ไบรโอไฟต์ในสวนสัตว์เปิดเขาเขียว จังหวัดชลบุรี

Bryophytes of Khao Kheow Open Zoo, Chonburi Province

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บทคัดย่อ

การศึกษาความหลากหลายของไบรโอไฟต์บริเวณเส้นทางศึกษาธรรมชาติ 1.5 กิโลเมตร พื้นที่เขาคันร่ม พื้นที่เขาเจดีย์ และป่าด้านหลังศูนย์วิจัย ภายในสวนสัตว์เปิดเขาเขียว ได้ดำเนินการตั้งแต่เดือนตุลาคม พ.ศ. 2555 ถึงสิงหาคม พ.ศ. 2556 จากไบรโอไฟต์ที่รวบรวมได้ 265 ตัวอย่าง พบ 24 ชนิด (16 มอสส์, 8 ลิเวอร์เวิร์ต) ใน 16 สกุล (10 มอสส์, 6 ลิเวอร์เวิร์ต) 13 วงศ์ (9 มอสส์, 4 ลิเวอร์เวิร์ต) มอสส์วงศ์ที่พบจำนวนชนิดมากที่สุด คือ Fissidentaceae (6 ชนิด) ลิเวอร์เวิร์ตวงศ์ที่พบจำนวนชนิดมากที่สุด คือ Lejeuneaceae (5 ชนิด) นอกจากนี้ ในจำนวนชนิดของไบรโอไฟต์ที่พบทั้งหมด *Lejeunea anisophylla* Mont. พบบ่อยที่สุด พื้นที่ที่พบจำนวนชนิดของไบรโอไฟต์มากที่สุด คือ เส้นทางศึกษาธรรมชาติ 1.5 กิโลเมตร

ABSTRACT

An investigation of bryophyte diversity of 1.5 km nature trail, Khao Kan Rom area, Khao Je Dee area, and forest behind research centre in Khao Kheow open zoo was carried out from October 2012 to August 2013. From 265 enumerated specimens, 24 species (16 mosses, 8 liverworts) in 16 genera (10 mosses, 6 liverworts) and 13 families (9 mosses, 4 liverworts) were found. Among these the most common family of mosses was Fissidentaceae (6 species) and family of liverworts was Lejeuneaceae (5 species). In addition, of all bryophyte species found, *Lejeunea anisophylla* Mont. was the most common. The highest species richness of bryophytes among the four areas was found in 1.5 km nature trail.

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Introduction

Bryophytes including mosses, liverworts, and hornworts are non-vascular and spore producing land plants. There are about 17,900 species worldwide (12,500 mosses, 5,250 liverworts, 100-150 hornworts) (Frey and Stech, 2009). In Thailand, approximately 1,101 species of bryophytes (708 mosses, 380 liverworts, 13 hornworts) are known (Lai et al., 2008; He, 1995 - 2014; Sukkharak and Chantanaorrapint, 2014). The bryophytes of Thailand were collected mostly from plant communities in the northern part of Thailand. Few studies have been conducted in eastern area of the country (Sukkharak and Chantanaorrapint, 2014). Only Thaithong (1984) reported nine bryophytes from the mangrove forest in Chanthaburi province.

Khao Kheow open zoo covering a total area of eight square kilometers is situated in the foothills of the remaining forest left in Chonburi province. The highest area reaches 400 m asl. The zoo area consists of three parts including 1) the presentation area, in which wild animals live in; 2) the service area, in which there are places to take a rest, a food court, and the lake; and 3) the education and research area, in which the wild animals live within their natural environment. The education and research area covered by dry evergreen forest includes 1.5 km nature trail, Khao Kan Rom area, Khao Je Dee area, and forest behind research centre (Khao Kheow open zoo, 2009). Yet no study of bryophytes has been taken place in the area before. The aim of this study, therefore, was to investigate the diversity of bryophytes of Khao Kheow open zoo. List of bryophytes is presented in this paper.

Research Methodology

The investigation of bryophyte diversity of Khao Kheow open zoo area including nature trail, Khao Kan Rom area, Khao Je Dee area, and forest behind research centre (Figure 1) was carried out from October 2012 to August 2013. Both morphological and anatomical features were studied. Bryophyte specimens were identified using both keys and descriptions from various taxonomic literatures previously reported e.g. Mizutani (1961), Eddy (1988a; 1988b). The classification system of the families and genera used in this list are followed Goffinet et al. (2008) and Crandall-Stotler et al. (2008) for mosses and liverworts, respectively. The specimens are kept in Department of Biology, Faculty of Science, Burapha University.



Figure 1 Study areas in Khao Kheow open zoo: (a) 1.5 km nature trail, (b) Khao Kan Rom area, (c) Khao Je Dee area, (d) forest behind research centre.

Results

From 265 enumerated specimens, 24 species (16 mosses, 8 liverworts) in 16 genera (10 mosses, 6 liverworts) and 13 families (9 mosses, 4 liverworts) were found (Table 1). Hornwort was not found in the area. Some species are shown in the Figure 2.

