Occurrence of fungi on tissues of *Livistona chinensis*

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Ninety-one species of saprobic fungi were identified from decaying leaves and petioles of *Livistona chinensis*. Leaves of *L. chinensis* were dominated by two species of *Pseudospiropes* during the first month, and subsequently by *Lachnum palmae* and *Zygosporium echinosporum*. *Appendicospora hongkongensis* and *Oxydothis elaeicola* dominated on petiole tips, mid-petioles and petiole bases of the palm. The frequency of occurrence and the relative abundance of the latter two species increased during the first 4 months. *Astrosphaeriella bakariana* dominated the petiole tips and mid-petioles after 10 months of decay. Fungi with sporadic dominance include *Cocoicola livistonicola* and *Verticillium* cf. *dahliae* on petiole tips, and *Oxydothis obducens* on mid-petioles and petiole bases. A correspondence analysis performed for fungi occurring on different tissue types revealed distinct clusters, corresponding to leaves and petiole parts. The high percentage of fungal taxa confined to the leaves or petiole parts indicated that saprobic palmicolous fungi exhibit tissue specificity.

Key words: fungal distribution, fungal ecology, palm, plant decomposition, tissue specificity.

Introduction

There are an estimated 1.5 million fungi globally (Hawksworth, 1991) and less than 5% are presently known (Hyde and Hawksworth, 1997). The question "where are these unknown fungi?" has often been asked (Hyde and Hawksworth, 1997; Hyde 1998; Fröhlich and Hyde, 1999). In this laboratory, we have been investigating the microfungi on monocotyledonous hosts in the tropics, including bamboo, grasses, palms and the *Pandanaceae*. Bamboo supports a rich diversity of fungi, but we have found few new species (Dalisay, 1998). Palms, on the other hand, are rich in fungal diversity and numerous new species have been discovered from this substratum over the last decade (Goh and Hyde, 1996; Hyde and Fröhlich 1997; Yanna *et al.*, 1997, 1998a,b). Hyde *et al.* (1997) analysed the occurrence of fungi on two species of palms, *Licuala* sp. and *Archontophoenix alexandriae* in north Queensland and provided a conservative estimation that the ratio of palm host to fungal species is 1:26. The large numbers of fungi on palms, can in part provide examples of numerous missing undescribed fungi.

Fröhlich (1997) and Taylor (1998) studied the biodiversity and biogeography of palm fungi, and concurrently attempted to determine whether these fungi exhibited tissue specificity on the leaves and petioles of the palm. Very little or no evidence for tissue specificity was shown in these studies, probably due to their experimental design that addressed biodiversity and biogeography. If fungi on palms are tissue specific, this may account for the high fungal diversity on these substrata, and may account for the largely unknown species estimated (Hawksworth, 1991).

As neither Fröhlich (1997) nor Taylor (1998) was able to conclusively resolve whether fungi on palms exhibited tissue specificity, this issue remains unresolved. We therefore initiated a study in order to establish if there is a difference between the fungi occurring on different tissues on palms. The plant chosen in this study, *Livistona chinensis*, is one of the larger palms that can produce large quantities of woody material and support a diverse fungal community, especially on petioles and leaves (Hyde *et al.*, 1997). *Livistona chinensis* is found in the southern part of China, Vietnam, and Japan, and is widely cultivated in gardens, and along roadsides and paddy fields (Chen and Wu, 1991). It is one of the most common palms on the hillsides of Hong Kong.

Materials and methods

Visits were made to Lung Fu Shan on the western part of Hong Kong Island (22°16'N 114°8'E). Fresh fronds were cut from five well-developed individuals of *Livistona chinensis* on 13 August 1996. The fronds were marked and placed on the forest floor in the way similar to naturally fallen fronds. Decomposing fronds were collected on 19 August, 1 and 14 September, 19 October, 13 December 1996 and 10 June 1997 respectively. These fronds were divided into four parts; leaf, petiole tip, mid-petiole and petiole base. Palm parts were incubated separately in sterile plastic boxes on moist sterile tissue paper and examined within two months. Fungi fruiting on the substrata were identified and dried specimens are held at The University of Hong Kong Herbarium, Centre for Research in Fungal Diversity, The University of Hong Kong.

