## CHAPTER 2 LITERATURE REVIEW

#### Tar spot disease

Tar spot or tar leaf spot is easily visible. It can be easily diagnosed simply by its symptoms. The term 'Tar spot' is referred to the shiny blackened leaf spots on upper side of leaf with dome- or clypeus-like stroma covering the immersed fructification of the fungal pathogens. They are so called because of the appearance similar to tar droplets on leaf surface (Thaung, 2008). The stroma splits open to expose the underlying apothecia as in *Rhytisma* (Horst, 1990; Webster, 1980), or the ostioles of embedded perithecia as in *Phyllachora*, to allow discharge of ascospores for dissemination and infection (Holliday, 1992). The causal fungi in *Rhytismales* are frequently found in forest areas or in foothills of high ranges occupying a special niche mostly on forest plants, but *Phyllachorales* prefers a cropland environment or open plain which more commonly found (Thaung, 2008).

Tar spot fungi are a biological strategy group rather than a taxonomically defined one, and the term is used here in a loose sense to include fungi with significant blackening of at least the surface layers of their fruit-bodies. The blackening is thought primarily to protect the developing tissues from damage caused by UV radiation (Durrell and Shields, 1960), although in some high-latitude areas the blackening may absorb heat from the sun in early spring, promoting growth (Sherwood, 1981). As with many other fungi, the blackening in the species treated here is caused by melanin deposits both within and between cells in the stromatic tissues, often interspersed with or invading host call. The fungal cells are frequently strongly disrupted, and are unlikely to be alive once the fruiting-body has reached maturity. There have been some studies focusing on Tar spot disease surveying and diagnosis, mostly are referred to those two fungal groups (Table 1).



**Figure 1.** Tar spot symptoms on different hot plants. A. On Norway maple leaves (Cornell University, 2017). B. On maple samaras (Cornell University, 2017). C. On maize. (Chalkley, 2017)

<b>Table I</b> Historical review of ta	ir spot diseases.
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Year	Content	Reference
1976	- Tar spot of Ficus was reported caused by several species of	Ridings (1976)
	Ophiodothella, it producing an unsightly appearance on the	
	leaves, this disease may result in premature leaf drop.	
1984	- Tar spot of Leucothoe populifolia and Placuntium	El-Gholl et al.
	andromedae were reported their tar spot symptoms,	(1984)
	assumed caused by fungi. Disease may render nursery	
	grown plant unsalable and may reduce plant vigour by	
	impairment of the photosynthetic process.	
1987	- Tar spot of oak was reported causing by Trabutia quercina	El-Gholl &
	was. The fungus was an ascomycetous fungus which from	Schubert
	parithecia within the black stoma.	(1987)
1992	- Two series of pictorial standard diagrams were developed	Hock et al.,
	for field assessment of tar spot disease complex of maize	(1992)
	caused by Phyllachora maydis, Monographella maydis and	rsitv
	Coniothyrium maydis in Latin America was tested.	a d
1992	- Phyllachora maydis was reported as the most important	Ceballos &
	pathogen associated with Tar spot complex (TSC) of	Deutsch (1992)
	maize, can cause serious yield losses in Latin American	
	countries.	

**Table 1** Historical review of tar spot diseases (Continued).

Year	Content	Reference
1995	- The epidemiology of the tar spot disease complex of maize	Hock <i>et al</i> .
	caused by Phyllachora maydis, Monographella maydis and	(1995)
	Coniothyrium phyllachorae was studied on in Mexico	
	under field condition. P. maydis symptoms was appeared	
	first, followed by symptoms of either M. maydis or C.	
	phyllachorae. M. maydis causes leaf necrosis and has the	
	most devastating effect.	
1998	- Two ascomycetes from the middle Eocene Princeton chart	Gurrah et. al.
	were described from Eocene tar spot on a fossil palm and	(1998)
	its fungal hyperparasite.	
1999	– Trabutia nothofagi and its anamorph Baeumleria	Johnston
	nothofagi, Manostichella nothofagi, Piggotia nothofagi	(1999)
	were reported as causing tar spot disease on Nothofagus in	
	New Zealand.	//
2008	- Tar spot in a tropical dry to wet monsoon ecosystem of	Thaung, (2008)
	lowland Burma were reported.	
2010	- Phyllachora serjaniicola was firstly reported as causing tar	Pereira et al.
	spot on Cerdiospermum grandiflorum.	(2010)