Discussion and Conclusion

The most common family of mosses was Fissidentaceae (6 species) and family of liverwort was Lejeuneaceae (5 species). Moreover, of all bryophyte species found, *Lejeunea anisophylla* Mont. (Figure 2g) which is widespread Palaeotropical species (Pócs, 2010) was the most common. The highest species richness of bryophytes among the four areas was found in 1.5 km nature trail (20 species). However, most species found in four areas are characteristic bryophytes of lowland rain forest e.g. members of Calymperes, Fissidens, Frullania, and Lejeunea (Gradstein et al., 2001).



Figure 2 Some bryophytes found in the beach forests: mosses (a) *Calymperes afzelii* Sw., (b) *Fissidens zollingeri* Mont., (c) *Pelekium bonianum* (Besch.) Touw, (d) *Vesicularia montagnei* (Schimp.) Broth.; liverworts (e) *Cololejeunea latilobula* (Herzog) Tixier, (f) *Heteroscyphus argutus* (Nees) Schiffn., (g) *Lejeunea anisophylla* Mont., (h) *Mastigolejeunea repleta* (Taylor) A.Evans.

Table 1 List of bryophytes found in Khao Kheow open zoo

Families	Species	Areas				Collecting numbers
		1	2	3	4	
Mosses						
Calymperaceae	*Calymperes afzelii* Sw. (Figure 2a)	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 1, 5, 11, 12, 27, 30, 52, 130, 134, 136, 147, 148, 162; Pearaksa, Kingjan, Vongla & Noihun 24, 75
	C. palisotii Schwägr.		✓			Sukkharak, Pearaksa & Sarawan 180
	Leucophanes glaucum (Schwägr.) Mitt.	✓	✓			Sukkharak, Pearaksa & Sarawan 183; Pearaksa, Kingjan, Vongla & Noihun 47
	Octoblepharum albidum Hedw.	✓			✓	Sukkharak, Pearaksa & Sarawan 133-2; Pearaksa, Kingjan, Vongla & Noihun 21
Fissidentaceae	*Fissidens biformis* Mitt.	✓	✓	✓		Sukkharak, Pearaksa & Sarawan 77, 174; Pearaksa, Kingjan, Vongla & Noihun 10, 26, 37, 39, 44, 51, 53, 83
	F. ceylonensis Dozy & Molk.	✓			✓	Sukkharak, Pearaksa & Sarawan 13, 18, 89; Pearaksa, Kingjan, Vongla & Noihun 5, 8, 40, 48, 76, 81
	F. gymnogynus Besch.				✓	Sukkharak, Pearaksa & Sarawan 107, 131, 132
	F. hollianus Dozy & Molk.	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 9, 80, 82, 86, 90, 94, 98, 135, 152, 175; Pearaksa, Kingjan, Vongla & Noihun 1, 12, 19, 20, 28, 29, 38, 49, 66, 67, 68, 69, 72, 74, 78, 80, 82
	F. zippelianus Dozy & Molk.	✓	✓			Sukkharak, Pearaksa & Sarawan 146; Pearaksa, Kingjan, Vongla & Noihun 57
	F. zollingeri Mont. (Figure 2b)	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 40, 56, 81, 83, 87, 91, 92, 96, 97, 140; Pearaksa, Kingjan, Vongla & Noihun 18, 43
Hypnaceae	*Vesicularia montagnei* (Schimp.) Broth. (Figure 2d)	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 19, 39, 44, 45, 47, 109, 138, 141, 143; Pearaksa, Kingjan, Vongla & Noihun 6, 34, 56, 70
Neckeraceae	*Homalia pennatula* (Mitt. ex Dixon) S.He & Enroth				✓	Sukkharak, Pearaksa & Sarawan 112
Pottiaceae	*Hyophila involuta* (Hook.) A.Jaeger	✓		✓		Sukkharak, Pearaksa & Sarawan 46, 54; Pearaksa, Kingjan, Vongla & Noihun 11, 71
Pterigynandraceae	*Trachyphyllum inflexum* (Harv.) A. Gepp	✓	✓	✓		Sukkharak, Pearaksa & Sarawan 14, 16, 17, 35, 155
Pylaisiadelphaceae	*Taxithelium nepalense* (Schwägr.) Broth.	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 3, 4, 26, 28, 29, 31, 33, 34, 36, 41, 42, 43, 48, 51, 53, 55, 79, 85, 88, 93, 99, 100, 129, 133-1, 145, 149, 153; Pearaksa, Kingjan, Vongla & Noihun 23, 27, 36, 65, 73

