

A checklist of fungi isolated from honey (2000–2022)

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Abstract

Mycological studies focusing on fungal species thriving on honey related products have a series of critical applications ranging from the expansion of basic scientific knowledge, the exploration of their industrial utilization, understanding their contributions to food spoilage and even environmental pathogen monitoring. During the last two decades, several works dealing with the isolation and characterization of fungal species thriving on honey have been published. Nonetheless, a thorough summarization of these results has not yet been compiled. This work analyses and compiles a checklist of fungi isolated and identified/described from honey nectar, honey blossom and honeydew between the years 2000 and 2022. Based on this assessment, we detected that over 130 entries have been reported from honey samples worldwide. Consequently, this work provides a checklist of such fungi, that will be of interest to mycologists, microbiologists, food scientists working on the topic, and also beekeepers.

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Introduction

Beekeeping (or apiculture) is a zootechnical activity that aims to sustain and exploit, economically and rationally, the domestic bee *Apis mellifera*, in an effort to obtain their direct products and by-products. Goods such as honey, propolis, pollens, royal jelly, bee bread, waxes and apitoxins (bee venoms) have a wide and diverse range of applications, including in the cosmetic, food, pharmacological and therapeutical industries^[1]. This is noted, for instance, in the expansion of apitherapy (an alternative therapy that uses products coming directly from honeybees) in Western cultures in the last few years^[2]. Moreover, beekeeping is also considered a valuable example of an environmentally sustainable production system, with notorious positive impacts on global biodiversity and agriculture. Overall, this activity is mainly characterized by three advantageous outcomes, namely: (1) a confluence of economic interests (by the production of honey and by-products of the hive, which can provide financial gains), (2) social impact (since it contributes to the fixation of the rural population in territories where other economic activities are hard to be develop or maintain), and (3) a contribution to environmental conservation, sustainability and health (through pollination of cultivated and wild fields)^[3].

According to the European Union and Portuguese legislation (Decree-Law 179/2004) and the *Codex Alimentarius* (CODEX STAN 12-1981), honey is a natural sweetener produced by honey bees from: (1) flower nectars (blossom honey or nectar honey), or (2) carbohydrate-rich secretions of plants or even excretions of plant-sucking phytophagous aphids (honeydew),

after combination with the animal specific molecules, placement, dehydration, and storage in the honey comb (to ripen and mature)^[4–6]. Honey is composed by sugars turned into a super saturated solution containing mainly the monosaccharides (fructose and glucose, in a concentration not lower than 60%) and by a much lesser amount of oligosaccharides, organic acids, enzymes (amylases and α -glucosidase) and colloidal particles^[4].

The quality of honey is mainly determined by its sensorial, chemical, physical and microbiological characteristics. From a microbiological perspective, honey can have two sources of contamination by microorganisms: (1) primary sources: including pollen, the digestive tracts of honey bees, dust, air, soil and nectar (more difficult to control), and (2) secondary sources: arising from human honey manipulation, while also including risks related to air quality, food handlers, cross-contamination and the sanitary state of the equipment and buildings used in the process (more easily controlled by good manufacturing practices)^[7]. And though the European Commission sets maximum levels of mycotoxins for various types of food products, they are often incomplete when considering bee products^[8].

Honey spoilage is not an often-reported phenomenon, mainly due to their associated antimicrobial properties, which result from several different factors. These include contributions from the formation of hydrogen peroxide (H₂O₂), floral source, low pH, low moisture content, low redox potential, low protein content, high osmolarity, high viscosity and limitations to oxygen penetration^[9–12]. On the other hand, an important physicochemical property that can affect the development of microorganisms in honey is the substrate low water activity

