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Contributed Paper

Influence of Seasonality on the Occurrence of Myxomycetes

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ABSTRACT

The present study represented an effort to develop a better understanding of the assemblages of myxomycetes fruiting under natural conditions in the field during two different seasons in the tropical forests of Chiang Mai Province, northern Thailand. Sixty-seven species of myxomycetes were recorded, including eight new records for Thailand. Species richness and diversity were higher for the warm-wet season than for the cool-dry season. Some members of the order Stemonitales were encountered only during the warm-wet season, whereas members of the order Physarales appear to be better adapted to tolerate the dry conditions of the cool-dry season. General patterns of occurrence of myxomycetes in forest ecosystems are discussed.

Keywords: biodiversity; ecology; myxomycetes, tropical forests.

1. INTRODUCTION

The myxomycetes are eukaryotic micro-organisms that occur in association with decaying plant material in terrestrial ecosystems. In the life cycle of a typical myxomycete, the two vegetative stages-one consisting of uninucleate amoebae (with or without flagella) and the other a multinucleate motile plasmodium-are strongly influenced by temperature and humidity [1-3]. The fruiting bodies (sporocarps) that represent the reproductive stage and are used as indicators of myxomycetes in field and laboratory studies tend to be produced from plasmodia only under certain conditions, such as after a period of precipitation during the rainy season in the tropics or during the summer and early autumn in temperate regions [4]. Moreover, certain groups of myxo-mycetes generally appear only during a certain period of the year in the habitats in which they occur. For example, the nivicolous (snowbank-associated) species that are restricted largely to alpine regions of the world usually produce fruiting bodies only during the short period of time when the particular snowbank where they are found is melting back. During the remainder of the summer, the species that found in these alpine regions are the same as those collected at lower elevations in the same region [5]. Furthermore, significant seasonal effects on the patterns of occurrence, species diversity, species composition and the fruiting phenology of myxomycetes in both in temperate and tropical forests have been reported in several previous studies [6-8]. Although the moist chamber culture technique has been used in an effort to overcome, at least in part, seasonal-dependent patterns of occurrence, some of the very common species are rarely (if ever) recorded from moist chamber cultures, and other species have been recorded only in the field under natural condition. For these reasons, the influence of seasonality represents one of the more interesting parameters to investigate in any effort to develop a more complete under-standing of the distribution and ecology of myxomycetes in terrestrial ecosystems.

Thailand has a warm, tropical climate that is strongly seasonal. There are three distinct seasons-a cool-dry season between November and February, a hot-dry season from March to June, and a warm-wet season between July and October. Annual precipitation ranges from about 1,100 to 1,500 mm, and the average annual temperature is 26.2 °C. The warm-wet season is also referred as the rainy season, and the majority of the annual precipitation normally occurs in this season. During the dry season that extends through December, January and February, there is virtually no precipitation.

Many studies have addressed the biodiversity of myxomycetes in various regions of the world [9-15] but few previous studies have considered the myxomycetes of Thailand, and there are fewer than 150 species documented for the entire country [7, 8, 16-19]. Moreover, the data generated from early studies of myxomycetes in Thailand consisted only of short lists of species noted to occur in the country and/or brief notes on the occurrence of a few species at particular locality [16-19]. More recently, results from two studies of the ecology (distribution and occurrence) of myxomycetes in northern Thailand [7, 8] have appeared. The first of these indicated that the fruiting phenology of myxomycetes under natural field conditions in mid-elevation forests differed, depending upon the time of the year and the substrates being considered [7]. The second study described seasonal patterns of occurrence and distribution of myxomycetes on agricultural ground litter and forest floor litter, using data from both laboratory cultures and specimens that fruited under natural conditions in the field [8]. Data from these two studies, which encompassed 62 species from mid-elevation forests and 70 species from forest floor litter in three forest study sites and three agricultural study sites, provided clear evidence of the high biodiversity of myxomycetes in northern Thailand. Consequently, it would seem necessary to document more completely one aspect of myxomycete ecology during different seasons in different types of forests in northern Thailand. The primary objective of the study reported herein was to investigate the effect of seasonality on the species composition of the assemblages of myxomycetes associated with different forest types in northern Thailand and the patterns of occurrence of these organisms in these same forests.

