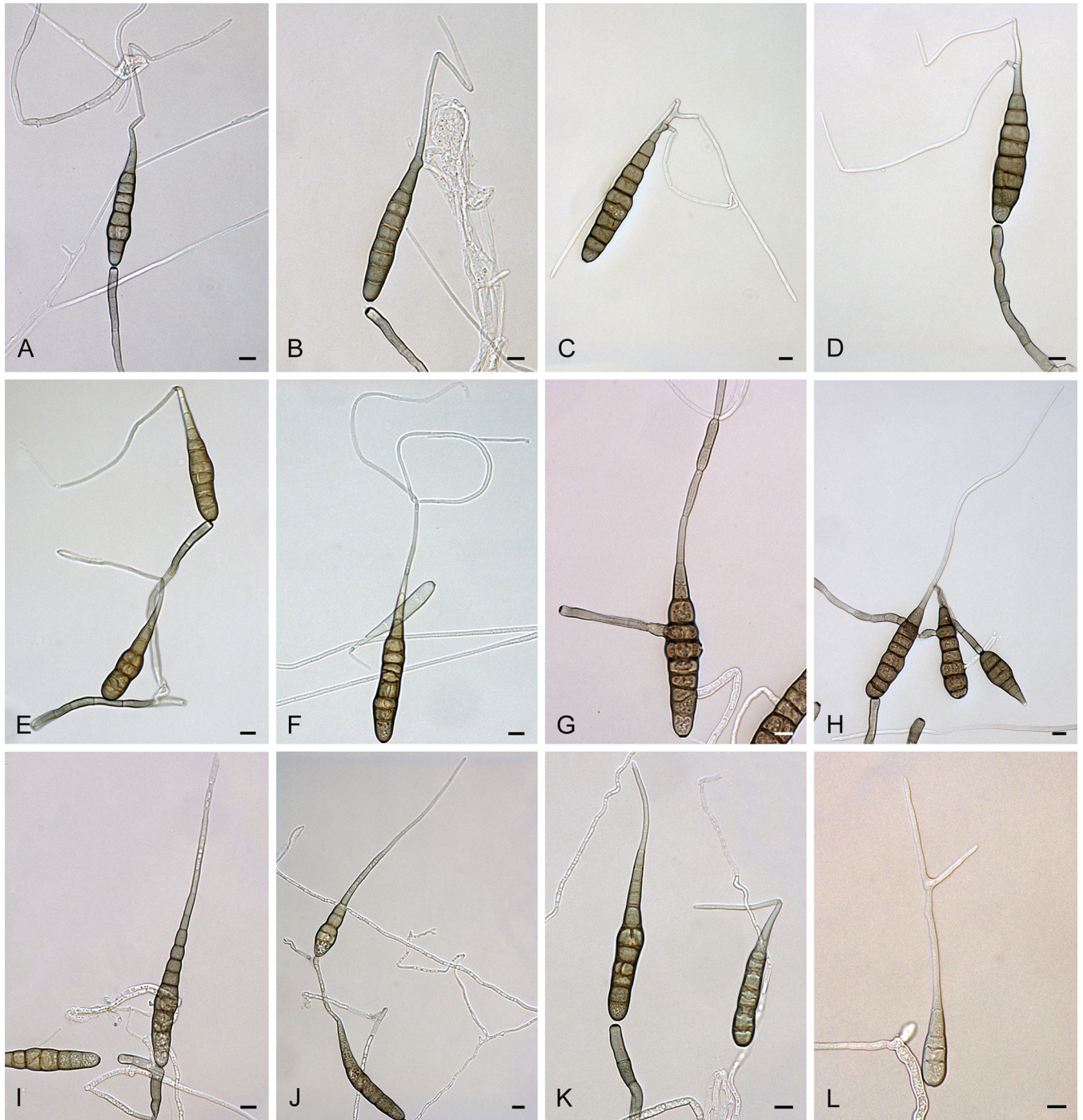


Fig. 21. *Alternaria passiflorae*: conidia and conidiophores. A–B. CBS 117102. C–D. CBS 117103. E–F. CBS 116333. G–H. CBS 166.77. I–J. CBS 630.93. K–L. CBS 629.93. Scale bars = 10 µm.

Passiflora caerulea (*Passifloraceae*), Jul. 2004, C.F. Hill, representative isolate of *A. passiflorae* CBS 117103 = E.G.S. 52.032; Auckland, from leaf spot of *Gaura lindheimeri* (*Onagraceae*), May 2002, C.F. Hill, culture **ex-type** of *A. gaurae* CBS 116333 = E.G.S. 50.121; Waitakere, from leaf of *Capsicum frutescens* (*Solanaceae*), May 1975, CBS 166.77. **USA**, Hawaii, from *Passiflora edulis*, before Oct. 1968, M. Aragaki, culture **ex-type** of *A. hawaiiensis* CBS 630.93 = E.G.S. 29.020 = QM 9050.

Notes: By synonymising *A. gaurae* with *A. passiflorae*, and including CBS 166.77, formerly identified as *A. solani*, the host range of *A. passiflorae* has been broadened to include *Gaura* sp. (*Onagraceae*) and *Capsicum frutescens* (*Solanaceae*).

Alternaria pipionipisi E.G. Simmons, CBS Biodiversity Ser. (Utrecht) 6: 302. 2007.

Materials examined: **India**, Andhra Pradesh, Hyderabad, from seed of *Cajanus cajan* (*Fabaceae*), before Feb. 1990, K.M. & Ch. Reddy, culture **ex-type** of *A. pipionipisi* CBS 116115 = E.G.S. 40.096 = IMI 340950. **USA**, California, Encinitas, from *Euphorbia pulcherrima* (*Euphorbiaceae*), Sep. 1994, C.F. Hill, CBS 134265 = E.G.S. 42.047; California, Encinitas, from *Euphorbia pulcherrima*, Sep. 1994, C.F. Hill, representative isolate of *A. obtecta* CBS 117365 = E.G.S. 42.048.

Alternaria porri (Ellis) Cif., J. Dept. Agric. Porto Rico 14: 30. 1930 [1929]. **Fig. 22.**

Basionym: *Macrosporium porri* Ellis, Grevillea 8 (no. 45): 12. 1879.

≡ *Alternaria porri* (Ellis) Sawada, Rep. Dept. Agric. Gov. Res. Inst. Formosa, 61: 92. 1930.



Fig. 22. *Alternaria porri*: conidia and conidiophores. A–D. CBS 116698. E–H. CBS 116699. I–L. CBS 116649. Scale bars = 10 µm.

Type: (Lectotype, designated in Simmons 2007) NY, Ellis Collection: on leaves of *Allium porrum*, Newfield, N.J. Sept. 78.

Materials examined: USA, Nebraska, Lincoln, from leaf of *Allium cepa* (Amaryllidaceae), 1965, D.S. Meredith, representative isolate of *A. allii* CBS 116649 = E.G.S. 17.082 = QM 8613; New York, Ithaca, from leaf of *Allium cepa*, 1996, M.J. Yáñez Morales, representative isolate of *A. porri* CBS 116698 = E.G.S. 48.147; New York, Orange County, from leaf of *Allium cepa*, 1996, M.J. Yáñez Morales (epitype designated here CBS H-21746, MBT178117, culture ex-type CBS 116699 = E.G.S. 48.152).

Alternaria protenta E.G. Simmons, Mycotaxon 25: 207. 1986. Fig. 23.

= *Alternaria pulcherrimae* T.Y. Zhang & J.C. David, Mycosystema 8-9: 110. 1996.

= *Alternaria hordeiseminis* E.G. Simmons & G.F. Laundon, CBS Biodiversity Ser. (Utrecht) 6: 150. 2007.

