

Bryophytes in the vicinity of Jenolan Caves, New South Wales

A. J. Downing, H. P. Ramsay and W. B. Schofield

Abstract

Downing, A.J.¹, Ramsay, H.P.¹ & Schofield, W.B.² (¹ School of Biological Sciences, Macquarie University, Sydney, NSW, Australia 2109; ² Department of Botany, University of British Columbia, Vancouver, B.C., V6G 2B1, Canada) 1991. *Bryophytes in the vicinity of Jenolan Caves, New South Wales* *Cunninghamia* 2(3): 371-384. A total of 115 bryophytes (96 mosses in 56 genera, 18 hepatics in 12 genera, and one anthocerot) were collected from eight localities in the vicinity of Jenolan Caves, and two localities at Kanangra Walls in the Central Tablelands of NSW. Geology, vegetation, climate and European settlement appear to influence distribution of bryophytes within the Jenolan Caves Reserve. The species list includes 5 new records of mosses for New South Wales and 18 additions to the mosses of the Central Tablelands. The bryophyte assemblage on limestone at Jenolan Caves is unique and distinctive, and many species present on limestone at Jenolan are either not present or not common on the sandstones and shales of the nearby Blue Mountains plateau.

Introduction

The Jenolan Caves are located in an elongated body of limestone in the Jenolan River Valley in the Great Dividing Range, 110 km west of Sydney and 30 km south-west of Katoomba, NSW (33°47'S, 150°05'E) (Figure 1). The blue-grey cliffs of Jenolan Caves Limestone form a massive barrier across the bottom of the valley, 790 metres above sea level. Three streams meet at a point below the Grand Arch (Figure 2) and flow eastward as the Jenolan River. Surveyors Creek flows from the south-west, and has cut through the limestone ridge to form the Grand Arch. Two streams, McKeown's Creek from the north, and Camp Creek from the south flow through the limestone, each creating a complex system of caverns for approximately 1 km on each side of the Grand Arch (Dunlop 1967). The Jenolan River runs through a young, steep-sided, v-shaped valley cut into the eastern side of the Great Dividing Range.

The main body of limestone at Jenolan is an ancient, Upper Silurian coral reef, composed of quite pure fossiliferous limestone, 96% to 99% calcium carbonate. Limestone lenses interbedded with shale are found 1.5 km to the east of Jenolan Caves (Chalker 1970).

The western valley sides are steep slopes derived from chert, with a spilite intrusion in the vicinity of Caves House. To the east a sequence of sediments and volcanics includes shales, pyroclastic rocks, cherts, tuffs, quartzite, sandstone and shaley limestone (McClellan 1983). Alluvial deposits can be found in the valleys of McKeown's Creek and Camp Creek.

Climate at Jenolan Caves tends to be more extreme than that of Katoomba and the surrounding Upper Blue Mountains. Summer temperatures can exceed 40°C while winter temperatures can fall as low as -10°C. Temperatures on the plateau top are approximately 2°C to 3°C cooler than temperatures at the caves. Heavy snowfalls are not unusual in winter. Rainfall is evenly distributed throughout the year and ranges from 960 mm per annum at the Caves (790 metres a.s.l) to 1150 mm per annum on the plateau top at Jenolan State Forest, 1158 metres a.s.l (Bureau of Meteorology 1979).

Vegetation

Montane moist forest occurs at higher altitudes on moist, fertile, relatively deep clay and sandy loams. This open-forest is characterised by *Eucalyptus fastigata* and *Eucalyptus dalrympleana* subsp. *dalrympleana* occasionally with *Eucalyptus viminalis* and *Eucalyptus radiata* subsp. *radiata*. *Eucalyptus* woodland occurs on steep slopes, narrow ridges and gullies on quartzites, shales, cherts and tuffs. Characteristic species include *Eucalyptus fibrosa*, *Eucalyptus crebra*, *Eucalyptus eugenioides* and *Eucalyptus punctata* (Keith & Benson 1988).

Trees on shales in the immediate vicinity of the Grand Arch include *Eucalyptus punctata*, *Eucalyptus dives*, *Eucalyptus eugenioides* and *Eucalyptus radiata* subsp. *radiata*. Understory shrubs include *Bursaria spinosa*, *Oxylobium ilicifolium*, *Lissanthe strigosa*, *Persoonia linearis* and *Acacia falciformis*.

Vegetation on the limestone is relatively sparse *Poa* grassland, with scattered trees and shrubs. This contrasts sharply with shale, chert, rhyolite and tuff valley sides which are heavily wooded with little grass cover. Trees found on limestone include *Eucalyptus viminalis*, *Brachychiton populneus* (Kurrajong), *Acacia melanoxyton*, and *Ficus rubiginosa*. Shrubs on the limestones include *Acacia falciformis*, *Dodonaea viscosa*, *Swainsona galegifolia* and *Citriobatus multiflorus*. Climbing plants are more numerous on the limestones and include *Clematis aristata* and *Hardenbergia violacea*. Herbs include grasses (*Poa* spp., *Themeda australis*) and ferns (*Adiantum aethiopicum*). *Urtica incisa* (Stinging Nettle) is abundant in the vicinity of Caves House. Many exotic species, including *Rhododendron*, flowering cherries and roses have been planted in the gardens of the Caves House Hotel. Weeds and garden plants that have escaped from the gardens to invade the surrounding hillsides, include *Acer pseudoplatanus*, *Pinus radiata*, (Monterey pine), *Lunaria* (Honesty) and *Hypericum perforatum* (St. John's wort).