2. MATERIALS AND METHODS

2.1 Collecting the Specimens

Based on a previous study of myxomycetes in Chiang Mai Province [7], the occurrence of myxomycetes in nature was not appreciably different between the two dry seasons (cool-dry and hot-dry) but these organisms were much more abundant in the warm-wet season. In the present study, field collecting was carried out during two seasons characterized by very different levels of precipitation. The first was July through October 2006, which represented the warm-wet (or rainy) season collecting period, and the second was November 2006 through February 2007, which represented the cool-dry (summer) season collecting period. The total amount of precipitation during warm-wet season is approximately 940 mm and that for cool-dry season is only about 110 mm. Average temperatures for the warm-wet season and cool-dry seasons are 27 ^{o}C and 22 ^{o}C, respectively.

The overall survey was carried out in seven study sites in Chiang Mai Province, northern Thailand (Figure 1). A brief description of each study site is given below:

Chiang Dao National Park (CD) -The predominant vegetation type in this park is a mixed deciduous forest (elevation *ca*. 779 m) located at 19^{o} 31.579′N, 98^{o} 57.092′E.

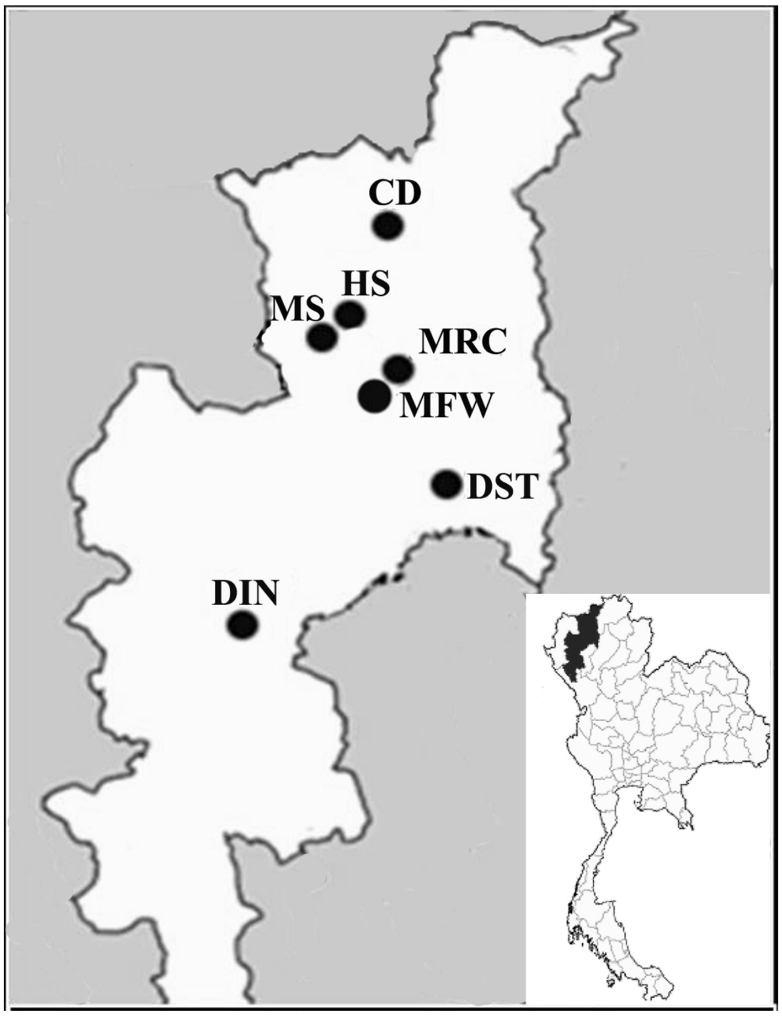

Figure 1. Locations of the study sites in Chiang Mai Province.

Note: Chiang Dao National Park (CD), Doi Inthanon National Park (DIN), Doi Suthep-Pui National Park (DST), Mae Sae National Park (MS), Mork Fa Waterfall (MFW), the Mushroom Research Centre (MRC) and Pong Duet Hot Spring (HS).

Doi Inthanon National Park (DIN) - This park encompasses a highland forest (elevation *ca*. 1700 m) located at 18^{o} 13.260′N, 98^{o} 29.042′ E. This study site is a typical example of the type of highland forest that occurs throughout northern Thailand, in which most of the trees are evergreen.

