Vertebrate browsing impacts in a threatened montane plant community
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ABSTRACT
Montane ecosystems are vulnerable to the removal of vegetation cover through grazing or browsing by feral or native vertebrate fauna. The highest elevated peaks of the Stirling Range in Western Australia provide habitat for an endemic plant community, critically endangered due to plant disease, frequent fire and an emerging threat of browsing by vertebrate fauna. Survey and camera trapping confirmed the herbivorous feral rabbit (*Oryctolagus cuniculus*) and native quokka (*Setonix brachyurus*) are present. Dietary analysis through faecal examination revealed contrasting diets and implicates native rather than feral species as responsible for impacts on dicotyledonous species, and in particular those of conservation significance. Exclosure experiments conducted over one year revealed significant changes in abundance, cover and height of perennial herbs and an increase in growth and reproduction of three threatened endemic plants. Detrimental impacts caused by native browsing fauna are not unprecedented and suggest disequilibrium in normal ecosystem process, potentially due to multiple interacting threats. Montane ecosystems may be particularly vulnerable to browsing due to their naturally slow recovery after disturbance and browsing may also create environmental conditions more conducive to plant disease. For plant species with critically low population numbers, the impact of browsing poses a threat to population persistence and undermines investment into other conservation recovery actions.

INTRODUCTION
Montane ecosystems are highly vulnerable to the removal of vegetation cover due to slow plant growth rates and high erosion hazards (Bridle *et al.* 2001, Kirkpatrick 1997). Vegetation removal though grazing or browsing by feral animals is implicated in detrimental impacts in several mountainous biomes. For example, pig and goat have caused severe damage to tropical montane habitats and livestock grazing by sheep, cow, goat and horse in the feldmark of Eastern Australia have caused large areas of erosion (Cole *et al.* 2012, Scowcroft *et al.* 1987, Pickard *et al.* 1976, Leigh *et al.* 1987). Similarly, rabbit, hare, several deer species and brushtail possum have had significant impacts in New Zealand (Norbury 1996, Wong and Hickling 1999, Bellingham *et al.* 1999). Within Western Australia, livestock grazing has been reported to significantly alter environmental conditions and processes in Eucalypt woodlands and has contributed to the decline of a lowland Threatened Ecological Community (TEC) (Yates *et al.* 2000, Gibson *et al.* 1999). Grazing generally refers to the consumption of grasses and forbs, whereas browsing is defined as eating plant material of any description, often including leaves and stems of perennial plants.

Browsing by native vertebrate fauna has been reported to cause significant floristic and structural changes to native jarrah (*Eucalyptus marginata*) forest in Western Australia (Shepherd *et al.* 1997). However, browsing by native fauna is rarely considered detrimental unless numbers of browsing individuals become unnaturally elevated due to imbalance in the ecosystem, as reported for koala populations in the Mt Lofty Ranges (Bryan 1996). In montane biomes, examples of grazing and browsing impacts by feral species are frequent, but a paucity of studies exists on impacts resulting from native fauna (Bridle and Kirkpatrick 1999).

The "Montane Heath and Thicket of the Eastern Stirling Range" is a Threatened Ecological Community (TEC), ranked critically endangered in Western Australia due to the root-rot disease (*Phytophthora* dieback), caused by the plant pathogen *Phytophthora cinnamomi,* frequent fire and more recently from browsing (Barrett 1999, Keith *et al.* 2014). The upper slopes of Bluff Knoll form the highest elevated plateau in the Stirling Range and contain the largest contiguous extent of this community. Only 14 per cent of the TEC retains a representation of the original suite of plant species and many *Phytophthora* dieback-susceptible species have become locally extinct (Barrett *et al.* 2015). The emerging threat of browsing in this TEC became apparent after fire in 2000, with visible impacts and faecal evidence of the native marsupial quokka (*Setonix brachyurus*) and the feral rabbit (*Oryctolagus cuniculus*). Subsequent rabbit control using 1080 oats and the establishment of plant cages was associated with a significant recovery of selected threatened flora (Rathbone *et al.* 2011).

Significant investment has been made undertaking conservation actions for several threatened endemic plants in the Montane Heath and Thicket. These comprise of either threat mitigation i.e. application of the fungicide phosphite to mitigate *Phytophthora* dieback or *ex-situ* conservation strategies i.e. germplasm storage and translocations. Underpinning these actions is a reliance on extant populations reaching maturity and producing flowers and viable seed. Consequently, integrated management that addresses threats of browsing in combination with management of dieback and fire is vital in this ecosystem (Rathbone *et al.* 2011). However, selection of appropriate management actions to mitigate browsing is further complicated by the presence of both native and feral browsing species.