Materials examined: Australia, Queensland, Brisbane, Chapel Hill, from *Euphorbia pulcherrimae* (Euphorbiaceae), 25 Aug. 1986, J.L. Alcorn, representative isolate of *A. pulcherrimae* CBS 121342 = E.G.S. 42.122 = IMI 310506. Israel, from *Helianthus annuus* (Asteraceae), 1996, collector unknown, representative isolate of *A. protenta* CBS 116697 = E.G.S. 45.024 = IMI 372957; from *Helianthus annuus*, 1996, collector unknown, representative isolate of *A. protenta* CBS 116696 = E.G.S. 45.023 = IMI 372955. New Zealand, Hastings, from *Solanum tuberosum* (Solanaceae), Mar. 1997, C.F. Hill, representative isolate of *A. solani* CBS 135189 = E.G.S. 45.053; Levin, from fruit rot of *Solanum lycopersicum* (Solanaceae), before Jul. 1979, G.F. Laundon, CBS 347.79 = E.G.S. 44.091 = ATCC 38569 = LEV 14726; Palmerston North, from seed of *Hordeum vulgare* (Gramineae), Jul. 1977, G.F. Laundon, culture ex-type of *A. hordeiseminis* CBS 116437 = E.G.S. 32.076 = CBS 116443 = E.G.S. 46.163. USA, California,

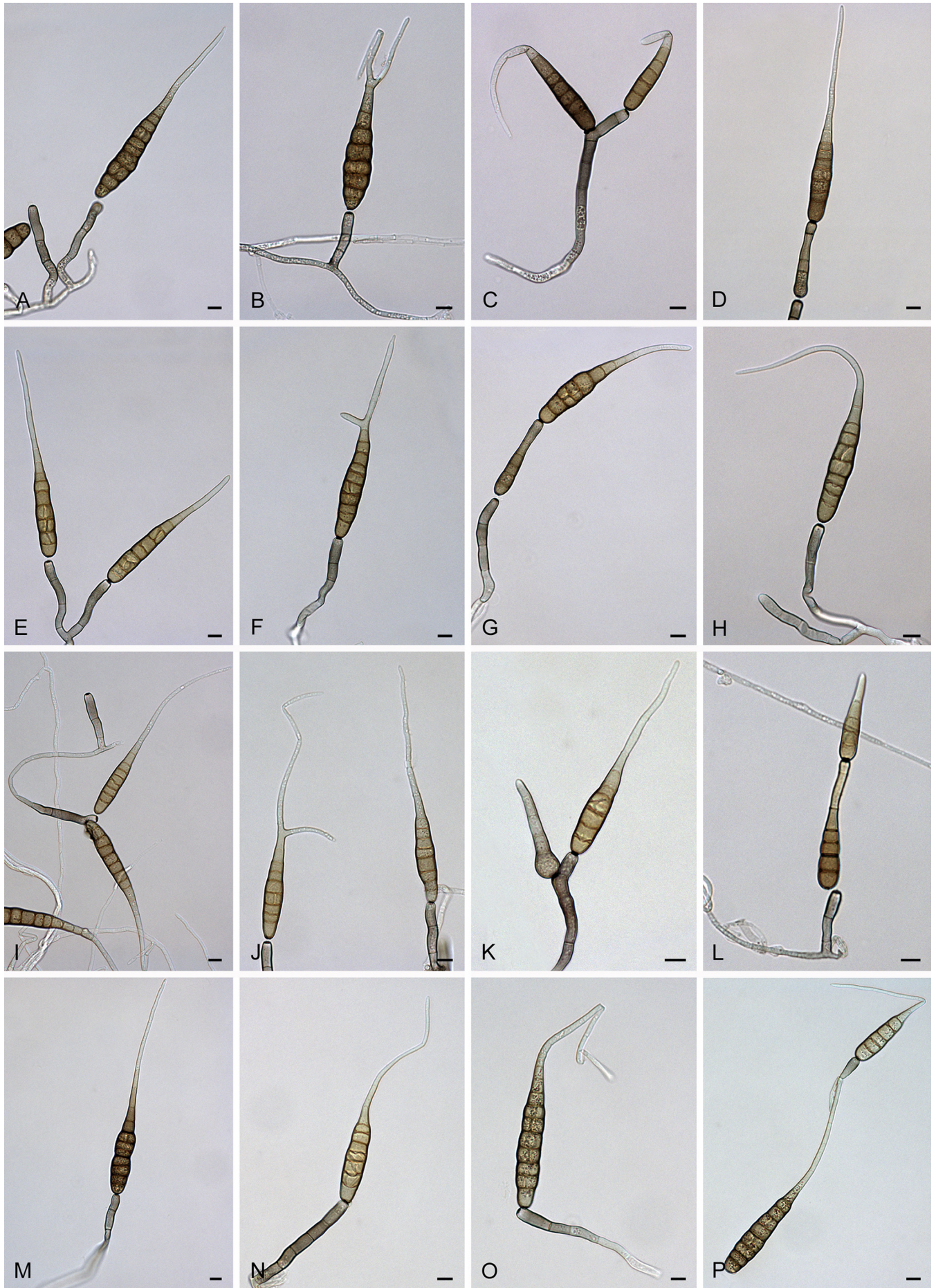


Fig. 23. *Alternaria protenta*: conidia and conidiophores. A–B. CBS 116696. C–D. CBS 116697. E–G. CBS 116643. H–J. CBS 116651. K–M. CBS 121342. N–P. CBS 347.79. Scale bars = 10 μ m.

Siskiyou, from *Solanum tuberosum*, 1996, D. Fogle, representative isolate of *A. solani* CBS 116651 = E.G.S. 45.020.

Notes: By synonymising *A. pulcherrimae* and *A. hordeiseminis* with *A. protenta* and including three isolates formerly identified as *A. solani* (CBS 347.79, 116651 and 135189), the host range of *A. protenta* has expanded extensively. It now comprises plants from the *Asteraceae*, *Euphorbiaceae*, *Gramineae* and *Solanaceae*. Based on molecular (and morphological) data, *A. protenta* is closely related to *A. solani*, and these two species can only be distinguished based on 9 nt differences in their RPB2 sequences (see RPB2 alignment in TreeBASE).

Alternaria pseudorostrata E.G. Simmons, Mycotaxon 57: 398. 1996.

Material examined: USA, California, Encinitas, from *Euphorbia pulcherrimae* (*Euphorbiaceae*), Dec. 1994, C.F. Hill, culture **ex-type** of *A. pseudorostrata* CBS 119411 = E.G.S. 42.060.

Alternaria ranunculi E.G. Simmons, CBS Biodiversity Ser. (Utrecht) 6: 212. 2007.

Material examined: Israel, Palestine, from seed of *Ranunculus asiaticus* (*Ranunculaceae*), 10 Apr. 1984, collector unknown, culture **ex-type** of *A. ranunculi* CBS 116330 = E.G.S. 38.039 = IMI 285697.

Alternaria ricini (Yoshii) Hansf., Proc. Linn. Soc. Lond. : 53. 1943.

Basionym: *Macrosporium ricini* Yoshii, Bult. Sci. Fak. Terk. Kjusu Imp. Univ. 3(4): 327. 1929.

Type: (Lectotype, designated in Simmons 1994) BPI 445446, *Macrosporium ricini*, Japan, Fukuoka, *Ricinus communis*, July 1928.

Materials examined: Italy, Sardinia, Sassari, from *Ricinus communis* (*Euphorbiaceae*), before Aug. 1986, J.A. von Arx, CBS 353.86. Japan, *Ricinus communis*, deposited Feb. 1931 by K. Nakata (**epitype designated here** CBS H-21747, MBT178118, culture **ex-epitype** CBS 215.31). USA, Virginia, Holland, from leaf of *Ricinus communis*, 9 Aug. 1954, C.A. Thomas, representative isolate of *A. ricini* CBS 117361 = E.G.S. 06.181.

Alternaria rostellata E.G. Simmons, Mycotaxon 57: 401. 1996.

Material examined: USA, California, Encinitas, from leaf of *Euphorbia pulcherrimae* (*Euphorbiaceae*), Jan. 1995, C.F. Hill, culture **ex-type** of *A. rostellata* CBS 117366 = E.G.S. 42.061.

Alternaria scorzonerae (Aderh.) Loer., Netherlands J. Pl. Pathol. 90(1): 37. 1984.

Basionym: *Sporidesmium scorzonerae* Aderh., Arbeiten Kaiserl. Biol. Anst. Land-Forstw. 3: 439. 1903.

= *Alternaria linicola* J.W. Groves & Skolko, Canad. J. Res., Sect. C, Bot. Sci. 22: 223. 1944.

= *Alternaria linicola* Neerg, Danish species of *Alternaria* & *Stemphylium*: 302. 1945. (nom. illegit., Art. 53.1)

Type: (Lectotype, designated in Simmons 1997) Aderhold, Arbeiten Kaiserl. Biol. Anst. Land-Forstw. 3: 440. fig. w/o number. 1903.

Materials examined: Netherlands, Reusel, from leaf spot of *Scorzonera hispanica* (*Asteraceae*), 1982, W.M. Loerakker (**epitype designated here** CBS H-21748, MBT178119, culture **ex-epitype** CBS 478.83 = E.G.S. 38.011). UK,

Scotland, from *Linum usitatissimum* (*Linaceae*), 22 Nov. 1945, J.W. Groves, CBS 103.46; Derbyshire, from seed of *Linum usitatissimum*, 1983, C. Nicholls, representative isolate of *A. linicola* CBS 116703 = E.G.S. 36.110 = IMI 274549.

Notes: None of the three isolates sporulated on SNA or PCA after 3 wk of incubation, also not after scarification. Corlett & Corlett (1999) already stated that, after sub-cultivation, *A. linicola* sporulates poorly, or not at all. By synonymising *A. linicola* with *A. scorzonerae*, the host range of *A. scorzonerae* is expanded to include *Linum usitatissimum* (*Linaceae*).

Alternaria sennae Woudenb. & Crous, **sp. nov.** Myco-Bank MB809000. Fig. 24.

Etymology: Named after the host genus on which it occurs, *Senna*.