Doi Suthep-Pui National Park (DST) - This park is located at 18^{o}48.307′ N, 98^{o} 54.1′ E (elevation *ca*. 1145 m). The major vegetation types represented in the park include examples of the deciduous forests characteristic of the lowland along with evergreen forests of the uplands.

Mae Sae National Park (MS) - The study site in this park is a mid-elevation mixed forest (elevation *ca*. 960 m) located at 19^{o} 14.599′ N, 98^{o} 38.456′ E and containing both lowland and highland tree species, with bamboo present in the understory.

Mork Fa Waterfall (MFW) -This study site is in a mid-elevation bamboo-deciduous forest (elevation *ca*. 675 m), located at 19^{o} 06.809′ N, 98^{o} 46.252′ E.

Mushroom Research Centre (MRC) -The forests surrounding the Centre are representative of the mid-elevation (elevation *ca*. 900 m) tropical forests located at 19^{o} 07.123′ N, 98^{o} 44.009′ E.

Pong Duet Hot Spring (HS) -Collecting at this study site was carried out in a mixed evergreen deciduous forest located at 19^{o} 07.108′N, 98^{o}43.617′E (elevation *ca*. 895m).

Two collecting trips were made to each study site in each of the two seasons being considered. On each collecting trip, all types of substrates that might be expected to represent potential microhabitats for myxomycetes were examined, and any specimens of fruiting bodies present were collected and recorded. Specimens were gently placed in plastic collecting boxes and brought back to the laboratory. All of the specimens were glued in small paper boxes and air-dried for a few days. Vouchers were deposited in the herbaria of Chiang Mai University and the Mushroom Research Centre, Chiang Mai, Thailand. Identification of the collected specimens was carried out in the manner described previously by Martin and Alexopoulos [1] and Stephenson [4]. Nomenclature follows Lado [20] and Hernandez-Crespo and Lado [21]. Classification of forest types and vascular nomenclature follow Gardner *et al.* [22] and Elliott and Cubitt [23].

2.2 Data Analysis

Species diversity indices were calculated using Shannon's diversity index, H' [24]: $H' = -\sum_{i=1}^{n} P_i \log_e P_i$ where $P_i = \frac{N_i}{N}$ where N_i is the number of individuals for *i* species and N is number of individuals for all species; P_i is the proportion of *i* species and *n* is the number of species. Evenness indices were calculated by using the formula *Evenness* = $\frac{H'}{H'_{max}}$ where H' is the number derived from the Shannon diversity index and H' max is the maximum value of H'. Evenness indices were estimated to establish the degree of equability of the species present [25]. The total number of taxa (species richness, S) was recorded and calculated for each study site in both seasons. Taxonomic diversity indices (species per genera, S/G ratio) for the study sites as well as for the seasons were calculated, according to the methodology described by Stephenson *et al.* [26]. A low value for S/G implies a higher overall taxonomic diversity than a high value because a biota in which the species are divided among many genera is intuitively more 'diverse' than one in which most species belong to only a few genera. Sørensen's coefficient of community index was calculated for the assemblages of species recorded for the two different seasons. Coefficient of community (CC) values were calculated by using the formula $CC = \frac{2C}{(A+B)}$ where A and B are the numbers of species occurring in each season, respectively; C is the number of species common to both seasons. The CC value can range between 0 (when the datasets being compared share no species in common) and 1.0 (all species are present in both datasets). All statistical analyses were performed using SPSS [Release 16.0.0, SPSS Inc., Chicago, IL, U.S.A.]. Values of Shannon's diversity index (H') calculated for the two seasons were compared using two-way ANOVA followed by Tukey multiple comparison tests (HSD). The percent occurrence of species per season was calculated using the formula given below.

$$\%\text{ occurrence of species in one season} = \frac{\text{Total species collected at one season}}{\text{Total species collected at both seasons}} \times 100$$

3. RESULTS AND DISCUSSION

3.1 Patterns of Diversity and Occurrence of Myxomycetes in the Cool-dry and Warm-wet Seasons

One hundred and ninety-nine specimens of myxomycetes representing 67 species in 23 genera were collected from the seven different localities during the two seasons (Table 1). Of the 67 species, eight (*Arcyria obvelata*, *Cribraria costata*, *C. minutissima*, *Leocarpus fragilis, Metatrichia vesparia, Stemonitopsis typhina*, *Symphytocarpus impexus* and *Trichia favoginea*) represent new records for Thailand (Figure 2).