The objective of this study was to provide novel information on browsing of native and feral vertebrate fauna in a threatened montane ecosystem and to determine the implications for management. The specific questions assessed were:- What browsing species are present?, What is the relative browsing pressure exerted by native and non-native species?, What is the magnitude of browsing impacts in a montane environment?; Does browsing inhibit growth or reproduction of plant species of conservation significance?

METHODS

Study site

The study was conducted in an occurrence of the Montane Heath and Thicket TEC on the upper slopes of Bluff Knoll in the Stirling Range National Park (Figure 1). All sites were on gently inclined south or south east facing slopes between 960m to 1070m above sea level.

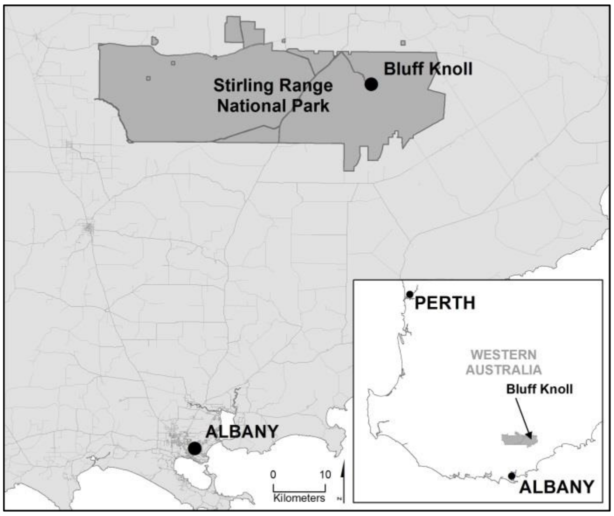

Figure 1. Study site located on the summit of Bluff Knoll in the Stirling Range National Park, Western Australia.

Motion camera trapping

Motion sensing cameras (Reconyx PC900) were used to identify vertebrate herbivores responsible for browsing of native vegetation. Cameras were deployed intermittently between 2011-2015 targeting areas with high browsing impacts and where threatened flora was present. Images were batch-uploaded into the freeware database tool Camera Base Version 1.6.1 (Tobler 2014). The number of browsing events was scored for all observed fauna species. Events were defined as individuals of a particular species observed with an interval greater than 30 minutes between images.

Diet analysis of browsing fauna

Analysis of plants fragments in the scats of quokka and rabbit were compared with reference plant specimens to determine the relative composition of their diets and to determine if threatened flora were included. Existing protocols for faecal analysis of marsupials (Shepherd *et al.* 1997) and rabbit (Williams 1969) were followed with some adaptions. A reference collection was prepared for 24 dicotyledonous and five monocotyledonous species that occurred more than once in 24 1 x 1 m vegetation quadrats. Either entire leaves or fragments of large leaves (approx. 0.5 x 0.5 cm) were incubated at 80 degrees in 50% glacial acetic acid for 48-72 hours. The length of time depended on the thickness and digestibility of the leaf mesophyll tissue. Peels of both adaxial and abaxial leaf surfaces were prepared and stained with 2% Safranin solution for 10-20 minutes and mounted on glass slides with Eukit paramount. Photos and line drawings of key identifying features were compiled using a light microscope mounted camera and IS Capture Imaging Software (Version 2.5.1 Scienon Technology Co. LTd).

Scats of quokka and rabbit were collected over the month of June 2015 from several locations in the study site. Samples were dried then ten scats per species from each location were separated in a mortar and pestle and sorted under a dissecting microscope. Fragments of plant material were identified by morphological features or were rehydrated and stained in 2% Safranin solution for 10-20 mins and inspected under light microscope. Morphological features such as leaf shape, margin and presence of hairs were used to identify partially digested leaves. For smaller fragments a light microscopy was used to identify anatomical features as described by Storr (1961) and Halford *et al.* (1984), including stomata shape, size and density and the presence of oil glands and indumentum. Where possible, all dicotyledonous species were identified to species level and their presence or absence scored in each individual scat. The presence of monocotyledonous species, insects or other material was also noted.

