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To cite this article: N. G. Hodgetts, M. K. Essilfie, A. Adu-Gyamfi, E. Akom, J. Kumadoh & J. Opoku (2016): Bryophytes of Atewa Forest, Eastern Region, Ghana, Journal of Bryology, DOI: [10.1080/03736687.2016.1145525](https://doi.org/10.1080/03736687.2016.1145525)

To link to this article: <http://dx.doi.org/10.1080/03736687.2016.1145525>



Published online: 13 Jun 2016.



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Bryophytes of Atewa Forest, Eastern Region, Ghana

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Atewa Forest is a biodiverse tropical forest in the Eastern Region of Ghana, highly threatened by illegal mining, farming and hunting activities, and by proposals for industrial-scale bauxite mining. Conservation bodies are active in trying to save the forest and promote its future as a national park. Very little is known about its bryophyte flora, and this short expedition was intended as a first step to remedy that situation. Survey work in March 2014 was targeted mainly at areas thought likely to be bryophyte-rich, notably swamp forest and upland evergreen forest. A total of 164 species was recorded, including about 58 new to Ghana and at least one new species. The importance of Atewa Forest for biodiversity in western Africa is reinforced.

Keywords: Africa, Conservation, Ecology, Inventory, Liverworts, Mosses, Rainforest, Survey

Introduction

Atewa (or Atiwa) Forest, located in south-eastern Ghana, is one of the largest remaining areas of rainforest in the country, covering 23,665 ha and reaching an altitude of 842 m, the second highest point in Ghana. The Atewa range of hills runs roughly from north to south and is characterised by a series of forested plateaux. It represents about 33.5% of the remaining closed forest in Ghana's Eastern Region, harbouring a high diversity of species, including vascular plants, butterflies, dragonflies, katydids, amphibians and birds. There are many endemic and rare species. Some of the seasonal marshy grasslands, swamps and thickets on the Atewa plateaux are nationally unique, and it is one of only two reserves in Ghana with upland evergreen forest (Hall & Swaine, 1981). The known biodiversity of Atewa Forest was summarised in a 'rapid biological assessment' by McCullough *et al.* (2007).

Atewa Forest was established as a national forest reserve in 1926 and has since been designated as a Globally Significant Biodiversity Area and an Important Bird Area (Abu-Juam *et al.*, 2003). It has long been recognised as a nationally important reserve. It is a source of food and water for five million people, with the headwaters of three major river systems, the Ayensu, Densu and Birim rivers, within its boundaries. These three rivers are the most

important sources of domestic, agricultural and industrial water for local communities as well as for many of Ghana's major population centres, including Accra.

The forest is under threat from numerous pressures, including illegal farming, gold-mining and hunting. Even more seriously, the whole forest is under a potential threat from industrial-scale bauxite mining. Set against this, there is an active campaign to keep the forest more or less intact for its biodiversity, ecosystem services and eco-tourism. A Rocha Ghana, part of the international conservation organisation A Rocha, is in the forefront of this campaign, along with Permian Global and IUCN (Ghana and Netherlands), and is making great strides in promoting the forest as a potential national park, educating the local population and campaigning at both national and international levels. McCullough *et al.* (2007) covered vascular plants, birds, mammals, reptiles, amphibians and several groups of invertebrates, but contained no mention of bryophytes. N.G.H. therefore offered to do some bryophyte work in the forest, in association with A Rocha Ghana, in order to boost the case for its protection and to add to the knowledge of the Ghanaian bryophyte flora, which is very under-worked.

Bryological history of Atewa Forest and Ghana

There have been very few bryophyte surveys in Ghana, and most of what is known results from the careful

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work of the late Dr Eustace Jones. He visited Atewa Forest on at least one occasion and made many valuable records of liverworts, although a visit to the imprecisely localised 'Kaolin Swamp' was 'greatly curtailed' by a thunderstorm and failing light, according to Jones & Harrington (1983). Jones's records are documented in the same publication. His fieldwork in Atewa Forest and elsewhere in western Africa also contributed to his series on African Hepatics, published over many years in the *Transactions of the British Bryological Society* and later the *Journal of Bryology*. Consequently the liverworts of Ghana are much better documented than the mosses. Wigginton (2009) lists 135 liverwort and hornwort taxa for Ghana, records largely due to the work of Jones, but O'Shea (2006) lists only 67 moss taxa. There has been virtually no bryophyte work in Ghana since Jones, apart from a few casual collections by staff and visiting academics at the University of Ghana.

Materials and Methods

The first author visited Atewa Forest between 10–19 March 2014, together with Jacqueline Kumadoh, Emmanuel Akom and Jeffrey Opoku of A Rocha Ghana and Dr Kweku Essilfie and Anthony Adu-Gyamfi of the Botany Department at the University of Ghana. Local knowledge was used to target areas of probable high bryophyte diversity, notably streams, hill summits (where cloud gathers and creates increased humidity) and small areas of swamp forest. However, coverage was far from comprehensive, and the species recorded represent no more than the results of targeted sampling in a very large area of forest.

While some of the more common bryophytes were identified in the field, most taxa were identified later by N.G.H. from collected specimens. Some specimens were sent to specialists for identification or confirmation. A wide range of literature was used, but Wigginton (2004) was a particularly useful tool for the identification of liverworts. Specimens have been lodged in the Royal Botanic Garden Edinburgh (E), the herbarium in the Botany Department at the University of Ghana (GC), A Rocha Ghana and the personal herbarium of N.G.H.

Nomenclature follows Wigginton (2009) for the liverworts and O'Shea (2006) for the mosses, except where otherwise indicated.

Bryophyte assemblages

The survey was not sufficiently comprehensive to be able to make definitive statements about the ecology of individual species, but some general comments may be useful. There is a clear altitudinal zonation in the forest, and the bryophyte flora can conveniently be split into three broad groups: widespread (occurring throughout the forest), low altitude (occurring mainly

below about 600 m) and high altitude (occurring mainly above about 680 m), the latter also encompassing areas of swamp forest at lower altitudes.

Widespread

A number of common species can be found throughout the forest. *Lepidozia succida*, *Fissidens marthae* and *Callicostella africana* grow on compacted soil and rocks on and next to tracks. Shaded banks, rocks, dead wood and decaying organic matter support a suite of common forest species, notably *Leucomium strumosum*, *Pelekium varians*, *Rhacopilopsis trinitensis*, *Vesicularia galerulata*, *Cryptolophocolea martiana*, *Radula* cf. *holstiana*, *Radulina borbonica*, *Telaranea nematodes*, *Lejeunea anisophylla*, *L. eckloniana*, *Ectropothecium regulare* and *Isopterygium palmarum*.