#### Rhytismatales as causal agent of Tar spot and species concepts

Rhytismatales are an order of endophytic, parasitic or saprotrophic fungi in class Leotiomycetes (Ascomycota), the inoperculate discomycetes. The group includes economically important parasites, particularly on conifers, oak and maple, and these are also among the most studied of the order (Darker 1967, Minter 1981). The most well known species are commonly called "tar spots" because the black stromatic layer makes ascomata recognizable to the naked eye. Most species of Rhytismatales have fruiting bodies immersed in the host tissue, and a layer of black stromatic tissue often surrounds the fruiting body at an early stage. As ascomata mature the black stromatic layer splits to expose the hymenium and mature ascomata open or close depending on humidity. Microscopic characters include a poorly developed excipulum, asci with undifferentiated thin-walled apices and hyaline ascospores. Spore and ascoma shapes traditionally have been emphasized in delimitation of genera. In particular the presence or absence of filiform spores in combination with a circular or an elliptic to elongate ascoma shape has been used (Johnston 2001; Lumbsch and Huhndorf 2007) (Figure 2.).

Lantz *et al.* (2011) showed strong host specificity and geographic distribution of Rhytismatales. Phylogenetically, several strongly supported clades are restricted to specific plant genera or even species. Geographically, several clades of species are known only from Sweden or New Zealand. *Hypoderma* and *Meloderma* species are known from New Zealand. However there are also examples of clades with a broad distribution.



Figure 2. Line drawing morphological characteristics of Rhytisma umbonatum. (Minter, 2017)

#### Phyllachorales as causal agent of Tar spot and species concepts

Initial classification systems for phyllachoraceous species relied heavily on host identity. This culminated in an explosion of species descriptions, often with little comparison made to extant taxa, even on the same host genus. While it is impossible not to consider host identity in the classification of holobiotrophic fungi given coevolutionary pressures, classification must rely on fungal morphology as well.

Classification of the *Phyllachoraceae* remains a relatively subjective process, as is the case with most other fungal groups. Traditional methods utilize differences in fungal morphology and occurrence on specific host taxa. Baral (1992) noted differences in morphology between living and dead cell of ascomycetes, which also varied varied according to the type of mounting media used in slide preparation. A detailed appraisal of taxonomic characters used to define *Phyllachora* species, was undertaken by Parbery (1963a, b) and Parbery and Langdon (1963, 1964). Only 2 characters were found to be stable enough for taxonomic delineation, the length of the ascus pedicel relative to that of ascospore position, and the morphology of ascospores. In addition, Pardery and Langdon (1964) suggested several alternative characters not traditionally utilized, appressorium morphology (when germinated on host tissue) and the morphology of the sporohores produced by the *Leptrostromella*-like states. Characters with limited reliability at the species level were listed as ascospore size and arrangement in the ascus, ascus length, and sporophore size.

The taxonomic character used to define the *Phyllachoraceae* were reviewed in detail by Cannon (1991). The taxonomic criteria of Cannon (1991), which has a narrower host species definition to that of Parbery (1963a, b, 1967), has been adopted in this study. Taxonomic characters of typical Phyllachora are shown in Figure 3. and briefly reviewed below.



**Figure 3.** Line drawing morphological characteristics of *Phyllachora laurinearum*. (Li & Hsieh, 1991) Leaf spots or fungal stroma

The majority of phyachoceous taxa in Australia are leaf parasites therefore, in this book, the part of the leaf infected by the fungus is referred to as the leaf spot, or in the case of *Coccodialla*, fungus stroma. The rare infection courts found on green stems or fruit are identified under the leaf spot caption. In most cases, the leaf spot is a blackened region on the host leaf surface. Occasionally the blackened region is surrounded by a halo of discoloured host tissue, which may be necrotic. Parbery (1978) they stated that in most cases this degradation of surrounding leaf tissue is caused by co-inhabitants or mycoparasites. Cannon (1991) they reported that while most species of *Phyllachora* on legumes appear to be true biotrophs, some, e.g. *P. coninna* and

*P.leucospila*, appear to cause the death and bleaching of the leaf tissue surrounding the ascomata.