(a_w), which inhibits the growth of almost all organisms^[12]. Nonetheless, if the moisture content is high enough (above 21%), xerotolerant and xerophile microorganisms can develop causing honey fermentation and spoilage^[4,12]. The microbes of interest in honey are primarily yeasts, fungi and spore-forming bacteria, since their presence can influence the products stability and sanitary quality. Since bees collect pollens and nectars, yeast and fungi presence in honey is unavoidable^[5,7] and examples of filamentous fungi usually found in honey encompass *Aspergillus*, *Penicillium*, *Mucor* and *Monascus*, along with some osmophile yeasts such as *Saccharomyces*^[7,13]. Moreover, additional common fungal contaminants of honey are the obligate xerophiles *Ascosphaera apis* and *Bettsia alvei*, several xerotolerant species^[4], various species of plant pathogenic fungi^[14], mycotoxin-producing species^[15], and fungi commonly found in pollens and the digestive tract of bees^[16].

During the last two decades, several studies focusing on the isolation and characterization of fungal species thriving in honey have been published. However, a thorough summary of these results has not been compiled so far. With this in mind, the aim of this work is to elicit a checklist of fungi isolated from honey, honey blossom and honeydew, during the time period of 2000 to 2022. As such, this work provides critical information that can be helpful to mycologists, beekeepers and the industrial sector to improve honey and quality and production levels.

Materials and methods

The present checklist is based on a survey of scientific papers using morphological and/or molecular methods to identify fungal taxa isolated from honey, honey blossom and honeydew, during the time period of 2000 to 2022^[4–7,13,15–29]. Moreover, the checklist was annotated to contain currently accepted fungal names according to the Index Fungorum (www.indexfungorum.org) to provide an up-to-date analysis and facilitate future knowledge sharing.

Results

Checklist

Conclusions

So far, more than 130 entries have been reported from honey samples worldwide. Overall, the most represented genera are *Penicillium* (23 species), *Aspergillus* (17 species), *Zygosaccharomyces* (seven species) and *Talaromyces* (six species). Consequently, most representative fungal families isolated from honey are *Aspergillaceae*, *Saccharomycetaceae* and *Trichocomaceae*. *Aspergillus*, *Penicillium* and *Talaromyces* species are considered to hold important industrial and pharmacological applications, but also to be associated with food spoilage, mycotoxins production, and human and plant diseases (e.g., Houbraken et al.^[30]). Due to the ability of various of the identified species to produce both mycotoxins and other extracellular enzymes and organic acids, their study is also of significant industrial interest^[31]. Indeed, the industrial applications of *Saccharomycetaceae* and their ability to act as food spoilage yeasts is well known. Moreover, the detection of common bee pathogens (e.g., *Monascus mellicola*) also highlights the importance of such studies to monitor bee pathogens and, consequently, maintain or improve ecosystem balance and biodiversity.

Check list Fungi isolated and identified from honey, honey blossom and honeydew between 2000 and 2022.