Widespread epiphytes include *Archilejeunea* spp., *Lejeunea anisophylla*, *L. autoica*, *L. confusa*, *L. eckloniana*, *Lopholejeunea subfusca*, *Metzgeria furcata*, *Plagiochila moenkemeyeri*, *P. praemorsa*, *Porotrichum elongatum*, *Radula* cf. *holstiana* and *Sematophyllum subpinnatum*. Species of *Neckeropsis* are encountered occasionally, especially hanging off branches. The black greasy-looking patches of *Stictolejeunea balfourii* are occasional on tree bases and especially exposed tree roots. *Campylopus savannarum*, *Groutiella laxotorquata* and *Cheilelejeunea serpentina* are widespread canopy 'sun epiphytes'.

Epiphyllous species are mainly a feature of higher altitudes, but some of them seem indifferent to altitude, although they tend to occur only in more humid pockets at lower levels. *Cololejeunea obtusifolia*, *C. pusilla*, *Leptolejeunea astroidea* and *Radula flaccida* fall into this category. *Leptolejeunea astroidea* is probably the most frequent epiphyllous species in the forest, but the three other species are also common.

Low-altitude dry forest

The drier parts of the low-altitude forest are not very diverse, supporting a sparse and largely predictable bryophyte flora on the ground and on rocks, dead wood, etc., as described above, with the addition of *Pelekium gratum*, apparently an exclusively low-altitude plant in Atewa Forest. The forest edge is heavily impacted by human activities, with illegal banana plantations and evidence of mining activities interspersed amongst the natural vegetation. Exposed and insolated tree trunks, including planted cocoa trees at the forest edge, have *Caudalejeunea hanningtonii*, *Frullania* spp. (although this genus is surprisingly uncommon in Atewa Forest generally), *Lejeunea autoica*, *L. tuberculosa*, *Mastigolejeunea* spp. and *Schiffneriolejeunea fragilis*. Other species growing on dead and living wood apparently favouring low altitudes (consistently below 600 m) in the forest are *Chameleion cryptocarpus*, *Fissidens danckelmannii*, *F.*

microcarpus, *Jaegerina scariosa*, *Lejeunea setacea*, *L. villaumei*, *Radula appressa* and *Trichosteleum chryso-phyllum*. *Cololejeunea androphylla*, which grows as an epiphyll in humid forest at higher altitudes, grows on dead and rotting wood at low altitudes.

The streamsides are much more diverse than the bulk of the lowland forest. Not only do they provide a more humid and congenial environment for many species, but also there tends to be more exposure of rocks near the streams than elsewhere in the forest, providing more habitat niches. These are colonised by a variety of bryophytes, notably *Fissidens* spp. (with *F. ramulosus* and *F. submarginatus* confined to lower altitudes), *Plagiochila integerrima*, *Lopholejeunea nigricans*, *Pinnatella minuta*, *Porotrichum stipitatum* and *Riccardia* spp. *Bryum apiculatum* and *Hyophila involuta* occur as small colonies in earthy rock crevices. The only record of *Cyclodictyon vallis-gratae* made during the fieldwork was from a rock by a stream at low altitude.

High altitude and swamp forest

At higher altitudes and in areas of swamp forest, both the diversity and overall biomass of bryophytes increase substantially. Branches are usually festooned with pendent species of pleurocarpous mosses, with *Floribundaria floribunda* and *Orthostichella versicolor* often abundant, and *Aerobryopsis capensis* and *Orthostichidium involutifolium* only a little less so. *Callicostella* spp., *Plagiochila* spp., *Fissidens* spp. and Lejeuneaceae are also more abundant and diverse than lower down. Of the species of *Fissidens* confined to higher altitudes in the forest, *F. lachmannii* and *F. sciophyllus* are epiphytes, growing on tree trunks, and *F. grandifolius*, *F. intramarginatus*, *F. pellucidus*, *F. porrectus*, *F. punctulatus* and *F. weirii* grow on earth banks or rocks. *Plagiochila* is often pendent from tree trunks and branches. In addition to the common species found at lower levels, *Bazzania decrescens* subsp. *molleri*, *Plagiochila pectinata*, *Radula boryana* and *R. stenocalyx* are examples of montane species found only at these higher altitudes and rare or unknown elsewhere in Ghana. At just over 600 m, *Leucophanes* spp. begin to appear on tree trunks and rotten logs, and *Lepidopilidium devexum* appears on branches and twigs, and both become more frequent with altitude and increasing humidity. *Metzgeria* spp., *Porotrichum* spp. and *Syrrhopodon* spp. become more diverse above about 750 m. *Plagiochila salvadorica* is a beautiful species that was found at a single site in the forest at 750 m, where it was abundant.

Canopy epiphytes are likewise more diverse with altitude, with *Macromitrium sulcatum* joining those mentioned above as a common plant. The range of small liverworts increases, with *Ceratolejeunea calabariensis* often found creeping through tufts of

Campylopus savannarum, and *Cheilolejeunea* spp. and *Lejeunea brenanii* becoming conspicuous members of the flora.

Epiphylls are abundant, diverse and sometimes luxuriant on the summit plateaux and in swamp forest. The epiphyllous flora here includes several *Cololejeunea* spp., *Colura* spp., *Drepanolejeunea cultrella* (and more rarely *D. physaefolia*), *Prionolejeunea grata*, *Schiffneriolejeunea pappeana* and *Taxilejeunea pulchriflora*. Some species (e.g. *Odontolejeunea lunulata*) may be locally abundant at one or more sites in the forest but absent from others.

Species list

Family placement and order follow the classification on the Southern Illinois University Carbondale website (<http://bryophytes.plant.siu.edu/index.html>), in which the liverwort classification is based on Crandall-Stotler et al. (2009) and the moss classification on Goffinet et al. (2008). Taxa new to Ghana are denoted with an asterisk (*), and their distribution elsewhere in Africa is briefly described. For the sake of gathering all the existing information together in one place, species recorded previously in Atewa Forest but not seen during this fieldwork (all of them liverworts) are included in square brackets.

Liverworts

Metzgeriaceae

Metzgeria furcata. Epiphytic on tree trunks, 540–800 m, frequent.

**Metzgeria madagassa*. Epiphytic in swamp forest, 750 m, rare. Widespread in sub-Saharan Africa.

Metzgeria saxbyi. Epiphytic, epiphyllous and on rotten wood, 750–840 m, occasional.

Aneuraceae

Aneura pseudopinguis. Epiphytic and saxicolous, 420–690 m, frequent.

Riccardia amazonica. Dead wood in swamp forest, 690 m, rare. Plants with relatively wide translucent wings and a narrow central opaque region in the ultimate branches, and thick-walled internal cells, were assigned to this species, following the description in Reeb & Bardat (2014).

