Fungi associated with leaf litter of para rubber (*Hevea brasiliensis*)

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The objective of this research was to study the diversity of fungi associated with the degradation of para rubber leaf litter. Samples were collected at three periods in 2010: January (during the late rainy season), April (during the dry season) and July (early in the rainy season) in Nakhon Si Thammarat and Songkhla Provinces, both in southern Thailand. Each sample comprised the following three groups; newly fallen leaves, middle stage decaying leaves and old decaying fallen leaves. Moist chamber and dilution pour-plate methods were used. Fungal identification was based on morphological examination under compound and stereo microscopes. A total of 447 species of fungi were identified from the para rubber leaf litter, comprising 405 anamorphic taxa, 38 ascomycetes, two zygomycetes, one oomycete and one basidiomycete. *Cladosporium tenuissimum* was the dominant species in newly fallen leaves. *Kirschsteinothelia* sp., *Nigrospora sphaerica* and *Veronaea coprophila* were the dominant species in middle stage decaying leaves. In addition to *Kirschsteinothelia* sp., *Lasiodiplodia cf. theobromae*, *Panchanania jaipurensis*, *Subulispora procuvata* and *Veronaea coprophila* were the dominant species in old decaying fallen leaves.

**Keywords**: decaying; leaf litter; fungal diversity

Introduction

The para rubber tree (*Hevea brasiliensis*, Euphorbiaceae) is an economically important plant species in south Thailand. Its white sap-like extract, commonly known as latex, can be collected and is the primary source of natural rubber (Kush et al. 1990).

Thailand’s para rubber plantations have been poorly investigated. No data on fungal communities associated with para rubber leaf litter degradation are available. In the para rubber plantation ecosystem, leaf litter is a major contributor to nutrient cycling pathways; however, little is known about fungal diversity on this host.

Decomposition of organic substrates is mainly carried out by various fungal groups. No single fungal species is capable of using all the components of a substrate and a succession of different fungal groups will be involved (Kannangara and Deshappriya 2005; Ananda and Sridhar 2004). There have been a number of studies on fungal communities occurring on leaf litter in both temperate and tropical regions (Duong et al. 2004). Leaf litter fungal communities play a key role in the ecology of a tropical forest. They are the major agents of leaf decomposition and nutrient cycling. Decomposition rates of various substrates are regulated by biotic factors, such as microorganisms and larger soil fauna (Paulus et al. 2006), and abiotic factors, such as climate, microclimate and nutrient properties of the substrata. Climatic factors, such as rainfall, temperature and humidity, are unhelpful in predicting the decomposition rates of the various types of leaf litter and mobilization of nutrients (Braga-Nato et al. 2008). Duong et al. (2006) reported that the plant leaf litter from specific hosts have different chemical contents, which may influence the fungi growing on it.

There are few studies on fungal communities occurring on leaf litter in tropical forests and, to the best of our knowledge, our study is the first on fungal diversity associated with para rubber leaf litter in southern Thailand. However, some studies have been carried in northern Thailand; for example, on the fungi associated with *Magnolia garrettii* (Promputtha et al. 2002), fungi on the leaf litter of *Magnolia lilifera* (Promputtha et al. 2004; Kodsbue et al. 2008), fungi on peat swamp palms (Pinnoi et al. 2006; Pinruan et al. 2007), fungi on *Dracaena loureiri* and *Pandanus* spp. (Thongkantha et al. 2008), fungi on fallen leaves of *Ficus* spp. (Wang et al. 2008), fungi on *Castanopsis diversifolia* (Duong et al. 2008) or fungi on *Shorea obtuse* (Osono et al. 2009).

The purpose of this study was to assess the diversity and distribution of saprobic fungi on para rubber (*H. brasiliensis*) leaf litter at each stage of decay, namely...
newly fallen leaves, middle stage decaying leaves and old decaying fallen leaves, and to evaluate the fungal communities involved in litter decay at each stage.

Materials and methods

Leaf samples

Leaf samples were collected at three periods in 2010: January, April and July. Each sample, which contained variously decayed leaves, was divided into several leaf groups based on external appearance and the degree of decomposition. Leaf litter belonging to the following three groups were used for fungal isolation: newly fallen leaves, i.e. relatively undecomposed, middle stage decaying leaves which were partly discolored, i.e. slightly decomposed, and old decaying fallen leaves which were highly discolored, i.e. decomposed leaf litter (Tokumasu 1990).

Study sites

The study was conducted at para rubber plantations, comprising trees of the *H. brasiliensis* RRIM 600 variety, in Nakhon Si Thammarat and Songkhla Provinces, in southern Thailand. Rainfall varied greatly throughout the year due to the influence of monsoon winds.

Nakhon Si Thammarat Province is located in the central southern area at latitude 8°47′–9°00′ N and longitude 99°97′–100°04′ E. The province has two seasons: a dry season (many Thais call it "summer" because the weather is hot and dry) and a rainy season. The dry season is February–April and the rainy season runs from May to January (Nakhon Si Thammarat 2010).

Songkhla Province is located on the eastern coast of southern Thailand at latitude 6°17′–7°56′ N and longitude 100°01′–101°06′ E. Like Nakhon Si Thammarat, the province has two seasons, but the dry season is from February to the middle of July (Songkhla Province 2010).

Both areas experience the highest rainfall and precipitation in November and highest temperature in May. The total rainfall in 2009 was 1581.5 mm and temperatures averaged 27.2°C (Thai Meteorological Department 2010).

Sampling design

Para rubber leaf litter was collected at two sites in a 25-year-old para rubber plantation. Three plots were distributed on a grid system of 200×200 m and the site study was conducted on 30 subplots of 50×50 m. In the decomposition study, material was collected three times in 2010: January, April and July.

The first collection was made in January, which was late in the rainy season with temperatures between 26.6 and 27.6°C. Rainfall was recorded at between 68.3 and 75.4 mm. The second collection occurred during April, in the dry season ("summer") when temperatures ranged 27.2–29.8°C and no rainfall was recorded. The third collection was in July, which is in the early rainy season when temperatures ranged 27.9–28.2°C and rainfall was 115.5–132.0 mm.

Leaves representing all stages of decay were selected from the litter from within 1-m² quadrants at each site. Leaves of each stage were placed in separate Ziplock plastic bags and taken to the laboratory within 24 h (Polishook et al. 1996).

Incubation, observation and data analyses

Four sets of fallen leaf litter at each stage were collected from the two locations and isolation, moist chamber and dilution pour-plate methods were used to study the fungi. In the moist chamber technique, all leaves were cut into 5×5 cm pieces and incubated in moistened Petri dishes at room temperature (28–32°C). After a 24-h incubation, the fungal colonies were scraped from the leaf surface with cellophane tape and mounted on slides using lactophenol as the mounting medium. Fungi isolated by the dilution pour-plate method were cultured on 3% malt extract agar. Identification was based on morphological examination under stereo and compound microscopes (Manoch et al. 2008).

Definition and statistical analyses

Fungal species were recorded as either present or absent from each stage of litter decomposition. The number of leaves on which a fungal species was found was designated as the occurrence of a fungus and was used to calculate the percentage occurrence of a species on leaves of each stage using the following formula (Yanna et al. 2002; Wang et al. 2008): % occurrence of taxon A = occurrence of taxon A/occurrence of all taxa in each stage)×100%. Fungal species diversity at each stage of degradation and each season was calculated using the Shannon–Wiener index (*H*) and Simpson’s index (*D*).