Primary conidiophores solitary, simple, straight to slightly curved, septate, dark brown with a hyaline tip, (43–)67–81(–108) × (5–)6(–7) µm, bearing a single, darkened, apical conidiogenous locus, but may produce geniculate conidiogenous extensions. **Conidia** solitary, conidium body pale olive-brown, smooth-walled, narrowly ovoid, (46–)55–62(–69) × (8–)10–12(–14) µm, with (7–)7–8(–10) *transverse distosepta* and (1–)2–3(–4) *longitudinal septa*. The conidial body can be slightly constricted near some transverse septa. Conidia have a single, aseptate, filamentous beak, which occasionally branches once; basal lateral *secondary conidiophores* can be formed. **Beaks** (38–)99–163(–314) µm long, ca. 2 µm diam. **Sexual morph** not observed.

Culture characteristics: After 7 d cultures on SNA flat, fimbriate, white to opaque with two olivaceous concentric circles; aerial mycelium sparse, white, floccose, colonies reaching 35–40 mm diam; cultures on PCA flat, undulate, white with grey-olivaceous zones; aerial mycelium felty, pale olivaceous-grey, colonies reaching 50–55 mm diam; reverse with pale olivaceous-grey zones.

Material examined: India, Uttar Pradesh, Gorakhpur, from leaf of *Senna corymbosa* (*Fabaceae*), 10 Apr. 1981, R.P. Verma (**holotype** CBS H-21741, culture **ex-type** CBS 477.81 = E.G.S. 34.030 = IMI 257253).

Alternaria sesami (E. Kawam.) Mohanty & Behera, Curr. Sci. 27: 493. 1958.

Basionym: *Macrosporium sesami* E. Kawam., Fungi 1: 27. 1931.

Materials examined: Egypt, from *Sesamum indicum* (*Pedaliaceae*), 1972, S.B. Mathur, CBS 240.73. India, from seedlings of *Sesamum indicum*, Dec. 1959, E.E. Leppik, representative isolate CBS 115264 = CBS 117214 = E.G.S. 13.027.

Alternaria sidae E.G. Simmons, Mycotaxon 88: 202. 2003.

Material examined: Kiribati, Phoenix islands, Canton Island, from leaf spot of *Sida fallax* (*Malvaceae*), 11 Feb. 1958, O. & I. Degener, culture **ex-type** of *A. sidae* CBS 117730 = E.G.S. 12.129.

Alternaria silybi Gannibal, Mycotaxon 114: 110. 2011.

Materials examined: Russia, Vladivostok, Trudovoe, from leaf lesion of *Silybum marianum* (*Asteraceae*), 1 Sep. 2006, Ph. B. Gannibal, culture **ex-type** of *A. silybi* CBS 134092 = VKM F-4109; Vladivostok, Trudovoe, from leaf lesion of *Silybum marianum*, 1 Sep. 2006, Ph. B. Gannibal, CBS 134094 = VKM F-4118; Vladivostok,



Fig. 24. *Alternaria sennae* sp. nov. CBS 477.81: A–L. Conidia and conidiophores. Scale bars = 10 µm.

Botanical Garden-Institute, from leaf lesion of *Silybum marianum*, 6 Sep. 2006, Ph. B. Gannibal, CBS 134093 = VKM F-4117.

Alternaria solani Sorauer, Z. Pflanzenkrankh. Pflanzenschutz 6: 6. 1896. Fig. 25.

= *Macrosporium solani* Ellis & G. Martin, Amer. Naturalist 16(12): 1003. 1882 (non *M. solani* Cooke, 1883)

≡ *Alternaria solani* (Ellis & G. Martin) L.R. Jones & Grout, Vermont Agric. Exp. Sta. Annual Rep. 9: 86. 1899. (nom. illegit., Art. 53.1)

≡ *Alternaria americana* Sawada, Rep. Dept. Agric. Gov. Res. Inst. Formosa 51:117. 1931. (nom. nov. for *A. solani* (Ellis & G. Martin) L.R. Jones & Grout (1899), non *A. solani* Sorauer (1896))

≡ *Alternaria porri* f. sp. *solani* (Ellis & G. Martin) Neerg, Danish species of *Alternaria* & *Stemphylium*: 260. 1945.

= *Sporidesmium solani-varians* Vaňha, Naturwiss. Z. Forst- Landw. 2: 117. 1904.

= *Alternaria danida* E.G. Simmons, Mycotaxon 65: 78. 1997.

= *Alternaria viciae-fabae* E.G. Simmons & G.F. Laundon, CBS Biodiversity Ser. (Utrecht) 6: 234. 2007.

Materials examined: **Italy**, from seed of *Ageratum houstonianum* (Asteraceae), 27 Aug. 1941, P. Neergaard, culture **ex-type** of *A. danida* CBS 111.44 = E.G.S. 07.029 = QM 1772. **New Zealand**, from *Vicia faba* (Fabaceae), Jun. 1979, G.F. Laundon, culture **ex-type** of *A. viciae-fabae* CBS 116442 = E.G.S. 46.162 = ICMP 10242. **Unknown**, from leaf spot of *Solanum aviculare* (Solanaceae), before May 1941, P. Neergaard, CBS 111.41; unknown host, before Nov. 1921, isolated by Künkel, CBS 106.21. **USA**, Washington, Douglas County, from leaf spot of *Solanum tuberosum* (Solanaceae), 25 Aug. 1996, E.G. Simmons, representative isolate of *A. solani* CBS 109157 = E.G.S. 44.098.

Notes: By synonymising *A. danida* and *A. viciae-fabae* with *A. solani*, the host range of this pathogen has expanded to

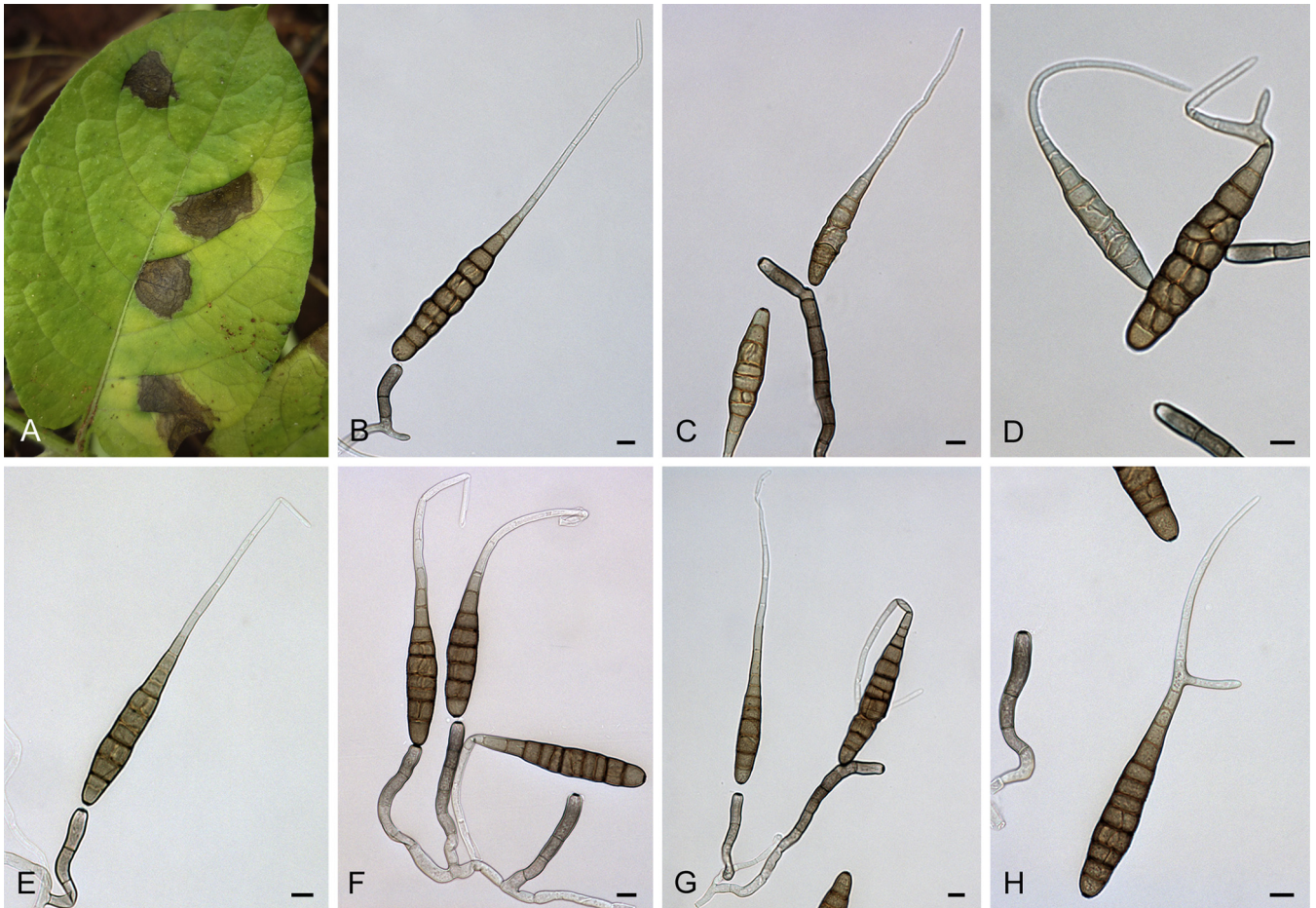


Fig. 25. *Alternaria solani*. A. Disease symptoms on *Solanum tuberosum* (Photo J.E. van der Waals, University of Pretoria, South Africa). B–H. Conidia and conidiophores. B–D. CBS 109157. E–H. CBS 116442. Scale bars = 10 μ m.

include *Asteraceae* and *Fabaceae* host plants. The isolates CBS 106.21 and CBS 111.44 did not sporulate after 3 wk of incubation on SNA (both were already labelled as sterile in the CBS collection database). Isolate CBS 111.41 did sporulate, but the spore formation was atypical.