Riccardia limbata. Banks and rocks by streams, 450–625 m, frequent. These plants differ from *R. amazonica* in having relatively narrow translucent wings and a wider central opaque region in the ultimate branches, and thin-walled internal cells.

Naming specimens of African *Riccardia* is very difficult, so the names presented here should be regarded as provisional. Reeb & Bardat (2014) have undertaken a study of the type specimens of African *Riccardia*, and are working on a full revision of the genus in Africa. These specimens will need to be re-examined in the light of that revision.

Radulaceae

Radula appressa. Epiphytic and saxicolous, 350–550 m, occasional.

Radula boryana. Epiphytic on tree trunks, 750–805 m, occasional.

Radula flaccida. Mainly epiphyllous, but also occasionally epiphytic on tree bases and twigs, 400–805 m, frequent.

Radula fulvifolia. Epiphytic on branches, 625 m, rare.

Radula cf. *holstiana* Steph. On rotten wood and occasionally epiphytic, 350–840 m, occasional. This is the taxon referred to in Jones & Harrington (1983). *Radula holstiana* was synonymised with *R. ankefinensis* by Grolle (2001). However, the leaves of the Atewa Forest plants are very caducous, unlike (according to Grolle, 2001, reported in Wigginton, 2004) those of *R. ankefinensis*, and the cortex is clearly differentiated, unlike that of *R. fulvifolia*. Unfortunately, like the material examined by Jones previously, these specimens are sterile. However, on current evidence it may be appropriate to reinstate *R. holstiana* as a species in its own right until its status is clarified.

Radula stenocalyx. Epiphyllous in humid places, 680–840 m, occasional.

Frullaniaceae

Frullania apicalis. Epiphytic on tree trunks and on branches in canopy, 620–820 m, occasional.

[*Frullania apiculata*. In crowns of *Braeya* and *Antiaris* (Jones & Harrington, 1983).]

Frullania diptera. Epiphytic on well-illuminated tree trunks, 350–360 m, rare.

Frullania epicata. Epiphytic on dead tree trunk, 625 m, rare.

Frullania spongiosa. Epiphytic, 540 m, rare.

**Frullania variegata*. Epiphytic on dead tree trunk, 625 m, rare. Widespread but apparently scarce in sub-Saharan Africa.

Lejeuneaceae

Acrolejeunea emergens var. *emergens*. Epiphytic on dead tree trunk, 625 m, rare.

Aphanolejeunea jovetastiana. Epiphyllous, 400–750 m, rare.

Archilejeunea abbreviata. Epiphytic and saxicolous, 350–750 m, frequent. Several of the collections made in Atewa Forest match the plant described by Vanden Berghen (1973) as *A. autoica*, but regarded as a 'depauperate hygromorphic form' of *A. abbreviata* in Wigginton (2004).

Archilejeunea africana. Epiphytic on bark and twigs and epiphyllous, 560–840 m, occasional.

Caudalejeunea hanningtonii. Epiphytic on tree by stream and cocoa tree at forest edge, 390–450 m, occasional.

Ceratolejeunea calabariensis. Epiphytic on twigs and branches, especially in canopy, often creeping through tufts of *Campylopus savannarum*, occasionally epiphyllous, 540–840 m, locally frequent.

**Cheilolejeunea cordistipula*. Epiphytic on branches in canopy, 815 m, rare. Widespread but apparently scarce in tropical Africa.

Cheilolejeunea intertexta. Epiphyllous, 800 m, rare.

Cheilolejeunea newtonii. Epiphytic on tree trunks and bases, especially near streams, 445–630 m, occasional.

Cheilolejeunea serpentina. Epiphytic, mainly on branches in canopy, 540–820 m, locally frequent.

Cheilolejeunea trifaria. Epiphytic on branches in canopy, often with *Macromitrium sulcatum*, 740–820 m, locally frequent.

Cololejeunea androphylla. Rotten wood and sometimes epiphyllous, 440–750 m, occasional.

**Cololejeunea bolombensis*. Epiphyllous, 750–820 m, occasional but always in very small quantity. Widespread in tropical Africa.

Cololejeunea cuneifolia. Epiphyllous in humid places, 800 m, rare. Very close to *C. zenkeri*. Only one specimen matched the description of *C. cuneifolia* convincingly, with consistently small lobules.

[*Cololejeunea elegans*. Epiphytic on tree boles in swamp forest (Jones & Harrington, 1983).]

[*Cololejeunea lanceolata*. Epiphyllous in swamp forest (Jones & Harrington, 1983).]

Cololejeunea obliqua. Epiphyllous in humid places, 680–840 m, locally frequent.

Cololejeunea obtusifolia. Epiphyllous in humid places, 490–820 m, frequent or locally abundant.

Cololejeunea pusilla. Epiphyllous in humid places, 540–820 m, occasional.

**Cololejeunea zenkeri*. Epiphyllous in humid places, 680–840 m, locally frequent. These specimens were originally identified as *C. divignaudii*, but that species has recently been synonymised with *C. zenkeri* (Pócs et al., 2015) on the basis that the position and shape of the teeth and hyaline papilla on the lobule are very variable, even within a single specimen (Tamás Pócs, pers. comm., May 2015). Some of these specimens were at first assigned to *C. cuneifolia*, but that species has consistently smaller lobules. Widespread in tropical Africa.

**Cololejeunea* sp. Epiphyllous, 750 m, rare. This very small *Cololejeunea* with conically mamilllose cells resembles the North American *C. diaphana* A. Evans but is distinct (Tamás Pócs, pers. comm., August 2015). It will be described as a new species in a subsequent paper.

Colura digitalis. Epiphyllous, 800–820 m, occasional and always in very small quantity.

Colura dusenii. Epiphyllous in swamp forest, 750 m, rare.

[*Diplaisiolejeunea aulae*. Epiphytic on boughs in crown of *Lophira* Banks ex C.F.Gaertn. and on upper part of bole of *Antiaris africana* Engl. (Jones & Harrington, 1983).]

**Drepanolejeunea cultrella*. Epiphyllous, 680–840 m, occasional or locally frequent. Widespread in tropical Africa.

Drepanolejeunea physaefolia. Epiphytic in canopy, 800 m, rare.

Lejeunea anisophylla Mont. Epiphyllous and epiphytic on tree trunks and twigs, 420–815 m, frequent. African collections formerly named *L. caespitosa* (e.g. *sensu* Jones, 1972) have been assigned to *Lejeunea anisophylla* (Reiner-Drehwald & Schäfer-Verwimp, 2008; Pócs, 2010).

Lejeunea autoica. Epiphyllous and epiphytic on tree trunks and twigs, 400–840 m, frequent.

Lejeunea brenanii. Epiphytic on branches and twigs in canopy, 750–840 m, very locally abundant.

Lejeunea confusa. Epiphytic and on twigs, 540–805 m, occasional.