Frequency of occurrence and abundance of occurrence were calculated with the following formulas.

Frequency of occurrence = (number of samples on which a given taxa occurred/ number of samples examined) × 100

Abundance of occurrence = (occurrence of a given taxa/ occurrence of all taxa) × 100

Differences in the fungal communities from the frond parts were compared graphically by correspondence analysis (Anon, 1995), with the rare species (frequency of occurrence ≤ 20%) being excluded.

Results

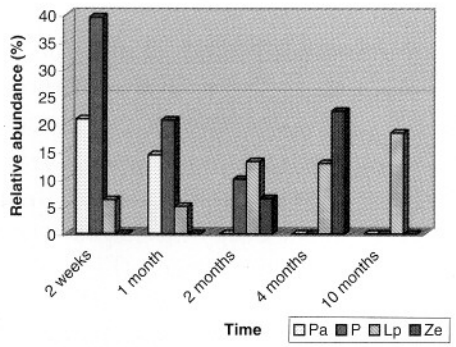
Ninety-one species of fungi, including 19 ascomycetes and 72 mitosporic fungi, were found in this study. Two species of *Pseudospiropes* were the most frequent and abundant fungi on leaves which have been decayed for two weeks and up to one month, while *Lachnum palmae* and *Zygosporium echinosporum* were frequent and abundant on leaves which have been decayed for more than one month. These fungi dominant on leaves at different decaying stages were either absent or rare in the petiole parts of the same stage of decay (Figs. 1-2; Table 1).

Appendicospora hongkongensis and *Oxydothis elaeicola* were common on the three petiole parts and their frequency of occurrence and relative abundance increased during the first four months of decay. *Astrosphaeriella bakariana* dominated the petiole tips and mid-petioles after ten months of decay (Figs. 1-2; Table 1). Fungi with sporadic dominance include *Cocoicola livistonicola* and *Verticillium* cf. *dahliae* on petiole tips and *Oxydothis obducens* on mid-petioles and petiole bases (Figs. 1-2).

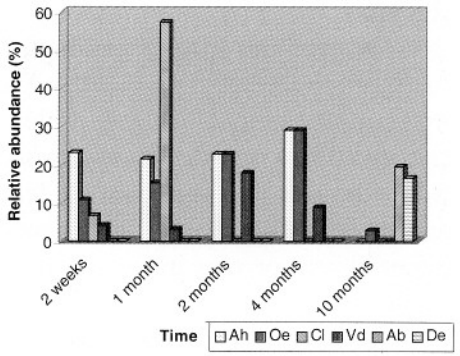
Two dimensional graphical displays of the correspondence analysis comparing the fungal communities of different front parts at different periods of decay have total inertia, explained by the two axes, of 100% (2 weeks), 86.1% (1 month), 90.25% (2 months), 88.21% (4 months) and 86.56% (10 months) respectively. The principal-coordinate axes c1 and c2 separate distinct clusters of species (Fig. 3). For fungal communities at 2 weeks, axis c1 separate mid-petioles from petiole tips and leaves, while axis c2 separate petiole tips and leaves (Fig. 3a). For fungal communities at 2 weeks, 1 month, 2 months, 4 months, and 10 months, axis c1 separate leaves from petiole tips, mid-petioles and petiole bases. However, axis c2 provides little evidence for differences in fungal communities between the three petiole parts (Figs. 3b, c, d).