The warm-wet season was more productive, yielding 69% of all specimens; only 31% of the specimens were obtained during the cool-dry season. The percentage occurrence of species value (90%) calculated for the warm-wet season was also higher than the corresponding value calculated for the cool-dry season (52%). As already noted, myxomycetes generally produce fruiting bodies only under certain conditions, and the conditions that exist after a period of precipitation during the rainy season in the tropics or during the summer and early autumn in temperate regions appear to be most favorable for the fruiting of myxomycetes in natural forest ecosystems [4]. In a previous study carried out in mid-elevation tropical forests of northern Thailand [7], the occurrence of myxomycetes under natural conditions differed with the time of the year. Few specimens were collected during the dry season (November to May), whereas specimens were relatively abundant during the rainy season (June to July). Additional data obtained from a survey carried out in some of the same study areas [8] indicated that there was a seasonal effect on the patterns of occurrence of myxomycetes on agricultural ground litter and forest floor litter, both under natural field conditions and in laboratory cultures. One pattern apparent from the data obtained in the present study was the larger proportion of specimens from warm-wet season as compared with the cool-dry season. This would conform to the results reported in an earlier study [7] that the fruiting phenology of myxomycetes is influenced by seasonal effects in tropical forests.

Taxonomic diversity indices calculated for the assemblages of species in the warm-wet season and cool-dry season were 2.73 and 1.94, respectively (Table 2). Shannon's diversity index (H') was significantly higher for the warm-wet season than for the cool-dry season (Tukey test, significance level: p = 0.036). The evenness component of

Table 1. Occurrence of myxomycetes during the warm-wet (WW) and cool-dry (CD) seasons. Figures given in the table are numbers of specimens.

Myxomycetes	Season		Collecting Sites
	WW	CD	
Arcyria cinerea (Bull.) Pers.	12	6	MFW, HS, DST, MS, CD, DIN, MRC
Arcyria denudata (L.) Wettst.	7	3	HS, MS, DIN, MRC
Arcyria globosa Schwein.	1	-	MS
Arcyria incarnata (Pers. ex J.F. Gmel.) Pers.	2	3	DST, MS, CD, MRC
Arcyria obvelata (Oeder) Onsberg	1	-	CD
Arcyria sp. A	-	1	CD
Ceratiomyxa fruticulosa (O.F. Müll.) T. Macbr.	3	3	MFW, HS, DST, MS, MRC
Clastoderma debaryanum A.Blytt.	2	2	HS, DST, CD, DIN
Collaria arcyrionema (Rostaf.) Nann.-Bremek. ex Lado	2	-	CD
Comatricha laxa Rostaf.	1	1	DST, DIN
Comatricha tenerrima (M.A. Curtis) G. Lister.	1	-	MRC
Craterium leucocephalum (Pers. ex J.F. Gmel.) Ditmar	1	1	MRC
Craterium minutum (Leers) Fr.	1	1	HS, DIN
Cribraria cancellatum (Batsch) Nann.-Bremek.	1	-	MRC
Cribraria costata Dhillon & Nann.-Bremek.	1	-	DST
Cribraria microcarpa (Schrad.) Pers.	6	2	MFW, MS, CD, DIN, MRC
Cribraria minutissima Schwein.	2	-	DIN, MRC
Cribraria violacea Rex	3	-	CD
Diachea leucopodia (Bull.) Rostaf.	1	-	HS
Diachea splendens Peck	-	1	HS
Diderma effusum (Schwein.) Morgan	4	1	MFW, HS, MS, MRC
Diderma hemisphaericum (Bull.) Hornem.	2	1	CD, DIN, MRC
Diderma rugosum (Rex) T. Macbr.	2	2	HS, MS, MRC
Didymium bahiense Gottsb.	1	-	HS
Didymium iridis (Ditmar) Fr.	2	2	HS, MS
Didymium leoninum Berk. & Broome	2	1	HS, DIN, MRC
Didymium minus (Lister) Morgan	1	-	HS
Didymium nigripes (Link) Fr.	3	2	HS, MRC, DIN
Didymium squamulosum (Alb. & Schwein.) Fr.	7	5	MFW, DST, MS, CD, DIN, MRC
Hemitrichia calyculata (Speg.) M.L.Farr.	7	3	MFW, HS, CD, DIN, MRC
Hemitrichia serpula (Scop.) Rostaf. ex Lister	3	3	DST, CD, MRC
Lamproderma scintillans (Berk. & Broome) Morgan	3	1	HS, DST, MS, MRC
Lamproderma sp. A	1	-	HS
Leocarpus fragilis (Dicks.) Rostaf.	1	1	DIN
Licea biforis Morgan	1	-	MRC

