ABSTRACT. A total of 56 taxa in 31 genera and 14 families of mosses were collected from Golden Hope Oil Palm Plantation area. This represents 9.3% of the 597 species of mosses reported for Sabah and 7.7% of the 724 species reported for Borneo. *Acroporium convolutum* var. *horridulum* is a new record for Borneo, whereas *Ectropotheciella distichophylla* is a new record for Sabah. The largest family is Calymperaceae with six genera and 14 species, followed by Hypnaceae with four genera and nine species. Oil palm plantation recorded 25 species of mosses in 16 genera, while its surrounding natural areas recorded 42 species in 25 genera.

INTRODUCTION

There are few reports of mosses in lowland areas in Sabah. Suleiman et al. (2003) listed 47 species in 24 genera and 12 families from Lower Kinabatangan. In the present study, one species is shown to be new to Borneo and one species new to Sabah. This shows that lowland areas in the state of Sabah harbour part of the richness of the bryoflora of Borneo.

MATERIALS AND METHOD

A general survey was conducted in February of 2008 in a number of oil palm plantations and vicinity in five estates (Binuang, Mongkok, Mostyn, Sungang, and Table) located in two districts (Kunak and Tawau) in Sabah (Table 1; Figure 1). Habitat information for each of the moss specimens collected was recorded, and the mosses identified were later grouped in two categories, namely, oil palm plantation and surrounding areas, for a comparison of species association and diversity (see Table 2; Appendix 1).

RESULTS

In spite of the extensive cultivated areas in Malaysia planted with oil palms, this report is the first moss checklist prepared for oil palm plantation in the country. To date, there were 25 species of mosses collected from the oil palm plantations located in several estates in Kunak and Tawau districts (Table 2). The most common species found on the plantation floor is *Vesicularia dubyana*, whereas *Syrhopododon ciliatus* and *Arthroicormus schimperi* are among the commonest mosses on oil palm trunks.

Additionally, there were 42 species of mosses collected from the natural areas surrounding the plantations (Table 2). The figure is nearly twice the number of moss taxa found in the man-made oil palm plantation (Table 2). Of these, *Acroporium convolutum* var. *horridulum*, *Acroporium johannis-winkleri*, *Ectropotheciella distichophylla*, *Fissidens*...
Table 1. Collection localities, dates and numbers.

<table>
<thead>
<tr>
<th>Collection Number</th>
<th>Date</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>2435-2440</td>
<td>19 February 2008</td>
<td>Kunak District, Mostyn Estate, around rest house.</td>
</tr>
<tr>
<td>2441-2478</td>
<td>19 February 2008</td>
<td>Kunak District, Mostyn Forest Reserve.</td>
</tr>
<tr>
<td>2479</td>
<td>19 February 2008</td>
<td>Kunak District, Mostyn Estate, around water spring.</td>
</tr>
<tr>
<td>2480-2484</td>
<td>19 February 2008</td>
<td>Kunak District, Madai-Baturong Forest Reserve.</td>
</tr>
<tr>
<td>2485-2502</td>
<td>20 February 2008</td>
<td>Kunak District, Mostyn Estate, oil palm plantation.</td>
</tr>
<tr>
<td>2503-2517</td>
<td>21 February 2008</td>
<td>Tawau District, Table Estate, base of Bombalai Hill.</td>
</tr>
<tr>
<td>2518-2532</td>
<td>22 February 2008</td>
<td>Tawau District, Table Estate, Kg. Indah, Somel Water Spring.</td>
</tr>
<tr>
<td>*125</td>
<td>26 February 2008</td>
<td>Kunak District, Mostyn Estate.</td>
</tr>
</tbody>
</table>

* Collected by Dunstan Polus Masundang

Figure 1. Map of Sabah showing Golden Hope Oil Palm Plantation.
Table 2. Summary of mosses found in oil palm plantation and its surrounding areas.