The Shannon-Wiener index $H = - \sum P_i \ln P_i$, where $P_i$ is the frequency of fungal species $i$ occurring at a specific leaf stage or season. Values of $H$ for real communities are often fall between 1 and 6.

Simpson’s index $D = 1 - \frac{\sum (n_i(n_i-1))}{N(N-1)}$, where $n_i$ is the number of individuals of species $i$ and $N$ = total number of species in the community. Values of $D$ range between 0 and 1.

Sørensen’s similarity index ($S$) was applied to compare the similarity of species on leaves of different stages and seasons: $S = 2c/(a+b)$, where $a$ is the number of species in stage or season A, $b$ is the number of species at stage or season B, and $c$ is the number of species in both stages or seasons. Similarity is expressed with values between 0 (no similarity) and 1 (absolute similarity) (Wang et al. 2008).
Results

Fungal taxonomic composition

Examination of decaying leaves of *H. brasiliensis* RRIM 600 variety at three stages of decomposition yielded 447 fungal taxa, comprising 405 anamorphic taxa, 38 ascomycetes, two zygomycetes, one oomycete and one basidiomycete (Table 1).

Fungal succession of *H. brasiliensis* leaf litter on the plantation floor showed variations in fungal composition between the decomposition stages. A total of 303 species were found in newly fallen leaves, 311 species were found in middle stage decaying leaves and 211 species were found in old decaying fallen leaves. In both areas, it was shown that 45 species (14.85%) overlapped in newly fallen leaves, 60 species (19.29%) in middle stage decaying leaves and 35 species (16.58%) were overlapping in old decaying fallen leaves.

In Nakhon Si Thammarat Province, 295 fungal taxa were found, including 268 anamorphic taxa, 26 ascomycetes and one basidiomycete. A total of 161 taxa were recorded on newly fallen leaves, 166 taxa on middle stage decaying leaves and 106 taxa from old decaying fallen leaves.

The 268 fungal taxa found in Songkhla Province included 243 anamorphic taxa, 21 ascomycetes, two zygomycetes, one oomycete and one basidiomycete. A total of 142 taxa were recorded from newly fallen leaves, 145 from middle stage decaying leaves and 105 species were recorded from old decaying fallen leaves. Eighteen taxa were common to both provinces and at all stages of decomposition, including *Kirschsteiniothelia* sp., *Bactrodesmium rhamni*, *Cladosporium tenuissimum*, *Curvularia lunata*, *C. pallescens*, *Dactylaria hyaline*, *Hansfordia pulvinata*, *Idriella lunata*, *Lasiodiplodia* cf. *theobromae*, *Nigrospora sphaerica*, *Pestalotiopsis* sp., *Subulispora procurvata*, *Trichoderma harzianum*, *Veronaea carlinae*, *V. coprophila*, *Wiesneriomyces javanicus*, *Zygosporium theobromae*, *Zygosporium echinosporum* and *Z. gibbrum*. Four taxa were found at all stages of decomposition in Nakhon Si Thammarat Province, comprising *Cladosporium flavum*, *C. orchidis*, *Dictyosporium manglietiae* and *Hormiactis candiada*. In addition, four taxa were found at all stages of decomposition in Songkhla Province, including *Hypoxylon* sp. 3, *Cladosporium oxyacridum*, *Pleurothecopsis pusilla* and *Sporidesmium harknesii*.

Species richness and dominant fungi

The dominant fungi on para rubber leaf litter, with over 3% occurrence at each stage, is shown in Table 2. One species, *Cladosporium tenuissimum*, was dominant on newly fallen leaves. Three species, *Kirschsteiniothelia* sp., *Nigrospora sphaerica* and *Veronaea coprophila* were dominant species on middle stage decaying leaves. Five species, *Kirschsteiniothelia* sp., *Lasiodiplodia* cf. *theobromae*, *Panchanania jaipurensis*, *Subulispora procurvata* and *Veronaea coprophila* were dominant on old decaying fallen leaves. In addition, *Kirschsteiniothelia* sp., *Veronaea carlinae*, *Lasiodiplodia* cf. *theobromae* and *Torula herbarum* were common species on all stages of leaf decay.

Fungal diversity and abundance

The fungal taxa at different stages of leaf decay were distinct. The number of taxa in newly fallen and middle stage decaying leaves tended to be higher than on old decaying fallen leaves. The number of taxa found on newly fallen leaves and middle stage decaying leaves in Nakhon Si Thammarat Province was 161 and 166 taxa, respectively, whereas the number of taxa found on the old decaying fallen leaves was 106. The results obtained in Songkla Province corresponded to the results from Nakhon Si Thammarat Province. In Songkla Province, 142 and 145 taxa were found on newly fallen and middle stage decaying leaves, respectively, whereas 105 taxa were found on old decaying fallen leaves (Table 3).

The similarity in fungal communities associated with para rubber leaf litter at each stage of decomposition was closest in newly fallen and middle stage decaying leaves. Newly fallen and old decaying fallen leaves were least similar. Middle stage decaying and old decaying fallen leaves (Table 4) showed slightly less similarity newly fallen versus middle stage decaying leaves.

The number of taxa recorded from samples during the different seasons was also distinct. During the dry season, the number of taxa was higher than in the early and late rainy seasons in both provinces (Table 5). In the late rainy and dry seasons, the communities were similar compared to both the late and early rainy and dry seasons and early rainy seasons (Table 6).

Discussion

Fungal diversity and colonization

This is the first report of fungal communities associated on para rubber leaf litter decay in Thailand. Fungal community structure and its variation during the three decomposition stages (newly fallen leaves, middle stage decaying leaves and old decaying fallen leaves) were studied.

Differences in fungal communities occur during fungal succession on decaying *H. brasiliensis* leaves. In newly fallen leaves (303 taxa) and middle stage decaying leaves (311 taxa), the number of species was higher than on old decaying fallen leaves (211 taxa). Some fungi, such as *Hypoxylon* sp. 2., *Talaromyces flavus*, *Cladosporium britanicum*, *Drechslera heavae* and *Fusarium semitectum*, were recorded only from samples of newly fallen leaves, suggesting that they may be carried over from the
Table 1. Occurrence (%) of fungi on para rubber leaf litter at different stage of decomposition collected from Nakhon Si Thammarat and Songkhla provinces.