Table 1. (Continue)

Myxomycetes	Season		Collecting Sites
	WW	CD	
Lycogala epidendrum (L.) Fr.	5	-	MFW, HS, CD, MRC
Lycogala exiguum Morgan	2	-	MRC
Metatrichia vesparia (Batsch) Nann.-Bremek.	1	1	CD
Perichaena chrysosperma (Curr.) Lister	-	3	DST, DIN
Perichaena depressa Lib.	1	1	DST, MRC
Physarella oblonga (Berk. & M.A Curtis) Morgan	1	1	MRC
Physarum bogoriense Racib.	1	1	MFW, MRC
Physarum cinereum (Batsch) Pers.	-	2	MRC
Physarum compressum Alb. & Schwein.	-	1	MS
Physarum crateriforme var. *columellatum* (Nann.-Bremek. & Y.Yamam.) D.W. Mitch.	2	1	CD, DIN
Physarum cf. *galbeum* Wingate	1	-	HS
Physarum globuliferum (Bull.) Pers.	1	1	CD, DIN
Physarum melleum (Berk. & Broome) Massee	1	-	MRC
Physarum nucleatum Rex	1	-	CD
Physarum pezizoideum (Jungh.) Pavill. & Lagarde	1	-	MRC
Physarum pusillum (Berk. & M.A. Curtis) G. Lister	2	1	HS, DIN
Physarum retisporum G.W. Martin	-	1	HS
Physarum roseum Berk. & Broome	1	-	HS
Physarum serpula Morgan	1	-	CD
Physarum stellatum (Massee) G.W. Martin	1	-	MFW
Physarum viride (Bull.) Pers.	9	-	MFW, HS, MS, CD, DIN, MRC
Stemonitis axifera (Bull.) T. Macbr.	3	-	MS, DIN, MRC
Stemonitis fusca Roth	4	1	MFW, HS, CD, MRC
Stemonitis fusca var. *nigrescens* (Rex) Torrend	1	-	MS
Stemonitis herbatica Peck	1	-	HS
Stemonitis smithii T. Macbr.	1	-	MFW
Stemonitis splendens Rostaf.	2	-	HS, DST
Stemonitopsis typhina (F.H.Wigg.) Nann.-Bremek.	2	-	HS, MRC
Stemonitopsis sp. A	1	-	MRC
Stemonitopsis sp. B	1	-	MRC
Symphytocarpus impexus Ing & Nann.-Bremek.	1	-	CD
Trichia favoginea (Batch) Pers.	-	1	CD

Note: Specimens that could be identified only to genus but which clearly represented a species other than one already listed for the genus in question are indicated as sp. A or sp. B.