Discussion

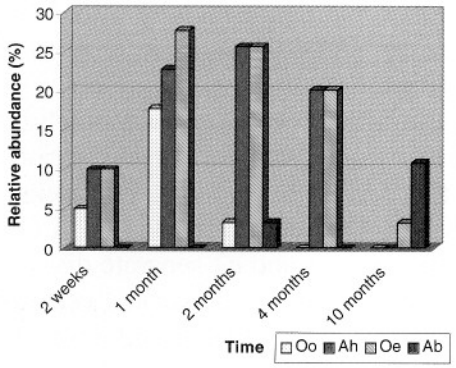
Pirozynski (1972) described many fungi from different tissues on oil palms including dead rachides (e.g. *Anthostomella bicincta* and *Chaetospermum chaetosporum*), dead seeds and fruit scales (e.g. *Bactrodesmium atrum*), blades of dry fallen leaves (e.g. *Dicyma vesiculifera*) and dead fallen spathes (e.g. *Physalidium elegans*). Hyde *et al.* (1997) reviewed the ascomycetes reported from palms, and compiled a list of some



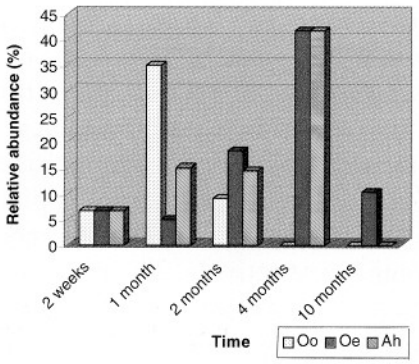
a. Leaves



b. Petiole tips



c. Mid-petioles

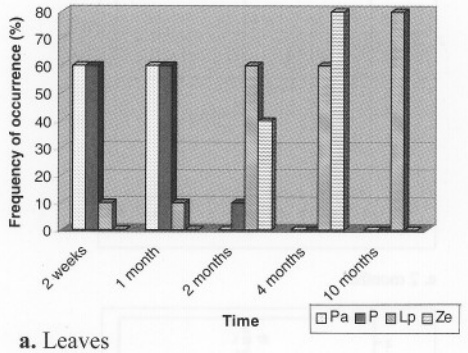


d. Petiole bases

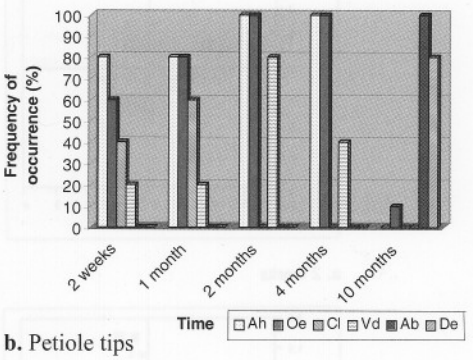
Fig. 1. Relative abundance of dominant species on different parts of fronds throughout the study. **a**. Dominant species on leaves. **b**. Dominant species on petiole tips. **c**. Dominant species on mid-petioles. **d**. Dominant species on petiole bases.

Keys:

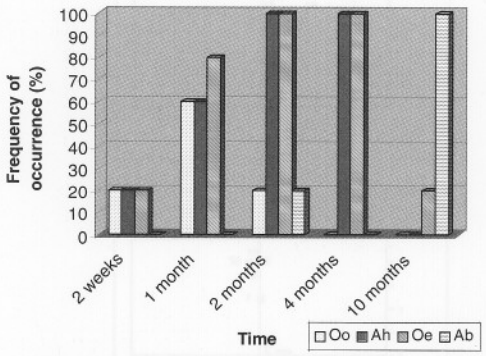
Ab	*Astrosphaeriella bakeriana*	Oe	*Oxydothis elaeicola*
Ah	*Appendicospora hongkongensis*	Oo	*Oxydothis obducens*
Cl	*Cocoicola livistonae*	P	*Pseudospiropes* sp.
De	*Dictyosporium elegans*	Pa	*Pseudospiropes arecacensis*
Lp	*Lachnum palmae*	Vd	*Verticillium* cf. *dahliae*