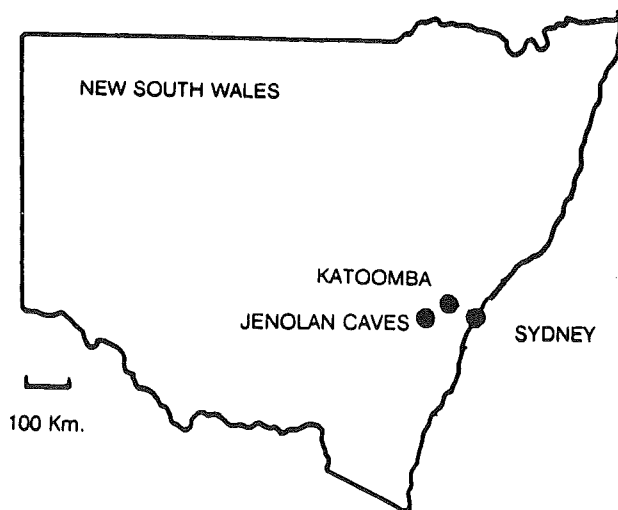


Figure 1. New South Wales showing location of Jenolan Caves.

Previous bryophyte collections from Jenolan Caves.

In the late 1890s, bryophytes were collected at Jenolan Caves by W. J. Blakely, J. H. Maiden, H. Malthouse and W. Forsyth. Among the earliest collections at the New South Wales National Herbarium are *Papillaria flavolimbata* (C. Muell. & Hampe) Jaeg. collected by H. Malthouse 572 (as *Papillaria cerina* (Hook. f. & Wils.) Par.) in August, 1898, *Tortula antarctica* (as *Tortula princeps*) J.H. Maiden (1898) 45, 368, Blakely (Oct 1899) 367, 476. Blakely collected *Thuidium sparsum* (as *Thuidium suberectum*) and *Papillaria amblyacis* (C. Muell.) Jaeg. (as *Meteorium amblyacis* (C. Muell.) Mitt. in June, 1899 (refer also to Watts & Whitelegge 1902, 1905). The National Herbarium (NSW) holds 28 mosses and 3 hepatics recorded as having been collected from Jenolan Caves (see Tables 1 & 2).

In 1901, W. J. Blakely, a gardener at Jenolan Caves and J. C. Wibur, a guide for many years and caretaker from 1903 to 1932, published *A List of Plants Collected in the Vicinity of Jenolan Caves* (Blakely & Wibur 1901). Included in the introduction by J. H. Maiden is the note 'Mr. W. Forsyth has the mosses in hand and a list of this and of other groups of plants not yet included in this preliminary Florula, may be expected in due course'. Unfortunately this list was never published and we have been unable to find the the manuscript of this list or the specimens on which it was based.

There are no detailed studies of bryophyte distribution on limestones in NSW, and indeed few published bryophyte species lists for particular localities (see Ramsay, Downing & Schofield 1990). This study was undertaken to determine the bryophyte species which occur on and in the vicinity of the Jenolan Caves limestone.

Results

Bryophytes were collected from numerous sites in the vicinity of Jenolan Caves during a number of field trips between October 1987 and December 1989. Collecting sites have been grouped into ten localities, eight in the vicinity of Jenolan Caves (Figure 2) and two in the vicinity of Kanangra Walls (Figure 3). Identifications were based on Sainsbury (1955), Scott & Stone (1976), Catcheside (1980), Scott (1985) and some more recent revisions of specific taxa including *Campylopus* (Frahm 1987) *Hypnum* (Ando 1982), *Orthotrichum* (Lewinsky 1984), *Macrocoma* and *Macromitrium* (Vitt & Ramsay 1985), *Mielichhoferia* (Shaw 1985), *Tortula* (Kramer 1988), *Thuidium* (Touw & van Haak 1990) and *Papillaria* (Streimann 1991). Reference was also made to Scott & Bradshaw (1986) for hepatics, and Streimann & Curnow (1989) for mosses.

A total of 115 bryophytes including 96 species of mosses (56 genera), 18 species of hepatics (12 genera) and one anthocerot were recorded (Tables 1 & 2) from the 10 localities. Results were based on 336 collections of mosses and 40 collections of hepatics including some earlier collections of H.P. Ramsay and D.G. Catcheside. Voucher specimens of all species collected will be deposited at the National Herbarium (NSW) for future reference and lists (as Appendices 1 & 2) will be held in the Royal Botanic Gardens Library for reference.

Details of the collecting localities are as follows; 1. *Binoomea Ridge Road* [BRR] (Figures 2, 4b): consists of steep hillside slopes, roadside cuttings and embankments of the Hampden – Jenolan Caves Road. Collections were made from the top of the plateau to Inspiration Point Lookout just above the Jenolan River. Substrata include shales, cherts, tuffs, quartzite and sandstones. Vegetation consists of *Eucalyptus* woodland with grasses (*Poa* spp.), herbs, low shrubs and climbing plants such as *Clematis aristata* and *Hardenbergia violacea*.