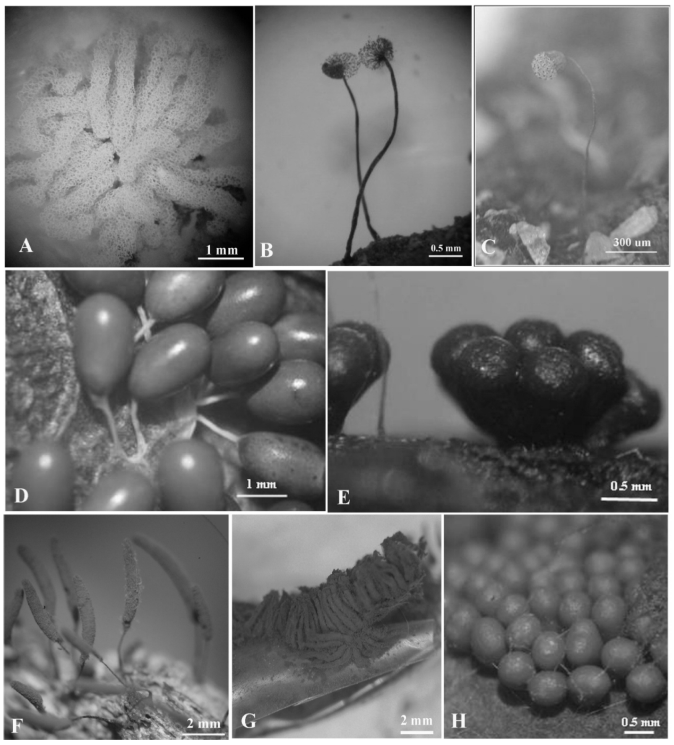

Figure 2. New records of myxomycetes for Thailand.
A. *Arcyria obvelata* **B.** *Cribraria costata* **C.** *Cribraria minutissima*
D. *Leocarpus fragilis* **E.** *Metatrichia vesparia* **F.** *Stemonitopsis typhina*
G. *Symphytocarpus impexus* **H.** *Trichia favoginea.*

diversity varied very little among the seven study sites and between the two seasons. Values of species richness (S) were 60 and 35 for the warm-wet season and cool-dry season, respectively; 28 species were common to both seasons (Table 1, Table 2). The higher values for both Shannon's diversity index (H') and species richness (S) for the various forests during warm-wet season data would seem to indicate the existence of a seasonal effect on the assemblages of myxomycetes that produce fruiting bodies in the field under natural conditions. This is not surprising, since it is generally agreed that temperature and moisture are critical factors in the myxomycete life cycle, and these organisms require favorable conditions of moisture and temperature for their growth and development [2]. The primary characteristic of the warm-wet season in northern Thailand is the alternation of rainy and sunny periods, and these seem to provide favorable conditions of adequate levels of moisture and suitable temperatures to allow myxomycetes to complete their life cycle. Stephenson *et al.* [26] also reported that myxomycete plasmodia are likely to be adversely affected by other organisms or by physical factors such as excessive rain and, as a result, the high density and diversity of living organisms and the moist environmental conditions that often prevail in tropical moist forests probably impose some major constraints on the growth and development of these organisms. On the other hand, the harsh conditions of a cool-dry season would present a situation characterized by a shortage of moisture for sporocarp development. This hypothesis was certainly supported by the results obtained in a previous study [7] in which an effort to collect all specimens that had fruited in the field under natural forest conditions yielded 62 species in the rainy season and only two species in the dry season.

Values of species richness and diversity calculated for the sets of data from the various study sites showed some variation (Table 2). Diversity indices were highest for the data sets from the MRC, HS and CD study sites that are characterized by the presence of mid-elevation (between *ca.* 750-900 m) forests, whereas values were lower for the study site MFW, which is located at a lower elevation (at *ca.* 675 m), and the study sites MS and DST, located at higher elevations. In contrast, the study site DIN that is located at the very highest elevation had a higher value for the diversity index than other sites (MFW, MS and DST) located at lower elevations. It seems to support the fact that the overall pattern of diversity of myxomycetes appears to be correlated somewhat with the elevation gradient, vegetation cover and substrate richness [11,14,27]. However, difference in microclimate and vegetation types represent other possible factors for the observed differences in the occurrence of myxomycetes. The forest surrounding MRC is representative of montane tropical forests and is also a mixture of natural forests and agricultural habitats. This combination would seem likely to produce the highest diversity value for myxomycetes in the general study area. In the HS study site, the hot spring itself is surrounded by a mixed evergreen deciduous forest and this environment presumably provides favorable warm and moist conditions. Although there are waterfalls at both the CD and MFW sites, the higher tree species diversity characteristic of CD would appear to support the more diverse assemblage of myxomycetes, whereas the vegetation at MFW is more of a woodland than a forest. The DST study site is apparently too wet in the warm-wet season and too dry in cool-dry season to provide favorable conditions for myxomycetes. Interesting, the

Table 2. Summary data on the distribution of myxomycetes collected in the various study sites during the two different seasons.