Exclosure construction

Ten fenced exclosures were constructed between December 2013 and March 2014. The exclosures were located in sites that were completely or partially burnt by wildfire in 2000 and were chosen to protect focal areas of the TEC that contained high densities of threatened flora. Locations were selected to ensure minimal visual impact from the adjacent walk trail.

Exclosure walls were approximately 90 cm high with a 30 cm skirt, both constructed of heavy duty plastic coated netting with a 4 cm aperture. Netting was held by horizontal top and bottom lengths of plastic coated in 1.6 mm fencing wire. Corner straining boxes were constructed with galvanised star iron pickets. Extensive rock and shallow soil prevented hammering pickets into the ground; therefore they were modified with a metal plate that was fixed onto the underlying rock by a chemically anchored bolt (Figure 2). After construction the exclosures were inspected throughout the study period to ensure their integrity.

Figure 2. Modified star iron used to fix corner posts of exclosure. 8 x 60 mm threaded rod was held in rock by Sika AnchorFix chemical anchor into holes drilled with a cordless rotary hammer TE 6-A36-AVR.

Figure 3. Corner straining box constructed of galvanized star iron pickets.

Figure 4. Example of a 25 by 25 m wire exclosure.

Monitoring of browsing exclusion

Growth and recruitment of all vascular plant species was assessed by monitoring at establishment and after one year at four of the ten exclosures. Changes in vegetation cover and abundance was assessed within 1 x 1 m permanently marked floristic quadrats. Three quadrats inside and outside four different exclosures (n= 24) were scored for count (number of individuals), foliage cover, and maximum height for every plant species present. Only individuals rooted in the quadrat were counted, any overhanging foliage of surrounding plants was included in cover estimate. To assess browsing impacts in relation to natural growth rate and recruitment, the change in plant count, foliage cover and average height was calculated for each species between the time of establishment and after one year. Foliage cover was Arcsine transformed prior to analysis. Unpaired, two tailed t-tests were conducted between fenced exclusion and non-fenced treatments for each species individually and as well as life form groups.

Three critically endangered, threatened flora were selected to monitor the effects of browsing on growth and reproduction, *Darwinia collina*, *Latrobea colophona* and *Leucopogon gnaphalioides*.

Individuals of each species were selected along a randomised transect inside and outside fenced exclosures at two to three different sites. Individual plants were identified with a metal tag and the following was recorded:- GPS location, height, two perpendicular widths, flower and/or fruit abundance and signs of browsing. All plants were monitored at the time of exclosure construction and after one year. Flowering and fruiting of *Latrobea colophona* and *Leucopogon gnaphalioides* was assessed after 18 months, due to seasonal timing. Growth was calculated for each individual as change in plant volume (cm^3) between time of fence construction and after one year, then data was log-transformed prior to analysis. Unpaired, two tailed t-tests were conducted on growth and counts of reproductive structures between fenced and non-fenced treatments for each threatened species.

RESULTS

A total of 304 camera days of footage captured 96 events triggered by seven mammalian fauna (Table 1). Quokka was the only strictly herbivorous native species recorded and was responsible for 75% of the events. Quokka was also captured directly browsing on two threatened species, namely *Latrobea colophona* and *Leucopogon gnaphalioides* (Figure 5). All other native species observed were carnivorous, omnivorous or nectivorous, including mardo (*Antechnius flavipes*), bush rat (*Rattus fuscipes*), quenda (*Isoodon obesulus*) and honey possum *(Tarsipes rostratus)*. Two feral species were infrequently observed, including the herbivorous rabbit *(Oryctolagus cuniculus*; Figure 6) and the carnivorous feral cat (*Felis catus*). These data indicate both quokka and rabbit are potential candidates responsible for browsing impacts, although the population of rabbit in recent years may be orders of magnitude less than quokka.

Table 1. Number of browsing events for each species recorded over 304 camera trapping days on Bluff Knoll from 2011 to 2015. Events are defined as individuals of a species observed with an interval greater than 30 minutes between visitations.

Species	Number of events
Quokka *(Setonix brachyurus)*	72
Mardo *(Antechnius flavipes)*	7
Bush rat *(Rattus fuscipes)*	6
Quenda *(Isoodon obesulus)*	6
Honey possum *(Tarsipes rostratus)*	1
Rabbit *(Oryctolagus cuniculus)*	1
Cat *(Felis catus)*	3

Figure 5. Quokka browsing on *Leucopogon gnaphalioides* captured with a motion sensing camera on Bluff Knoll.

Figure 6. Rabbit captured with a motion sensing camera on Bluff Knoll.