| Location               | Taxa                      | New | Middle | Old | New | Middle | Old |
|------------------------|---------------------------|-----|--------|-----|-----|--------|-----|
| **Ascomycetes**        | Acarocybe sp.             | 0.43|        |     | 0.26|        |     |
|                        | A. deightonii             | 0.87|        |     |     |        |     |
|                        | Amerosporium sp.          | 0.21|        |     |     |        |     |
|                        | Aquaticheirospora lignicola | 0.21|        |     |     |        |     |
|                        | Astrosphaeriella          | 1.31|        |     |     |        |     |
|                        | Broomella acuta           | 0.22|        |     |     |        |     |
|                        | Ceratocystis ulmi         | 0.43|        |     |     |        |     |
|                        | Chaetomium sp.            | 0.29|        |     |     |        |     |
|                        | Claussenomyces prasinulus | 0.25|        |     |     |        |     |
|                        | Cucurbitaria elongata     | 0.51|        |     | 0.76|        |     |
|                        | Dothidotthia sp. 1        |     | 0.51   |     |     |        |     |
|                        | Dothidotthia sp. 2        |     | 0.65   |     |     |        |     |
|                        | Dothiorella sp.           |     | 0.25   |     |     |        |     |
|                        | Eupenicillium sp.         |     |        | 0.10|     |        |     |
|                        | Gaemannomyces graminis    | 1.09|        |     |     |        |     |
|                        | Genicularia cystospora    |     |        | 0.51|     |        |     |
|                        | Glomerella cingulata      |     | 2.14   | 1.17|     |        |     |
|                        | Gnomonia amoena           | 0.22|        |     |     |        |     |
|                        | G. fragariae              | 1.75|        |     |     |        |     |
|                        | Griphoshaeria corticola   |     |        | 0.29|     |        |     |
|                        | Hypoxylon sp. 1           | 1.53|        | 1.46| 1.54|        |     |
|                        | Hypoxylon sp. 2           | 0.44|        |     | 0.26|        |     |
|                        | Hypoxylon sp. 3           |     | 1.28   | 0.76| 2.56|        |     |
|                        | Hypoxylon sp. 4           |     | 0.51   |     |     |        |     |
|                        | Hypoxylon sp. 5           |     |        | 0.96|     |        |     |
|                        | Hypoxylon sp. 6           |     | 0.76   |     |     |        |     |
|                        | Hypoxylon cohaerens       | 0.22| 1.28   |     |     |        |     |
|                        | Linocarpus sp.            | 0.65| 0.21   | 1.75| 0.25|        |     |
|                        | Linospora sp.             | 0.22| 0.21   | 1.78|     |        |     |
|                        | Lophiostoma semiliberum   |     |        |     |     | 0.32   |     |
|                        | L. viridarium             |     |        |     |     | 0.26   |     |
|                        | Kerststeinothelia sp.     | 2.83| 3.63   | 3.51| 4.36| 4.33   | 6.73|
|                        | Panchanania jaipurensis   | 1.92| 3.22   |     | 0.76| 0.33   | 5.13|
|                        | Thyridaria sambucina      | 0.85| 1.75   |     | 0.26| 1.53   | 3.57|
|                        | Talaromyces flavus*       | 0.33| 0.39   |     |     |        |     |
|                        | Truncatella sp.           | 0.22|        |     |     |        |     |
|                        | Xylaria hypoxylon         | 0.22| 0.43   |     |     |        |     |
|                        | Xylaria sp.               |     | 0.64   |     |     |        |     |
| **Mitosporic fungi**   | Acremonium sp. 1          | 0.29|        |     |     |        |     |
|                        | Acremonium sp. 2          | 0.58|        |     |     |        |     |
|                        | A. alternatum             | 0.22|        |     |     | 0.26   |     |
|                        | A. butyri                 |     |        |     |     | 0.51   |     |
|                        | A. fusidioides            | 0.21| 0.29   |     |     | 1.54   |     |
|                        | A. kiliense*              | 0.21|        |     |     |        |     |
|                        | A. murorum                | 0.43|        |     |     |        |     |
|                        | A. strictum               | 0.21|        |     |     |        |     |
|                        | Acrodictys sacchari       |     |        | 0.51|     |        |     |
|                        | Acrostaurus turneri       |     |        | 0.32|     |        |     |
|                        | Alternaria sp.            | 0.22|        |     |     |        |     |
|                        | A. radicina               | 1.17|        |     |     |        |     |
|                        | A. rhodosporum            | 0.29|        |     |     | 0.25   |     |
|                        | Annellophora solani       |     |        |     |     | 0.88   |     |
|                        | Annellophragmia sp.       |     |        |     |     |        |     |

(Continued)
Table 1. (Continued).

| Taxa                        | Location | Nakhon Si Thammarat | Songkhla |
|-----------------------------|----------|----------------------|----------|
|                             | New      | Middle   | Old     | New      | Middle   | Old     |
| Apophaeria pezziozoides     | 3.49     | 1.28     |         | 0.26     | 1.27     |         |
| Arthrobotryum atrocephalum  |          |          |         |          |          |         |
| Articulospora tetracladia   | 1.28     | 1.17     |         | 0.51     | 4.49     |         |
| Aspergillus sp. 1           | 1.33     | 2.04     |         |          |          |         |
| Aspergillus sp. 2           | 1.33     | 1.16     |         | 0.51     |          |         |
| Aspergillus sp. 3           | 1.16     |          |         |          |          |         |
| A. aculeatus*               |          |          |         | 0.51     |          |         |
| A. caespitosus*             |          | 0.17     |         |          | 0.10     |         |
| A. carbonarium*             |          |          |         |          |          |         |
| A. flavus*                  |          |          |         | 0.26     |          |         |
| A. japonicus*               | 0.68     |          |         | 1.03     | 0.87     | 0.10    |
| A. niger*                   |          |          |         | 0.68     | 0.87     | 0.08    |
| A. parasiticus*             |          |          |         |          |          |         |
| A. pulvinularis*            |          |          |         | 0.51     |          |         |
| A. puniceus*                |          |          | 0.29     | 0.48     | 0.64     |         |
| A. restrictus*              |          |          |         | 0.68     | 0.29     | 0.43    |
| A. terreus*                 | 0.39     |          | 0.25    |          |          |         |
| Bacillispora aquatica       |          |          |         | 0.25     |          | 0.64    |
| Bactrdesmum sp.             |          |          |         |          |          |         |
| B. betulicola               |          |          |         |          |          |         |
| B. longispora               |          |          |         |          |          |         |
| B. pallidum                 |          |          |         |          |          |         |
| B. rahmii                   | 0.87     | 2.99     | 3.51    | 0.26     | 3.82     | 1.60    |
| B. spilomeum                | 1.09     |          |         | 2.05     |          | 2.56    |
| Bipolaris havae             |          | 0.43     |         | 0.26     | 0.25     |         |
| Balladynopsis vanderystii   | 0.65     |          |         |          |          |         |
| Belltraniella pizozynskii   |          |          |         | 0.51     | 0.32     |         |
| Beltrania rhombica          |          |          |         |          | 0.32     |         |
| B. fertilis                 |          |          |         | 1.54     | 1.60     |         |
| B. odinae                   |          |          |         | 0.32     | 0.32     |         |
| B. pini                     |          |          |         | 0.32     | 0.32     |         |
| B. santapauli               |          |          |         | 0.29     |          |         |
| Berkleasium macropus        | 0.65     |          |         |          |          |         |
| B. cf. minutissimum         | 0.21     |          |         | 0.26     | 0.51     |         |
| Bidenticula cannae          |          |          |         | 0.26     |          |         |
| Bispora antennata           |          |          |         |          | 0.32     |         |
| Bipolaris ellisii*          |          |          |         | 0.43     |          |         |
| Botryodiplodia acerina      | 4.79     | 1.71     | 2.80    | 0.51     |          | 1.92    |
| Botryotrichum sp.           | 0.43     |          |         | 0.26     |          |         |
| B. piluliferum              |          |          |         | 0.32     |          |         |
| Brachysdesmiella bisepulta  | 0.65     |          |         | 0.51     |          |         |
| Camarosporium rosae         |          |          |         | 0.29     |          |         |
| C. salicinum                | 0.65     |          |         |          |          |         |
| Camposporium sp.            | 0.87     | 0.21     |         | 0.26     | 0.36     | 3.85    |
| C. antennatum               | 0.22     |          |         | 2.05     | 1.78     | 0.64    |
| C. cambrense                | 0.44     |          |         | 5.1      | 1.02     |         |
| C. laudonii                 | 0.22     |          |         | 0.26     | 0.32     |         |
| Canalispora pallidum        |          |          |         | 0.25     |          |         |
| Canalisporium exiguum       |          |          |         | 0.25     |          |         |
| C. pallidum                 |          |          |         | 0.26     | 1.02     |         |
| Ceratothorium uncinatum      | 0.43     |          |         |          |          |         |
| Cercospora sp. 1            | 0.44     |          |         | 0.25     |          |         |
| Cercospora sp. 2            | 0.21     |          |         | 0.25     |          |         |
| Cercospora sp. 3            | 0.21     |          |         | 0.32     |          |         |
| Cercospora sp. 4            | 0.22     |          |         | 0.32     |          |         |