Class	Order	Family	Genus	Synonym	Studied substrate:
Phylum Ascomycota Caval.-Sm. <i>Dothideomycetes</i> O.E. Erikss. & Winka	<i>Capnodiales</i> Woron.	<i>Cladosporiaceae</i> Chalm. & R.G. Archibald	<i>Cladosporium</i> Link	<i>Cladosporium cladosporiooides</i> (Fresen.) G.A. de Vries.	Nectar Honey; Honeydew ^[5, 16, 27] .
			<i>Cladosporium</i> sp. Link.		Honey Blossom; Honeydew; Nectar Honey ^[7, 15, 18, 23, 25–26] .
	<i>Dothideales</i> Lindau	<i>Saccotheciaceae</i> Bonord.	<i>Aureobasidium</i> Viala & G. Boyer	<i>Aureobasidium pullulans</i> (de Bary & Löwenthal) G. Arnaud.	Nectar Honey; Honeydew ^[5] .
				<i>Aureobasidium</i> sp. Viala & G. Boyer.	Honey Blossom; Honeydew; Nectar Honey ^[23, 26] .
				<i>Atichia</i> sp. Flot..	Honey Blossom; Honeydew ^[18] .
	<i>Incertae sedis</i>	<i>Seuratiaceae</i> Vuill. ex M.E. Barr	<i>Seuratia</i> Pat.	<i>Seuratia</i> sp. Pat..	Honey Blossom; Honeydew ^[18] .
				<i>Peyronella</i> sp. Cif. & Gonz. Frag..	Honey Blossom; Honeydew ^[18] .
				<i>Alternaria</i> Nees	Nectar Honey; Honeydew ^[5, 16] .
				<i>Alternaria alternata</i> (Fr.) Keissl..	Honey Blossom; Honeydew ^[4] .
	<i>Mytilinidiales</i> E. Boehm, C.L. Schoch & Spatafora <i>leosporales</i> Luttr. ex M.E. Barr	<i>Mytiliniaceae</i> Kirschst. <i>Pleosporaceae</i> Nitschke	<i>Alternaria</i> Nees	<i>Alternaria multififormis</i> (E.G. Simmons) Woudenh. & Crous.	Honey Blossom; Honeydew; Nectar Honey ^[7, 15, 18, 23, 26] .
				<i>Alternaria</i> sp. Nees.	

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Class	Order	Family	Genus	Synonym	Studied substrate:
(continued)		Didymellaceae Gruyter, Aveskamp & Verkley	Stemphylium Wallr.	Stemphylium sp. Wallr..	Honey Blossom ^[26] .
			Epicoccum Link	Epicoccum sp. Link.	Honey Blossom; Honeydew ^[15,18] .
Eurotiomycetes O.E. Erikss. & Winka	Ascosphaerales Gäum. ex Benny & Kimbr.	Torulaceae Corda	Phoma Sacc.	Phoma sp. Sacc..	Honey Blossom; Honeydew ^[15,18] .
			Torula Pers.	Torula mellis Fabian & Quinet. Torula sp. Pers..	Honey Blossom; Honeydew ^[18] . Honey Blossom; Honeydew ^[18] . Honey Blossom; Honeydew ^[4] .
		Ascosphaerales L.S. Olive & Spiltoir	Ascosphaera L.S. Olive & Spiltoir	Ascosphaera atra Skou & K. Hackett.	Honey Blossom; Honeydew ^[18] . Honey Blossom; Honeydew ^[4,18] .
			Bettsia Skou	Ascosphaera sp. L.S. Olive & Spiltoir. Bettsia alvei (Betts) Skou ex Pitt, Lantz, Pettersson & Leong, Cyphellophora jingdongensis H. Yang & K.D. Hyde.	Nectar Honey ^[24] .