Table 1. Mosses collected in the vicinity of Jenolan Caves, N.S.W. (see text for locality descriptions).

Taxon	1	2	3	4	5	6	7	8	9	10
	BRR	BP	GAE	MCV	GAW	CA	SFT	OH	KW	BRC
+ <i>Amphidium cyathicarpum</i>						L				
+ <i>Anoetangium bellii</i>						L				
<i>Atrichum androgynum</i>	x									
<i>Barbula crinita</i>				x	x	x				
+ <i>Barbula luteola</i>						L				
+ <i>Barbula unguiculata</i>	x			x		x				
* <i>Bartramia papillata</i>	x			x				x		
+ <i>Brachymenium preissianum</i>						L				
* <i>Brachythecium rutabulum</i>	x		x	x		x	x			
+ <i>Brachythecium salebrosum</i>	x				x	x				
* <i>Breutelia affinis</i>	x		x				x	x		
<i>Bryum argenteum</i>			x		x	x				
<i>Bryum billardieri</i>	x					x	x	x		
<i>Bryum campylothecium</i>						x	x			
* <i>Bryum capillare</i>	x					x				
<i>Bryum clavatum</i> (<i>B. erythrocarpoides</i>)						x		x		
<i>Bryum dichotomum</i>						L				
<i>Bryum creberrimum</i>	x				x					
<i>Bryum pseudotriquetrum</i>	x					x		x		
+ <i>Bryum rubens</i>							x			
<i>Bryum torquescens</i>					x	x				
+ <i>Bryum sp. nov.</i>			x							
<i>Campylopus clavatus</i>					x				x	x
+ <i>Campylopus incrassatus</i>					x	x				
<i>Campylopus introflexus</i>	x		x	x			x		x	
* <i>Ceratodon purpureus</i>	x			x		x		x	x	
<i>Conostomum pusillum</i>										x
<i>Dawsonia longiseta</i>			x							
<i>Desmatodon convolutus</i>					x	x				
+ <i>Desmatodon recurvatus</i>					x					
<i>Dicnemoloma pallidum</i>	x		x				x			x
<i>Didymodon torquatus</i>				x						
<i>Ditrichum difficile</i>	x		x					x	x	
* <i>Encalypta vulgaris</i>			L		L	L				
<i>Fabronia australis</i>						x	x			
+ <i>Fabronia scottiae</i>						x				
<i>Fissidens asplenioides</i>					x					
<i>Fissidens humilis</i>						L				
* <i>Fissidens leptocladus</i>			x	x	x	x				
<i>Fissidens pungens</i>						L				
<i>Fissidens rigidulus</i>		x								
* <i>Fissidens taylorii</i>			L	L						
<i>Fissidens vittatus</i>	x		x	x		x				
<i>Funaria apophysata</i>					x					
<i>Funaria glabra</i>			L			L				
* <i>Funaria hygrometrica</i>				x					x	
<i>Gigaspermum repens</i>			L	L		L				
<i>Grimmia laevigata</i>						L				
<i>Grimmia pulvinata</i> var. <i>africana</i>	x		x	x	x	x	x			
<i>Grimmia trichophylla</i>								x		
<i>Gymnostomum aeruginosum</i>	x		x			x				
<i>Hedwigia ciliata</i>	x		x			x	x			
<i>Hedwigidium integrifolium</i>							x			

Taxon	1	2	3	4	5	6	7	8	9	10
	BRR	BP	GAE	MCV	GAW	CA	SFT	OH	KW	BRC
<i>Hypnum cupressiforme</i> var. <i>cupressiforme</i>						x	x	x		
+ <i>Hypnum cupressiforme</i> var. <i>lacunosum</i>						L				
<i>Hypopterygium rotulatum</i>				L						
<i>Lembophyllum divulsum</i>				L		L				
* <i>Leptodon smithii</i>			L	L		L				
<i>Lopidium concinnum</i>						L				
<i>Macrocoma tenue</i> subsp. <i>tenue</i>	x			x						
<i>Orthodontium lineare</i>	x									
<i>Orthotrichum assimile</i>	x				x	x				
<i>Orthotrichum cupulatum</i> var. <i>cupulatum</i>			L	L	L	L				
<i>Papillaria crocea</i>				x	x	x				
* <i>Papillaria flexicaulis</i>			L	L	L	L				
<i>Philonotis scabrifolia</i>	x									
<i>Philonotis tenuis</i>	x									
+ <i>Plagiomnium novaezealandiae</i>				L						
<i>Pohlia nutans</i>									x	
* <i>Polytrichum juniperinum</i>	x		x							x
<i>Pottia truncata</i>						x				
<i>Pseudoleskeopsis imbricata</i>			L	L	L	L				
<i>Ptychomitrium australe</i>			x	x		x	x			
<i>Racomitrium crispulum</i>								x		
+ <i>Racomitrium lanuginosum</i> var. <i>pruinosum</i>										x
<i>Racopilum cuspidigerum</i> var. <i>cuspidigerum</i>				x	x	x				
<i>Rhacocarpus purpurascens</i>										x
<i>Rhaphidorrhynchium amoenum</i>				x						
* <i>Rhyncostegium tenuifolium</i>	x		x			x				
* <i>Schistidium apocarpum</i>	x		x		x	x				
<i>Schizomenium bryoides</i> (<i>Mielichhoferia bryoides</i>)	x					x				
* <i>Tayloria octoblepharis</i>									x	
* <i>Thuidium cymbifolium</i>				L		L				
+ <i>Thuidium sparsum</i>	x		x	x	x	x	x			
+ <i>Tortella cirrhata</i>			L							
+ <i>Tortella dakinī</i>					L					
* <i>Tortula antarctica</i> (<i>T. princeps</i>)	x			x	x	x	x			
<i>Tortula muralis</i>			L		L	L				
<i>Tortula norvegica</i>				L						
<i>Tortula pagorum</i>					x	x	x			
<i>Tortula papillosa</i>				x		x	x			
+ <i>Trichostomum brachydontium</i>			x	x		x	x			
<i>Triquetrella papillata</i>	x			x		x				
* <i>Weissia controversa</i>	x		x		x	x				
<i>Weissia controversa</i> var. <i>gymnostoma</i>						L				
<i>Zygodon intermedius</i>						L				
Total	31	1	30	32	27	59	18	10	7	6