Lejeunea eckloniana. Epiphytic, epiphyllous and on rotten wood and dead twigs, 440–840 m, frequent or abundant. Many of the specimens collected have apiculate leaves, and thus resemble *Taxilejeunea conformis*, which was not found in the forest.

Lejeunea flava s.l. Epiphytic, especially in canopy, 560–840 m, locally frequent. Sterile material, not identifiable to species, belonging to the *L. flava* complex was collected on a number of occasions. It may be that all of it is *L. brenanii*, which seems to be the most common canopy epiphyte of this complex in Atewa Forest, but the occurrence (albeit rarely) of *L. ramosissima* and the record of *L. flava* subsp. *tabularis* by Jones (Jones & Harrington, 1983) indicate that other members of the complex are also present.

[*Lejeunea flava* subsp. *tabularis*. Epiphytic on bough in crown of *Cassipourea* Aubl., as *L. grossecristata* (Jones & Harrington, 1983).]

**Lejeunea ramosissima*. Epiphytic on branches in canopy, 830 m, rare. Widespread but apparently rather scarce in tropical Africa.

Lejeunea setacea. Twig of liana, 535 m, rare.

Lejeunea tuberculosa. Trunk of cocoa tree, 300 m, rare. This plant was at first assigned to *L. obtusata*. However, careful examination by M. Wigginton ruled out that species. The distal cell of the free margin is not elongated and does not reach or overlap the apical tooth. On the other hand, the arrangement looks very like that of *L. tuberculosa*, and other characters, such as the crenulate lobe margin, also suggest this species. Unfortunately no perianths are present in the collection.

**Lejeunea villaumei*. Tree trunk, 540 m, rare. Identification confirmed by M Wigginton. Known from several countries in eastern and southern Africa

and the eastern African islands but this is the first record from western Africa.

Two further species of *Lejeunea* were collected that have so far defied identification. One, an epiphyllous plant found at 800 m, resembles *L. autoica* but differs in several respects. It has differently-shaped perianths, fewer stem medullary cells, a deeper sinus between the lobule keel and lobe margin, a different apical tooth and lobule mouth structure, and rather large underleaves with lobes not ending in two uniseriate cells. The other, epiphytic on twigs and bark at 540–625 m, is similar but with compressed rather than terete perianths. It also resembles the description of *L. ibadana*, but the leaf cells are too small for that species.

Leptolejeunea astroidea. Epiphyllous, mainly in humid places, 560–840 m, locally abundant.

Leptolejeunea maculata. Epiphyllous in humid places, 680–820 m, occasional.

Lopholejeunea nigricans. Damp shaded rocks by streams, 350–630 m, locally abundant.

Lopholejeunea subfusca. Epiphytic, including on cocoa tree, rarely saxicolous, 300–820 m, frequent.

[*Marchesia excavata*. Near top of bole of large *Lophira* and on large branch of *Cassipourea* (Jones & Harrington, 1983).]

Mastigolejeunea auriculata. Epiphytic on branches in canopy and on cocoa tree, 395–750 m, rare.

Mastigolejeunea florea. Epiphytic and saxicolous, 350–550 m, rare.

Mastigolejeunea nigra. Epiphytic on tree trunks, including cocoa trees, 395–450 m, rare.

Microlejeunea africana. Epiphytic on bark and twigs and epiphyllous, 490–840 m, frequent.

**Microlejeunea kamerunensis*. Epiphyllous and epiphytic, 490–810 m, rare. Widespread in tropical Africa.

**Odontolejeunea lunulata*. Epiphyllous, 800 m, rare but very locally abundant. Widespread in tropical Africa.

Prionolejeunea grata. Epiphyllous and epiphytic in humid places, 680–815 m, rare.

[*Pycnolejeunea contigua*. Boughs in crown of *Lophira* (Jones & Harrington, 1983).]

Schiffneriolejeunea fragilis. Epiphytic, including on cocoa tree, 390–550 m, rare.

**Schiffneriolejeunea pappeana*. Epiphytic on branches in canopy, 810–815 m, rare. Widespread in sub-Saharan Africa.

Stictolejeunea balfourii. Exposed tree roots and tree bases, 440–840 m, occasional.

Taxilejeunea pulchriflora. Epiphyllous and on twigs and leaf petioles, 680–810 m, rare.

Lepidoziaceae

Bazzania decrescens subsp. *molleri*. Tree trunks in swamp forest, 750 m, rare but very locally frequent. Ghanaian material differs slightly from material seen

in Malawi and Uganda, having larger leaf cells and something approaching a weak vitta.

Lepidozia succida. Earthy banks and tracksides, occasionally on rocks or exposed tree roots, 300–840 m, frequent to locally abundant. This is essentially a lowland taxon, and only poor material was collected from altitudes over about 700 m.

Telaranea coactilis. Rotten wood, 840 m, rare.

Telaranea nematodes. Dead and rotten wood, occasionally epiphytic on tree trunks, 350–760 m, frequent.

Lophocoleaceae

Cryptolophocolea martiana (Nees) L.Söderstr., Crand.-Stotl. & Stotler. Rotten wood, dead twigs and dead vegetation, occasionally epiphytic, 350–805 m, abundant. This taxon was recently transferred into the newly described genus *Cryptolophocolea* by Söderström et al. (2013), having formerly been included in both *Chiloscyphus* and *Lophocolea*.

Heteroscyphus dubius. Epiphytic on tree trunks and on standing dead timber, 350–840 m, frequent or locally abundant. Less common in the forest than *Cryptolophocolea martiana*.

Plagiochilaceae

Plagiochila fusifera. Epiphytic on tree bases, 560–630 m, occasional.

Plagiochila integerrima. Shaded rocks and banks by streams; once epiphytic on a liana, 350–840 m, frequent and locally abundant.

Plagiochila moenkemeyeri. Epiphytic, usually on tree trunks, 390–840 m, occasional, locally frequent. Some of the material collected in Atewa Forest corresponds to the '*P. effusa*' form with fragile leaves.

Plagiochila neckeroidea. Epiphytic, usually on tree trunks; occasionally epiphyllous, 440–690 m, occasional or locally frequent.

Plagiochila pectinata. Epiphytic, 800 m, rare.

Plagiochila praemorsa. Epiphytic and epiphyllous, 440–820 m, frequent and locally abundant.

Plagiochila salvadorica. Epiphytic on tree trunks, 750 m, rare but very locally frequent.

Plagiochila strictifolia. Epiphytic on tree trunks, but also often on twigs and small branches; occasionally epiphyllous or on leaf petioles, 680–840 m, frequent and locally abundant.