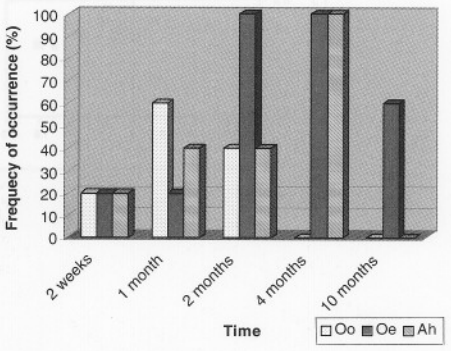
a. Leaves



b. Petiole tips



c. Mid-petioles



d. Petiole bases

Fig. 2. Frequency of occurrence of dominant species on different parts of fronds throughout the study. **a**. Dominant species on leaves. **b**. Dominant species on petiole tips. **c**. Dominant species on mid-petioles. **d**. Dominant species on petiole bases.

Keys:

Ab	*Astrosphaeriella bakeriana*	Oe	*Oxydothis elaeicola*
Ah	*Appendicospora hongkongensis*	Oo	*Oxydothis obducens*
Cl	*Cocoicola livistonae*	P	*Pseudospiropes* sp.
De	*Dictyosporium elegans*	Pa	*Pseudospiropes arecacensis*
Lp	*Lachnum palmae*	Vd	*Verticillium* cf. *dahliae*