* = species collected at Jenolan Caves prior to 1987.

+ = additions to the species listed for Central Tablelands in Ramsay (1984).

L = occurred exclusively on limestone.

Species underlined = New records for N.S.W.

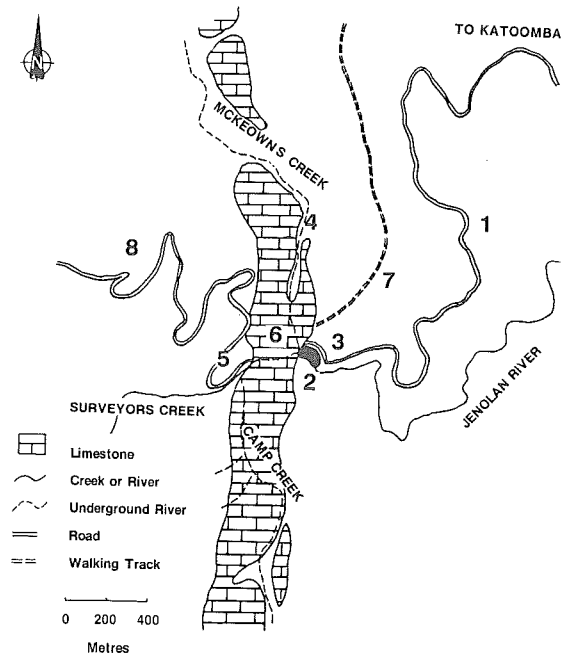


Figure 2. Jenolan Caves, NSW showing the location of collecting sites and limestone outcrops. Adapted from McClean, 1983. 1. Binoomea Ridge Road, 2. Blue Pool, 3. Grand Arch East, 4. McKeowns Valley, 5. Grand Arch West, 6. Carlotta Arch, 7. Six Foot Track, 8. Oberon Hill.

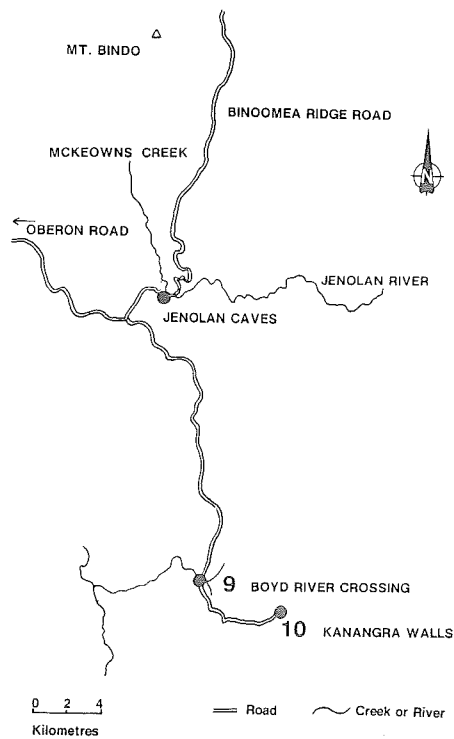


Figure 3. Collecting sites in the vicinity of Jenolan Caves.

Thirty nine species (31 mosses, 8 hepatics) were recorded along Binoomea Ridge Road. Most species collected along the road are relatively common on the sandstones and shales of the Blue Mountains. Two exceptions are *Philonotis scabrifolia* and *Atrichum androgynum*. Few epiphytes were collected, but more hepatics (8) were collected here than from any other locality.

2. *Blue Pool*. [BP] (Figure 2, 4a&b): an artificially created lake on the eastern side of the Grand Arch. The only bryophyte collected, *Fissidens rigidulus*, was growing under water, at 1.5 metres below the surface on a large, rounded, non-limestone cobble.

3. *Grand Arch East* [GAE] (Figure 2, 4a): covers the area on the eastern side of the Grand Arch, excluding the Blue Pool. Substrata include shale, limestone and rhyolite porphyry. Vegetation consists of *Eucalyptus* woodland on the lower hillsides, with *Ficus rubiginosa* on limestone outcrops, and taller eucalypts and tree ferns in moist and shaded positions.