Cephaloziellaceae

**Cylindrocolea nigerica*. Epiphytic on tree trunks and on dead wood, 440–630 m, occasional. Supposedly the rarest of the western African species of this genus, this was the only one collected in Atewa Forest. Otherwise known only from Nigeria and, apparently, Djibouti.

Mosses

Fissidentaceae

**Fissidens danckelmannii*. Epiphytic, 360 m, rare. According to Ida Bruggeman-Nannenga (pers.

comm., March 2015), 'This probably is *F. danckelmannii* Müll.Hal., a species of which the type is lost'. Otherwise known only from Cabo Verde and Equatorial Guinea (Rio Muni).

**Fissidens glaucissimus*. Rocks and earth banks, 400–625 m, occasional. Widespread in tropical Africa.

**Fissidens grandifolius*. Old earthy stump, 760 m, rare. Widespread in tropical western Africa.

Fissidens intramarginatus. Rocks, 840 m, rare.

**Fissidens lachmannii*. Epiphytic on tree trunk, 840 m, rare. Det. Ida Bruggeman-Nannenga. A rare African endemic otherwise known only from Cameroon, Côte d'Ivoire, Equatorial Guinea (Bioko) and Uganda.

Fissidens marthae. Epiphytic and on banks, 440–840 m, occasional.

**Fissidens microcarpus*. Epiphytic on tree trunks, 540 m, rare but very locally frequent. Widespread in tropical western Africa.

Fissidens pellucidus. Earth banks, 800–840 m, occasional.

**Fissidens porrectus*. Earth bank, 800 m, rare. There is also an old specimen of *F. porrectus* ('expr. *rufolimbatus*' – Ida Bruggeman-Nannenga, pers. comm., March 2015) in GC, collected in Atewa Forest by Prof. G. W. Lawson in 1971. Widespread in sub-Saharan Africa.

**Fissidens punctulatus* Sande Lac. On ground and epiphytic, 810–840 m, occasional. This species is listed as *F. ellipticus* in O'Shea (2006), but that species was synonymised with *F. punctulatus* by Bruggeman-Nannenga & Arts (2010). Widespread but rather scarce in sub-Saharan Africa; also known from SE Asia, Australasia and Oceania.

Fissidens ramulosus. Earthy banks and rocks, 350–450 m, occasional.

Fissidens sciophyllus. Tree trunks, 750 m, rare.

Fissidens submarginatus. Earth banks, 350–490 m, occasional.

Fissidens weirii. Saxicolous, 800 m, rare. Originally named *F. dasyphus* Welw. & Duby, this taxon was synonymised with the neotropical *F. weirii* (Bruggeman-Nannenga & Pursell 1996). However, the authors of that paper later had second thoughts, considering that *F. dasyphus* should probably be reinstated as the correct name (Ida Bruggeman-Nannenga, pers. comm., March 2015). According to Bruggeman-Nannenga & Pursell (1996), 'The type specimen and other specimens of this African species (*F. dasyphus*) differ from the neotropical populations (*F. weirii*) only in the absence of the short spurs of the limbidium that penetrate the chlorophyllose laminal cells'.

Dicranaceae

**Leptotrichella subnitidula*. Earth bank, 800 m, apparently rare but almost certainly overlooked, as it is a very inconspicuous plant. *L. nitidula* has been

recorded from Ghana before (Bizot, 1967, reported in Schultze-Motel, 1975) but the Atewa Forest specimen matches the description and illustration of *L. subnitidula* in Potier de la Varde (1936), with slightly falcate leaves that taper gradually from the base to a long fine apex, and an erect capsule with a persistent and conspicuous annulus and a longly rostrate lid. There is an old specimen of the same species in GC, collected in Atewa Forest by Prof. G. W. Lawson in 1971. Otherwise known only from Central African Republic, Democratic Republic of Congo and Gabon.

Leucobryaceae

**Campylopus hensii*. Epiphytic on dead tree trunk, 625 m, rare. Widespread in sub-Saharan Africa.

Campylopus savannarum. Branches in canopy, 540–840 m, frequent or locally abundant. Although this species is described in Frahm (1985) as having a hyaline hair-point or a sub-hyaline yellow awn, the awn of the specimens collected in Atewa Forest is green, albeit very long and narrow.

**Leucobryum cameruniae*. Rotten wood, 550–840 m, rare. This name must be regarded as provisional, as *Leucobryum* in Africa is in need of revision. The specimens from Atewa Forest strongly resemble the type of *L. cameruniae* but are a little more slender (Len Ellis, pers. comm., March 2015). Scarce in western Africa.

Calymperaceae

Calymperes afzelii. Epiphytic, 350–750 m, frequent but usually in small quantity.

Calymperes erosum. Epiphytic and on dead wood, 400–840 m, occasional and in small quantity.

Calymperes palisotii. Epiphytic, 440–625 m, occasional but always in small quantity.

Calymperes pallidum. Epiphytic on base of palm tree in Kibi, 300 m, rare. This is a casual record, from outside Atewa Forest.

**Chameleion cryptocarpus*. Epiphytic, 410 m, rare. Otherwise known in Africa only from Democratic Republic of Congo, Gabon and Guinea; also central and southern America.

Leucophanes angustifolium. Epiphytic on branches, 690 m, rare.

Leucophanes molleri. Epiphytic and on rotten wood, 625–840 m, occasional to locally frequent.

Octoblepharum albidum. Epiphytic on tree trunks and standing dead wood, 620–745 m, occasional to locally frequent.

**Syrrhopodon africanus*. Epiphytic, 540–810 m, occasional. Widespread in tropical Africa; also central and southern America.

**Syrrhopodon gardneri*. Epiphytic in humid places, 750–805 m, rare. Widespread in tropical Africa; pantropical.

**Syrrhopodon parasiticus*. Epiphytic on fallen tree, 750 m, rare. *Det.* L. Ellis. Otherwise known in Africa

only from Cameroon and disjunct in Madagascar and Réunion; pantropical.

**Syrrhopodon perdusenii*. Epiphytic on fallen tree near forest pool, 750 m, rare. *Det.* L. Ellis. Otherwise known in Africa only from Cameroon and Uganda.

Pottiaceae

Bryoerythrophyllum campylocarpum. Stonework in Kibi, 300 m, frequent. This is a casual record, from outside Atewa Forest.

**Hyophila involuta*. Rock by stream, 360 m, rare. There are many names in African *Hyophila*, but there seems to be no compelling reason to name this sample anything other than *H. involuta*. The genus is in need of revision, and many of the existing names are probably synonyms of *H. involuta*. Widespread in sub-Saharan Africa; pantropical and also present in subtropical and warm-temperate areas.

Bryaceae

**Brachymenium nepalense*. Branches in canopy, 815 m, occasional. Widespread in sub-Saharan Africa; also Asia, Australasia, Oceania.