	Chaetothyriales M.E. Barr	Cyphellophoraceae Rèblova & Unte.	Cyphellophora G.A. de Vries	Emericella discophora.	Nectar Honey; Honeydew ^[5] .
			Aspergillus P. Micheli ex Haller.	Aspergillus discophorus Samson, Zalar & Frisvad. Aspergillus nidulans (Eidam) G. Winter.	Nectar Honey ^[27] .
	Eurotiales G.W. Martin ex Benny & Kimbr.	Aspergillaceae Link	Aspergillus qinqixianii Y. Horie, Abliz & R.Y. Li.	Emericella nidulans.	Nectar Honey; Honeydew ^[5] .
			Aspergillus asperescens Stolk.	Emericella qinqixianii.	Honey Blossom; Honeydew ^[4] .
			Aspergillus candidus Link.	Aspergillus qinqixianii Y. Horie, Abliz & R.Y. Li.	Nectar Honey; Honeydew ^[13,16,27] .
			Aspergillus clavatus Desm..	Aspergillus candidus Link.	Honey Blossom; Honeydew ^[15] .
			Aspergillus flavus Link.	Aspergillus flavus Link.	Honey Blossom; Honeydew; Nectar Honey ^[13,15-16,27] .
			Aspergillus fumigatus Fresen..	Aspergillus fumigatus Fresen..	Honey Blossom; Honeydew; Nectar Honey ^[7,13,15-16,27] .
			Aspergillus montevicensis Talice & J.A. Mackinnon.	Aspergillus montevicensis Talice & J.A. Mackinnon.	Honey Blossom; Honeydew; Nectar Honey ^[5,7,13,15-16,27] .
			Aspergillus niger Tiegh..	Aspergillus niger Tiegh..	Honey Blossom; Honeydew; Nectar Honey ^[15-16] .
			Aspergillus ochraceus G. Wilh..	Aspergillus ochraceus G. Wilh..	Honey Blossom; Honeydew; Nectar Honey ^[5] .
			Aspergillus proliferans G. Sm..	Aspergillus proliferans G. Sm..	Nectar Honey; Honeydew ^[5] .
			Aspergillus pseudoglaucus Blochwitz.	Aspergillus pseudoglaucus Blochwitz.	Honey Blossom; Honeydew ^[4] .
			Aspergillus sp. P. Micheli ex Haller.	Aspergillus sp. P. Micheli ex Haller.	Honey Blossom; Honeydew; Nectar Honey ^[7,15,18,25-26] .
			Aspergillus speluncae Raper & Fennell.	Aspergillus speluncae Raper & Fennell.	Nectar Honey; Honeydew ^[5] .
			Aspergillus terreus Thom.	Aspergillus terreus Thom.	Nectar Honey ^[16] .
			Aspergillus versicolor (Vuill.) Tirab..	Aspergillus versicolor (Vuill.) Tirab..	Honey Blossom; Honeydew; Nectar Honey ^[15-16,27] .
			Paecilomyces sp. Bainier.	Paecilomyces sp. Bainier.	Nectar Honey; Honey Blossom ^[23] .
			Penicillium italicum Wehmer.	Penicillium italicum Wehmer.	Nectar Honey; Honeydew ^[5] .
			Penicillium solitum Westling.	Penicillium solitum Westling.	Honey Blossom; Honeydew ^[18] .
				Penicillium crustosum.	