Alternaria solani-nigri R. Dubey, S.K. Singh & Kamal [as “*solani-nigri*”], *Microbiol. Res.* 154: 120. 1999. [Fig. 26.](#)

- = *Alternaria cyphomandrae* E.G. Simmons, *Mycotaxon* 75: 86. 2000.
- = *Alternaria ascaloniae* E.G. Simmons & C.F. Hill, *CBS Biodiversity Ser. (Utrecht)* 6: 168. 2007.
- = *Alternaria beticola* E.G. Simmons & C.F. Hill, *CBS Biodiversity Ser. (Utrecht)* 6: 170. 2007.
- = *Alternaria glyceriae* E.G. Simmons & C.F. Hill, *CBS Biodiversity Ser. (Utrecht)* 6: 148. 2007.
- = *Alternaria herbiculiniae* E.G. Simmons, *CBS Biodiversity Ser. (Utrecht)* 6: 166. 2007.

Materials examined: **New Zealand**, Canterbury, Ashburton, from leaf lesion of *Beta vulgaris* (*Chenopodiaceae*), Jul. 1999, B. Alexander, culture **ex-type** of *A. beticola* CBS 116447 = E.G.S. 47.196; Hastings, from leaf spot of *Allium ascalonicum* (*Amaryllidaceae*), Oct. 1997, C.F. Hill, culture **ex-type** of *A. ascaloniae* CBS 121347 = E.G.S. 46.052; New Plymouth, from fruit of *Cyphomandra betacea* (*Solanaceae*), May 1991, C.F. Hill, culture **ex-type** of *A. cyphomandrae* CBS 109155 = E.G.S. 40.058; Taranaki, Otaki, from stunted *Petroselinum crispum* (*Apiaceae*), 14 Jun. 2001, J.B. Wong, culture **ex-type** of *A. herbiculiniae* CBS 116332 = E.G.S. 49.180; Waikato, Kopuku, from leaf spot of *Glyceria maxima* (*Gramineae*), Apr. 2003, C.F. Hill, culture **ex-type** of *A. glyceriae* CBS 116334 = E.G.S. 51.107; Waikato, Whangamarino swamp, from leaf spot of *Solanum nigrum* (*Solanaceae*), 21 Jun. 2003, C.F. Hill, representative isolate of *A. solani-nigri* CBS 113403 = E.G.S. 51.106 = CPC 10620; Waikato, Whangamarino swamp, from leaf spot of *Solanum nigrum*, 6 Feb. 2003, C.F. Hill, representative isolate of *A. solani-nigri* CBS 117101 = E.G.S. 51.032.

Notes: By synonymising these five *Alternaria* species with *A. solani-nigri*, this becomes a species with a broad host range found on *Amaryllidaceae*, *Apiaceae*, *Chenopodiaceae*, *Gramineae* and *Solanaceae*. All studied specimens originate from New Zealand, but the holotype of *A. solani-nigri* was described from India. The five sequenced genes are 100 % identical between all the specimens studied.

Alternaria steviae Ishiba, T. Yokoy. & Tani, *Ann. Phytopathol. Soc. Japan* 48(1): 46. 1982.

Materials examined: **Japan**, Kagawa, Kida-gun, Miki-cho, Ikenobe, from leaf spot of *Stevia rebaudiana* (*Asteraceae*), CBS 631.88 = IFO 31212; Kagawa, Kida-gun, Miki-cho, Ikenobe, from leaf spot of *Stevia rebaudiana*, Jun. 1980, CBS 632.88 = IFO 31183; Kagawa, Zentsuji, Harada-cho, from leaf spot of *Stevia rebaudiana*, Aug. 1978, C. Ishiba, culture **ex-type** of *A. steviae* CBS 117362 = IFO 31182 = E.G.S. 37.019.

Alternaria tagetica S.K. Shome & Mustafee, *Curr. Sci.* 35: 370. 1966.

Materials examined: **UK**, from seed of *Tagetes* sp. (*Asteraceae*), before May 1979, G.S. Taylor, CBS 297.79; from seed of *Tagetes* sp., before May 1979, G.S. Taylor, CBS 298.79; England, Manchester, from seed of *Tagetes erecta* (*Asteraceae*), before Apr. 1980, G.S. Taylor, representative isolate of *A. tagetica* CBS 479.81 = E.G.S. 33.081. **USA**, Ohio, Butler County, Oxford, from leaf of cultivated *Tagetes* sp., 14 Jun. 1996, M.A. Vincent, representative isolate of *A. tagetica* CBS 117217 = E.G.S. 44.045; South Carolina, Clemson, from seed of *Tagetes* sp., before Mar. 1981, E. Smallwood Hotchkiss, representative isolate of *A. tagetica* CBS 480.81 = E.G.S. 33.184.

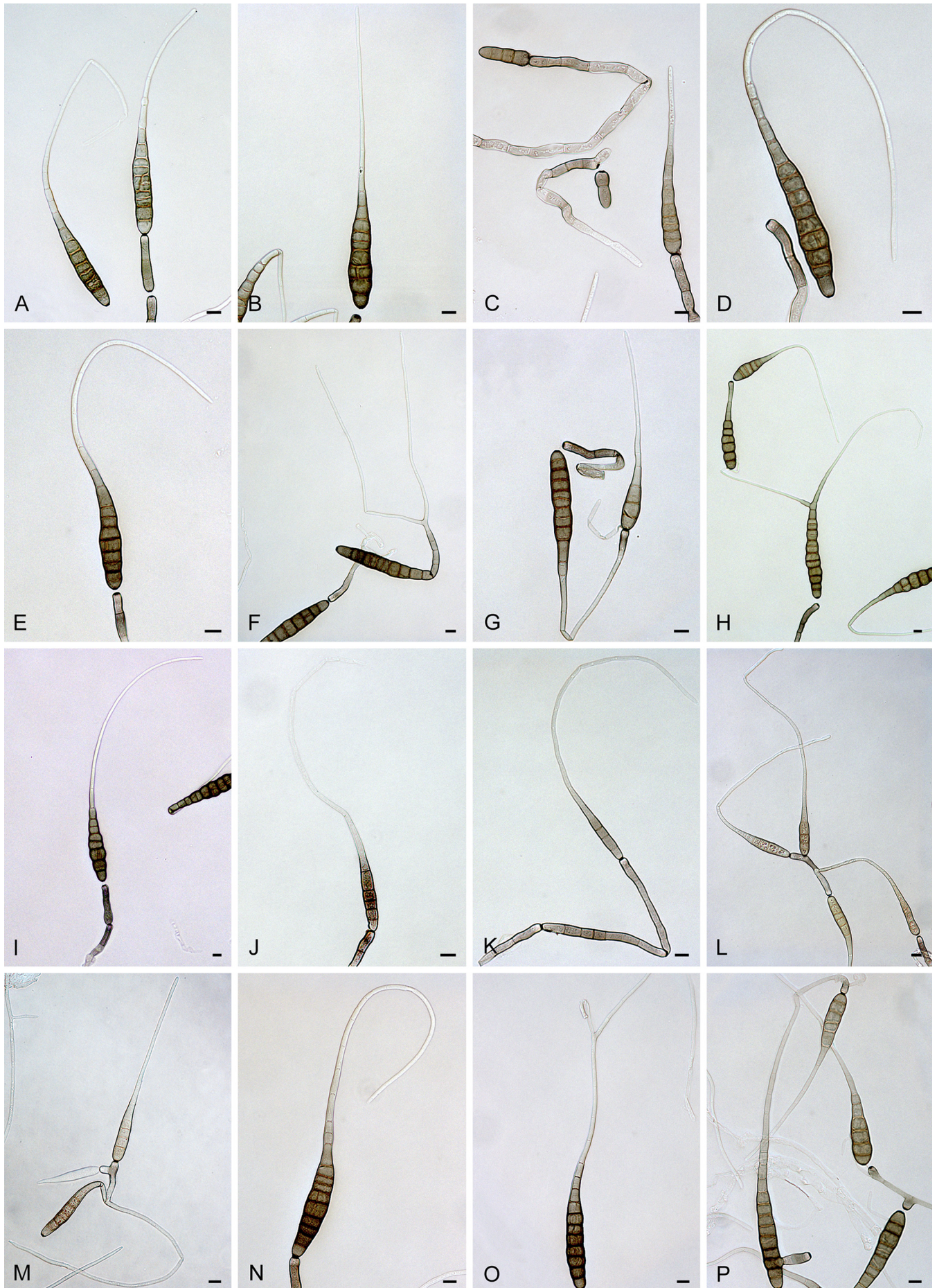


Fig. 26. *Alternaria solani-nigri*: conidia and conidiophores. A–B. CBS 113403. C–D. CBS 116447. E–G. CBS 109155. H–I. CBS 116334. J–K. CBS 121347. L–M. CBS 116332. N–P. CBS 117101. Scale bars = 10 μ m.