Leaf spot may occur as discrete single spots, or gregarious colonies, they may be single, or coalesce, they may appear flat on the leaf surface, or raised and sometimes strongly domed. Parbery and Langdon (1964) they stated that leaf spot size and shape depended on the influence of the physical structure of host tissue and environmental conditions, and not on the fungal species. The position and arrangement of individual leaf spot or colonies, in part depends on the initial intensity of inoculum and points of leaf penetration, and these characters are not of taxonomic significance. However, Swart (1985) they reported the infiltration by P. ficuum fungal hyphae into the host vascular tissue and suggested the confluent infection spots in this species, were the result of fungal expansion via vascular pathways. This is therefore an example where leaf spot morphology can be of taxonomic significance.

Variation in the degree of leaf spot pigmentation is evident in some species, such as Phyllachora banksiae in which dark pigmentation is often restricted to around the ostiole, whereas Phyllachora ficumm can form extensive black leaf spots covering a large proportion of the leaf surface. The depth of blackening in the leaf spot is to a degree, dependent on environmental condition and maturity of the leaf spot, and may serve a protective role against ulteaviolet radiation. The ostioles are often difficult to see until the ascoma is mature or over mature. Many of the leaf spots of Australian taxa, like the leguminous species described by Cannon, incorporate the host leaf cuticular ornamentation, demonstrating that superficial leaf spot structure may result from the host and not the fungus.

Leaf spot are generally shiny. Parbery (1978) they suggested that phyllachoraceous leaf spots with a matt appearance might be hyperparasitised. This was confirmed by Cannon, who also found overly mature leaf spots were also dull in appearance. These observation have proven correct in this study.

The description of 'leaf spot' in this study refers to microscopic characters observed through a dissecting microscope. While Parbery (1967) they suggested leaf spot characters are not of taxonomic significance, that has not always been found to be the case in non-graminicolous phyllachoraceous taxa and their inclusion in this book completes the overall description of the fungal taxa.

#### Clypeus

The clypeus in this study refers to the blackened region which may have limited development around the ostiole, or develop extensively above the ascomata, and in some cases also below the ascomata. Parbery (1963b) confirmed that clypeus formation occurs independently of ascomatal development in graminicolous phyllachoraceous species. They found the clypeus developed within host epidermal cells, and not as an outgrowth from the ostiole. The clypeus is generally composed of a mixture of host and fungal tissue, which is often difficult to fifferentiate due to varying degrees of melanisation. This pigmentation may also extend to the lateral wells of the ascomata, and in rare instances, below the ascomata. Variation in the degree of pigmentation may result from environmental conditions and ascomatal maturity. The clypeus may appear to merge with the upper ascomatal peridium, and be difficult to differentiate from this structure. Reported observations of the clypeus in this study are made from microscopic examination of vertical section of the leaf spot, and are not considered to be of high taxonomic importance.

#### Ascomata

Theissen and Sydow (1915) they considered the developmental position of the ascomata in the leaf tissue to be an important taxonomic character for delineation of genera. As already discussed, Petrak (1924, 1927) they recognised that this definition was invalid. The developmental position and morphology of ascoma and the position of the ostiolar canal is largely affected by the structure of host tissue. The development of immersed ascomata results in significant disruption to the host tissue, by compression and distortion of dead host cells, and by infiltration by fungal hyphae. Descriptions of ascomata in this study, are made from microscopic examination of vertical sections of the leaf spot. These characters are not considered to be of taxonomic importance, but contribute to the overall description of the fungus, and when considered in conjunction with other characters, may contribute to taxonomic delineation at the species level. *Paraphyses and periphyses* 

Paraphyses are usually thin-walled, as long as the asci, or sometimes longer than asci, up to 6 um diam, often septate, sometimes branching at the base, and tapering apically. They appear to deliquesce with ascomatal maturity and release of ascospore (Cannon, 1991). Periphyses are similar but much smaller, and difficult to measure,

generally non-septate and line the ostiolar canal. Paraphyses and periphyses are present in most phyllachoraceous taxa. These characters are not considered of taxonomic importance in species delineation.