Thirty three bryophytes (30 mosses and 3 hepatics) were recorded from this sheltered location where they are abundant on vertical, roadside rock walls, both on shale and limestone. Epilithic mosses (in particular *Orthotrichum cupulatum* subsp. *cupulatum*, *Grimmia pulvinata* and *Schistidium apocarpum*) and lichens are also abundant on the stone masonry of roadside walls. *Dawsonia longiseta* and *Reboulia hemisphaerica* were both collected from damp sand at the edge of a roadside drain below a shale rock wall. *Leptodon smithii* was collected from moist and shaded limestone boulders near the entrance to the Devils Coach House.

4. *McKeown's Valley* [MCV] (Figures 2, 5a-d): a narrow, canyon-like, limestone gully on the northern side of the Grand Arch, entered via the Devils Coach House (Figure 3). Grasses and shrubs predominate, with occasional trees of *Eucalyptus viminalis* and *Acacia melanoxylon*.

Thirty eight species (32 mosses, 6 hepatics) were collected in the valley where they obviously thrive in cool, moist and sheltered conditions. Epiphytic bryophytes, in particular, *Papillaria* spp., *Frullania* spp. and *Macrocoma tenue* subsp. *tenue* festoon the branches of shrubs and fallen logs.

One species of particular interest was *Plagiomnium novaezealandiae* which grows in luxuriant mats in seepages over rock. This species has not been reported previously from the Central Tablelands of NSW (Ramsay 1984). *Gigaspermum repens*, a species common in arid and semi arid areas of western New South Wales, occurs on soil in crevices in and between rocks.

5. *Grand Arch West* [GAW] (Figures 2, 4c): covers the western side of the Grand Arch, including Jenolan Caves House (gardens and stone walls) and the No. 1 carpark. Substrata include spilite and limestone. This sheltered position contains many exotic trees, shrubs, and introduced weed species. *Poa* grassland is present on the limestone at the rear of the hotel. Construction of buildings, roads, gardens and car parks has caused significant changes to the natural vegetation.

Thirty three species (27 mosses, 1 anthocerot, 5 hepatics) were collected on the western side of the Grand Arch. *Encalypta vulgaris*, a calcicolous moss, is present on damp rock on the western wall of the Grand Arch, and on limestone walls of the gardens. *Targionia lorbeeriana*, a thallose hepatic which we have not previously collected in the Blue Mountains, grows on damp soil in sheltered locations in the Jenolan Caves House garden, and under the shelter of overhanging vegetation along trackside embankments. *Anthoceros laevis*, an anthocerot, was also collected from similar environments. *Tortula antarctica* (*T. princeps*) and *Barbula crinita* are common on soil in the garden. *Marchantia polymorpha*, a thallose hepatic and *Bryum*

Table 2. Hepatics and anthercerote collected in the vicinity of Jenolan Caves, NSW (see text for locality descriptions).

Taxon	1 BRR	2 BP	3 GAE	4 MCV	5 GAW	6 CA	7 SFT	8 OH	9 KW	10 BRC
# <i>Anthoceros laevis</i>					x	x				
<i>Asterella drummondii</i>						L				
<i>Cephaloziella exiliflora</i>	x			x			x			
<i>Chiloscyphus semiteres</i>	x							x		
<i>Fossombronia wondraczekii</i>	x									
<i>Frullania falciloba</i>	x			x	x	x				
<i>Frullania pentapleura</i>				x		x				
<i>Frullania probosciphora</i>	x			x		x				
<i>Frullania squarrulosa</i>							x			
<i>Lophocolea biciliata</i>	x				x					
<i>Lophocolea bidentata</i>	x		x							
<i>Lophocolea novae-zeelandiae</i>					x					
<i>Lunularia cruciata</i>	x									
* <i>Marchantia polymorpha</i> var. <i>aquatica</i>					x					
<i>Metzgeria decipiens</i>			x							
<i>Metzgeria furcata</i>						x				
* <i>Porella crawfordii</i>				x						
<i>Reboulia hemisphaerica</i>			x							
<i>Targionia lorbeeriana</i>				x	x					
Total	8	0	3	6	6	6	2	1		

* = species collected at Jenolan Caves prior to 1987.

L = species collected exclusively on limestone.

= anthocerotum.

argenteum, a small, tufted moss, are two cosmopolitan bryophytes collected from the vicinity of Jenolan Caves House and the No. 1 carpark.

6. *Carlotta Arch* [CA] (Figure 2, 4a): includes exposed sites on limestone in the vicinity of the Carlotta Arch and the No. 2 carpark. Vegetation on limestone near the arch is sparse and dominated by shrubs, grasses and climbing plants. In the vicinity of the No. 2 carpark the area includes a number of rock outcrops sheltered by tall trees including *Eucalyptus globulus* subsp. *bicostata* and *Eucalyptus viminalis*.

Sixty five species (59 mosses, 5 hepatics, 1 anthocerotum) were collected in the vicinity of the Carlotta Arch and the No. 2 Carpark. Of particular interest was *Gymnostomum aeruginosum*, a calcicolous species often associated with bat guano, growing in damp limestone dust in a small cave bordering the Carlotta Arch. Three of the hepatics (*Frullania* spp.) are epiphytic on *Bursaria spinosa*. One thallose hepatic, *Asterella drummondii*, and the anthocerotum *Anthoceros laevis* both grow on the damp soil of a trackside bank, protected by overhanging *Poa* grass tufts. Epilithic mosses such as *Pseudoleskeopsis imbricata*, *Orthotrichum cupulatum* var. *cupulatum*, *Grimmia pulvinata* are abundant.