(Continued)
## Table 1. (Continued).

| Location            | Nakhon Si Thammarat | Songkhla |
|---------------------|---------------------|----------|
|                     | New  | Middle | Old  | New  | Middle | Old  |
| *Cercospora* sp. 5  | 0.44 |        |      |      |        |      |
| *Cercospora* sp. 6  | 0.85 |        |      |      |        |      |
| *Cercospora* apii   | 0.85 |        |      |      |        |      |
| *C. opuli*          | 0.22 |        |      |      |        |      |
| *C. vaginae*        | 0.22 |        |      |      |        |      |
| *Chaetopsina* sp.   | 0.22 |        |      |      |        |      |
| *Chaetoschizospora* | 0.26 |        |      |      |        |      |
| *Chalara* sp.       |      |        |      |      |        |      |
| *C. cylindrosporangium* | 0.64 |
| *C. elegans*        |      |        |      |      |        |      |
| *Chaetocalbarara* sp. | 1.31 |
| *Chryseidea* sp.    |        |        |      |      |        |      |
| *Chrysosporium* pannorum |      |        |      |      |        |      |
| *Chuppa* sarcofera  |        |        |      |      |        |      |
| *Circinotrichum* fertile | 0.44 |
| *C. maculiforme*    | 0.65 | 0.43   | 0.29 | 0.51 | 0.77   | 2.54 |
| *C. pannorum*       | 0.22 | 0.43   |      | 0.77 | 2.54   | 0.96 |
| *C. poonense*       | 0.22 | 0.43   |      | 0.77 | 2.54   | 0.96 |
| *Cladosporium* sp. 1 | 0.22 |
| *Cladosporium* sp. 2 | 0.87 |
| *Cladosporium* sp. 3 | 1.31 |
| *C. acaciicola*     |      |        |      |      |        |      |
| *C. balladyner*     |      |        |      |      |        |      |
| *C. britanicum*     | 0.22 | 0.58   |      | 0.51 |        |      |
| *C. elatum*         |      |        |      |      | 1.79   |      |
| *C. flavum*         | 2.18 | 3.42   | 3.22 |      |        |      |
| *C. gallicola*      | 0.65 | 0.58   |      |      | 0.25   |      |
| *C. nigrelum*       |      |        |      |      |        | 0.26 |
| *C. orchids*        | 2.61 | 2.56   | 0.29 |      |        |      |
| *C. oxysporum*      |      |        |      |      | 2.05   | 0.51 |
| *C. orchidearum*    |      |        |      |      |        | 0.32 |
| *C. psoraleae*      |      |        |      |      |        |      |
| *C. staurophorum*   |      |        |      |      |        |      |
| *C. tenuissimum*    | 3.49 | 1.07   | 1.17 | 3.59 | 1.53   | 1.60 |
| *C. uredinicola*    |      | 0.21   |      |      |        |      |
| *Clavariopsis* aquatica | 0.44 |
| *Codinaea* sp. 1    | 0.65 | 0.43   | 0.58 |      | 0.76   |      |
| *Codinaea* sp. 2    | 0.64 |        |      |      | 1.02   |      |
| *Codinaea* sp. 3    |      |        |      |      | 0.25   |      |
| *Codinaea* sp. 4    | 0.65 | 0.21   | 0.88 |      | 0.25   |      |
| *C. assamica*       | 1.31 |        |      |      | 0.25   | 1.92 |
| *C. britannica*     | 0.17 | 0.43   |      |      |        | 0.32 |
| *C. fertilis*       |      |        |      |      | 1.27   |      |
| *C. Hughesii*       |      |        |      |      | 0.25   | 0.64 |
| *Colletotrichum* sp. 1* | 0.21 |
| *Colletotrichum* sp. 2 | 0.87 |
| *Colletotrichum* sp. 3 | 1.31 |
| *C. dematium*       | 1.31 | 0.77   |      |      | 0.77   |      |
| *C. gloeosporioides*| 0.17 | 0.21   | 2.05 | 0.76 | 0.76   | 0.96 |
| *Conioscypha* sp.   |      |        |      |      | 0.26   |      |
| *Corynespora* sp.   |      |        |      |      | 0.43   |      |
| *C. cassincola*     |      |        |      |      | 0.85   | 0.88 |
| *C. novae-zelandiae*|      |        |      |      | 0.58   |      |
| *C. trichiliae*     |      |        |      |      | 0.26   |      |
| *Coryneum* sp.      | 0.65 |        |      |      |        |      |
| *C. elevatum*       |      |        |      |      | 0.29   |      |
| *Curvularia* sp. 1  |      |        |      |      | 0.25   |      |
| *Curvularia* sp. 2  |      |        |      |      | 1.03   | 0.25 |
| *Curvularia* sp. 3  |      |        |      |      |        | 0.51 |

(Continued)
Table 1. (Continued).

| Taxa                      | Location          | Nakhon Si Thammarat | Songkhla |   |
|---------------------------|-------------------|---------------------|----------|---|
|                           |                   | New | Middle | Old | New | Middle | Old |
| C. affinis                |                   | 0.26 | 0.26   | 0.26 | 0.32 | 0.32   | 0.32 |
| C. deightonii             |                   | 0.44 | 3.63   | 1.17 | 0.51 | 0.51   | 1.28 |
| C. geniculata             |                   | 0.65 | 0.21   | 0.58 | 1.28 | 1.02   | 1.28 |
| C. lunata                 |                   | 2.40 | 0.25   | 0.25 | 0.29 | 0.29   | 0.29 |
| C. pallescens             |                   | 0.65 | 0.21   | 0.58 | 1.28 | 1.02   | 1.28 |
| C. peniseti               |                   | 0.64 | 0.64   | 0.64 | 0.64 | 0.64   | 0.64 |
| C. richardiae             |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| C. senegalensis           |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| C. uncinata               |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Cylindocladium sp. 1      |                   | 0.22 | 1.92   | 1.41 | 0.77 | 1.02   | 1.60 |
| Cylindocladium sp. 2      |                   | 0.65 | 0.43   | 2.65 | 0.77 | 1.02   | 0.51 |
| C. oligospermum           |                   | 0.65 | 0.65   | 0.65 | 0.65 | 0.65   | 0.65 |
| C. parvum                 |                   | 0.88 | 0.88   | 0.88 | 0.88 | 0.88   | 0.88 |
| C. scoparium              |                   | 2.40 | 2.40   | 2.40 | 2.40 | 2.40   | 2.40 |
| Cylindrocarpon didymum    |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Cytosporina sp.           |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Dactylaria sp.            |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| D. hyalina                |                   | 0.22 | 1.92   | 1.46 | 0.77 | 1.02   | 1.60 |
| D. janci                  |                   | 0.65 | 0.43   | 2.56 | 0.77 | 1.02   | 4.17 |
| D. obtiangularia          |                   | 0.65 | 0.65   | 0.65 | 0.65 | 0.65   | 0.65 |
| Dactylella ellipsoidora    |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Dendrospora erecta        |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Dendryphiopsis atra       |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Dichomera prunicola       |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Dictyosporium sp.         |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Dictyosporium heptasporum |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| D. mangletiae             |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Diplococcium sp.          |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Diplodina sp.             |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Discosia artocreas        |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| D. maculicula             |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Drechlera sp.             |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Elletevera parasitica     |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Ellisembia vaginata       |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Ellisiopsis sp.           |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| E. galleisia              |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Endophragmia sp.          |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| E. bisbyi                 |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| E. cesatii                |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| E. elliptica              |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Endophragmiella theobromae|                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Ephelis borealis          |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Exosporium phyllanthemum  |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Fasariella sp.            |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Fibulococca sp.           |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Frasertiell sp.           |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |
| Fulvia sp.                |                   | 0.21 | 0.21   | 0.21 | 0.21 | 0.21   | 0.21 |