Asci

Parbery and Langdon (1964) they exmined ascus size and shape within single phyllachoraceous specimens, and from the wide range of variation observed, determined that these characters were unsuitable for taxonomic division. Differences in ascospore arrangement within the ascus were found to be the major cause of variation. The arrangement of ascospores within the ascus is variable, and not considered a reliable character in this study. However, if ascus shape is consistent, as it is in some species of Phyllachora, it can be of limited use. The length of the ascus pedical (the basal, non-ascospore bearing component of the ascus) has been suggested as being a useful character for species delineation, if the length of the ascus pedical is defined accurately.

Determination of ascus wall and apex structure is often the most difficult task. The ascal wall of phyllachoraceous taxa vary markedly in thickness. Immature asci are often thick-walled, while mature asci may have a variable wall thickness within a single microscope slide, often distending and becoming break off near the pedicel. Some characters of ascal morphology are not observed in dried herbaria specimens (Baral, 1992; Pascoe, 1990b). Pascoe (1990b) examined fresh material of *Plectosphaera eucalypti*, and reported bitunicate asci exhibiting fissitunicate dehiscence, which was not observed in dried specimens. In this study, fresh collection were examined where possible, but the majority of observations were made from dried herbaria material.

Apical morphology is another variable character. The asci of *Phyllachora pseudostromatica*, are often papillate, whereas other taxa have a commonly rounded or truncate apex. Occasionally concaved apices are observed. Many phyllachoraceous taxa do not have an apical apparatus, however where an apical apparatus is present, it is usually an opaque apical disc, which may be concaved, and non-reactive in Melzer's reagent. The apical structures of immature asci are often observed to be different to those of mature whole asci or broken asci. Similar observation have been made by Cannon (1991).

The asci of most phyllachoraceous taxa are 8-spored. *Phyllachora cladiiglomerati* is typically 4-6-spored. Cannon (1991) they reports several leguminous taxa which are consistently 4-spored, *Phyllachora lacteal*, *P. lespedezae* and *P.dolichogena* subsp. *atromaculans*. These taxa appear to be the exception. The ascal characters highlighted are considered to be of low taxonomic importance, but when considered in conjunction with other characters, may contribute to taxonomic delineation.

#### Ascospores

Phyllachoraceous ascospores in this study are predominantly 1-celled, hyaline, thin-walled and smooth (*Phyllachora, Polystigma*). A hyaline mucilaginous sheath was not uncommon, particularly in fresh specimens. *Coccodialla banksiae* was found to have similar, but quite thick-walled ascospores. The golden brown spinose ascospores of *Parberya* are distinctive in the *Phyllachoraceae*, as are the slightly verrucose, pale brown ascospores of *Sphaerodothiella*, which are sheathed in a thick brown mucilaginous exosporium. *Rehmiodothis* are identified by their 2-celled, hyaline ascospores, in which one cell is larger than the other. *Marinosphaera* and *Haloguignardia* are distinguished by their distinctive spore shape and 2-3 septation. The filiform, hyaline ascospores of *Ophiodothella* are also distinctive.

Parbery and Langdon (1964) concluded that ascospore morphology was the most useful taxonomic character for delineation of species in the Phyllachoraceae, whereas ascospore size was of limited use. Cannon (1991) employed both ascospore charaters, but was careful to point out that mature ascospores should de measured only. He noted that ascospores often increase significantly in size prior to release from the ascus, or prior to germination. He also noted that ascospores may shrink with senescence, therefore an accurate assessment of ascospore maturity must be made prior to measurement. It is therefrom impossible to measure ascospores without some degree of subjectivity and experience. Of the generally 15 ascospores measured per specimem in this study, haft were measured from within mature asci, and if possible the rest as mature liberated ascospores. This appears to be the most sound way of recognising ascospore size variation.