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Class	Order	Family	Genus	Species	Synonym	Studied substrate:
				<i>Penicillium apimei</i> R.N. Barbosa, Souza-Motta, N.T. Oliveira & Houbraken.		Nectar Honey ^[21] .
				<i>Penicillium aurantioroseum</i> Dierckx.		Honey Blossom; Honeydew ^[15] .
				<i>Penicillium brevicompactum</i> Dierckx.		Honey Blossom; Honeydew; Nectar Honey ^[7, 15, 18] .
				<i>Penicillium brocae</i> S.W. Peterson, Jeann. Pérez, F.E. Vega & Infante.		Nectar Honey ^[21] .
				<i>Penicillium camemberti</i> Thom.		Honey Blossom; Honeydew ^[4] .
				<i>Penicillium chrysogenum</i> Thom.		Honey Blossom; Honeydew; Nectar Honey ^[7, 15, 18] .
				<i>Penicillium citrinum</i> Thom.		Honey Blossom; Honeydew; Nectar Honey ^[4, 15, 21] .
				<i>Penicillium commune</i> Thom.		Nectar Honey ^[7] .
				<i>Penicillium corylophilum</i> Dierckx.		Honey Blossom; Honeydew; Nectar Honey ^[4, 5, 7, 15, 21] .
				<i>Penicillium cravenianum</i> Visagie & K. Jacobs.		Honey Blossom; Honeydew ^[4] .
				<i>Penicillium decumbens</i> Thom.		Nectar Honey; Honeydew ^[5] .
				<i>Penicillium echinulatum</i> Biourge.		Nectar Honey; Honeydew ^[5] .
				<i>Penicillium expansum</i> Link.		Honey Blossom; Honeydew; Nectar Honey ^[7, 15] .
				<i>Penicillium griseofulvum</i> Dierckx.		Honey Blossom; Honeydew; Nectar Honey ^[7, 15, 18] .
				<i>Penicillium</i> sp. Link.		Honey Blossom; Honeydew; Nectar Honey ^[5, 13, 16, 18, 21, 23, 25, 26] .
				<i>Penicillium meliponae</i> R.N. Barbosa, Souza-Motta, N.T. Oliveira & Houbraken.		Nectar Honey ^[21] .
				<i>Penicillium mellis</i> R.N. Barbosa, Souza-Motta, N.T. Oliveira & Houbraken.		Nectar Honey; Honeydew ^[5, 7] .
				<i>Penicillium polonicum</i> K.W. Zaleski.		Honey Blossom; Honeydew ^[15] .
				<i>Penicillium raistrickii</i> G. Sm..		Nectar Honey ^[21] .
				<i>Penicillium sclerotiorum</i> J.F.H. Beyma.		Honey Blossom; Honeydew ^[15] .
				<i>Penicillium watroi</i> Houbraken, López-Quint., Frisvad & Samson.		Nectar Honey ^[21] .
			<i>Talaromyces</i>	<i>Talaromyces affinitatimellis</i> Rodr.-Andr., Stchigel & Cano.		Nectar Honey ^[21] .
				<i>Talaromyces basipetosporus</i> Stchigel, Cano & Rodr.-Andr..		Honey Blossom; Honeydew ^[4] .
				<i>Talaromyces brunneosporus</i> Rodr.-Andr., Cano & Stchigel.		Honey Blossom; Honeydew ^[4] .
				<i>Talaromyces funiculosus</i> (Thom)	<i>Penicillium funiculosum</i> .	Nectar Honey ^[27] .
				Samson, N. Yilmaz, Frisvad & Seifert.		Nectar Honey ^[21] .
				<i>Talaromyces brasiliensis</i> R.N. Barbosa, Souza-Motta, N.T. Oliveira & Houbraken.		Nectar Honey ^[21] .
				<i>Talaromyces scorteus</i> (Nakaz., Y. Takeda & Suematsu) S.W. Peterson & Jurjević.		Nectar Honey ^[21] .