Bryum apiculatum. Earth banks and rocks by streams, 350–410 m, occasional.

Orthotrichaceae

Groutiella laxotorquata. Epiphytic on higher parts of tree trunks and branches in canopy, 400–840 m, occasional to locally frequent.

Macromitrium sulcatum var. *sulcatum*. Epiphytic on branches, twigs and other vegetation (e.g. orchids) in canopy, 750–840 m, frequent to locally abundant.

Racopilaceae

**Racopilum africanum*. Epiphytic and on rotten wood, 815–840 m, occasional. Characterised by the rather short leaves, the large, slightly mamillate lamina cells 15–20 µm long, the weakly but variably differentiated alar cells forming very weak auricles, the strong marginal teeth, and having relatively few stereids in the nerve. Widespread in tropical Africa.

**Racopilum buettneri*. On branches fallen from canopy, 745 m, rare. This species is close to *R. crassiuspidatum*, but differs by some of the characters mentioned in the key by Potier de la Varde (1936): it has shorter, more ovate leaves with a more contracted leaf base, relatively well-differentiated alar cells forming weak auricles, and small, relatively strongly mamillate lamina cells 12–15 µm long. An additional character that may be useful, based on the specimens collected in Atewa Forest, is that the nerve is relatively deep in transverse section, strongly convex dorsally, with more stereid cells than in any of the other species. Widespread in tropical western Africa.

**Racopilum crassiuspidatum*. Epiphytic, especially on branches in canopy, and saxicolous on iron-rich rock, 380–840 m, frequent. Characterised by the rather long, oblong leaves, the often relatively small cells 12–15(–20) µm long, the well-differentiated alar

cells forming weak auricles, the variable marginal teeth, and having relatively few stereids in the nerve, seen in transverse section. Otherwise known only from Central African Republic and Gabon.

**Racopilum marginatum*. Saxicolous, 390 m. Easily recognised by the clearly differentiated band of elongate marginal cells. Other characters include the leaves tapering rather gradually, the large laminal cells 15–20 µm long, the very well differentiated alar cells, and having relatively few stereids in the nerve. Widespread but apparently scarce in tropical Africa.

Previous records of *Racopilum* from Ghana have been assigned to either *R. capensis* or *R. orthocarpioides*. It seems likely that *R. capensis*, which has leaf cells 7–12 µm long (Magill & van Rooy, 1998), much smaller than in any of the specimens found in Atewa Forest, should be more narrowly circumscribed as a southern African species; and none of the specimens found in Atewa Forest has the distinctive ‘shouldered’ leaf shape of *R. orthocarpioides*, illustrated by Potier de la Varde (1927). On the other hand, according to van Zanten (pers. comm., reported in O’Shea, 2006), all the African species of *Racopilum* may belong to *R. africanum*. However, until and unless that conclusion is published, it is considered preferable to reflect the considerable range of variation in the specimens collected in Atewa Forest by adhering to the current nomenclature.

Leucomiaceae

Leucomium strumosum. Epiphytic, on rocks, forest floor and dead wood and twigs, 400–815 m, frequent.

Pilotrichaceae

Callicostella africana. Rocks, compacted soil on tracks and occasionally on dead wood, 300–750 m, frequent. Apparently the most frequent member of the genus in Atewa Forest, this species is characterised by the strongly toothed leaves, not expanded at the base, the nerves fairly strongly toothed dorsally near the apex, the upper leaf cells small, longer than wide, 6–10 × 8–12 µm, strongly papillose and variably thickened at the angles. These plants were assigned to this species rather than *C. brevipes* on the basis of the strong papillae. The position of the papillae on the cells is highly variable, making this part of the key in Demaret & Potier de la Varde (1952) virtually impossible to use.

**Callicostella attenuata*. Rocks, 840 m, rare. Rather similar to *C. africana*, but this specimen was assigned to *C. attenuata* on the basis of the slightly less strongly toothed leaves, the expanded leaf base and the predominantly slightly smaller (no more than 8 µm wide) and more isodiametric upper leaf cells. Scarce in tropical western Africa.

**Callicostella erosotruncata*. Rocks by stream and epiphytic, 620–690 m, occasional. This species has truncate or sometimes emarginate leaves, with the

nerves strongly convergent at the apex, strongly toothed above dorsally and ending very close to the leaf margins; the upper leaf cells are small and nearly isodiametric. Widespread in tropical western Africa and also recorded from Tanzania and Mauritius.

**Callicostella gabonensis*. Rotten wood, 690 m, rare. Like *C. erosotruncata*, this has strongly convergent nerves that are strongly toothed above dorsally, but the leaves are acute at the apex; the upper leaf cells are rather elongate, thick-walled, and strongly papillose, with corner thickenings. The strong papillae are suggestive of *C. chevalieri*, according to the key in Demaret & Potier de la Varde (1952), but it lacks the strongly elongated marginal cells of that species. Scarce in tropical western Africa.

**Callicostella perpapillata*. Epiphytic, 690–750 m, occasional. This species is characterised by the quite strongly elongate (15 µm or more long) and strongly papillose upper leaf cells, with thick walls and corner thickenings, along with the strongly toothed leaves and the nerves strongly toothed dorsally near the apex. Widespread in tropical western Africa and also recorded in Tanzania and Uganda.

**Callicostella seychellensis*. Rotten log, 360 m, rare. The leaves are strongly toothed, but the upper leaf cells are elongate (up to 20 µm long, or even more), and only weakly papillose. Widespread in tropical western Africa and disjunct in the eastern African islands.

Callicostella is a common feature of Atewa Forest, often occurring on soil, rocks, trees and rotten wood. It is a difficult genus because the species are extremely plastic, with leaf shape, dentition, cell size and shape, and nerve characters all varying considerably, even from leaf to leaf on a single stem. Demaret & Potier de la Varde (1952) remains the standard treatment for the African species, but there are almost certainly far too many names in the African flora, and any new taxonomic and molecular work would be expected to reduce these considerably. Demaret & Potier de la Varde (1952) was used to determine the species, but several of the dichotomies in the key do not work well, and the assignment of a specimen to one species or another is sometimes arbitrary. We have tried to be conservative and sensible, so that the names given here are at least credible. There is certainly a considerable range of variation within *Callicostella* in Atewa Forest, but whether the species listed above actually represent discrete taxonomic entities is another matter.

**Cyclodictyon krebedjense*. Epiphytic and on old earthy stump, 750–760 m, occasional. Whether this is assigned to var. *argutidens* depends largely on which leaf from the stem is examined. Widespread but scarce in tropical western Africa and also recorded in Kenya.

**Cyclodictyon vallis-gratiae*. Rocks by streams, 450 m, rare. Possibly 'forma *breutelianum*' but this probably has no taxonomic value. Widespread in sub-Saharan Africa.