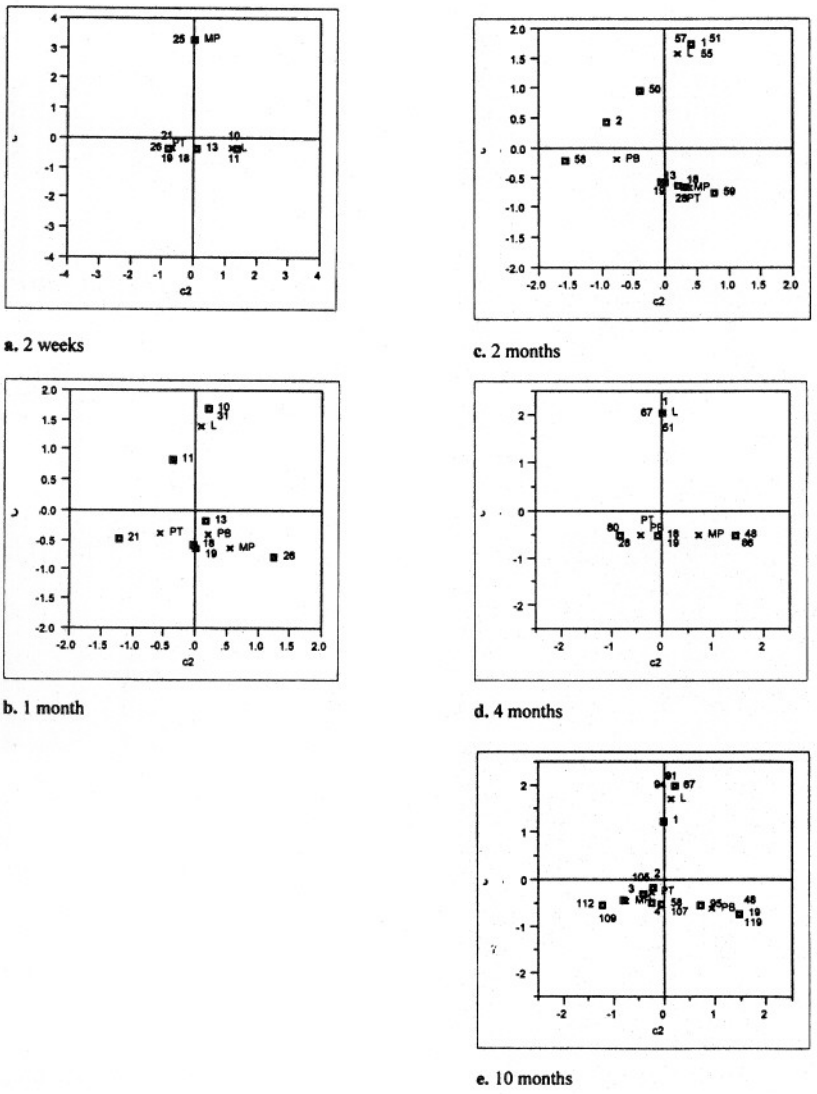


Fig. 3. Results of the ordination by simple correspondence analysis. L, leaves; PT, petiole tips; MP, Mid-petioles; PB, Petiole bases. (fungi with frequency less than 20% are excluded) **a.** Fungal community at 2 weeks. This plot accounts for 100% of the variation in the data set. **b.** Fungal community at 1 month. This plot accounts for 86.1% of the variation in the data set. **c.** Fungal community at 2 months. This plot accounts for 90.25% of the variation in the data set. **d.** Fungal community at 4 months. This plot accounts for 88.21% of the variation in the data set. **e.** Fungal community at 10 months. This plot accounts for 86.56% of the variation in the data set.

common ascomycete genera reported from different palm structures. These include species of *Anthostomella*, *Auerswaldia*, *Lembosia*, *Meliola*, *Mycosphaerella*, *Phyllachora* and *Sphaerodothis* that occurred on leaves, and species of *Anthostomella*, *Astrosphaeriella*, *Linocarpon*, *Oxydothis*, *Rosellinia* and *Xylaria* that occurred on rachides. Although these studies illustrated some evidence of tissue specificity, host specificity, spatial, temporal and some other confounding factors were not considered.

In this study, we standardised the host and spatial variation factors by collecting samples of *Livistona chinensis* from Lung Fu Shan. We also considered temporal variation. Correspondence analysis demonstrated that tissue specificities characterize the fungal communities on leaves and petioles.

Twenty-five to 70% of fungi recorded during different periods of decay had restricted occurrence on either leaves or petioles. Among the 91 species recorded, 20 species (22%) were confined to leaves throughout the decay process, while 54 species were (59%) confined to petioles.

Fungi with a restricted occurrence may play an important role in the degradation of respective tissue types. The enzymatic activities of these fungi warrant further investigation to understand whether their abundance on specific tissue types is due to their enzymatic capability.

The petioles differ from the leaves as they have more concentrated supportive tissue (Tomlinson, 1990). The outer region of the petioles (i.e. sclerotic cylinder) is composed of a sclerenchyma with associated bundles (Tomlinson, 1990). This may explain the high number of fungi confined to specific tissues.

Fungal tissue specificity is also recorded in mangrove habitats. Hyde (1990) compared the fungal communities on five mangrove tree species, and found that some fungi repeatedly occurred on, or were specific to certain wood types. For instance, *Passeriniella savoryellopsis* and *Swampomyces triseptatus* were most common on *Xylocarpus* (hard wood), whereas *Halorosellina oceanica* (as *Hypoxylon oceanicum*), *Lulworthia* spp. and *Halosarpheia ratnagiriensis* were most common on *Avicennia alba* and *Sonneratia alba* (softwood). In addition, *Cirrenalia pygmea*, *Carysporella rhizophorae* and *Leptosphaeria australiensis* were most common on the medium wood of *Rhizophora* sp. Hyde (1990) suggested that different taxa may be best adapted for growth on different wood types, and wood quality may provide a stimulatory effect for fungal spore germination.