7. *Six Foot Track* [SFT] (Figure 2): a track in a shale band on the steep valley sides to the east of the Devils Coach House. Vegetation consists of *Eucalyptus* woodland, with occasional shrubs. Much of the ground is covered in thin plates of shattered rock. Lichens are abundant on exposed, flaking boulders.

Table 3. Bryophytes recorded at the National Herbarium of NSW as having been collected from Jenolan Caves prior to 1987 but not collected in the course of this study.

1. *Breutelia pendula* (probably incorrect identification)
2. *Dicranoloma dicarpum*
3. *Hypnodendron vitiense*
4. *Leptotheca gaudichaudii*
5. *Papillaria amblyacis*
6. *Papillaria flavo-limbata*
7. *Pyrrhobryum parramattense*
8. *Wijkia extenuata*
9. *Symphyogyna interrupta*

Twenty bryophytes (18 mosses and 2 hepatics) were collected from shales along the Six Foot Track. *Hedwigidium integrifolium* and *Hedwigia ciliata* are both common on rock, together with dense patches of lichens. *Campylopus introflexus* is most conspicuous on the ground, growing on charcoal and on soil between rock fragments.

8. *Oberon Hill* [OH] (Figure 2): consists of sheltered roadside embankments of the steep hillside on the western side of McKeowns Valley, along the Oberon Road. Moist montane forest has a dense cover of grasses (including *Poa* spp.) and herbs. There are very few rock outcrops and very little exposed soil.

Eleven species were collected on the Oberon Hill (10 mosses, 1 hepatic). Bryophytes were collected from exposed roadside embankments. We have not previously collected *Grimmia trichophylla* in the Blue Mountains and it is rare in the Central Tablelands (Ramsay 1984). Although *Racomitrium crispulum* is common in the vicinity of Megalong Valley, we have found it only at this site in the Jenolan area.

9. *Kanangra Walls Lookout* [KW] (Figure 3): the exposed sandstone plateau overlooking Kanangra Walls.

Seven mosses (no hepatics) were collected from the sandy soils of the Kanangra Walls Lookout. Most grow in compacted sandy soil by the side of walking tracks. Three species, *Funaria hygrometrica*, *Pohlia nutans* and *Tayloria octoblepharis* were collected at Kanangra Walls but were not collected from any of the Jenolan Caves sites although all three species are common on sandstones and shales in the Blue Mountains.

10. *Boyd River Crossing* [BRC] (Figure 3): an area of *Eucalyptus* woodland and heath on granite, approximately 7 km north of the Kanangra Walls Lookout.

Six mosses were collected from the Boyd River Crossing. Bryophytes and lichens are abundant in and around heath plants on a large area of exposed granite moist with seepage. Two species, *Conostomum pusillum* and *Racomitrium lanuginosum* var. *pruinatum* were not collected in the immediate vicinity of Jenolan Caves, and we have not previously collected *Racomitrium lanuginosum* var. *pruinatum* in the Blue Mountains area. *Racocarpus purpurascens* was collected from an exposed boulder in *Eucalyptus* woodland adjoining the heath. This species is common in the Blue Mountains area on sandstone, but was not collected from any other site at Jenolan during this study.

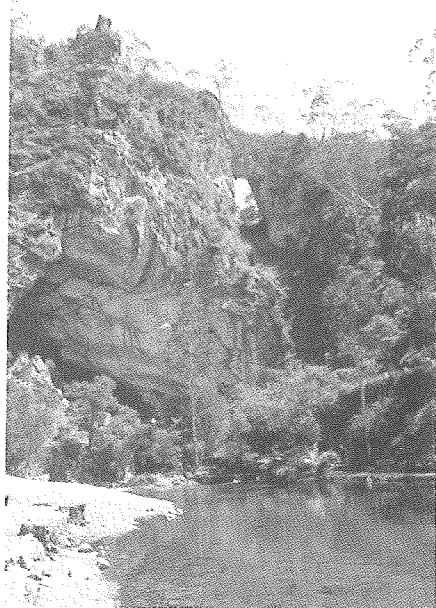
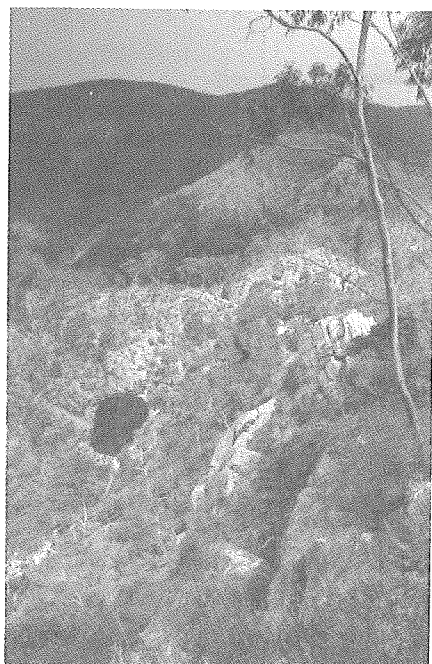
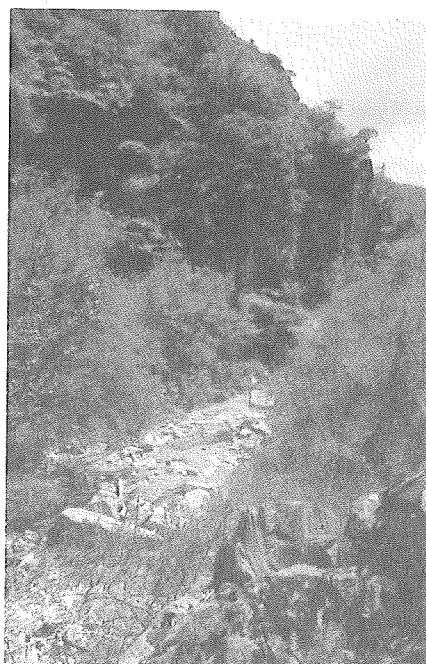
**a****b****c**