Diet analysis

Monocotyledonous species were frequently observed in scats of both quokka and rabbit, indicating these species constitute a major component of their diet (Table 2). Dicotyledonous species were less frequent overall and were present in the scats of both species. Quokka scats contained a wider variety of dicots than rabbit scats with an average of nine and one species per scat identified, respectively. The identified plant species included shrubs and perennial herbs from four different families. Four species of conservation significance were incorporated only in the diet of quokka, including two threatened flora and two priority species (Table 2).

Table 2. Frequency of plant species identified in scats of quokka and rabbit. Monocotyledonous species includes all plant fragments identified from the Cyperaceae, Poaceae and Anarthriaceae. Several fragments from the Ericaceae family were not identifiable to species level due to similar anatomy.

	% Frequency	
Plant species	**Quokka**	**Rabbit**
Monocotyledonous species	100	100
Dicotyledonous species		
Myrtaceae		
Kunzea montana	80	-
Calothamnus montanus	70	-
Darwinia collina (threatened)	60	-
Taxandria floribunda	60	-
Beaufortia anisandra	50	-
Astartea montana	10	-
Melaleuca thymoides	10	-
Ericaeae		
Leucopogon gnaphalioides (threatened)	20	-
Dielsiodoxa tamariscina (priority two)	70	-
Sphenotoma sp. Stirling Range (priority three)	70	-
Ericaceae species	50	-
Euphorbiaceae		
Amperea conferta	40	-
Apiaceae		
Xanthosia rotundifolia	80	20

Effect of browsing exclusion

Approximately 6,250 square meters of the Montane Heath and Thicket was protected from browsing by vertebrate fauna in ten fenced wire exclosures. A total of 51 plant species were recorded in 24 quadrats inside and outside exclosures (Appendix 1). Species richness varied from nine to 20 species per quadrat with a mean of 13. A trend of higher count, foliage cover and height was observable in the fenced exclusion treatment although no significant difference was detected in pairwise comparisons for each species. When species were grouped by life form, perennial herbs showed a significant ($P<0.05$) increase in count, cover and height after one year of exclusion from browsing (Table 3).

Table 3. Mean change in count (number of individuals), foliage cover (%) and plant height (cm) of different life forms over one year, with or without exclusion of browsing. Cover values were Arcsine transformed prior to analysis. Classification of species life form shown in Appendix 1. n = total number of observations.

Life form	No. of species	n	Browsing exclusion			No browsing exclusion		
			count	cover	height	count	cover	height
Re-sprouting shrubs	8	85	1.05	0.45	5.83	0.39	0.07	4.25
Seeding shrubs	15	86	0.23	0.25	8.34	0.74	0.01	5.65
Perennial herbs	9	58	1.16*	0.31**	4.03**	-0.85*	0.00**	0.15**
Annual herbs	8	21	1.71	0.32	1.21	0.14	0.07	0.14
Monocots	8	64	0.47	0.26	1.24	-0.85	0.00	1.67

The response of three selected threatened flora to browsing was measured by comparing the change in plant volume over one year between plants inside or outside fenced exclosures (Figure 7 & 8). The growth of *Darwinia collina* was significantly greater in the absence of browsing, with a mean change in plant volume of 2,706 cm^3 compared to 177 cm^3 in the non-fenced, browsed treatment (*P<0.001*). Similarly, the mean change in plant volume of *Leucopogon gnaphalioides* was 1,325 cm^3 without browsing, compared to -26 cm^3 (*P<0.001*); and for *Latrobea colophona* the increment was 44,690 cm^3 without browsing, compared to 2,690 cm^3 (*P<0.00005*) for non-fenced plants. Reproductive output was also measured after one year for *Darwinia collina* and after 18 months for *Leucopogon gnaphalioides* and *Latrobea colophona*. For each species plants protected from browsing had significantly (*P<0.002*) more flowers than those in the non-fenced treatment.

Figure 7. *Latrobea colophona* at time of fence construction (left) and growth response after one year (right).