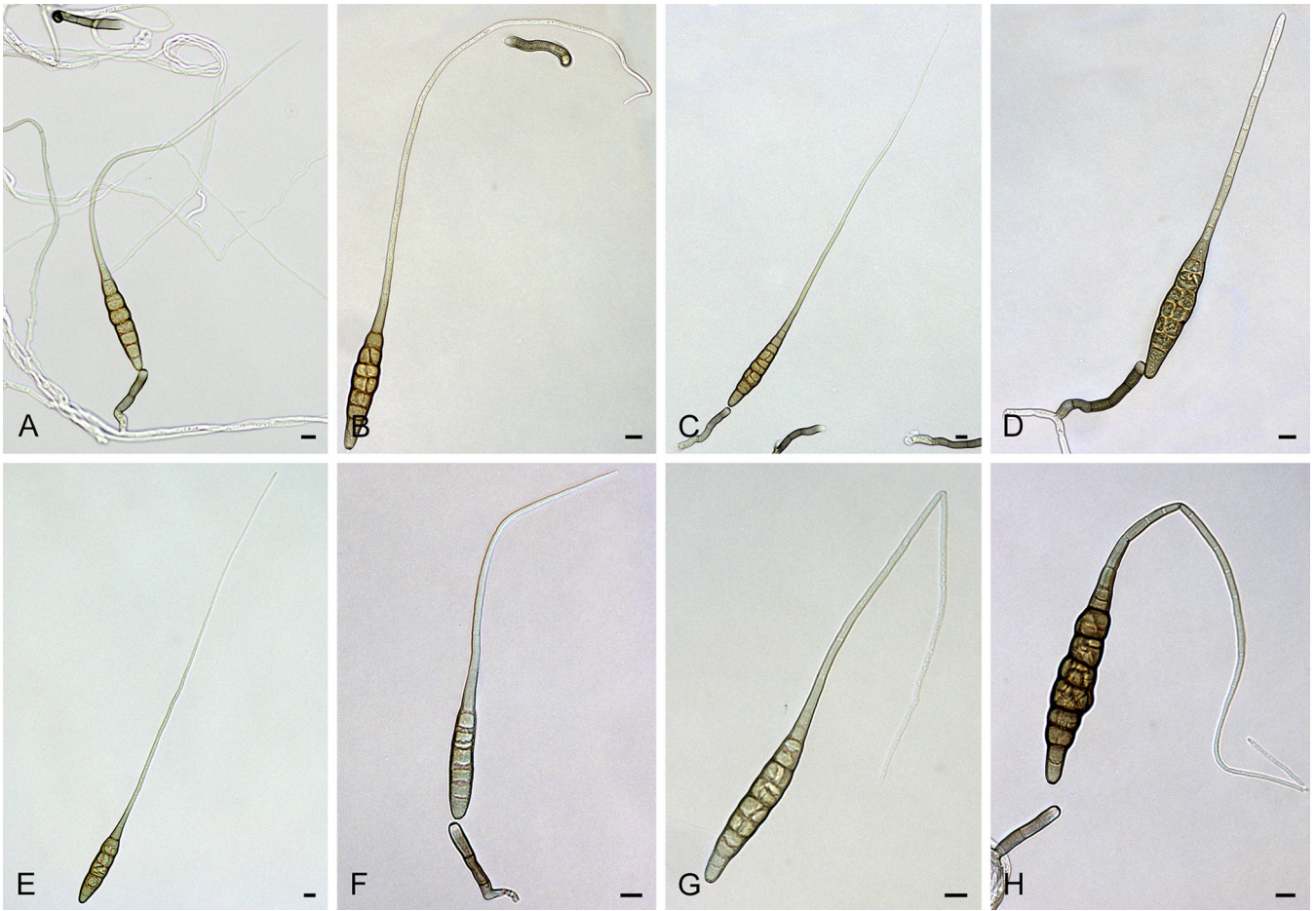


Fig. 27. *Alternaria thunbergiae*: conidia and conidiophores. A–C. CBS 116331. D–E. CBS 122597. F–H. CBS 120986. Scale bars = 10 μ m.

Alternaria thunbergiae E.G. Simmons & Alcorn, CBS Biodiversity Ser. (Utrecht) 6: 136. 2007. Fig. 27.

= *Alternaria iranica* E.G. Simmons & Ghosta, CBS Biodiversity Ser. (Utrecht) 6: 122. 2007.

Materials examined: **Australia**, Queensland, Brisbane, Chapel Hill, from leaf spot of *Thunbergia alata* (Acanthaceae), 6 Feb. 1986, J.L. Alcorn, culture **ex-type** of *A. thunbergiae* CBS 116331 = E.G.S. 41.073 = BRIP 14963. **Iran**, Miandoab, from leaf of *Allium cepa* (Amaryllidaceae), 13 Sep. 2001, Y. Ghosta, culture **ex-type** of *A. iranica* CBS 120986 = E.G.S. 51.075. **New Zealand**, Auckland, Mangere, Tidal Road, from *Thunbergia alata*, 4 Jun. 2001, C.F. Hill, CBS 122597.

Notes: By synonymising *A. iranica* with *A. thunbergiae*, the host range of this taxon has expanded to include *Allium cepa*. The five sequenced genes are 100 % identical between the **ex-type** strains of *A. thunbergiae* and *A. iranica*. As both species were originally described in the same publication, there is no case for nomenclatural priority. Therefore we chose to synonymise *A. iranica* under *A. thunbergiae* because *A. thunbergiae* is more commonly used in literature (Leahy 1992, Melo *et al.* 2009).

Alternaria tillandsiae E.G. Simmons & C.F. Hill, CBS Biodiversity Ser. (Utrecht) 6: 314. 2007.

Material examined: **USA**, from *Tillandsia usneoides* (Bromeliaceae), Dec. 1995, B. Milnes, culture **ex-type** of *A. tillandsiae* CBS 116116 = E.G.S. 43.074.

Alternaria tropica E.G. Simmons, Mycotaxon 46: 187. 1993.

Materials examined: **USA**, Florida, Homestead, from fruit of *Passiflora edulis* (Passifloraceae), May 1990, R.T. McMillan Jr., culture **ex-type** of *A. tropica* CBS 631.93 = E.G.S. 39.126; Florida, Homestead, from fruit of *Passiflora edulis*, May 1990, R.T. McMillan Jr., representative isolate of *A. tropica* CBS 117216 = E.G.S. 39.125.

Alternaria venezuelensis E.G. Simmons & Rumbos, CBS Biodiversity Ser. (Utrecht) 6: 128. 2007.

Material examined: **Venezuela**, Maracay, from leaf spot of *Phaseolus vulgaris* (Fabaceae), before Oct. 1999, R. Rumbos, culture **ex-type** of *A. venezuelensis* CBS 116121 = E.G.S. 48.065.

Alternaria zinniae M.B. Ellis, Mycol. Pap. 131: 22. 1972.

= *Alternaria zinniae* H. Pape, Angew. Bot. 24: 61. 1942. (nom. inval., Art. 36.1)

Materials examined: **Hungary**, from seed of *Callistephus chinensis* (Asteraceae), 12 Aug. 1942, P. Neergaard, CBS 118.44. **Italy**, Sardinia, Sassari, from *Zinnia elegans* (Asteraceae), 18 Oct. 1958, U. Prota, CBS 117.59. **Netherlands**, Huizum, from leaf of *Zinnia* sp., 27 Jul. 1948, A. Jaarsveld, CBS 107.48. **New Zealand**, Auckland, Royal Oak, from leaf spot of *Zinnia elegans*, May 1996, C.F. Hill, representative isolate of *A. zinniae* CBS 117223 = E.G.S. 44.035. **UK**, from seed of *Zinnia* sp., 1979, G.S. Taylor, CBS 299.79; from seed of *Zinnia* sp., 1979, G.S. Taylor, CBS 300.79. **Unknown**, from *Zinnia elegans*, summer 1961, Smith, CBS 108.61.