Table 1 (continued) List of bryophytes found in Khao Kheow open zoo

Families	Species	Areas				Collecting numbers
		1	2	3	4	
Thuidiaceae	*Pelekium bonianum* (Besch.) Touw (Figure 2c)	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 2, 32, 37, 38, 49, 84, 137, 139, 142, 144; Pearaksa, Kingjan, Vongla & Noihun 7, 9, 15, 16, 17, 25, 30, 31, 32, 33, 46, 55, 77
Liverworts						
Frullaniaceae	*Frullania muscicola* Steph.	✓				Sukkharak, Pearaksa & Sarawan 25
Lejeuneaceae	*Cololejeunea latilobula* (Herzog) Tixier (Figure 2e)	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 57, 58, 59, 60, 61, 62, 63, 65, 66, 67, 101, 111, 113, 114, 125, 128, 198, 205; Pearaksa, Kingjan, Vongla & Noihun 45
	Lejeunea anisophylla Mont. (Figure 2g)	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 69, 70, 71, 73, 74, 76, 103, 106, 108, 115, 117, 118, 119, 120, 123, 124, 126, 127, 156, 158, 159, 160, 161, 163, 164, 165, 166, 168, 169, 170, 171, 173, 176, 177, 184, 185, 186, 187, 190, 191, 192, 194, 197, 201, 202, 204; Pearaksa, Kingjan, Vongla & Noihun 52, 58, 59, 60, 61, 63
	L. wightii Lindenb.	✓	✓	✓	✓	Sukkharak, Pearaksa & Sarawan 64, 68, 104, 105, 110, 122, 193, 196; Pearaksa, Kingjan, Vongla & Noihun 54
	Mastigolejeunea indica Steph.	✓	✓			Sukkharak, Pearaksa & Sarawan 22, 24, 203; Pearaksa, Kingjan, Vongla & Noihun 79
	M. repleta (Taylor) A.Evans (Figure 2h)	✓				Pearaksa, Kingjan, Vongla & Noihun 2, 3, 4, 13, 50
Lophocoleaceae	*Heteroscyphus argutus* (Nees) Schiffn. (Figure 2f)		✓	✓	✓	Sukkharak, Pearaksa & Sarawan 75, 102, 116, 121, 157, 167, 172, 178, 181, 195, 199, 200
Radulaceae	*Radula javanica* Gottsche	✓				Pearaksa, Kingjan, Vongla & Noihun 14

Note: 1 = 1.5 km nature trail, 2 = Khao Kan Rom area, 3 = Khao Je Dee area, 4 = forest behind research centre

In eastern part of Thailand, the collections of bryophytes were rarely carried out. Only the bryophytes in mangrove forest in Chantaburi province was surveyed (Thaithong, 1984). Comparison of the results of this previous study with the bryophytes of Khao Kheow open zoo revealed that only *Octoblepharum albidum* Hedw., which is widespread and locally abundant in Malesian area from sea-level to c. 1600 m (Eddy, 1988b) was found in common from both studied sites. The difference of species found the two studied sites is probably due to the forest types.

Table 2 Bryophytes of Khao Kheow open zoo and their habitats and microhabitats

Species	Habitats/Microhabitats					
	Epiphytes				Terrestrials	
	Co	Ep	Li	Ra	Ru	Te
Calymperes afzelii Sw.	✓				✓	✓
C. palisotii Schwägr.						✓
Cololejeunea latilobula (Herzog) Tixier	✓				✓	
Fissidens biformis Mitt.					✓	✓
F. ceylonensis Dozy & Molk.	✓				✓	✓
F. gymnogynus Besch.					✓	✓
F. hollianus Dozy & Molk.	✓					✓
F. zippelianus Dozy & Molk.					✓	✓
F. zollingeri Mont.					✓	✓
Frullania muscicola Steph.			✓			
Heteroscyphus argutus (Nees) Schiffn.			✓		✓	
Homalia pennatula (Mitt. ex Dixon) S.He & Enroth						✓
Hyophila involuta (Hook.) A.Jaeger					✓	
Lejeunea anisophylla Mont.	✓		✓	✓	✓	
L. wightii Lindenb.	✓				✓	
Leucophanes glaucum (Schwägr.) Mitt.	✓					
Mastigolejeunea indica Steph.	✓					
M. repleta (Taylor) A.Evans	✓					
Octoblepharum albidum Hedw.			✓			
Pelekium bonianum (Besch.) Touw			✓		✓	✓
Radula javanica Gottsche	✓					
Taxithelium nepalense (Schwägr.) Broth.	✓		✓	✓	✓	✓
Trachyphyllum inflexum (Harv.) A. Gepp			✓		✓	✓
Vesicularia montagnei (Schimp.) Broth.					✓	✓

Note: Co = Corticolous, Ep = Epiphyllous, Li = Lignicolous, Ra = Ramicolous, Ru = Rupicolous, Te = Terricolous

A summary of habitats of bryophytes found in the area is shown in Table 2. The most common bryophytes in the area are both epiphyte and terrestrial growth (10 species). According to Gradstein and Pócs (1989), epiphytes are divided into 1) corticolous growing on bark of trees, 2) epiphyllous growing on leaf surfaces, 3) lignicolous growing on rotten logs, and 4) ramicolous growing on branches and terrestrials are subdivided into 1) rupicolous growing on rocks, and 2) terricolous growing on soils. The most epiphyte bryophytes in the study areas are corticolous species whereas

terrestrial ones are both rupicolous and terricolous species. Epiphyllous growth has not been observed in the area probably due to the epiphylls are capable to grow on the leaves in constantly humid forests (Bates, 2008, and references therein).

The results of the study increase the knowledge on bryophytes in Eastern region of Thailand, in which few studies have been conducted.

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