The results of this study are preliminary observations on the fungal communities on different tissue types of fronds of *Livistona chinensis* in Hong Kong. Only the palms at Lung Fu Shan in Hong Kong were examined. If *Livistona chinensis* from other sites were included, the results may be more

Table 1. Fungi on *Livistona chinensis*. Relative species abundance in percentages

		2 weeks				1 month				2 months				4 months				10 months			
Species code	**Species name**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**
91	*Anthostomella livistonae* Girz.																4	10.33		3.33	
18	*Appendicospora hongkongensis* Yanna, K.D. Hyde and J. Fröhl.		23.4	10	6.6		21.5	22.86	15		23	25.67	14.3		29	20.2	41.7				
89	*Asterina* sp.															3.33					
2	*Astrosphaeriella bakeriana* K.D. Hyde and J. Fröhl.	6.25				5				8		3.33	3.33	5				10	19.6	19.52	10. 9
72	*Beltraniella numicola* Ramarao													2.2							
64	*Beltraniopsis esenbeckiae* Bat. and J.L. Bezerra												2								
99	*Bloxamia truncata* Berk. and Broome																	2			
98	*Camposporium antennatum* Harkness																	2			
37	*Chaetasbolisia erysiphoides* (Griff. and Maubl.) Speg.					6.3															
24	*Chaetospermum artocarpi* (Nag Raj) Nag Raj		3.13	5																	2.2 2
30	*Chaetostica* sp.				6.6																
70	*Circinotrichum* sp. 1													2.2				2			
84	*Circinotrichum* sp. 2															3.33				5	4
36	*Circinotrichum* sp. 3					3.1															
56	*Cladosporium* sp.						2.9														
97	***Clasterosporium flagellatum*** (Syd.) M.B. Ellis																	5			
21	***Cocoicola livistonae*** K.D. Hyde, J. Fröhl. and J.E. Taylor		6.7	5			57.5	2.86													
124	*Costantinella palmicola* K.M. Wong, Yanna, Goh and K.D. Hyde																				4
20	*Cylindrocladium brasiliense* (Bat. and Cif.) Peerally		12.5					2.86						2.2							
59	*Cytosphaeria* sp.										6.86										
67	*Dactylaria havanensis* R.F. Castañeda													6.7				5			
46	***Desmidiospora myrmecophila*** Thaxt.								20												
119	*Diaporthe palmarum* J.E. Taylor, K.D. Hyde and E.B.G. Jones																				6
123	*Dictyochaeta assamica* (Agnihothr.) Aramb., Cabello and Mengasc							6.67													

Table 1. comtinued

		2 weeks				1 month				2 months				4 months				10 months			
Species code	**Species name**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**
43	*Dictyochaeta fertilis* (S. Hughes and Kendr.) Hol-Jech.							5		4									2.86		
4	*Dictyosporim elegans* Corda																	3.33	16.75	11.19	4.22
81	*Dictyosporium alatum* van Emden.															2.86					
60	*Dictyosporium tetraseriale* Goh, Yanna and K.D. Hyde										4										
74	*Diplococcium aquaticum* Goh, K.D. Hyde and Umali													5							
58	*Dischloridium roseum* (Petch) Seifert and W. Gams										4		6	4					5.08	6.19	4.22
12	*Drechslera* sp.	8.25																			
3	*Endocalyx melanoxanthus* (Berk. and Broome) Petch																		7.86	13.33	2
75	*Endocalyx* sp.													2.2							
57	*Endomelanconium phoenicicola* Yanna, K.D. Hyde and Goh									12			2			4					
95	*Fasciatispora petrakii* (Mhaskar and V.G. Rao) K.D. Hyde																	10	5.08	3.33	10
33	***Fusamen amentorum*** (Delacr.) Arx					3.1															
68	*Fusarium* sp.													5							
22	*Gliocladium cylindrosporium* (Arnaud) Matsush.		3.13																		
27	*Gliomastix* sp.		3.57													2.86					
104	*Guignardia cocoës* (Petch) K.D. Hyde																		2.86		2.22
41	*Guiguardia cocogena* (Cooke) Punith.						4														
77	*Gyrothrix circinata* (Berk. and Curt.) S. Hughes														5						
73	*Gyrothrix circinata* (Berk. and Curt.) S. Hughes													2.2				2			
100	*Gyrothrix citricola* Piroz.																	2			
35	*Gyrothrix podosperma* (Corda) Rabenh.					3.1															
121	*Hyalopycnis* sp.																				4
62	*Kabatia* sp.											5									
1	*Lachnum palmae* (Kanouse) Spooner	6.25				5				13				13				18.33	9.52	3.33	
86	*Lasiodiplodia theobromae* (Pat.) Griff. and Maubl.															6.67			2.22		