Ascospore shape, as Parbery (1963a) and Parbery and Langdon (1964) reported, must be considered as a three dimensional shape, rather than the normal two dimensional microscopic view. Parbery and Langdon (1964) they suggested 'rolling ascospore' while examining them to obtain this perspective. In this study, ascospore shape was found to be variable, but within a consistent range, and remains an important character for classification of phyllachoraceous species.

Parbery and Langdon (1964) they found length/breadth estimations to be of limited use, and sometime extremely variable. In this study this character has been utilised to define some closely related taxa, and has been found useful when considered in conjunction with other taxonomic characters.

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#### Appressoria

Parbery (1963) they discovered that appressorium morphology (when germinated on host leaf tissue), of gramicolous *Phyllachora* species was a useful taxonomic character (Parbery nad Langdon, 1964). This study has relied largely on herbaria collections, therefore appressoria morphology has not been utilised.

#### Anamorph

A very definition of anamorph is provided by the 'Dictionary of Fungi' (Hawksworth rt.al., 1995): the presence of conidia or asexual spores. Pascoe (Pearce, 2000) they suggested a narrower definition: that the anamorph is the state of fungi produces dehiscent, dispersible, asexual reproductive propagules. This state therefore consists of conidiomata, conidiophores, conidiogenous cell and conidia. There is sufficient evidence to suggest that the filiform, non-viable 'conidia' often associated with *Phyllachora* species, are in fact, spermatia, and act as male gametes and not conidia (Parbery, 1996b). The term andromorph, as suggested by Parbery (1996a) has therefore been adopted in this book to describe this state.

*Phyllachora quadraspora* Tehon is the only true ananorph described in this sutudy. Conidiomata are produced similar to the ascomata and conidia of *P*. *quadraspora* have been shoen to germinate and new host.

#### Andromorph

Parbery and Langdon (1963, 1964) they provide convincing evidence for spermatial function in graminicolous species. Other studies support the role of spermatia in non-graminicolous *Phyllachora* species. Tilak (1959) they reported on the spermatial fertilisation of *Phyllachora actinodaphne* on *Actinodaphne hookeri* which

utilises a unique approach. Ostiole development in the round or flattened spermatogonial locules, immersed in the host tissue, was not observed. Instead, spermatia were released through a basal canal that communicates with the ascomata initials. The ascomata initials. The ascomata initials appear to have developed specialised larger, deep staining, cell within their basal layers. The spermatia were then reported to diploidise the specialised ascogonial cells, although the process of copulation was not observed. Kamat and Pande-Chiplonkar (1972) they report a similar mechanism of spermatisation by Cyclotheca kamatii (Microthyriales), discovered by Ananthanarayanan (1964c, 1969). Jagtap (1967) they provides further evidence of spermatisation in non-graminicolous Phyllachora taxa, but by a different process. Jagtap (1967) observed P. symplocicola on Symplocos (Symplocaeae), froming trichogynes which project through papillae above the leaf surface, and from contact with surface expelled by nearby spermatogonia. The presence of insects was thought to accelerate the process. The binucleate nature of the ascogonial cell at the base of the trichogyne was given as proof of fertilisation. The graminicolous phyllachoroid spermatia are very similar to spermatia found in association with Phyllachora species on moraceous, myrtaceous and some leguminous hosts.

The filiform spermatia of the andromorph usually ascribed to *Phyllachora* has been referred to the from genus Linochora. Parbery and Langdon (1964) they state that while spermatial length and general shape was quite variable within groups of specimens, the shapes of the sporophores were constant in groups that demonstrated common ascospore and appressorium morphology. Useful sporohore characters included general shape of each individual or branched sporophore, the type of apex, presence of absence of branching and to a limited degree, size. Cannon (1991) found anamorph/andromorph characters useful for delineation of genera, particularly for distinguishing *Phyllachora* from *Diachora* and *Glomerella* which have distinctive anamorps, and conidia with a dispersive function.