	Cool-dry Season (July-October)							
	MRC	**DST**	**CD**	**DIN**	**MS**	**MFW**	**HS**	**Pooled data**
Species richness (S)	13	4	8	7	5	6	10	35
Taxonomic diversity index	1.40	1.30	1.30	1.20	1.25	1.00	1.40	1.94
Shannon's diversity index (*H'*)	2.42	1.39	2.04	1.91	1.61	1.80	2.30	3.37
Evenness (E)	0.94	0.99	0.98	0.98	1	1	1	0.95
	Warm-wet Season (November-February)							
	MRC	**DST**	**CD**	**DIN**	**MS**	**MFW**	**HS**	**Pooled data**
Species richness (S)	26	8	19	15	12	8	22	60
Taxonomic diversity index	1.90	1.00	1.60	1.50	1.70	1.14	2.00	2.73
Shannon's diversity index (*H'*)	3.20	2.08	2.86	2.64	2.40	2.04	3.02	3.77
Evenness (E)	0.98	0.99	0.97	0.97	0.96	0.99	0.98	0.92

assemblage of myxomycetes recorded for the MS forest had relatively low value based on specimens collected during the present study in 2006 - 2007; however, the value was higher during the collecting season of October 2004 - October 2005 [8]. Nevertheless, the higher values of species richness (S) and Shannon's diversity index (H') recorded for the individual study sites and for the pooled data set for the warm-wet season would seem to indicate that seasonality does exert some influence on the occurrence of myxomycetes.

3.2 Myxomycete Assemblages in Different Seasons

The Sorensen's coefficient of community value calculated for a comparison of the assemblages of myxomycetes recorded in the two seasons was 0.59 and the value seems to indicate that there were not large numbers of species shared common for the two seasons. Similar results have been reported for the occurrence of myxomycetes surveyed for more or less dissimilar forest ecosystems and/or geographical locations [7, 11]. However, coefficient of community values calculated in the present study were based on data obtained for the same forest ecosystem, and it clearly seems that the species composition of the assemblages of myxomycetes differs within a season. Only 41.8% of the species recorded in the present study were common to both seasons, and most of these are considered to be among the most common species of myxomycetes. It is interesting that specimens of many members of the order Stemonitales (for example, members of the genera *Stemonitis*, *Stemonitopsis* and *Symphytocarpus*) were recorded only during the warm-wet season. One possible reason for such a pattern is that members of the Stemonitales are characterized by aphanoplasmodia, which appear require relatively high levels of moisture in their immediate environment. Such conditions would be more characteristic of the warm-wet season than the cool-dry season in tropical forests [2].

On the other hand, the presence of species such as *Diachea splendens*, *Physarum cinereum*, *Ph. compressum* and *Ph. retisporum* only in the cool-dry season would seem to indicate that some species of myxomycetes clearly have the capability of tolerating the two extremes of the moisture gradient. Not unexpectedly, most of these species belong to the order Physarales, members of which are characterized by a phaneroplasmodium [28]. Martin and Alexopoulos [1] noted that among the three types of myxomycete plasmodia, the phaneroplasmodium seems more robust and adaptable than the other types. Moreover, members of some genera of lignicolous myxomycetes (for example *Cribraria*, *Lycogala*, *Stemonitis* and *Stemonitopsis*) were more predominant in the warm-wet season than in the cool-dry season, whereas the genera *Arcyria*, *Didymium* and *Physarum* were prominent in both seasons. The previous study by Tran *et al.* [8] reported that *Arcyria cinerea*, *A. denudata*, *Cribraria microcarpa*, *Diderma effusum*, *Didymium squamulosum*, *Hemitrichia calyculata*, *Lycogala epidendrum* and *Physarum viride* were common species in the warm-wet season, whereas *A. cinerea* and *D. squamulosum* were common in the cool-dry season.

In contrast, 21 and 32 of the other species recorded in the present study for a particular season were represented by only a single collection during the cool-dry season and the warm-wet season, respectively. Stephenson [6] documented a similar situation for a study of myxomycete assemblages represented by specimens that had fruited in the field under natural condition in temperate forests. Gochenaur [29] suggested that assemblages of myxomycetes appear to display an organizational structure characteristic of many other organisms in which a few species are abundant and the majority are relatively uncommon or rare. The data obtained in the present study confirm to this pattern.