(to be continued)

Class	Order	Family	Genus	Synonym	Studied substrate:			
(continued)	Incertae sedis	Monascaceae J. Schröt.	Xerochrysiium Pitt	Xerochrysiium xerophilum (Pitt) Pitt.	Honey Blossom; Honeydew ^[4] ; Nectar Honey ^[21] .			
			Monascus Tiegh.	Monascus mellicola R.N. Barbosa, Souza-Motta, N.T. Oliveira & Houbraken.				
			Eremascaceae Engl. & E. Gilg	Eremascus Eidam	Monascus purpureus Went.	Honey Blossom; Honeydew ^[4] ;		
				Monascus ruber Tiegh...	Monascus purpureus Went.	Honey Blossom; Honeydew ^[4] ;		
			Onygenales Cif. ex Benny & Kimbr.	Helicoarthrosporaceae Stchigel, Rodr.-Andrade & Cano	Helicoarthrosporum Stchigel, Cano & Rodriguez-Andrade.	Helicoarthrosporum mellicola Stchigel, Cano & Rodriguez-Andrade.	Honey Blossom; Honeydew ^[4] ;	
					Strongyloarthrosporum Rodr.-Andr., Cano & Stchigel	Strongyloarthrosporum catenulatum Rodr.-Andr., Cano & Stchigel.	Honey Blossom; Honeydew ^[4] ;	
			Leotiomyces O.E. Erikss. & Winka	Helotiales Nannf.	Incertae sedis	Coniothecium Corda	Coniothecium sp. Corda.	Honey Blossom; Honeydew ^[18] ;
						Tripasporium Corda	Tripasporium sp. Corda.	Honey Blossom; Honeydew ^[18] ;
			Saccharomycetes G. Winter	Incertae sedis	Myxotrichaceae Locq. ex Currah	Oidiendron Robak	Oidiendron mellicola Rodr.-Andr., Cano & Stchigel.	Honey Blossom; Honeydew ^[4] ;
						Skoua A.A. Wynns	Skoua asexualis Rodr.-Andr., Cano & Stchigel.	Honey Blossom; Honeydew ^[4] ;
Saccharomycetales Luerers.	Incertae sedis	Sclerotiniaceae Whetzel	Botrytis Micheli ex Pers.	Skoua fertilis (Stoppel) A.A. Wynns.	Honey Blossom; Honeydew ^[4] ;			
			Oosporidium Stautz	Botrytis sp. P. Micheli ex Pers..	Honey Blossom; Honeydew ^[15, 18] ;			
	Saccharomycetales Luerers.	Incertae sedis	Oosporidium Stautz	Oosporidium sp. Stautz.	Honey Blossom; Honeydew ^[18] ;			
			Candida Berkhout	Candida sp. Berkhout.	Honey Blossom; Honeydew ^[18] ;			
			Candida lundiana Saks., M. Suzuki, Lumyong, Ohkuma & Chantaw.	Candida lundiana Saks., M. Suzuki, Lumyong, Ohkuma & Chantaw.	Nectar Honey ^[29] ;			
			Candida parapsilosis (Ashford) Langeron & Talice.	Candida parapsilosis (Ashford) Langeron & Talice.	Nectar Honey ^[6] ;			
			Candida suthpensis Saks., M. Suzuki, Lumyong, Ohkuma & Chantaw..	Candida suthpensis Saks., M. Suzuki, Lumyong, Ohkuma & Chantaw..	Nectar Honey ^[29] ;			
			Starmerella C.A. Rosa & Lachance	Starmerella magnoliae (Lodder & Kregger-van Rij) C.A. Rosa & Lachance.	Honey Blossom; Honeydew; Nectar Honey ^[4, 6] ;			
			Starmerella sorbosivorans (S.A. James, C.J. Bond & I.N. Roberts) C.A. Rosa & Lachance.	Starmerella sorbosivorans (S.A. James, C.J. Bond & I.N. Roberts) C.A. Rosa & Lachance.	Honey Blossom; Honeydew; Nectar Honey ^[4, 6] ;			
			Lipomyces Lodder & Kregger-van Rij	Lipomyces sp. Lodder & Kregger-van Rij.	Honey Blossom; Honeydew ^[18] ;			
			Debaryomyces Klöcker & Kregger-van Rij	Debaryomyces hansenii (Zopf) Lodder & Kregger-van Rij.	Nectar Honey; Honeydew ^[5] ;			
			Pichia E.C. Hansen	Pichia sp. E.C. Hansen.	Honey Blossom; Honeydew ^[18] ;			
			Pichia membranifaciens (E.C. Hansen) E.C. Hansen.	Nectar Honey ^[6] ;				

(to be continued)