(Continued)
Table 1. (Continued).

| Taxa                        | Location        |    |    |    | Location        |    |    |    |
|-----------------------------|-----------------|----|----|----|-----------------|----|----|----|
|                            | Nakhon Si Thammarat |    |    |    | Songkhla        |    |    |    |
|                            | New    | Middle | Old |    | New    | Middle | Old  |    |
| \(F. \text{berkheyae}\)    | 1.28    |         |     |    |         |         |     |    |
| \(Fusarium\) sp. 1         | 0.88    | 1.79   |     |    |         |         |     |    |
| \(Fusarium\) sp. 2         | 0.88    |         |     |    |         |         |     |    |
| \(Fusarium\) sp. 3         | 1.09    | 0.85   |     |    | 0.64   | 1.53   |     |    |
| \(Fusarium\) sp. 4         | 1.09    | 1.50   |     |    | 2.05   |         |     |    |
| \(Fusarium\) sp. 5         | 1.74    | 1.07   |     |    | 0.77   | 1.53   | 0.64 |    |
| \(Fusarium\) sp. 6         | 0.22    | 0.64   |     |    | 1.79   | 1.78   |     |    |
| \(Fusarium\) sp. 7         | 0.65    | 0.43   |     |    | 1.07   |         |     |    |
| \(Fusarium\) sp. 8         |         | 1.07   |     |    |         |         |     |    |
| \(F. \text{moniliforme}\)  | 0.22    |         |     |    |         |         |     |    |
| \(F. \text{oxysporum}\)   | 0.22    |         |     |    |         |         |     |    |
| \(F. \text{semitectum}\)  | 1.31    |         |     |    | 0.26   |         |     |    |
| \(F. \text{solani}\)      | 0.10    |         |     |    |         |         |     |    |
| \(Fusoma\) rubricosa       | 1.07    |         |     |    | 0.32   |         |     |    |
| \(Graphium\) putredinis    |         |         |     |    |         |         |     |    |
| \(Gyrothrix\) circinata    | 0.43    | 0.51   | 0.76 |    | 1.92   | 0.32   |     |    |
| \(G.\) podosperma          | 0.64    | 0.58   | 1.53 |    | 0.32   |         |     |    |
| \(Gliocladium\) roseum    | 0.10    |         |     |    |         |         |     |    |
| \(Hansfordia\) pulvinata   | 1.09    | 1.92   | 0.29 |    | 1.79   | 3.05   | 0.64 |    |
| \(H.\) ovalispora          |         |         |     |    | 0.32   |         |     |    |
| \(Haplaritopsis\) fagicola |         | 0.26   |     |    |         |         |     |    |
| \(Haplographium\) mangiferae| 0.22   | 0.25   |     |    |         |         |     |    |
| \(Harknessia\) sp.         | 0.22    |         |     |    |         |         |     |    |
| \(Harpographium\) sp.      | 0.65    |         |     |    |         |         |     |    |
| \(Harposporium\) sp.       | 0.21    | 1.28   |     |    | 0.26   |         |     |    |
| \(Helicorhoidion\) botryoideum| 0.26  |         |     |    |         |         |     |    |
| \(Helicosporium\) aureum   | 0.65    | 0.21   | 0.29 | 0.51 | 1.75   | 3.53   |     |    |
| \(Helminthosporium\) sp.   | 2.56    |         |     |    | 0.29   |         |     |    |
| \(Hendersonia\) celitofila | 1.71    | 1.75   | 1.53 |    | 3.53   |         |     |    |
| \(Hendersonula\) sp.       | 0.29    |         |     |    | 0.25   |         |     |    |
| \(Henicospora\) coronata   | 1.28    | 2.92   | 0.51 |    | 1.86   |         |     |    |
| \(Heterocentrum\) sp.      | 0.29    |         |     |    | 0.32   |         |     |    |
| \(H.\) chaetospira         |         | 0.64   |     |    | 0.25   |         |     |    |
| \(Heteropatella\) alpina   | 0.65    |         |     |    | 0.29   |         |     |    |
| \(Hobsonia\) mirabilis     |         |         |     |    | 0.32   |         |     |    |
| \(Hormiacis\) alba         | 0.22    | 0.21   | 0.88 | 0.51 | 0.25   |         |     |    |
| \(H.\) candida             | 0.22    | 0.21   | 0.88 | 0.51 | 0.32   |         |     |    |
| \(Humicola\) grisea        | 0.22    | 0.21   | 0.88 | 0.64 | 0.25   |         |     |    |
| \(Hyalotiella\) sp.        | 0.64    | 2.34   |     |    | 0.64   |         |     |    |
| \(Hyphodiscostia\) jaipurensis| 0.88  |         |     |    | 0.64   |         |     |    |
| \(Idriella\) sp. 1         | 0.64    |         |     |    | 0.64   |         |     |    |
| \(I.\) lunata              | 1.74    | 2.56   | 0.58 | 0.26 | 1.78   | 0.64   |     |    |
| \(Kellermannia\) yaccaegena| 0.87    |         |     |    | 0.96   |         |     |    |
| \(Kramasamuhia\) sp.       | 0.22    | 0.29   |     |    | 1.07   |         |     |    |
| \(Lasiodiplodia\) cf. theobromae| 3.27 | 4.09  | 2.82 | 6.36 | 4.49   |         |     |    |
| \(Lateriramulosa\) uni-inflata| 0.65 |         |     |    |         |         |     |    |
| \(Leptodiscella\) africana | 0.65    | 0.64   | 1.17 | 0.64 | 1.28   |         |     |    |
| \(Massariothea\) sp.       |         | 0.64   |     |    | 0.64   |         |     |    |
| \(Menispora\) sp.          | 0.22    |         |     |    | 0.32   |         |     |    |
| \(Menisporopsis\) profusa  | 0.22    | 0.21   |     |    |         |         |     |    |
| \(M.\) theobromae          | 1.31    | 1.07   | 0.96 | 0.64 | 0.64   |         |     |    |
| \(Microsporum\) sp.        | 0.64    |         |     |    | 0.64   |         |     |    |
| \(Mnispora\) sp.           | 0.21    |         |     |    | 0.64   |         |     |    |
| \(Mitteriella\) ziziphina  | 0.26    |         |     |    | 0.26   |         |     |    |
| \(Monacrosporium\) sp. 1   |         | 1.28   |     |    |         |         |     |    |
Table 1. (Continued).