Section *Euphorbiicola* Woudenb. & Crous, sect. nov. MycoBank MB809001. Fig. 28

Type species: *Alternaria euphorbiicola* E.G. Simmons & Engelhard.

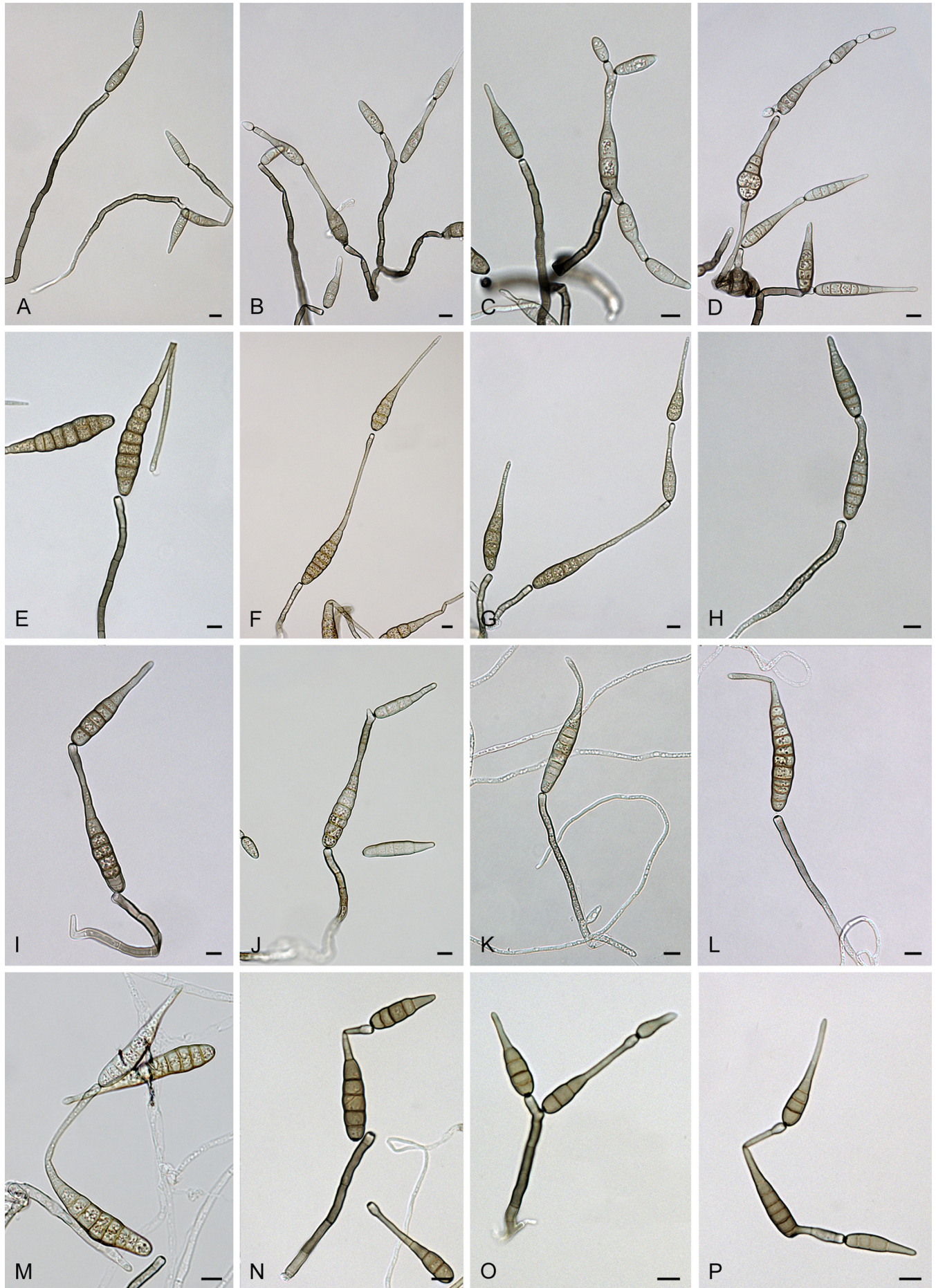


Fig. 28. *Alternaria* section *Euphorbiicola*: conidia and conidiophores. A–G. *Alternaria limicola*. H–P. *Alternaria euphorbiicola*. A–D. CBS 117360. E–G. CBS 483.90. H–J. CBS 198.86. K–M. CBS 119410. N–P. CBS 133874. Scale bars = 10 μ m.

Section *Euphorbiicola* is characterised by ovoid, obclavate, medium to large conidia that are disto- and euseptate, in short to moderately long chains, with no or a simple long beak in the terminal conidia. Conidia contain multiple transverse and some longitudinal septa and are slightly constricted near some transverse septa. Short to long, broad, apical, and sometimes lateral, secondary conidiophores are formed.

Note: The new *Alternaria* sect. *Euphorbiicola* can be easily distinguished from sect. *Porri* based on the formation of conidia in chains in sect. *Euphorbiicola*.

Alternaria euphorbiicola E.G. Simmons & Engelhard, Mycotaxon 25: 196. 1986.

≡ *Macrosporium euphorbiae* Reichert, Bot. Jahrb. Syst. 56: 723. 1921.
Nom. *Macrosporium euphorbiae* Bartholomew 1908. (nom. illegit., Art 53.1).

Materials examined: USA, Florida, from *Euphorbia pulcherrima* (*Euphorbiaceae*), 1985, A.W. Engelhard, CBS 198.86 = E.G.S. 38.082; Hawaii, Oahu, from *Euphorbia pulcherrima*, Mar. 1984, M. Aragaki, representative isolate CBS 119410 = E.G.S. 41.029; Louisiana, from *Euphorbia hyssopifolia* (*Euphorbiaceae*), 1986, L. Walker, CBS 133874 = E.G.S. 38.191.

Alternaria limicola E.G. Simmons & M.E. Palm, Mycotaxon 37: 82. 1990.

Materials examined: Mexico, Colima, from leaf of *Citrus aurantiifolia* (*Rutaceae*), May 1989, M. Palm, culture **ex-type** of *A. limicola* CBS 483.90 = E.G.S. 39.070; Jalisco, from *Citrus* sp., Sep. 1995, M. Palm, representative isolate CBS 117360 = E.G.S. 43.009.

DISCUSSION

In the present phylogenetic study aiming to delimit *Alternaria* species in sect. *Porri*, we reduced the 82 known morphospecies in this section to 63 based on our polyphasic approach. Some important plant pathogens have now been assigned to specific clades in the phylogenetic tree and correlated with their distinct morphology, which will aid plant pathologists to identify their newly collected isolates.

The 10 isolates named *A. solani* at the onset of this study cluster within five different species-clades, and only three of them retain the name *A. solani*. This is not surprising, as almost all large-spored, narrow-beaked *Alternaria* strains hitherto isolated from *Solanaceae* were called *A. solani*, following the concept of M.B. Ellis (1971). Simmons (2000) already noted that early blight of tomato is actually caused by *A. tomatophila* rather than *A. solani*, and also described two additional species on tomato, *A. cretica* and *A. subcylindrica*. These **tomato pathogens** all cluster in one clade based on our phylogenetic analysis, which also includes the ex-type strain of *A. linariae*. The basionym of *A. linariae*, *A. anagallidis* var. *linariae*, is the oldest name in this cluster, which therefore applies to this clade mainly represented by tomato pathogens. When Neergaard (1945) described this species he found the fungus on seeds and seedlings with damping-off symptoms from *Linaria marroccana* (*Scrophulariaceae*), *Antirrhinum majus* (*Scrophulariaceae*) and on a healthy seedling of *Papaver rhoeas* (*Papaveraceae*). His pathogenicity tests (Neergaard 1945) showed that *A. linariae* could also attack