Class	Order	Family	Genus	Genus	Synonym	Studied substrate:
(continued)			Saccharomyces Meyen	Saccharomyces sp. Meyen.		Honey Blossom; Honeydew; Nectar Honey ^[13, 18] .
				<i>Saccharomyces cerevisiae</i> (Desm.) Meyen.		Honey Blossom; Honeydew; Nectar Honey ^[6, 18] .
				<i>Schwanniomyces</i> Klöcker		Honey Blossom; Honeydew ^[18] .
				<i>Zygosaccharomyces</i> B.T.P. Barker		Nectar Honey ^[17] .
				<i>Zygosaccharomyces favi</i> G. Péter, Cadež & Diauchy.		Honey Blossom; Honeydew ^[4] .
				<i>Zygosaccharomyces gambellarensis</i> Torriani, M. Lorenzini, Salvetti & Felis.		Honey Blossom; Honeydew; Nectar Honey ^[4-6, 18] .
				<i>Zygosaccharomyces mellis</i> Fabian & Quinet.		Honey Blossom; Honeydew ^[18] .
				<i>Zygosaccharomyces priorianus</i> Klöcker. Yarrow.		Honey Blossom; Honeydew; Nectar Honey ^[6, 18] .
				<i>Zygosaccharomyces rouxii</i> (Boutroux) Yarrow.		Honey Blossom; Honeydew; Nectar Honey ^[4, 29] .
				<i>Zygosaccharomyces siamensis</i> Saks., M. Suzuki, Chantaw., Ohkuma & Lumyong.		Honey Blossom; Honeydew ^[18] .
		Trichomonascaceae Kurtzman & Robnett	Blastobotrys Klopotek	<i>Blastobotrys meliponae</i> R.N. Barbosa, Boekhout, G.A. Silva, Souza-Motta & N. Oliveira.		Nectar Honey; Honeydew ^[19] .
				<i>Wickerhamomyces</i> Kurtzman, Robnett & Bas.-Powers		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> Lindner		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> sp. Lindner.		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> sp. Lindner.		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> sp. Lindner.		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> sp. Lindner.		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> sp. Lindner.		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> sp. Lindner.		Honey Blossom; Honeydew ^[18] .
				<i>Schizosaccharomyces</i> sp. Lindner.		Honey Blossom; Honeydew ^[18] .
		Cordycipitaceae Kreisel ex G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora	Engyodontium de Hoog	<i>Engyodontium</i> sp. de Hoog.		Nectar Honey ^[25] .
				<i>Trichoderma hamatum</i> (Bonord.) Bainier.		Nectar Honey ^[27] .
				<i>Trichoderma</i> sp. Pers.		Honey Blossom; Honeydew ^[15, 18] .
				<i>Acremonium</i> Link		Honey Blossom; Honeydew; Nectar Honey ^[16, 18] .
				<i>Sarocladium strictum</i> (W. Gams) Summerb.		Nectar Honey ^[27] .
				<i>Sarocladium</i> sp. W. Gams & D. Hawksw.		Honey Blossom; Honeydew ^[18] .
				<i>Fusarium</i> Link		Honey Blossom; Honeydew; Nectar Honey ^[7, 15-16, 18] .
				<i>Fusarium</i> sp. Link.		Nectar Honey ^[27] .
				<i>Fusarium oxysporum</i> Schldtl.		Nectar Honey; Honey Blossom ^[23] .
				<i>Stachybotrys</i> Corda		
		Nectriaceae Tul. & C. Tul.	Fusarium Link	<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
				<i>Fusarium</i> sp. Link.		
		Stachybotryaceae L. Lombard & Crous	Stachybotrys Corda	<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		
				<i>Stachybotrys</i> sp. Corda.		

(to be continued)