| Location          | Taxa                  | Nakhon Si Thammarat | Songkhla |
|-------------------|-----------------------|---------------------|----------|
|                   | New       | Middle  | Old     | New       | Middle  | Old     |
| Monacrosporium sp. 2 | 0.22      |         | 0.58    |           |         |         |
| Monacrosporium sp. 3 |          |         |         |           |         |         |
| Monacrosporium sp. 4 |          | 0.43    |         |           |         |         |
| Monochaeta sp.     | 2.18      | 0.43    |         |           |         |         |
| Monodictys glauca  | 1.07      |         |         |           |         |         |
| Murogenella terricola |          | 0.58    |         |           |         |         |
| Myrothecium rosidum |          |         |         |           |         |         |
| Mystrosporiella litseae |           |         |         |           |         |         |
| Neototiosporella sp. |          |         |         |           |         | 1.60    |
| Nigrospora sphaerica | 1.96     | 3.21    | 2.34    | 2.82      | 4.07    | 2.88    |
| Oedothea vismiae  | 1.79      |         |         |           |         |         |
| Paecilomyces sp.   | 0.65      | 0.58    | 1.03    | 0.25      | 0.25    | 0.64    |
| Paranospora novae-zelandiae | 1.75 |         |         |           |         |         |
| Paecilomyces lilacinus* |        |         |         |           |         | 0.02    |
| Parasympodiella podocarpi | 0.44 |         |         |           | 0.32    |         |
| Paratomenticola lanceolatus |         |         | 0.32    |           |         |         |
| Penicillifer pulcher |          | 0.26    |         |           |         |         |
| Penicillum sp. 1   | 0.22      | 0.85    | 0.58    | 0.25      |         |         |
| Penicillum sp. 2   | 1.09      | 1.07    | 0.58    | 0.96      |         |         |
| Penicillum sp. 3   | 1.09      | 0.58    | 0.77    | 0.64      |         |         |
| P. chrysogenum*    |           |         | 0.19    | 0.64      |         |         |
| P. dissiminita*    |           |         | 0.23    |           |         |         |
| P. janthinellum*   | 0.43      |         |         | 0.77      |         |         |
| P. miczynskii*     |           |         |         | 0.51      |         |         |
| P. rofisi*         |           |         |         |           |         |         |
| P. rubrum*         | 0.44      | 1.07    | 0.88    | 0.51      | 0.32    |         |
| Pestalotia sp.     | 0.85      | 0.58    | 0.10    | 3.21      | 3.21    |         |
| Pestalotiopsis sp. 1 | 0.65    | 0.43    | 0.58    | 0.51      | 0.51    |         |
| Pestalotiopsis sp. 2 | 0.65    | 0.64    | 1.17    | 1.27      |         |         |
| Pestalotiopsis sp. 3 | 0.44    | 0.85    | 1.17    | 0.51      | 1.27    |         |
| Pestalotiopsis sp. 4 | 0.87     |         |         |           |         |         |
| P. dissiminita     | 0.87      |         |         |           |         |         |
| P. macroticha*     | 0.67      |         |         |           |         |         |
| Peyronellaea sp.   | 0.22      |         |         |           |         |         |
| Phaeoisaria sparsa | 0.87      |         |         |           |         |         |
| Phaeoisariopsis sp. | 0.64      |         | 0.64    |           |         |         |
| P. cercosporioides |          | 0.51    | 0.32    |           |         |         |
| Phaeosphaeria sp.  |          |         |         |           | 0.96    |         |
| P. capsicicola     |          | 0.26    |         |           |         |         |
| Phoma sp.          | 0.22      | 0.77    |         |           |         |         |
| Phomopsis sp.      | 0.65      | 0.64    | 1.07    |           |         |         |
| Phyllosticta sp.   | 0.43      |         |         |           | 0.32    |         |
| Pithomyces graminicola | 0.22 |         |         |           |         |         |
| Pleurotheciotis pusilla & 0.26 & 0.25 & 0.96  |
| Pleurothecium acutum | 2.18     | 1.03    | 1.02    | 0.51      |         |         |
| P. simplex        |          |         |         |           |         |         |
| Polyschema sp.     | 0.85      |         |         |           |         |         |
| Pseudobeltania penzigi     |          |         |         |           |         |         |
| Pseudogliomastix sp.  | 1.07      | 1.46    |         |           |         |         |
| Pseudospiropes Hughesi   | 1.02    |         |         |           |         |         |
| Pseudorobillarda sp.   | 0.25    |         |         |           |         |         |
| P. phragm*         | 0.43      |         |         |           |         |         |
| Pseudospiropes obclavatus | 0.51 |         |         |           |         |         |
| Pieroconium intermedium | 0.44 |         |         |           |         |         |
| Pucciniopsis sp.    | 0.15      | 1.50    | 0.76    |           |         |         |
| Pycnariopsis parasitica | 0.21 |         |         |           |         |         |
| Ramularia tulasnea  | 1.09      |         |         |           |         |         |

(Continued)
| Taxa                                      | Location               | Nakhon Si Thammarat | Songkhla   |
|-------------------------------------------|------------------------|---------------------|------------|
|                                           | New        | Middle   | Old     | New        | Middle   | Old     |
| *Rheoaumpullifer* sp.                    | 0.22       |          |         | 0.26       | 0.51     | 1.92    |
| *Rhinocladiella* sp.                     | 0.21       |          |         | 0.29       |          |         |
| *Rhomostilbella rosae*                   |            |          |         | 0.26       |          |         |
| *Robillarda phragmitis*                  |            |          |         |            |          |         |
| *Scolecobasidium compactum*              | 0.85       | 2.34     |         | 0.25       |          |         |
| *S. dendroides*                          |            |          |         |            | 0.51     | 0.51    |
| *S. salinum*                             | 0.58       |          |         |            | 1.79     | 5.77    |
| *Scolecobasidiella avellanea*            | 0.21       |          |         | 1.75       |          |         |
| *Scolecobasidium* sp.                    |            |          |         |            |          |         |
| *S. acanthacea*                          |            |          |         | 0.64       |          |         |
| *S. dendroides*                          | 0.58       |          |         |            |          |         |
| *Selenospora* sp.                        | 0.22       | 1.75     |         |            |          |         |
| *Setocyta* aromaticum                    | 0.29       |          |         |            |          |         |
| *Setocyta rubororum*                     |            |          |         | 1.03       |          |         |
| *Seynesiella* sp.                        | 0.65       |          |         |            |          |         |
| *Siroxporium antenniforme*               | 1.09       |          |         |            |          |         |
| *Spegazzina* lobulata                    |            |          |         | 0.51       |          |         |
| *Spegazzinia* deightoni*                 | 0.22       | 0.29     |         | 0.26       |          |         |
| *S. sundara*                             |            |          |         | 0.26       |          |         |
| *Speriptis* hyalospora                   | 0.44       | 2.35     | 0.88    | 0.77       | 2.80     |         |
| *S. pedatospora*                         | 0.21       | 0.58     |         |            |          |         |
| *Spermospora avenae*                     | 0.44       |          |         |            |          |         |
| *S. subulata*                            | 0.43       |          | 0.26    |            |          |         |
| *Spiropes* sp.                           |            |          |         |            |          |         |
| *S. capensis*                            | 1.07       | 0.88     |         |            |          |         |
| *S. effusus*                             | 0.64       |          |         |            |          |         |
| *S. fumosus*                             | 0.88       |          |         |            |          |         |
| *S. japonicus*                           | 0.64       |          |         |            |          |         |
| *S. penicillium*                         | 0.64       |          |         |            |          |         |
| *Spondylocladiella botrytioides*         | 0.43       | 0.29     | 0.51    | 0.87       |          |         |
| *Sporidesmium* sp. 1                     | 0.43       |          |         |            |          |         |
| *Sporidesmium* sp. 2                     | 0.43       |          |         |            |          |         |
| *Sporidesmium* sp. 3                     | 0.43       |          |         |            |          |         |
| *Sporidesmium* sp. 4                     | 0.21       |          |         |            |          |         |
| *Sporidesmium* sp. 5                     | 0.87       |          |         |            |          |         |
| *S. aburiense*                           | 0.21       |          |         |            |          |         |
| *S. baccharidis*                         | 0.22       |          |         | 0.22       | 0.25     | 0.64    |
| *S. bambusae*                            | 0.87       |          | 0.88    | 0.77       | 0.51     |         |
| *S. dioscooeae*                          | 0.58       |          |         | 0.25       |          |         |
| *S. harknesii*                           |            |          |         |            | 0.64     |         |
| *S. japonicus*                           | 1.46       |          |         | 0.43       |          |         |
| *S. javanicola*                          | 0.22       | 0.43     | 0.64    | 0.43       |          |         |
| *S. leptosporum*                         |            |          |         | 0.43       |          |         |
| *S. nodipes*                             | 0.58       | 0.51     | 0.25    |            |          |         |
| *S. rubi*                                | 0.22       | 0.58     | 0.88    | 1.54       | 0.25     |         |
| *S. socium*                              |            |          |         | 1.02       |          |         |
| *S. uniseptatum*                         |            |          |         | 0.76       |          |         |
| *Sporoschismopsis* sp.                   | 0.22       | 2.05     | 0.25    | 0.32       |          |         |
| *Sporothrix schenckii*                   |            |          |         | 1.03       |          |         |
| *Stachybotrys* sp.                       | 0.22       | 0.64     |         | 0.25       |          |         |
| *Stenella* pithecellobii                  | 1.31       | 0.43     |         |            |          |         |
| *Strigina combretii*                      | 0.22       |          |         |            |          |         |
| *S. combreticola*                        | 0.44       | 0.29     |         |            |          |         |
| *S. hartigiana*                          |            |          |         | 0.51       |          |         |
| *S. kranzii*                             | 0.21       |          |         |            |          |         |
| *Stilbospora* sp.                        | 1.09       |          |         |            |          |         |
| *Stilbum* sp.*                           | 0.33       |          |         |            |          |         |
Table 1. (Continued).