<table>
<thead>
<tr>
<th>No.</th>
<th>Moss species</th>
<th>Oil palm plantation</th>
<th>Surrounding areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Substrate</td>
<td>Oil palm trunks</td>
<td>Other trunks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other substrates</td>
<td>Other substrates</td>
</tr>
<tr>
<td>1</td>
<td>Acroporium convolutum var. horridulum</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Acroporium johannis-winkleri</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Aequatoriella bifaria</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>Arthrocormus schimperi</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bryum apiculatum</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Bryum cf. coronatum</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Callicostella papillata</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>8</td>
<td>Calymperes afzelii</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Calymperes boulayi</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>10</td>
<td>Calymperes erosum</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11</td>
<td>Calymperes lonchophyllum</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>12</td>
<td>Calymperes porrectum</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td>Calymperes taitense</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Calymperes tenerum</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>15</td>
<td>Chaetomitrium orthorrhynchum</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>16</td>
<td>Ectropotheciella distichophylla</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>17</td>
<td>Ectropothecium cf. butenzoegii</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Ectropothecium sp.1</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Ectropothecium sp.2</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Exostratum blumei</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>21</td>
<td>Fissidens ceylonensis</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>22</td>
<td>Fissidens crassinervis</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Fissidens crispulus var. crispulus</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Fissidens crispulus var. robinsonii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Fissidens cf. hollianus</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Fissidens nobilis</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Fissidens geminiflorus</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Fissidens zollingeri</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Himantocladium cyclophyllum</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>30</td>
<td>Homaliodendron microdendron</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Hyophila involuta</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Isopterygium albescens</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>33</td>
<td>Isopterygium minutirameum</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Isopterygium sp.1</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Leptotrichella miquelina</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Leucophanes candidum</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Leucophanes glaucum</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>38</td>
<td>Leucophanes octoblepharoides</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>39</td>
<td>Meiothecium microcarpum</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Mitthyridium flavum</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Mniomalia semilimbata</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Neckeropsis gracilenta</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Neolindbergia rugosa</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Octoblepharum albidum</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>
nobilis, Exostratum blumei, Mniomalina semilimbata and Neolindbergia rugosa are species of primary lowland rain forest in the region, and the rest are common species in disturbed and semi-open lowland tropical forests.

In summary, the total moss taxa documented from the Golden Hope Oil Palm plantation areas represents 9.3% of the 597 species of mosses reported for Sabah and 7.7% of the 724 species reported for Borneo (Suleiman et al., 2006). Furthermore, the largest family is Calymperaceae with six genera and 14 species, followed by Hypnaceae with four genera and nine species.

Two submerged species were collected at Somel Water Spring, namely Vesicularia dubyana and Fissidens geminiiflorus. This is an interesting find as true aquatic mosses are rare in Borneo. Mosses are becoming popular these days as aquarium plants in Southeast Asia (Tan & Loh, 2005). A good number of species of Fissidens and Vesicularia are sold in aquarium shops in Singapore, Japan, Europe and North America for use to decorate fish tanks and to do aquascape design.

**DISCUSSION**

Table 2 shows that there are more diversity of mosses found in the natural areas surrounding the oil palm plantations. One can presume that the greater diversity is due to the still primary nature of the remnant forests left after the plantation establishment. It remains to be seen if the high diversity of mosses surviving in the surrounding natural areas of the oil palm plantation will persist over the years of continued disturbance by man.

Undoubtedly, the trunk of oil palms with its persistent leaf bases left attached after the cutting of the fronds provides a unique habitat above the ground for plants to grow. In a previous study of pteridophytic plant association found in the leaf pockets of oil palm trunks in plantations in Peninsular Malaysia,
there was a constant association of fern taxa, which include *Nephrolepis auriculata*, *Goniophlebium percussum* and *Davallia denticulata* (Faridah *et al.*, 2003). Likewise, in the present survey, it appears that there is also a constant association of leucobryoid moss species growing epiphytically and in abundance on the trunks of oil palms, especially in leaf pockets. They include *Arthrocormus schimperi*, *Octoblepharum albidum*, three species of *Leucophanes*, and other mosses of less frequency, such as *Syrrophodon ciliatus* and *Calymperes erosum*. The last two mentioned mosses have built in dead cells or cancellinae in the leaf. The presence of constant association of leucobryoid and morpho-anatomically related mosses on the trunk and leaf pockets of oil palms may indicate an environment rich in humus substrate, but lacking regular supply of water.

**ACKNOWLEDGEMENTS**

We sincerely thank Golden Hope for funding this research and the hospitality given during the field trip.