Class	Order	Family	Genus	Synonym	Studied substrate:
(continued)					
	<i>Incertae sedis</i>	Apiosporaceae K.D. Hyde, J. Fröhl., Joanne E. Taylor & M.E. Barr	<i>Arthrinium</i> Kunze	<i>Arthrinium</i> sp. Kunze.	Honey Blossom; Honeydew; Nectar Honey ^[5,26] .
	<i>Sordariales</i> Chadeff. ex D. Hawksw. & O.E. Erikss.	Chaetomiaceae G. Winter	<i>Botryotrichum</i> Sacc. & Marchal <i>Chaetomium</i> Kunze	<i>Botryotrichum atrogriseum</i> J.F.H. Beyma. <i>Chaetomium globosum</i> Kunze.	Nectar Honey ^[27] . Nectar Honey; Honeydew ^[5] . Honey Blossom; Honeydew ^[18]
	<i>Xylariales</i> Nannf.	Hypoxylaceae DC.	<i>Trichocladium</i> Harz	<i>Trichocladium griseum</i> (Traaen) X. Wei Wang & Houbraken.	Nectar Honey; Honeydew ^[5] .
	Phylum Basidiomycota R.T. Moore				
	<i>Microbotryomycetes</i> R. Bauer, Begerow, J.P. Samp., M. Weiss & Oberw.	Sporidiobolaceae R.T. Moore	<i>Rhodotorula</i> F.C. Harrison	<i>Rhodotorula</i> sp. F.C. Harrison.	Honey Blossom; Honeydew ^[18] .
	<i>Filobasidiales</i> Jülich	Filobasidiaceae L.S. Olive	<i>Naganishia</i> Goto	<i>Rhodotorula mucilaginoso</i> (A. Jörg.) F.C. Harrison	Nectar Honey ^[6] .
	<i>Tremellales</i> Fr.	Cryptococcaceae Kütz. ex Castell. & Chalm.	<i>Cryptococcus</i> Vuill.	<i>Naganishia uzbekistanensis</i> (A. Fonseca, Scorzeti; Fell) Xin Zhan Liu, F.Y. Bai, M. Groenew. & Boekhout. <i>Cryptococcus neoformans</i> (San Felice) Vuill..	Nectar Honey; Honeydew ^[5] . Honey Blossom; Honeydew ^[18] .
	<i>Trichosporonales</i> Boekhout & Fell	Trichosporonaceae Nann.	<i>Cutaneotrichosporon</i> Xin Zhan Liu, F.Y. Bai, M. Groenew. & Boekhout	<i>Cutaneotrichosporon mucooides</i> (E. Guého; M.T. Sm.) Xin Zhan Liu, F.Y. Bai, M. Groenew. & Boekhout.	Nectar Honey ^[6] .
	<i>Ustilaginales</i> Bek. Warm.	Ustilaginaceae Tul. & C. Tul.	<i>Vanrija</i> R.T. Moore	<i>Vanrija humicola</i> (Dasz.) R.T. Moore.	Nectar Honey ^[6] .
	<i>Wallemiales</i> Zalar, de Hoog & Schroers	Wallemiaceae R.T. Moore	Not determined.	<i>Ustilaginaceae</i> sp. Tul. & C. Tul..	Honey Blossom; Honeydew ^[18]
			<i>Wallemia</i> Johan-Olsen	<i>Wallemia hederæ</i> S. Jančić, Zalar & Gunde Cimerman..	Nectar Honey ^[19] .
			<i>Wallemia mellicola</i> Jancic, Nguyen, Seifert & Gunde-Cimerman..		Nectar Honey ^[19] .
	Phylum Mucoromycota Doweld				
	<i>Mucorales</i> Dumort.	Cunninghamellaceae Naumov ex R.K. Benj. Mucoraceae Fr.	<i>Cunninghamella</i> Matr. <i>Mucor</i> P. Michell ex L.	<i>Cunninghamella elegans</i> Lendn.. <i>Mucor</i> sp. P. Michelli ex L..	Honey Blossom; Honeydew ^[4] . Nectar Honey ^[16] . Honey Blossom; Honeydew; Nectar Honey ^[13,15,18,23,26] . Honey Blossom; Honeydew ^[4] .
			<i>Rhizopus</i> Ehrenb.	<i>Rhizopus arrhizus</i> A. Fisch.. <i>Rhizopus</i> sp. Ehrenb.. <i>Rhizopus stolonifer</i> (Ehrenb.) Vuill..	Nectar Honey ^[16] . Honey Blossom; Honeydew ^[4] . Nectar Honey ^[7] . Nectar Honey ^[16] .

Peronosporaceae sp. de Bary and *Pythium* sp. Pringsh., have also been isolated, identified and noted as fungi, from Honey Blossom and Honeydew samples^[18].

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Conflict of interest

The authors declare that they have no conflict of interest.

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