| Taxa                              | Location |       |       |       |
|-----------------------------------|----------|-------|-------|-------|
|                                   | Nakhon Si Thammarat | Songkhla |
|                                   | New     | Middle | Old   | New     | Middle | Old   |
| Strumella coryneoidea             | 0.65    | 0.29   |
| Subulispora sp.                   | 0.87    | 2.99   | 4.97  | 2.56    | 3.56   | 6.73  |
| S. procurvata                     | 0.64    |
| Taenioloella scripta              | 0.21    |
| Taeniolina centaurii              | 0.43    |
| Taxosporium sp.                   | 4.06    | 1.75   |       | 0.25    | 0.64   | 1.31  |
| Tetraploa aristata                | 0.21    |
| Tiarospora sp.                    | 3.49    | 3.21   | 3.22  | 2.05    | 1.02   |
| Torula herbarum                   | 1.09    |
| Tretospora sp.                    | 0.44    | 0.43   |
| Triadelphia heterospora           | 0.33    | 0.58   | 0.11  |
| Trichoderma hamatum*              | 0.64    |
| T. harzianum*                     | 0.17    | 0.64   | 0.26  | 0.26    | 0.64   |
| T. koningii*                      | 1.07    |
| T. parceramosum*                  | 0.43    | 0.11   |
| T. viride*                        |         | 0.19   |
| Trichodochium disseminatum        | 1.07    |
| Trichothecium roseum              | 0.21    |
| Trichadium angulatum              | 0.87    | 0.43   | 0.25  | 4.17    |
| T. castaneicola                   |         | 0.64   |
| T. fuscom                         |         |
| Trimmatostroma betulinum          | 0.65    |
| Triscelophorus acuminatus         | 0.64    | 0.58   | 0.32  |
| T. monosporus                     | 0.22    | 1.50   | 4.09  | 1.02    | 0.64   |
| T. panapensis                     |         |
| Trisulcosporium acerinum          | 0.22    | 0.77   |
| Tubercularia vulgaris             | 0.44    |
| Varicosporium eladaceae           |         |
| Veronaea sp.                      |         |
| V. botryosa                       | 0.22    |
| V. carpinae                       | 1.53    | 1.07   | 1.75  | 8.46    | 3.56   | 6.09  |
| V. coprophila                     | 2.18    | 4.49   | 6.14  | 0.51    | 5.60   | 4.49  |
| V. musae                          |         |
| Verticillium sp.                  | 0.44    | 0.21   |
| V. dahiae                         |         |
| Volutella fructi                  | 0.44    |
| Wiesniromyces javanicus           | 1.31    | 2.56   | 1.75  | 1.28    | 0.76   | 1.60  |
| Zanclospora sp.                   | 0.64    |
| Z. brevispora                     |         |
| Zygosporium deightonii            | 0.65    | 0.21   | 0.29  | 0.26    | 0.76   | 0.32  |
| Z. echinosporum                   | 1.31    | 0.21   | 0.88  | 1.28    | 2.29   | 0.32  |
| Z. majus                          |         | 0.51   | 0.64  |
| Z. masonii                        | 1.31    | 1.50   | 0.77  | 1.27    |
| Z. oscheoides                     | 0.22    |
| **Basidiomycete**                 |         |
| Marasmius sp.                     | 2.05    |
| **Oomycete**                      |         |
| Phytophthora sp.                  |         |
| **Zygomycetes**                   |         |
| Rhizopus sp.                      |         |
| Mortierella polycephala           | 0.26    |

**Total number of species recorded at each stage**: 161 166 106 142 145 105

Note: *Isolated from dilution pour-plate.
Table 2. Dominant fungi found on para rubber leaf litter, with over 3% of occurrence at each stage.

| Decomposition stage       | Location                               |
|----------------------------|----------------------------------------|
|                            | Nakhon Si Thammarat | Songkhla                                |
| Newly fallen leaves        | Aphoshaeria pezizoides                 | Cladosporium tenuissimum                 |
|                            | Botryodiplodia acerina                 | Kirschsteiniothelia sp.                 |
|                            | Cladosporium tenuissimum               | Veronaea carlinae                       |
|                            | Lasiodiplodia cf. theobromae           |                                        |
|                            | Tetraploa aristata                    |                                        |
|                            | Torula herbarum                        |                                        |
| Middle stage decaying leaves | Cladosporium flavum                   | Bactrodesmium rahmii                    |
|                            | Curvularia lunata                      | HansfORDia pulvinata                    |
|                            | Kirschsteiniothelia sp.               | Kirschsteiniothelia sp.                |
|                            | Nigrospora sphaerica                  | Lasiodiplodia cf. theobromae           |
|                            | Torula herbarum                        | Nigrospora sphaerica                   |
|                            | Veronaea coprophila                   | Subulispora procuvata                  |
| Old decaying fallen leaves | Bactrodesmium rahmii                   | Veronaea coprophila                    |
|                            | Camposporium antennatum               |                                        |
|                            | Dactylaria junct                       |                                        |
|                            | Ellisospora sp.                       |                                        |
|                            | Henicospora coronata                  |                                        |
|                            | Kirschsteiniothelia sp.               |                                        |
|                            | Lasiodiplodia cf. theobromae          |                                        |
|                            | Panchanania jaipurensis               |                                        |
|                            | Subulispora procuvata                 |                                        |
|                            | Torula herbarum                        |                                        |
|                            | Triscelophorus panapensis             |                                        |
|                            | Veronaea coprophila                   |                                        |