As stated by Cannon (1991), not all *Phyllachora* species have been shown to have an associated spermatial state, and the relationship between the spermatial state and the teleomorph is not fully understood in temporal terms. In some species the andromorph appears to form first, in other species, or collection of the same taxon, the

teleomorph and the andromorph may develop side by side, with the andromorph sometimes maturing first, or continuing to produce spermatia for extended periods.

Australian collections of Phyllachora, similar to leguminous taxa (Cannon, 1991) were found to develop spermatogonia either within the stromatic development of the teleomorph, in small irregular shaped locules at the side or above the developing ascomata or independent locules which develop individually or peripheral to a central ascoma.

Generally the spermationphores or spermatia bearing cells arise directly from the spermatogonial wall that is very thin. Spermatioa bearing cells are usually cylindrical or gradually tapering at the apex, and thin-walled.Proliferation of spermatia appears to be percurrent, but the miunte size of the structures makes observation difficult. Periclinal thickening or a small collarette is sometimes observed. Cannon (1991) reports that in leguminous *Phyllachora*, no clear pattern of variation in shape of spermatiophores or spermatia bearing cells was detected between species. We concur with this observation. No variation in morphological structure was found in the Australian taxa examined.

#### Host identity

For reasons discussed under co-evolution, host identity remains an important character, which cannon be excluded, when identifying generally biotrophic fungi. Parbery and Langdon (1964) did not agree. They considered many characters used in taxonomic delineation were the result of host anatomy and physiology, and their interaction with fungal development. However, the intimate relationship that exists between holobiotrophic, endophytic, phyllachoraceouse taxa and their angiosperm hosts, suggests a process of stabilising selection, and therefore a co-evolutionary partnership. Initially, at least, *Phyllachora* species can be considered to be confined to phylogenetically related host, the plant family being accepted as a convenient starting point. The descriptions of Australian Phyllachoraceous taxa are grouped alphabetically within host angiosperm families in this book. This format was used successfully by Theissen and Sydow (1915) and Doidge (1942).

The correct identification of the host is not always achievable, given that host plants do not necessarily produce fertile structures at the time of fungus collection. It is often impossible to determine or confirm host identity from the limited volume of plant material found in fungal herbaria collections. Where possible, fertile host material with reference to fungal collection should be lodged in herbaria, so that changes in plant nomenclature can be assimilated in host and fungal classification.

# Historical review of the Phyllachoraceae

The history of the *Phyllachoraceae* is impossible to remove from that of its type genus, *Phyllachora*, which has been extensively reviewed by Cannon (1991) and Pearce and Hyde (2006), were summarized in Table 2.

Table 2 Historical review of the Phyllachoraceae.

Year	Contents	Reference
1867	-Genus Phyllachora was introduced with single species,	Cannon (1991)
	P. agrostis in herbarium label.	
1870	-Additional 18 species of Phyllachora were introduced	Fuckel (1870)
	and placed in Dothideaceae, which universally	
	understood as first published.	
1876	- Phyllachora, Mazzantia and Polystigma were accepted	Saccardo
	as members of the Dothideales, section Hyalosporae	(1876)
	which is defined as dothidaceous genera with hyaline	îi
	aseptate ascospores.	เทม
1883	-154 of Phyllachora species were added. Brightly	Saccardo (1883)
	coloured stroma of Polystigma were removed the genus	ed
	to Hypocrea.	
1885	- The broader generic concept of <i>Phyllachora</i> was used to	Cooke (1885)
	review Dothideaceae, Mazzantia and EuPhyllachora	
	were treated as subgenera. Term "subsection" was used	
	to described Auerswaldia, Dothidella, Microdothis,	
	Montagnella, Ophiodothis and Roumegueria including	
	an unnamed group 'sporidiis ignotis'	

1915 - Phyllachoraceae was recognized and published for the Theissen & first time within Dothideales, and divided into 3 Sydow (1915) subfailies namely Trabutiineae, Scirrhiineae and Phyllachoraiineae regarding to the depth of the ascomatal development in host tissue.