**REFERENCES**


APPENDIX 1. The list of mosses collected and identified

Presented below is a list of the mosses collected in the present study with their family classification. All the specimens reported are deposited at the BORNEENSIS Herbarium (BORH) of the Institute for Tropical Biology and Conservation, with duplicates sent to SING Herbarium. An asterisk (*) indicates a new species record for Sabah and double asterisks (**) indicates a species new to Borneo.

POLYTRICHACEAE
Pogonatum piliferum (Griff.) Mitt.
On soil, 200m, M.Suleiman & D.P. Masundang 2491.

FISSIDENTACEAE
Fissidens ceylonensis Dozy & Molk.
On rock and soil, 200m, M.Suleiman & D.P.Masundang 2448, 2488.

Fissidens crassinervis Sande Lac.
On Soil, 200m, M.Suleiman & D.P.Masundang 2493.

Fissidens crispulus Brid. var. crispulus
On rock and rotten log, 270m, M.Suleiman & D.P.Masundang 2503a, 2515.
This is the second report for this taxa for Sabah and Borneo (Suleiman et al., 2006).

Fissidens crispulus Brid. var. robinsonii
(Broth.) Z. Iwats. & Z. H. Li
On cliff and boulder, 200m, M.Suleiman & D.P.Masundang 2461, 2463, 2466.

Fissidens cf. hollianus Dozy & Molk
On rock, 200m, M.Suleiman & D.P.Masundang 2452.

Fissidens nobilis Griff.
On boulders, 200m, M.Suleiman & D.P.Masundang 2473, 2477.

Fissidens zollingeri Mont.
On rock, 200m, M.Suleiman & D.P.Masundang 2449.

Fissidens geminiflorus Dozy & Molk.
Submerged in water spring, 30m, M.Suleiman & D.P.Masundang 2529.

DICRANACEAE
Leptotrichella miqueliana (Mont.) Lindb. ex Broth.[syn. Microdus miquelianus (Mont.) Besch.]
On soil of uprooted tree, 200m, M.Suleiman & D.P.Masundang 2476.

LEUCOBRYACEAE
Octoblepharum albidum Hedw.
On oil palm trunk, 90-200m, M.Suleiman & D.P.Masundang 2436, 2489, D.P.Masundang 113.

PHYLLODREPANOPHYLLACEAE
Mniomalia semilimbata (Mitt.) Müll.Hal.
On rock, 30m, M.Suleiman & D.P.Masundang 2532.
Only two records of occurrence of this interesting species in Sabah in 1916 and 1975 (Suleiman et al., 2006).

CALYMPERACEAE
Arthrocormus schimperi (Dozy & Molk.) Dozy & Molk.
On oil palm trunk, 270m, M.Suleiman & D.P.Masundang 2508.

Calymeres afzelii Sw.
On tree trunk, 200m, M.Suleiman & D.P.Masundang 2475.

Calymeres boulayi Besch.
On rock and concrete, 30m, M.Suleiman & D.P.Masundang 2522a.

Calymeres erosum Müll.Hal.
On rock and oil palm trunk, 200m, M.Suleiman & D.P.Masundang 2496, D.P.Masundang 115.
Calymperes lonchophyllum Schwäegr.
On tree trunk and cliff, 200m, M.Suleiman & D.P.Masundang 2444, 2458.

Calymperes porrectum Mitt.
On boulder, 200m, M.Suleiman & D.P.Masundang 2472.

Calymperes tahitense (Sull.) Mitt.
On cliff and decaying log, 200m, M.Suleiman & D.P.Masundang 2456, D.P.Masundang 121.

Calymperes tenerum Müll.Hal.
On oil palm trunk and rock, 30-200m, M.Suleiman & D.P.Masundang 2500, 2527.

Exostratum blumei (Nees ex Hampe) L.T.Ellis
On decaying log, 200m, D.P.Masundang 122.

Leucophanes candidum (Schwägr.) Lindb.
On palm trunk, 270m, M.Suleiman & D.P.Masundang 2509.

Leucophanes glaucum (Schwägr.) Mitt.
On oil palm and ornamental palm trunks, 200m, M.Suleiman & D.P.Masundang 2437, 2499.