Brassica oleracea (*Brassicaceae*), *Solanum lycopersicum* (*Solanaceae*), *Lactuca sativa* (*Asteraceae*), *Godetia hybrida* (*Onagraceae*), *Nicotiana affinis* (*Solanaceae*) and *Papaver paeoniflorum* (*Papaveraceae*), indicating a very broad host range. The isolates included in this study also show that, besides its broad host range, *A. linariae* is also widespread, found in Europe, USA, New Zealand and Asia. Three other isolates formerly identified as *A. solani*, including a former representative isolate used by Simmons (2007), cluster with *A. protenta*, an *Alternaria* species originally described from *Helianthus annuus* (*Asteraceae*). CBS 116651 is mentioned as a representative strain of *A. solani* by Simmons (2007), but he later expressed doubt as to the identity of this isolate (Simmons pers. comm.). The host range of *A. protenta* has expanded extensively, now comprising plants from the *Asteraceae*, *Euphorbiaceae*, *Gramineae* and *Solanaceae*. A pathogenicity test performed on *A. protenta* isolated from sunflower seed (Wu & Wu 2003) concluded that sunflower was the only susceptible host among the 10 host plants tested. One of the host plants tested was *Solanum lycopersicum*, which we include as host of *A. protenta*. However, the authors did not clearly state how the *A. protenta* isolates, which they only found on seed of one out of seven cultivars of sunflower seeds tested, were identified. The manuscript also lacks molecular data, which could affirm their identification of *A. protenta*. To our knowledge, no pathogenicity tests have thus far been performed with the species synonymised under *A. protenta*, *A. hordeiseminis* or *A. pulcherrimae*. Based on molecular and morphological data, *A. protenta* is closely related to *A. solani*, and these two species can only be distinguished by the 9 nt differences in their RPB2 sequences. To confirm the **potato pathogen** clade, called *A. solani*, we sequenced the RPB2 region of multiple isolates collected from *Solanum tuberosum*, which are present in E.G. Simmons collection, now deposited at the CBS. Almost all (22/24 strains) cluster within the now recognised *A. solani* species clade (data not shown). The ex-type strain of *A. danida* (CBS 111.44), now a synonym of *A. solani*, was originally deposited in the CBS collection by P. Neergaard as *A. porri* f. sp. *solani*. Pathogenicity tests performed on this strain (Neergaard 1945) showed that it could attack hosts from several plant families [e.g. *Allium cepa* (*Amaryllidaceae*), *Brassica oleracea* (*Brassicaceae*), *Solanum lycopersicum* (*Solanaceae*) and *Lactuca sativa* (*Asteraceae*)], indicating a very broad host range. Our sequences of *A. danida* differ from those deposited in GenBank by Lawrence *et al.* (2013), and therefore we repeated the cultivation and DNA extraction to confirm our results and the resulting synonymy with *A. solani*. Although the other large-spored, long-beaked *Alternaria* species described from potato, *A. grandis* (Simmons 2000), differs only by 1 nt in its GAPDH sequence (position 99, T instead of C, see locus alignment in TreeBASE) within the 2 722 positions used in the phylogeny, we did not synonymise *A. grandis* under *A. solani*. The two isolates included, CBS 109158 and CBS 116695, have substantially larger conidia than the other *A. solani* isolates, and a recently published study revealed that *A. solani* (CBS 109157) and *A. grandis* (CBS 109158) differ on 8 out of 770 nt in their calmodulin sequence (Gannibal *et al.* 2014).

The oldest large-spored **onion pathogens**, *A. porri* and *A. allii*, form two closely related but distinct clades, which only differ based on 8 nt in their RPB2 sequences (see locus alignment in TreeBASE). The three newer species described from *Allium*, *A. ascaloniae*, *A. iranica* and *A. vanuatuensis* (Simmons 2007), are all synonymised with other species.

Alternaria ascaloniae is synonymised under *A. solani-nigri*, a species with a broad host range, mainly found in New Zealand. To our knowledge, no pathogenicity tests have been performed with the species now placed in synonymy with *A. solani-nigri*, which could affirm the broad host range for this species. *Alternaria iranica* is synonymised under *A. thunbergiae*, known as the causative agent of *Alternaria* leaf spot on *Thunbergia* (Leahy 1992), reported from Australia, USA and Brazil. *Alternaria vanuatuensis* clusters in the *Allium* clade, comprising *A. allii* and *A. porri*. Based on the sequence data generated here, it is synonymised under *A. allii*. According to Simmons (2007), the conidia of *A. allii* are distinguishable from those of *A. porri* and other large-spored species known on *Allium*, based on their multiple beaks and branches. However, the representative isolates of *A. allii* used by Simmons (2007) do not cluster in a single clade; CBS 116649 clusters with the two *A. porri* representative isolates. On the other hand, *A. vanuatuensis* is described as a single-beaked species, but clusters with the *A. allii* isolate deposited in the CBS collection by J.A.B. Nolla on 27 December 1927 as *A. allii* sp. nov. (CBS 107.28, recognised as the ex-type strain here). Simmons obtained this isolate from the CBS in February 2000 (E.G.S. 48.084), but was unable to induce sporulation. We observed few conidia, but these were only single-beaked. Unfortunately we could not induce CBS 116701 to sporulate, which leaves us at odds with Simmons's notes, with only single- to double-beaked conidia in the *A. allii* clade, and double- to triple-beaked conidia in the *A. porri* clade. The number of beaks and branches from the *Allium* isolates therefore is not suitable to make a distinction between the two major *Allium* species. The species can be easily differentiated on the basis of sequence data of the RPB2 gene region generated in this study.

Based on morphology, four large-spored *Alternaria* species with long beaks were described as **Passifloraceae pathogens**. Our phylogeny only supports three of these: *A. tropica*, *A. aragakii* and the more common *A. passiflorae*. The fourth species, *A. hawaiiensis*, is synonymised under *A. passiflorae* based on sequence data. Simmons (2007) described *A. hawaiiensis* as a new species lacking multiple beaks, which is a characteristic of *A. passiflorae*. Our sequence data led us to conclude that this characteristic is not suitable for species delimitation, which we also concluded from the data of the onion pathogens, *A. allii*, *A. vanuatuensis* and *A. porri*. The clustering of two isolates within our *A. passiflorae* clade, which originate from different host families (*Onagraceae* and *Solanaceae*), renders *A. passiflorae* as unspecific to *Passifloraceae*.

An ongoing study in South Africa on **sweet potato pathogens** reveals multiple *Alternaria* species on this host associated with blight symptoms on leaves, petioles, and stems. In addition to the known pathogen of sweet potato, *A. bataticola*, three other pathogenic species are delineated of which two are newly described as *A. ipomoeae* and *A. neoipomoea*. A new unknown *Alternaria* pathogen, causing sweet potato stem blight in Ethiopia, was reported by van Bruggen in 1984. This isolate (CBS 219.79) was sent to the CBS for identification, but the author did not agree with the morphological identification made at that time as *A. cucumerina*, a name under which it was still stored in the CBS collection. Our data indicate that this pathogen, which also is found in stem lesions of *Ipomoea batatas* in South Africa, should be recognised as a new species, now named *A. ipomoeae*. Most isolates from South Africa however cluster in

a clade close to *A. ipomoeae*, now named *A. neoipomoea*, which can clearly be distinguished from *A. ipomoeae* morphologically and by sequence data. Two more isolates from sweet potato in South Africa are identified as *A. argyroxiphii*, an *Alternaria* species originally described from *Argyroxiphium* sp. This finding is a new host report for *A. argyroxiphii*, and a first report of the fungus from South Africa.

Based on the sequence data generated in this study, *A. euphorbiicola* and *A. limicola* clearly separate from the other species in sect. *Porri* (Fig. 1). This separation is supported by morphological differences, and we therefore propose the new section, sect. *Euphorbiicola*. However, when we examined the phylogeny displaying the neighbouring sections of sect. *Porri* (Fig. 2), questions arose concerning sect. *Gypsophilae* and sect. *Radicina*. These two sections display almost similar branch length differences within the respective sections, comparable to what sect. *Porri* displays with sect. *Euphorbiicola*. An additional character of sect. *Gypsophilae* and sect. *Radicina* is that the species within these sections share the same host family, respectively *Caryophyllaceae* and *Apiaceae*. We therefore choose to retain these sections at present, but additional molecular and morphological studies could eventually lead to the recognition of additional sections.

The present polyphasic approach displays the current species delimitation in *Alternaria* sect. *Porri*. We recognise 63 *Alternaria* species in this section with medium to large conidia and a long (filamentous) beak, which can be distinguished based on molecular data. Not all species distinctions are 100 % clear based on DNA data only; nevertheless, we tried to be consistent in synonymising or not synonymising species: the number of genes with nt differences and the number of nt differences are taken into account, together with the morphology, host, country and time of isolation. All *Alternaria* isolates currently stored in the CBS collection, which cluster within sect. *Porri* based on their gene sequences, were included in our study. Some species, however, are under-sampled, which results in some uncertainty in keeping isolates as separate species or reducing them to synonymy. Although we attempted to use the available data as best as possible, with the inclusion of additional isolates some uncertain species boundaries are bound to be better resolved.

The finding of the third species on potato (*A. protenta*) is a good example of the importance of fungal systematics. Multiple manuscripts report on the high level of genetic variability observed among *A. solani* isolates (van der Waals et al. 2004; Lourenco et al. 2011; Leiminger et al. 2013) and based on secondary metabolite profiling *A. solani* isolates cluster in two distinct groups (Andersen et al. 2008). Furthermore, two genotypes are described based on the cytochrome b gene structure of *A. solani* isolates (Leiminger et al. 2014), which is an important gene in fungicide resistance. However, our study indicates that previous reports could actually be dealing with three (or more) different species. Without knowing the correct identity of your pathogen, many incorrect conclusions can be drawn about diversity, evolutionary mechanisms, host range, and options for disease control.