Table 1. comtinued

		2 weeks				1 month				2 months				4 months				10 months			
Species code	**Species name**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**
96	*Massariothea* sp.																	5			
112	***Myrothecium mansonii*** Tulloch																			7.86	
118	***Myrothecium roridum*** Tode ex Fr. Var. *apiculatuum* Haware and Pavgi																				2
105	*Nectria* sp. 1																		5.08		2
108	*Nectria* sp. 2																		2.22		
19	*Oxydothis elaeicola* Petr.		10.9	10	6.6		15.5	27.86	5		23	25.67	18.3		29	20.2	41.7		2.86	3.33	1 0.2
113	***Oxydothis maculosa*** Penzig. and Sacc.																			3.33	
13	*Oxydothis obducens* K.D. Hyde	6.25	9.82	5	6.6	19	11.9	17.86	35		13	3.33	9		4						
7	*Oxydothis rubella* K.D. Hyde																		5		
29	*Periconia cambrensis* Mason and M.B. Ellis				20													2			
26	*Pestalotiopsis palmarum* (Cooke) Steyaert		9.82	5		3.1	3.125	15	5				5.33								
80	*Phoma* sp.															2.86	11.7				
88	*Phoma* sp.															4					
92	*Phomatospora* sp.																	3.33			
82	*Phomopsis* sp.															2.86					
5	*Piricauda cochinensis* (Subram.) M.B. Ellis																	2	2.86		
10	*Pseudospiropes arecacensis* Fröhl., K.D. Hyde and G. Guest	20.8				14															
11	*Pseudospiropes* sp. 1	39.5	3.13			21	8	2.86		2.5					6.67						
63	*Pseudospiropes* sp. 2											3.33				3.33					
38	*Rhinocladiella* sp.						3.125		20												
109	*Selenosporella* sp.																		2.22	2.86	2.22
90	*Septomyrothecium uniseptatum* Matsush.																5				
45	*Septosporium rostratum* M.B. Ellis							6.7													
25	***Spiropes guareicola*** (Stev.) Ciferri		3.13	10																	

Table 1. continued

		2 weeks				1 month				2 months				4 months				10 months			
Species code	**Species name**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**	**L**	**RT**	**MR**	**RB**
87	*Sporidesmium macrurum* (Sacc.) M.B. Ellis															4					
107	*Stibella* sp.																		5.08	6.19	4.22
116	*Trematophoma* sp.																				2.22
48	*Trichoderma harzianum* Rifai			6.67												6.67			2.86		10.7
69	*Vernonaea* sp.													5							
28	*Verticillium* cf. *dahliae*		4.17				3.125	2.86		3.3	18	10.67	2	2.2	9	3.33					2
16	*Volutella* sp.	6.25																			
40	*Wiesneriomyces javanicus* Koorders						4														
51	*Zygosporium echinosporum* Bunting and Mason									6.5				22							
39	*Zygosporium masonii* S. Hughes						4			2.5					6.67						
50	*Zygosporium minus* S. Hughes			6.67						11			8	12							
31	*Zygosporium oscheoides* Mont.					14						4									
103	Unidentified mitosporic fungus 1																	2		3.33	
34	Unidentified mitosporic fungus 2					3.1															
42	Unidentified mitosporic fungus 3						10					5									
55	Unidentified mitosporic fungus 4									15											
71	Unidentified mitosporic fungus 5													2.2							
94	Unidentified mitosporic fungus 6																	3.33			

conclusive. These preliminary results, do however, show that fungi on palms may be tissue specific and therefore concomitant with the large number of fungi known to occur on palms and therefore may account for some of the missing fungal diversity.

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