Leucophanes octoblepharoides Brid.
On wooden staircase, 200m, M.Suleiman & D.P.Masundang 2441.

Mitthyridium flavum (Müll.Hal.) H.Rob.
On tree buttress, 200m, M.Suleiman & D.P.Masundang 2454.

Syrrhopodon ciliatus (Hook.) Schwägr.
On oil palm trunk, 200-270m, M.Suleiman & D.P.Masundang 2485, 2507.

Syrrhopodon parasiticus (Brid.) Besch.
On oil palm trunk, 200m, M.Suleiman & D.P.Masundang 2438.

POTTIACEAE
Hyophila involuta (Hook.) A.Jaeger
On rock and concrete, 30m, M.Suleiman & D.P.Masundang 2522b.

BRYACEAE
Bryum apiculatum Schwägr.
On soil and concrete, 30m, M.Suleiman & D.P.Masundang 2518, 2521.

Bryum cf. coronatum Schwägr.
On soil and rock, 30-200m, M.Suleiman & D.P.Masundang 2495, 2502, 2525.

BARTRAMIACEAE
Philonotis hastata (Duby) Wijk & Margad.
On boulder, 200m, M.Suleiman & D.P.Masundang 2479.

Philonotis sp.1
On soil, 270m, M.Suleiman & D.P.Masundang 2512.

PTEROBRYACEAE
Neolindbergia rugosa (Lindb.) M.Fleisch.
On tree buttress, 200m, M.Suleiman & D.P.Masundang 2469.

NECKERACEAE
Himantocladium cyclophyllum (Müll.Hal.) M.Fleisch.
On cliff and rock, 30-200m, M.Suleiman & D.P.Masundang 2460, 2465, 2531.

Homaliodendron microdendron (Mont.) M.Fleisch.
On tree buttress, 200m, M.Suleiman & D.P.Masundang 2470.

Neckeropsis gracilentata (Bosch. & Sande Lac.) M.Fleisch.
On tree trunk, 200m, D.P.Masundang 124.

HOOKERIACEAE
Callicostella papillata (Mont.) Mitt
On rock and soil, 200-270m, M.Suleiman & D.P.Masundang 2478, 2483, 2510.

Chaetomitrium orthorrhynchum (Dozy & Molk.) Bosch & Sande Lac.
On tree trunk, 200m, D.P.Masundang 120a.
THUIDIACEAE

_Aequatoriella bifaria_ (Bosch & Sande Lac.) Touw
On boulder, 200m, _M.Suleiman & D.P.Masundang_ 2467, 2468.

_Pelekium velatum_ Mitt.
On rotten wood and branch, 200-270m, _M.Suleiman & D.P.Masundang_ 2471, 2517.

_Thuidium cymbifolium_ (Dozy & Molk.) Dozy
On decaying stump, 200m, _D.P.Masundang_ 123.

_Thuidium plumulosum_ (Dozy & Molk.) Dozy
On cliff, 200m, _M.Suleiman & D.P.Masundang_ 2459.

SEMATOPHYLLACEAE

* _Acroporium convolutum_ (Bosch & Sande Lac.) M.Fleisch. var. _horridulum_ (Bartr.) B.C.Tan, T.J. Kop. & D.H. Norris
On rock, 270m, _M.Suleiman & D.P.Masundang_ 2506.
This species was known previously as endemic to New Guinea (Tan _et al._, 2007).

_Acroporium johannis-winkleri_ Broth.
On rock, 200m, _M.Suleiman & D.P.Masundang_ 2492.

_Meiothecium microcarpum_ (Hook.) Mitt.
On palm trunks, 200m, _M.Suleiman & D.P.Masundang_ 2435, 2440.

_Taxithelium_ cf. _vernieri_ (Dubby) Besch.
On rock, 200m, _M.Suleiman & D.P.Masundang_ 2455a.

_Trichosteleum stigmosum_ Mitt.
On fungi (Ganoderma), 200m, _M.Suleiman & D.P.Masundang_ 2490a.

HYPNACEAE

* _Ectropotheciella distichophylla_ (Hampe) M. Fleisch. On cliff, 200m, _M.Suleiman & D.P.Masundang_ 2462.