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REFERENCES

- Abo-Elyours KAM, Abdel-Hafez SII, Abdel-Rahim IR (2014). Isolation of *Trichoderma* and evaluation of their antagonistic potential against *Alternaria porri*. *Journal of Phytopathology* **162**: 567–574.
- Andersen B, Dongo A, Pryor BM (2008). Secondary metabolite profiling of *Alternaria dauci*, *A. porri*, *A. solani*, and *A. tomatophila*. *Mycological Research* **112**: 241–250.
- Angell HR (1929). Purple blotch of onion (*Macrosporium porri* Ell.). *Journal of Agricultural Research* **38**(9): 467–487.
- Berbee ML, Pirseyedi M, Hubbard S (1999). *Cochliobolus* phylogenetics and the origin of known, highly virulent pathogens, inferred from ITS and glyceraldehyde-3-phosphate dehydrogenase gene sequences. *Mycologia* **91**: 964–977.
- Bruggen AHC van (1984). Sweet potato stem blight caused by *Alternaria* sp.: a new disease in Ethiopia. *Netherlands Journal of Plant Pathology* **90**: 155–164.
- Brun S, Madrid H, Gerrits van den Ende AHG, et al. (2013). Multilocus phylogeny and MALDI-TOF analysis of the plant pathogenic species *Alternaria dauci* and relatives. *Fungal Biology* **117**: 32–40.
- Carbone I, Kohn LM (1999). A method for designing primer sets for speciation studies in filamentous ascomycetes. *Mycologia* **91**: 553–556.
- Cifferi R (1930). Phytopathological survey of Santo Domingo, 1925–1929. *Journal of the Department of Agriculture of Porto Rico* **14**: 5–44.
- Cooke MC, Ellis JB (1879). New Jersey fungi. *Grevillea* **8**: 11–16.
- Corlett M, Corlett ME (1999). Fungi Canadenses. No. 341. *Alternaria linicola*. *Canadian Journal of Plant Pathology* **21**(1): 55–57.
- Crous PW, Gams W, Stalpers JA, et al. (2004). MycoBank: an online initiative to launch mycology into the 21st century. *Studies in Mycology* **50**: 19–22.
- Crous PW, Verkley GJM, Groenewald JZ, et al. (eds) (2009). *Fungal Biodiversity. CBS laboratory Manual Series 1*. CBS-KNAW Fungal Biodiversity Centre, Utrecht, Netherlands.
- Ellis MB (1971). *Dematiaceae hyphomycetes*. Commonwealth Mycological Institute, Kew, UK.
- Gannibal PB, Orina AS, Mironenko NV, et al. (2014). Differentiation of the closely related species, *Alternaria solani* and *A. tomatophila*, by molecular and morphological features and aggressiveness. *European Journal of Plant Pathology* **139**: 609–623.
- Hong SG, Cramer RA, Lawrence CB, et al. (2005). Alt a 1 allergen homologs from *Alternaria* and related taxa: analysis of phylogenetic content and secondary structure. *Fungal Genetics and Biology* **42**: 119–129.
- Hoog GS de, Gerrits van den Ende AHG (1998). Molecular diagnostics of clinical strains of filamentous Basidiomycetes. *Mycoses* **41**: 183–189.
- Horsfield A, Wicks T, Davies K, et al. (2010). Effect of fungicides use strategies on the control of early blight (*Alternaria solani*) and potato yield. *Australasian Plant Pathology* **39**: 368–375.
- Lawrence DP, Gannibal PB, Peever TL, et al. (2013). The sections of *Alternaria*: formalizing species-groups concepts. *Mycologia* **105**: 530–546.
- Leahy RM (1992). *Alternaria leaf spot of Thunbergia*. Plant pathology circular No. 352. Florida Department of Agriculture and Consumer Services, Division of Plant Industry.
- Leiminger JH, Auinger H-J, Wenig M, et al. (2013). Genetic variability among *Alternaria solani* isolates from potatoes in Southern Germany based on RAPD-profiles. *Journal of Plant Diseases and Protection* **120**: 164–172.
- Leiminger JH, Adolf B, Hausladen H (2014). Occurrence of the F129L mutation in *Alternaria solani* populations in Germany in response to QoI application, and its effect on sensitivity. *Plant Pathology* **63**: 640–650.
- Liu YJ, Whelen S, Hall BD (1999). Phylogenetic relationships among ascomycetes: evidence from an RNA polymerase II subunit. *Molecular Biology and Evolution* **16**: 1799–1808.
- Lourenço Jr V, Rodrigues TTMS, Campos AMD, et al. (2011). Genetic structure of the population of *Alternaria solani* in Brazil. *Journal of Phytopathology* **159**: 233–240.
- Melo MP, Soares DJ, Araújo JSP, et al. (2009). *Alternaria* leaf spot, caused by *Alternaria thunbergiae*, recorded for the first time on *Thunbergia alata* from Brazil. *Australasian Plant Disease Notes* **4**: 23–25.
- Narayanan CD, Thompson AH, Slabbert MM (2010). First report of *Alternaria* blight of sweet potato caused by *Alternaria bataticola* in South Africa. *African Plant Protection* **16**: 7–9.
- Neergaard P (1945). *Danish species of Alternaria and Stemphylium*. Oxford University Press, London.
- Nirenberg HI (1976). Untersuchungen über die morphologische und biologische Differenzierung in der *Fusarium*-Section Liseola. *Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft Berlin-Dahlem* **169**: 1–117.
- Nolla JAB (1927). A new *Alternaria* disease of onions (*Allium cepa* L.). *Phytopathology* **17**(2): 115–132.
- O'Donnell K, Kistler HC, Cigelnik E, et al. (1998). Multiple evolutionary origins of the fungus causing Panama disease of banana: concordant evidence from nuclear and mitochondrial gene genealogies. *Proceedings of the National Academy of Sciences of the United States of America* **95**: 2044–2049.
- Osiru M, Adipala E, Olanya OM, et al. (2007). Occurrence and distribution of *Alternaria* leaf petiole and stem blight on sweetpotato in Uganda. *Plant Pathology Journal* **6**(2): 112–119.
- Osiru MO, Adipala E, Olanya OM, et al. (2008). Leaf petiole and stem blight of sweet potato caused by *Alternaria bataticola* in Uganda. *Plant Pathology Journal* **7**(1): 118–119.
- Page RDM (1996). TreeView: an application to display phylogenetic trees on personal computers. *Computer Applications in the Biosciences* **12**: 357–358.
- Rayner RW (1970). *A Mycological Colour Chart*. Commonwealth Mycological Institute, Kew, UK.
- Rodrigues TTMS, Berbee ML, Simmons EG, et al. (2010). First report of *Alternaria tomatophila* and *A. grandis* causing early blight on tomato and potato in Brazil. *New Disease Reports* **22**: 28.
- Schubert K, Groenewald JZ, Braun U, et al. (2007). Biodiversity in the Cladosporium herbarum complex (Davidiellaceae, Capnodiales) with standardisation of methods for Cladosporium taxonomy and diagnostics. *Studies in Mycology* **58**: 105–156.
- Simmons EG (1994). *Alternaria* themes and variations (74–105). *Mycotaxon* **50**: 219–270.
- Simmons EG (1995). *Alternaria* themes and variations (112–144). *Mycotaxon* **55**: 55–163.
- Simmons EG (1997). *Alternaria* themes and variations (151–223). *Mycotaxon* **65**: 1–91.
- Simmons EG (2000). *Alternaria* themes and variations (244–286). Species on Solanaceae. *Mycotaxon* **75**: 1–115.
- Simmons EG (2007). *Alternaria: an Identification Manual*. CBS Biodiversity Series 6. CBS Fungal Biodiversity Centre, Utrecht, Netherlands.
- Sung G-H, Sung J-M, Hywel-Jones NL, et al. (2007). A multi-gene phylogeny of *Clavicipitaceae* (Ascomycota, Fungi): identification of localized incongruence using a combinational bootstrap approach. *Molecular Phylogenetics and Evolution* **44**: 1204–1223.
- Thomma BPHJ (2003). *Alternaria* spp.: from general saprophyte to specific parasite. *Molecular Plant Pathology* **4**: 225–236.
- Waals JE van der, Korsten L, Slippers B (2004). Genetic diversity among *Alternaria solani* isolates from potatoes in South Africa. *Plant Disease* **88**: 959–964.
- White TJ, Bruns T, Lee S, et al. (1990). Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: *PCR Protocols: a Guide to Methods and Applications* (Innis MA, Gelfand DH, Sninsky JJ, White TJ, eds). Academic Press, San Diego, California, USA: 315–322.
- Woudenberg JHC, Groenewald JZ, Binder M, et al. (2013). *Alternaria* redefined. *Studies in Mycology* **75**: 171–212.
- Wu HC, Wu WS (2003). Sporulation, pathogenicity and chemical control of *Alternaria protenta* a new seedborne pathogen on sunflower. *Australasian Plant Pathology* **32**: 309–312.
- Zitter TA, Drennan JL (2005). Shift in performance of fungicides for the control of tomato early blight. In: *Proceedings in the 20th Annual Tomato Disease Workshop*. Ohio State University, Ohio: 28–30.