Figure 4. Jenolan Caves area. **a.** Blue Pool, Grand Arch and Carlotta Arch. **b.** Blue Pool, and *Eucalyptus* woodland typical of vegetation along Binoomea Ridge Road. **c.** Grand Arch, western face.



a



b



c



d

Figure 5. McKeowns Valley. **a.** McKeowns Valley leading to the Devils Coach House viewed from Oberon Hill. **b.** Limestone outcrops along the dry creek bed of McKeowns Valley. **c.** Mosses (*Papillaria* spp.) festooning bases of shrubs in McKeowns Valley. **d.** Mosses (*Orthotrichum cupulatum* var. *capulatum*, *Tortula antarctica* and *Grimmia pulvinata*) growing in abundance on limestone boulders in McKeowns Creek Valley.

Discussion

More bryophyte species were recorded from localities that included limestone (Grand Arch East, McKeowns Valley, Grand Arch West and Carlotta Arch) than from localities based on non-limestone substrata (Binoomea Ridge Road, Six Foot Track, Oberon Hill, Kanangra Walls and Boyd River Crossing) (Tables 1 & 2). In the Jenolan Caves area twenty eight species (27 mosses and 1 hepatic) were recorded exclusively from limestone substrata. (Tables 1 & 2). However, not all species recorded only from limestone at Jenolan are exclusively calcicolous e.g. *Leptodon smithii* occurs as an epiphyte on the trunks of trees and *Hypopterygium rotulatum* and *Lopidium concinnum* can be found on a variety of substrata in closed forests of the Blue Mountains. None of the species collected from limestone is endemic to Australia. Some species such as *Encalypta vulgaris* and *Amphidium cyathicarpum* are widespread, while others such as *Pseudoleskeopsis imbricata* and *Orthotrichum cupulatum* var. *cupulatum* are restricted to Australia and New Zealand.

Three moss families (Pottiaceae, Bryaceae, Fissidentaceae) were well represented. From the Pottiaceae, 16 species in 9 genera (*Anoetangium*, *Barbula*, *Desmatodon*, *Didymodon*, *Pottia*, *Tortella*, *Tortula*, *Weissia* and *Trichostomum*) were collected. From the Bryaceae 16 species in 4 genera, (*Brachymerium*, *Bryum*, *Orthodontium*, *Pohlia*) were collected. More species of *Bryum* (12, including one undescribed species) were collected than of any other genus. From the Fissidentaceae, 7 species of *Fissidens* were collected.

Five species are reported as new records for NSW (*Anoetangium bellii*, *Bryum rubens*, *Bryum* sp. nov., *Tortella dakinii*, *Trichostomum brachyodontium*) and eighteen species (Tables 1 & 2) have been added to the list for the Central Tablelands of NSW (Ramsay 1984, Ramsay et al. 1990).

Twenty two of the 31 bryophytes previously collected at Jenolan Caves and held at the National Herbarium (NSW) were re-collected during this study (Tables 1, 2). We suggest the following possible explanations for the absence of 9 previously collected species from our collections:

a. Identification of one species is probably incorrect (Table 3).

b. Human influence has caused changes to habitat that may have affected bryophyte distributions. Construction of the bridge over McKeowns Creek and the damming of the Jenolan River valley downstream from the Grand Arch have produced the Blue Pool. Rampant weed growth on the western side of the Grand Arch may also have changed the nature of bryophyte assemblages. These changes may also have produced habitats suitable for colonisation by exotic bryophyte species, e.g. *Lunularia cruciata*, *Marchantia polymorpha* var. *aquatica*.

c. It is possible that some specimens were collected from sites outside our selected study area and lumped together under the name Jenolan Caves. Most of the species not collected in our survey are species which would be common in sheltered gullies in moist closed-forest e.g. in Megalong Valley (*Pyrrohobryum parramattense*, *Dicranoloma dicarpum*, *Wijkia extenuata*, *Papillaria amblyacis*, *Papillaria flavolimbatata*) rather than on exposed rocky outcrops in *Eucalyptus* woodland of the Jenolan Caves area today. In the late 1880s the Six Foot Track was surveyed from Katoomba, through Nellies Glen, Megalong Creek, Coxs River, Little River and over Black Range to Jenolan Caves (Smith 1984). It seems likely that in the late 1890s, botanists such as Maiden and Blakely would have travelled to Jenolan via the Six Foot Track and that some of the collections listed here may have been from the closed-forests of Megalong Valley near the start of the journey to Jenolan Caves.