3.3 General Patterns of Occurrence in Nature

In spite of the fact that assemblages of myxomycetes seem to exhibit seasonal patterns, certain uncommon species (for example, *Leocarpus fragilis* and *Metatrichia vesparia*) were recorded during both seasons from the same localities. *Leocarpus fragilis* is a well-known temperate zone species that appears to be absent from highly arid regions and the humid tropics [27]. It has not yet been recorded in tropical regions except for a single collection from the high-elevation (and thus not really tropical) paramo region of Costa Rica. However, the highest part of Thailand, Doi Inthanon National Park, seems to present a possible biogeographical situation and thus the prerequisite climatic conditions required for this species to develop on two different substrates in both seasons. This was consistent with the pattern displayed by this species in Israel and Spain, where records were obtained only from the less arid parts of these countries [27]. Another interesting record was represented by the collections of *M. vesparia* on decaying wood from Chiang Dao National Park in both seasons. Stephenson [4] reported that *M. vesparia* is a common and widely distributed species in temperate regions of the Northern Hemisphere. However, it is much less common in tropical regions and in those regions of the Southern Hemisphere investigated to date. One interesting point suggested by these data is the fact that the ecological distribution of a particular species may be influenced more by geographical variation and differences in elevation than seasonal or microhabitat factors that is relatively more important in determining the distribution of certain other species. For example, the climatic conditions appear to be a more critical factor for the occurrence of *L. fragilis* than the substrate upon which this species occurs [27].

Because of their small size, the fruiting bodies of *Clastoderma debaryanum* are virtually impossible to detect under field conditions. The occurrence of this species in the present study could be documented only when the collected substrates were examined under the microscope in the laboratory. This is also the case for other species with tiny fruiting bodies [6]. Some species of myxomycetes are known as fungivorous because they are capable of feeding upon the mycelia and/or sporocarps of various fungi. Based on data from studies carried out in temperate regions, Stephenson [6] reported *Physarum viride* and *Stemonitis fusca* as possible fungivorous species, and he recorded a total of seven myxomycetes (*Arcyria cinerea*, *A. denudata*, *Didymium melanospermum*, *Hemitrichia serpula*, *Physarum album*, *Ph. viride* and *Stemonitis fusca*) from the sporocarps of fungi. In the present study, the fruiting bodies of *Physarella oblonga* and *Symphytocarpus impexus* were collected in association with the fruiting bodies of cultivated mushrooms on the sawdust media that was being used as substrate.

In addition, some species of myxomycetes were observed to occupy the same substrate in the field under natural conditions. For example, this was the case for *Cribraria violacea* and *Stemonitis fusca*, *Arcyria cinerea* and *Hemitrichia calyculata*, and *C. microcarpa* and *M. vesparia* on decaying wood. Similar patterns of co-occurrence for some species belonging to different genera (for example, *Arcyria cinerea* and *Physarum viride*, *A. denudata* and *Ph. viride*, *Ceratiomyxa fruticulosa* and *Ph. viride*, *Clasdoderma debaryanum* and *Hemitrichia serpula*) were recorded in the upland forests of southwestern Virginia by Stephenson [6], and he suggested that possible interspecific associations between different species of myxomycetes represented something that should be investigated further.

Examination of the species lists compiled for different microhabitats in the present study indicated that the greater proportion (67.3%) of myxomycetes were recorded from various kinds of woody substrates (for example, decaying wood, twigs, bark). Litter substrates yielded 27.1% of all myxomycetes, and a few specimens (5.5%) were collected from other types of substrates such as soil, a freshly fallen leaf, the root of an orchid and mushroom media. The general pattern of these occurrences on substrates was not appreciably different for the two seasons. Martin and Alexopoulos [1] indicated that in forest ecosystems, the larger proportion of myxomycetes was generally associated with woody substrates, so the data reported herein would not be unexpected. In contast, the greater proportion of myxomycetes has been reported to be associated with litter in agricultural habitats [8].

4. Conclusions

The data obtained in the present study indicate that observations of species of myxomycetes that fruited in the field under natural conditions provided evidence of differences in the ecological distribution of these organisms in two seasons of the year characterized by different climatic conditions. Warm-wet conditions were characterized by a more diverse myxomycete assemblage than cool-dry conditions. Many of members of the order Stemonitales (for example, *Stemonitis*, *Stemonitopsis* and *Symphytocarpus*) were encountered only during the warm-wet season, whereas certain other species (*Diachea splendens*, *Physarum cinereum*, *Ph. compressum* and *Ph. retisporum*) appear to be well adapted to tolerate the dry conditions of the cool-dry season. A few species (*Arcyria cinerea* and *Didymium squamulosum*) were common in both seasons. This study confirms the results reported from previous studies that provided data on the influence of seasonal factors on the fruiting phenology of myxomycetes in tropical forests and provide a useful set of data that increases our understanding of myxomycete diversity and ecology in northern Thailand.

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