**Lepidopilidium devexum*. Epiphytic on branches, both in canopy and below, and occasionally on tree bases and epiphyllous, 625–840 m, frequent or locally abundant. These plants were named on the basis of the slightly revolute leaf margins, with nerves reaching from about 1/3 to over 1/2 the leaf length, and the short, slightly papillose seta with a more or less horizontal capsule. Otherwise known only from Equatorial Guinea (Bioko and Rio Muni), Cameroon and Tanzania.

**Lepidopilum niveum*. Epiphytic in swamp forest, 690 m, rare. Scarce in tropical western Africa.

Thuidiaceae

Pelekium gratum. Rotten wood and rocks, 350–500 m, frequent or locally abundant.

Pelekium varians. Epiphytic and on rocks, 300–840 m, abundant.

A key to *Pelekium* was produced recently by Phephu et al. (2013).

Meteoriaceae

Aerobryopsis capensis. Epiphytic, especially on branches in canopy, often ± pendent, and epiphyllous, 750–840 m. Locally frequent.

Floribundaria floribunda. Epiphytic and epiphyllous, especially pendent from branches, 690–840 m, frequent to abundant.

Hypnaceae

Ectropothecium afromolluscum. Epiphytic, 750–840 m, rare. This is an easily recognised species, as it strongly resembles the European boreo-temperate *Ctenidium molluscum*. The leaves are strongly falcato-secund, with the stem leaves and branch leaves differing significantly in shape, and the cells smooth or very weakly prorate.

**Ectropothecium regulare*. Epiphytic, saxicolous, on the ground and on fern stipes, 350–840 m, abundant. This, interpreted in a broad sense, is by far the most frequent of the three *Ectropothecium* taxa that have been identified from Atewa Forest. It is characterised by the more or less regularly pinnate branching, the neatly complanate and secund leaves, not unlike a species of *Hypnum*, and the leaf cells prorate to some degree. It is very variable in leaf shape, cell size and how prorate the cells are, and it may be that more than one taxon is involved. For example, some specimens are quite strongly prorate, while others are less so and seem to match the description of *E. perrotii*, a southern and eastern African species, whereas *E. regulare* is widespread in sub-Saharan Africa. African *Ectropothecium* is in need of revision, and it is considered prudent to treat the Atewa Forest specimens conservatively until that work has been done.

**Ectropothecium revolutum*. Dead and rotten wood, occasionally epiphytic, 300–760 m, occasional. Specimens were assigned to this species on the basis of the hardly falcate, narrowly lanceolate to acuminate leaves that taper gradually to a long fine, weakly toothed acumen. The perichaetial leaves are variably toothed at the apex. However, the name must be regarded as provisional. It seems to be a lowland species: the single specimen from 760 m is depauperate, although it is fertile. Scarce in tropical western Africa and also recorded in Tanzania.

Rhacopilopsis trinitensis. Epiphytic and on rotten wood and other organic detritus on the forest floor, 300–840 m, frequent or locally abundant.

**Rhacopilopsis variegata*. Epiphytic, 840 m, rare. Only a fragment of this species was found, collected inadvertently in a packet of other samples, but the characteristic alar and sub-alar cells are present. Widespread in sub-Saharan Africa, but less common than *R. trinitensis*.

**Vesicularia galerulata*. Epiphytic, and on banks, rotten wood and twigs, 400–815 m, frequent or locally abundant. Previous collections of *Vesicularia* from Ghana have been assigned to *V. ischyropteris*. However, material collected in Atewa Forest is indistinguishable from material collected elsewhere in Africa as *V. galerulata*. *V. ischyropteris* apparently has a longer and more abruptly tapering leaf apex (especially in the stem leaves) but, as Hedenäs & Watling (2005) say; '*Vesicularia ischyropteris* (Broth.) Müll.Hal. is closely related to *V. galerulata* and the relationship between these two taxa should be studied further'. Widespread in sub-Saharan Africa.

Pylaisiadelphaceae

**Isopterygium conangium*. Rotten wood, 750–840 m, occasional. Plants assigned to this species are small and untidy-looking, with relatively shortly pointed leaves with ± recurved margins and leaf cells variable in width, ca 7–10 µm wide; the basal cells at the leaf insertion are variable, but are not as notably or consistently lax as in *I. palmarum*. They are clearly close to *I. mbangae*, but are retained in *I. conangium* for now, as this is a widespread western African taxon, whereas *I. mbangae* is from central and eastern Africa.

**Isopterygium gabonense*. Saxicolous, 350 m, rare. Plants assigned to this species are neater than *I. conangium*, shiny (looking like *Plagiothecium* spp.), with rather wide, long, densely complanate leaves with plane margins, relatively shortly acuminate apices and leaf cells uniformly ca 6 µm wide; the basal cells at the leaf insertion are variable, but not as notably or consistently lax as in *I. palmarum*. Scarce in tropical western Africa.

**Isopterygium palmarum*. Fallen timber and rotten wood, 350–760 m, occasional. Plants assigned to this

species have very long narrow leaves, gradually drawn out to a very long, slender \pm uniseriate apex and leaf cells uniformly ca 6 μ m wide; the basal cells at the leaf insertion are notably lax. On the basis of existing descriptions, these specimens could almost equally well be assigned to *I. leucophanes*, but that occurs mainly in southern and eastern Africa, whereas *I. palmarum* is a scarce western African taxon.

These determinations of *Isopterygium* species are highly provisional, as the genus requires revision in Africa, and there are almost certainly many more names than there are species.

**Taxithelium planum*. Epiphytic on branches, 690 m, rare. *Taxithelium* subgenus *Taxithelium* was revised by Câmara (2011), and *T. planum* was confirmed as the most widespread species. Scattered in western in Africa, its main centre of distribution is in central and southern America.

Sematophyllaceae

Radulina borbonica. Dead and rotten wood, 300–760 m, occasional, and always in small quantity.

**Sematophyllum fulvifolium*. Rotten log, 490 m, rare. One plant was assigned to this taxon, which is as small as *S. subpinnatum* but with the leaves resembling those of *S. subsimplex*. Recorded in several western African countries, and disjunct in Tanzania and Mauritius (Rodriguez).

**Sematophyllum subpinnatum*. Epiphytic, 300–840 m, occasional or locally frequent. Recognisable by the short, wide ovate leaves and short leaf cells. Widespread in tropical Africa; probably pantropical.

Sematophyllum subsimplex. Epiphytic on branches in canopy, 830 m, rare. Larger than *S. subpinnatum*, with longer, lanceolate leaves and relatively long leaf cells.