Table 3. Diversity indices of saprobic fungi on para rubber leaf litter at different stage of decomposition.

| Decomposition stage | Location       | Nakhon Sri Thammarat | Songkhla |
|---------------------|----------------|----------------------|----------|
|                     |                | No. of species | Index D | Index H | No. of species | Index D | Index H |
| New*                |                | 161            | 0.9895  | 4.6422  | 142            | 0.9870  | 4.5725  |
| Middle*             |                | 166            | 0.9901  | 4.7275  | 145            | 0.9871  | 4.5734  |
| Old*                |                | 106            | 0.9854  | 4.3471  | 105            | 0.9802  | 4.1528  |

Note: *Newly fallen leaves, middle stage decaying leaves and old decaying fallen leaves.

phylllophane. Their occurrence on the surfaces of green foliage has been reported previously (Subramanian and Vittal 1980) and they are primary saprobes, which are ever-present inhabitants of aerial plant surfaces (Shanthi and Vittal 2010). Some species of fungi were recorded only on middle stage decaying leaves; for example, Phaeoisariopsis sp.2, Pyriculariopsis parasitica and Scoleobasidium sp.1. Marasmius sp. and Dactylella ellipsoidea were recorded only from the old decaying fallen leaf stage.

Kannangara and Deshapriya (2005) reported that differences in resource quality, such as nitrogen, and the presence of inhibitory tannin concentrations involved in decay, are important. According to Puranong et al. (2007) and Bill and Polishook (1994), colonization of leaf litter by various fungal species during decomposition is a
Table 4. Indices of similarity of fungi associated with different stages of decomposition in para rubber leaf litter.

| Decomposition stage | Location          | Nakhon Si Thammarat | Songkhla     |
|---------------------|-------------------|---------------------|--------------|
|                     | New   | Middle | Old   | New   | Middle | Old   |
| New                 | 0.4343| 0.3745 |       | 0.4042| 0.3968 |       |
| Middle              |       | 0.4044|       | 0.4000|        |       |
| Old                 |       |        | 0.3968| 0.4000|        |       |

Note: *Newly fallen leaves, middle stage decaying leaves and old decaying fallen leaves.

Table 5. Diversity indices of saprobic fungi on para rubber leaf litter in the late rainy, dry season and early rainy seasons.

| Location/season          | Location/season          | No. of fungi (species) | Total | Index D | Index H |
|--------------------------|--------------------------|------------------------|-------|---------|---------|
|                          | New*                     | Middle*                | Old*  |         |         |
| Nakhon Si Thammarat      | Late rainy season        | 70                     | 95    | 48      | 213     | 0.9806 | 2.9562 |
|                          | Dry season               | 95                     | 98    | 66      | 259     | 0.9854 | 3.1459 |
|                          | Early rainy season       | 85                     | 72    | 66      | 223     | 0.9847 | 3.0266 |
| Songkhla                 | Late rainy season        | 82                     | 77    | 53      | 212     | 0.9821 | 4.4162 |
|                          | Dry season               | 74                     | 70    | 70      | 214     | 0.9831 | 4.4246 |
|                          | Early rainy season       | 55                     | 71    | 43      | 169     | 0.9752 | 3.7138 |

Note: *Newly fallen leaves, middle stage decaying leaves and old decaying fallen leaves.

Table 6. Indices of similarity of fungi associated with para rubber leaf litter versus seasons: late rainy, dry season and early rainy season.

| Season                | Location          | Nakhon Si Thammarat | Songkhla     |
|-----------------------|-------------------|---------------------|--------------|
|                       | Late            | Dry              | Early         | Late             | Dry             | Early            |
|                       | rainy season     | rainy season      | season       | rainy season     | season         | season         |
| Late rainy season     | 0.4584          | 0.3255           |              | 0.3924           | 0.3887         |              |
| Dry season            | 0.3924           | 0.3887           |              | 0.3924           | 0.3887         |              |
| Early rainy season    | 0.3908           | 0.3887           |              | 0.3908           | 0.3887         |              |

sequential process with sequential replacement over time. Replacement or succession may be strongly affected by nutrient levels of the litter and/or competition between fungi. Substrate quality can even vary within a leaf.

Berg and Staaf (1980) and McClougherty and Berg (1987) have shown that, in the initial stages (0–3 months) of leaf breakdown, small soluble carbon-based molecules, such as starch and amino acids, are lost, leaving behind more recalcitrant molecules, such as lignin. Decomposition during this first phase is rapid because these small, soluble carbon-based molecules are energy rich and easily broken down, which allows the greater fungal growth associated with this stage. Fungal colonization of a substrate results in a loss in strength and changes in color. Species diversity tends to be richest and number of fungi usually highest during the early and middle stages of colonization; then the number of species begins to decline.

Fungal communities are classified into three successive decomposition stages: the pioneer stage, mature stage and the impoverished stage (Kannangara and Deshappriya 2005; Osono 2005). Pioneer communities are typically composed of a large number of different species occurring at low frequency with no obvious dominant species. Mature fungal communities consist of fewer species with one or two obviously dominant species common to all samples at a similar stage in the development of the fungal
community. Distinct succession of fungal communities has been recorded, based on the replacement of microfungi at each stage. Factors regulating leaf litter decomposition include resource composition, i.e. chemical and physical composition, temperature and aeration during the decomposition process. Succession studies are unclear as to which factor has the greater influence over decomposition rate and fungal diversity (Kannangara and Deshappriya 2005; Osono 2005; Shanthi and Vittal 2010). Promputtha et al. (2002) have recorded fungal succession on the leaves of Magnolia garrettii. Other studies have included bamboo (Zhou and Hyde 2002), Sphagnum fuscum, Carex aquatilis and Salix planifolia (Thorman et al. 2003), Quercus rotundifolis (Sadaka et al. 2003), Swida controversa (Osono 2005), Castanopsis fissa (Tang et al. 2005), Castanopsis diversifolia (Duong et al. 2008) and Shorea obtuse (Osono et al. 2009).

Seasonal effects on the fungal community

Seasonality is one factor that is believed to affect the fungal community. Studies on the diversity of fungi in leaf litter suggest that the communities vary according to the seasons (Kennedy et al. 2006). Nevertheless, it is unclear how the seasons affect fungal communities. As the presence or absence of aquatic hyphomycetes is regulated primarily by season, one can assume that this cause and effect operates via temperature (Nikolcheva and Bärlocher 2005).

In this study, samples collected in the dry season (April) tended to be richer in species and have a higher Shannon diversity index than samples collected in the early or late rainy season. Kodseub et al. (2007) studied the diversity of saprobic fungi on Magnoliaceae litter and reported that samples collected in the dry season had a greater species richness than samples collected in the wet season, which suggest a humidity factor. Rayner and Todd (1979) found a greater variety and number of fungi during the dry season. This may be due to an unsuitable ratio between moisture content and aeration of leaf litter, with high moisture and low aeration during the wettest period. High humidity is needed for the germination and dispersal of fungi (Pinnoi et al. 2006); consequently, fungal communities from wet season samples (which have a higher humidity) are more diverse.

Our results have shown that fungal communities during the dry season are more diverse (Rayner and Todd 1979). Thus, many factors affect the changes in community structure; for instance, the microclimate of the growing area, biological interaction within leaf litter, or substrate, microhabitat preference and host preferences (Lodge 1997).

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