**Table 2** Historical review of the *Phyllachoraceae*. (Continued).

Year	Contents	Reference
1924	-Phyllachora was reviewed not closely related to the	Orton (1924);
	Dothideales, the genera had affinities with Polystigma.	Petrak (1924)
	-Phyllachora, Physalosorina, Polystima and	Petrak (1924)
	Sphaerodothis were discussed as a family.	5
1927	-Generic concept introduced by Theissen & Sydow	Petrak (1924,
	(1915) regarding to the depth of the ascomatal	1927)
	development in host tissue was discussed as unrelieable.	//
1928	- Phyllachora was expanded into 600 taxa in Syllogue	Cannon (1991)
	Fungorum	
1931	-Phyllachora was lectotypified by P. graminis (Pers.)	Clements &
	Fuckel.	Shear (1931)
1932	- Phyllachoraceae were replaced by Polystigmataceae, as	Cannon, (1991)
	a family in the Spheariales	
1942	-72 taxa of Phyllachora and its relatives from South	Doidge (1942)
	Africa were monographed	e d
1944	-46 species of Phyllachora on grass in North America	Orton (1944)
	were monographed	
1951	-Phyllachorales was accepted as allied to the	Luttrell (1951)
	Sphhaeriales sensu lato	
	– Phyllachora ambrosiae was report its development	Miller (1951)
1954	- Phyllachora was included in Polystigmanaceae.	Arx & Miller

		(1954)
1956	-The first successful inoculation experiment using	Orton (1956)
	ascospore inoculum of Phyllachora was reported	
1962	-Some didymosporous genera and filiform ascospores	Muller & Arx
	Ophiodothella were included in Polystigmataceae.	(1962)

 Table 2 Historical review of the Phyllachoraceae. (Continued).

Year	Contents	Reference
1963	- Appressorial morphology of graminicolous Phyllachora	Parbery
	and cross inoculation determining the host range were	(1963a, b)
	suggested to include in taxonomic character.	
	-Anamorphs and hyperparasites association with	Parberry &
	Phyllachora were clarified.	Langdon
	900 - Trill 190	(1963)
1964	- Appressoria morphology and anamophic characters	Parberry &
	such as conidia (spermatia) and conidiophore	Langdon
	morphological characters were used to define	(1964)
	Phyllachora species.	
1967	-First world monograph of graminicolous Phyllachora	Parberry
	was published, reducing 278 to 95 accepted taxa,	(1967)
	provided a key to taxa and host index.	ใหม่
1973	- Phyllachorales was accepted as allied to the Sphaeriales	Muller & Arx
	sensu lato.	(1973)
1983	- The Phyllachorales was formerly described and placed	Barr (1983)
	in the subclass Edaphomycetidae.	
1987	-Genus Trabutia were suggested to place	Barr (1987)
	Phyllachoraceae.	
1988	-Sphaeriales was discussed as acceptable polyphyletic,	Eriksson &
	and its alliance between Phyllachorales.	Hawksworth
		(1988)
1990	– The <i>Phyllachoraceae</i> was included in the <i>Xylariales</i> .	Barr (1990)

- 1991 Monograph of Leguminosae *Phyllachora* was Cannon (1991) conducted, including a key to taxa and host index.
- 1993 Genus *Rikatlia* was described with banded ascospores. Cannon (1993)

Table 2 Historical review of the *Phyllachoraceae*. (Continued).

Year	Contents	Reference
1994	- The Leguminous Phyllachoraceae were reported their	Cannon (1994)
	on co-evolution. Phyllachora which restricted to some	
	legume tribes was replaced by Diachora or Stigmatula.	
1995	- The <i>Phyllachoraceae</i> was recognised as the only family	Hawksworth <i>et</i>
	of the Phyllachorales and comprises 42 genera and 59	al. (1995)
	synonyms, with 1150 species worldwide.	3-11
1996	-Polystigma was monogrphed, 8 taxa accepted.	Cannon (1996)
	Phyllachoraceae associated with Rosaceae were	
	revised, including Isothea (1 species), Phyllachora (4	
	species) and two Plectosphaera species.	
	- The term 'Andromorph' was proposed to use for	Parbery
	describe the spermatial state associated with many	(1996a)
	species of Phyllachora, rather than anamorph which	2:
	describes the asexual morph of a fungus.	เทม
	- The trophism and ecology of Phyllachora associated	Parbery
	with plants were reviewed. Phyllachora was classified	(1996b)
	as an endothrophic endophytic holobiotroph, that is, not	
	only Phyllachora require living plant tissue to obtain its	
	nutrient and carry out its lifecycle, the fungus lives	
	within asymptomatic plant tissue, where the fungal	
	mycelium is entirely inside the host cells.	
1996	-Phyllachorales and related genera were studies their	Silva (1996)
	phylogenetic relationships, concluded that	