Acknowledgments

We would like to thank the Jenolan Caves Scientific Committee for permission to work in the Jenolan Caves Reserve. We have particularly appreciated the encouragement, advice and assistance of Ernst Holland. We are grateful to David Catcheside, Graham Bell, Heinar Streimann, John Spence and Elizabeth Brown for assistance with the identification of a number of difficult species. Patricia Selkirk has supported the project from the outset, and has assisted us with field trips and advised on the text. We are most grateful to Ron & Margot Oldfield, Jeannette Gregory, Kevin Downing and Jean Edgecombe for their assistance on field trips.

References

- Ando, H. (1982) *Hypnum*. In Australasia and the Pacific. *Journal of the Hattori Botanical Laboratory* 52: 93–106.
- Blakely, W.J. & Wiburd, J.C. (1901) A list of plants collected in the vicinity of Jenolan Caves. *Agricultural Gazette of NSW* 1390–1394.
- Bureau of Meteorology (1979) *Climatic Survey, Sydney, region 5, New South Wales*. Department of Science and the Environment.
- Catcheside, D.G. (1980) *Mosses of South Australia* (Government Printing Service: Adelaide).
- Chalker, L. (1970) Limestone in the Jenolan Caves area. *Geological Survey Record. NSW* 13 (2): 53–60.
- Dunlop, B.T. (1967) *Jenolan Caves, New South Wales, Australia*. NSW Government Tourist Bureau.
- Frahm, J.P. (1987) A survey of the *Campylopus* species of Australia. *Journal of Bryology* 14: 701–727.
- Keith, D.A. & Benson, D.H. (1988) Natural vegetation of the Katoomba area. *Cunninghamia* 2(1): 107–145, with accompanying map sheet.
- Kramer, W. (1988) Bietrage zur Systematik und Bryogeographie einiger Sippen von *Tortula* Hedw. Sect. Rurales De Not. (Pottiaceae, Musci) unter besonderer Berücksichtigung der südhemisphäre. *Journal of the Hattori Botanical Laboratory*. 65: 81–144.
- Lewinsky, J. (1984) The genus *Orthotrichum* Hedw. In Australasia. A taxonomic revision. *Journal of the Hattori Botanical Laboratory*. 56: 369–460.
- McClellan, S.M. (1983) *Geology and cave formation, Jenolan Caves, NSW*, B. App. Sc. (Geology) Thesis, University of Technology, Sydney.
- Ramsay, H.P. (1984) Census of New South Wales mosses. *Telopea* 2(5): 455–534.
- Ramsay, H.P., Downing, A.J. & Schofield, W.B. (1990) Bryophytes of the Mount Tomah Botanic Garden. *Cunninghamia* 2(2): 295–303.
- Sainsbury, G.O.K. (1955) *A handbook of the New Zealand mosses* (Royal Society of New Zealand: Wellington).
- Scott, G.A.M. & Stone, I.G. (1976) *Mosses of southern Australia* (Academic Press: London).
- Scott, G.A.M. (1985) *Southern Australian liverworts* (Australian Government Publishing Service: Canberra).
- Scott, G.A.M. & Bradshaw, J.A. (1986) Australian Hepatics (Hepaticae): annotated list of binomials and check list of published species with bibliography. *Brunonia* 8(1): 1–171.
- Shaw, J. (1985) Nomenclatural changes in the Bryaceae Subfamily Mielichhoferioideae. *Bryologist* 88(1): 28–30.
- Smith, J. (1984) *From Katoomba to Jenolan Caves, the Six Foot Track* (Second Back Row Press: Katoomba).
- Streimann, H. (1989) *A revision of the moss family Meteoriaceae in Australia with detailed studies on the genus Papillaria (C.Muell.) Lor.* M.Sc. Thesis. University of New South Wales.
- Streimann, H. (1991) Taxonomic studies on Australian Meteoriaceae (Musci) 1: Introduction and genus *Papillaria*. *Journal of the Hattori Botanical Laboratory*. 69: 203–256.
- Streimann, H. & Curnow, J. (1989) *Catalogue of mosses of Australia and its external territories* (Australian Government Publishing Service: Canberra).

- Touw, A. & L.F. van den Haak. (1990) A revision of the Australasian Thuidiaceae (Musci) with notes on species from the adjacent regions. *Journal of the Hattori Botanical Laboratory* 67: 1-57.
- Vitt, D.H. & Ramsay, H.P. (1985) The *Macromitrium* complex in Australasia (Bryopsida: Orthotrichaceae) Part I. Taxonomy and phylogenetic relationships. *Journal of the Hattori Botanical Laboratory*. 59: 325-451.
- Watts, W.W. & Whitelegge, H.L.K. (1902 & 1905) Census Muscorum Australiensium. *Proceedings of the Linnean Society of New South Wales* Supplement 27: 1-90 & Supplement 30: 91-163.

Manuscript received 9 October 1990

Manuscript accepted 7 March 1991