Trichosteleum chrysophyllum. Epiphytic and on dead and rotten wood, 300–420 m, occasional. This identification can only be regarded as tentative. The specimens collected in Atewa Forest have narrowly lanceolate or acuminate leaves, which are variably recurved and very weakly denticulate at the margins, conspicuously papillose leaf cells and a smooth seta. One of the specimens has larger and laxer cells and may prove to be a different taxon. Of the other two species recorded previously in Ghana, *T. stictum* has the seta rough at the apex and *T. staudtii* has shorter leaves (Potier de la Varde, 1936). *Trichosteleum* in Africa is in need of revision. Buck (1993) says; ‘Unfortunately there are many African names in *Trichosteleum* and I have not had the opportunity to find types for more than a handful; the descriptions are singularly unhelpful.’ Little has changed in the last 23 years.

Pterobryaceae

Jaegerina scariosa. Tree trunk, 625 m, rare.

Orthostichidium involutifolium subsp. *involutifolium*. Epiphytic, especially in canopy, usually \pm pendent, 750–840 m, frequent to locally abundant. Superficially similar to *Orthostichella versicolor* but considerably more robust, so easily distinguished in the field.

Neckeraceae

**Homaliodendron piniforme*. Epiphytic, 560–840 m, frequent. Widespread in tropical Africa; also central and southern America.

Neckeropsis disticha. Epiphytic and on rotten wood, 350–815 m, occasional.

**Neckeropsis foveolata*. Epiphytic on shaded branches, 625 m, rare. Widespread in tropical western Africa; also central and southern America.

Neckeropsis liliana. Epiphytic on shaded branches, 625 m, rare.

Orthostichella versicolor (Müll.Hal.) B.H.Allen & W.R.Buck. Epiphytic and epiphyllous, especially pendent from branches, 690–840 m, frequent to abundant. This species is listed in O’Shea (2006) as *Pilotrichella communis*, which is now considered synonymous with *O. versicolor* (Allen & Magill, 2007).

Orthostichella welwitschii (Duby) Allen & Magill. Epiphyllous and epiphytic on fallen tree, 750–840 m, rare. This species is listed in O’Shea (2006) as *Pilotrichella sordidoviridis*, which is now considered synonymous with *O. welwitschii* (Allen & Magill, 2007).

**Pimmatella minuta*. Epiphytic and on damp shaded rocks by streams, 350–625 m, occasional but in always in very small quantity. Widespread in sub-Saharan Africa; also central and southern America.

Porotrichum caudatum. Epiphytic on tree trunk, 815 m, rare.

**Porotrichum elongatum*. Epiphytic, on leaf petioles and on rock, 350–810 m, frequent and locally abundant. Widespread in sub-Saharan Africa.

**Porotrichum quintasii*. Epiphytic, 800–840 m, occasional to locally frequent. Widespread in tropical western Africa.

Porotrichum stipitatum. Damp shaded rocks by streams and on shaded tree trunks, 420–840 m, occasional to locally frequent.

Conclusions

It is clear from this very limited survey that Atewa Forest is an important area for bryophytes and that bryophytes are an important component of the overall biodiversity of the forest. As this kind of upland forest is so scarce in Ghana, and increasingly so in western Africa generally, there are few other areas in the region that are even potentially as rich. The main communities of conservation importance are those associated with humid forest, which occurs on the highest hills and in small pockets of swamp

forest, where there are diverse assemblages of epiphytes and epiphylls, many of them rare or absent elsewhere in the region, as far as is known. A total of 164 taxa was recorded, of which about (considering some specimens have not yet been definitively named) 13 species of liverwort and 45 species of moss are reported here as new to Ghana. These include a new species of *Cololejeunea* that will be described later in a separate paper. It is difficult to comment on the significance or rarity of individual species, as the frequency and conservation status of most African bryophytes is so poorly known, and there are also taxonomic issues in many groups, but *Cylindrocolea nigerica*, *Chameleion cryptocarpus*, *Jaegerina scariosa*, *Leptotrichella subnitidula*, *Racopilum crassispicatum* and *Syrrhopodon perduse-nii* are all rarely recorded species, and *Lejeunea villau-mei* and *Syrrhopodon parasiticus* are new to western Africa. It could be argued that the most threatened species in the forest are those that are confined to lower altitudes, where the anthropogenic pressures are greatest. These include *Chameleion cryptocarpus*, *Jaegerina scariosa* and *Lejeunea villaumei*. On the other hand, the extent of the high altitude forest is of course much more limited, and it supports a much higher diversity of bryophytes.

The other important aspect of the bryophytes of Atewa Forest is their biomass. There is an enormous quantity of bryophyte material, particularly in the humid forest areas, that is bound to contribute significantly to the water-retentive capacity of the forest, absorbing water quickly and releasing it slowly. It is clear that the bryophytes are an important part of the ecosystem generally, helping to stabilise the hill-sides and acting as a source of water.

This survey therefore contributes further evidence for the importance of Atewa Forest and the necessity for conserving it and managing it properly.

There is much work still to be done, both in Atewa Forest and elsewhere in Ghana. This survey has merely scratched the surface, revealing a rich bryophyte flora, but there are bound to be other, as yet undiscovered, species in other parts of the forest. Surveys in other forest areas in Ghana would also help to place Atewa in context. More taxonomic research is also needed. Several groups are still very poorly known in Africa, with *Callicostella*, *Ectropothecium*, *Isopterygium*, *Leucobryum*, *Racopilum* and many genera in the Sematophyllaceae in particular in urgent need of revision.

Acknowledgements

We would like to offer our sincere thanks to several organisations and individuals. A Rocha supplied much logistical assistance, including personnel, advice, transport, accommodation and food. In particular, the support of Seth Ken Appiah-Kubi, head

of A Rocha Ghana, was crucial in organising the field-work. Dr Jeremy Lindsell (A Rocha UK) supplied maps and useful advice and comments. We would like to thank the University of Ghana, especially Prof. Gabriel Ameka and Prof. Alfred Oteng-Yeboah, for allowing two of their staff to join the team, and for hospitality and useful discussions after the fieldwork. We would also like to thank the people of Kibi for their unfailing friendliness and hospitality.

N.G.H. would like to thank the British Bryological Society Bequest Fund for a generous contribution, which covered the cost of his air fare to Ghana.

We would also like to thank the following bryologists, who helped with identifying or confirming specimens, supplying information or institutional support: Ida Bruggeman-Nannenga (Zeist), Dr Paolo Câmara (Universidade de Brasilia), Len Ellis (Natural History Museum, London), Dr Lars Hedenäs (Naturhistoriska riksmuseet, Stockholm), Dr David Long (Royal Botanic Garden Edinburgh), Howard Matcham (Chichester), Dr Tamás Pócs (Eszterházy Károly College, Eger), Martin Wigginton (Peterborough) and Jo Wilbraham (Natural History Museum, London).

Taxonomic Additions and Changes: Nil.

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