*Phyllachorales* is polyphyletic and that *Glomerella* should be placed in its own order. The true phallachoraceous fungi (*Phyllahchora* and *Coccodiella*) are best placed as a sister group to the *Sordariales*, which together from a sister group of the *Diaporthales*.

**Table 2** Historical review of the *Phyllachoraceae*. (Continued).

Year	Contents	Reference
1997	-Phyllachoraceae was estimated the potential	Cannon (1997)
	biodivaersity of the family in the tropics and the world	
	by analysing the number of phyllachoraceous taxa from	
	the Dominican Republic and Puerto Rico, resulting	
	157,800 species.	
1997	- Phaeochora and Serenomyces were removed from the	Hyde et al.
	Phyllachoraceae and placed in a new family of the	(1997)
	Phyllachorales and Phaeochoraceae.	
1999	-Tar spot fungi on palms were monographed, 16	Hyde &
	phyllachoraceous taxa are described, including 3 new	Cannon (1999)
	genera, Brodbingnagia, Malthomyces and Oxeodora,	
	Camarotella and Coccostromopsis were re-established.	
	- Phyllavhora on the Asclepiadaceae were revision.	Pearce et al.
	ลิสสิทธิ์แหกกิทยกลัยเชียก	(1999)
2000	- Phyllachora shiraiana complex on Bambusa was	Pearce et al.
	discussed. Shi by Chiang Mai Unive	(2000)
	-Haloguignardia were transferred to the Lulworthiales,	Kohlmeyer et
	Lulworthiaceae.	al. (2000)
2001	- Phyllachoracae and Phaeochoraceae were recognised	Kirk et al.
	as the families of the Phyllachorales, comprising 51	(2001)
	genera.	
	-Two new genera were introduced in the	Pearce & Hyde
	Phyllachoraceae to accommodate species with coloured	(2001)
	ascospores from grasses.	

### **Table 2** Historical review of the *Phyllachoraceae*. (Continued).

Year	Contents	Reference
2003	-Phyllachorales was proved as polyphyletic using	Wanderlei-
	segment of the 18S rRNA gene and supported the	Silva <i>et al</i> .
	placement of Glomerella in a separate family.	(2003)
	Coccodiella was closest to Phyllachora, while	
	Magnaporthe was more closely related to the	
	Diaporthales. Ophioodothella was found to be better	5
	placed in the <i>Xylariales</i>	2.
2005	- Phyllachorales was not related to the	Sakayaroj <i>et al</i> .
	Hypocreomycetidae incertae sedis, Sordariomycetes.	(2005)
2006	- Phyllachoaceae and Phaeochoraceae was comprised in	Eriksson
	Phyllachorales, incorporating 47 genera. Lichenochora,	(2006)
	Ophiodothella, Marinosphaera and Phycomelaina were	
	retained in the Phyllachoraceae, Haloguignardia was	
	placed in the Lulworthiales, Lulworthiaceae and	ใหม่
	Glomerella was placed in the Sordariomycetes.	LINJ
2012	- Phyllachora feijoae was neotypified and transferred to	Costa et al.
	the genus Catacauma.	(2012)
2015	-Polystigma was studied its relationship to	Habibi <i>et al</i> .
	Phyllachorales phylogenetically using ribosomal DNA	(2015)
	internal transcribed. Polytima amygdalinum was	
	indicated not group with Phyllachora species	
	(Phyllachorales).	