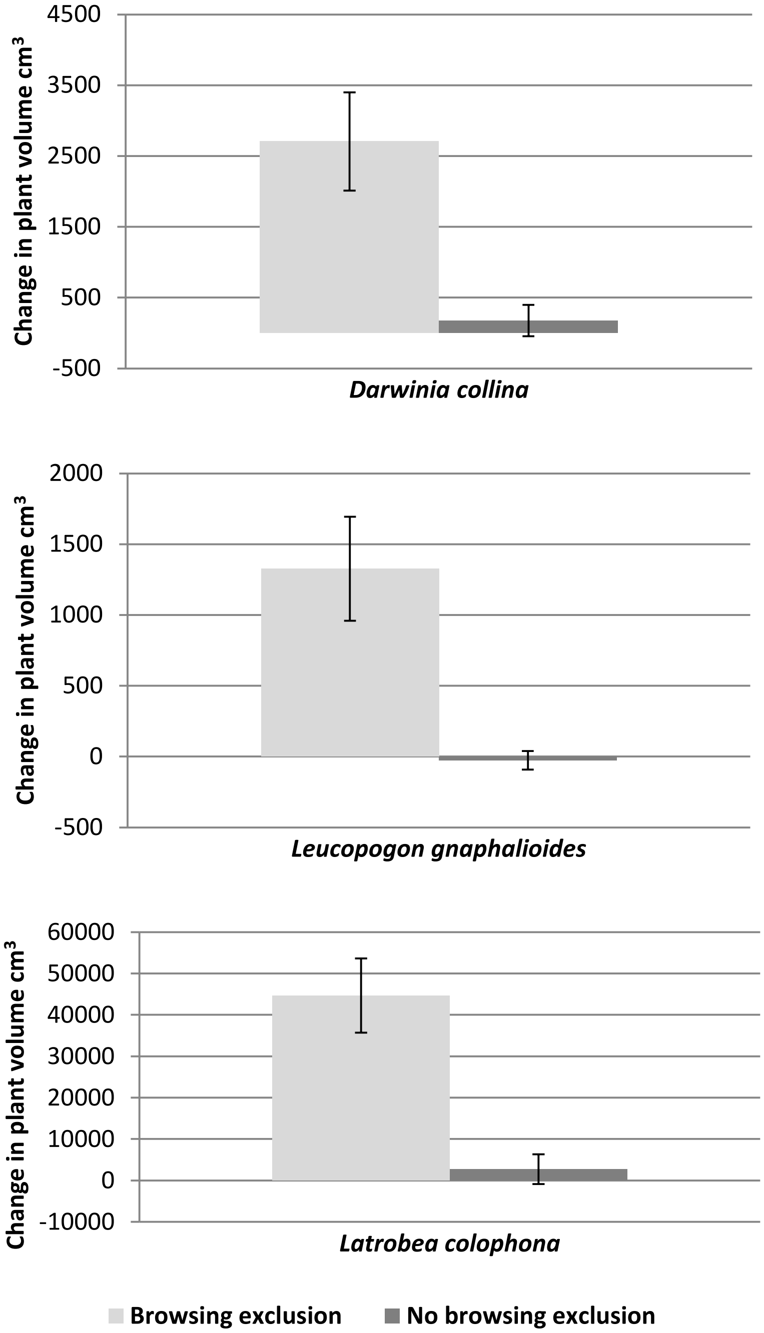

Figure 8. Change in plant volume (cm^3) of three threatened flora after one year with fenced browsing exclusion and non-fenced treatments. Unpaired, two tailed t-tests showed highly significant differences between treatments for each species (****P<0.001*).**

DISCUSSION

Incidence and diet of browsing fauna

During the study period, quokka were a frequent component of the vertebrate fauna of Bluff Knoll observed by motion camera detection. Rabbits were apparently less abundant, assuming similar trap success rates between species. Trap shyness, feeding behaviours and habitat use may have partially influenced the result. Temporal variation in the abundance of different fauna is also likely, therefore browsing impacts will be the result of past and present population densities. Both rabbit and quokka populations are reported to increase after fire due to an abundance of regenerating species (Leigh *et al.* 1987, Hayward 2005), therefore current populations in predominantly 15 year old vegetation may be lower than at previous times. Rabbit numbers may be also be lower than expected due to control using selective 1080 baits that has been undertaken intermittently since 2008.

The relative frequency of different plant species recovered in faecal remnants revealed contrasting diets between quokka and rabbit in this montane environment. Quokka were found to consume a wide variety of different plants, which is consistent with other studies using comparable faecal assessment techniques (Hayward 2005). Lowland jarrah forest populations of quokka were reported to have a diet of leaves and stems of 29 species, with five dicotyledonous species accounting for 79% of their diet. In contrast, the diet of rabbit in this study was less diverse and constituted mainly monocotyledons species or perennial herbs. Studies of rabbit in other montane regions showed their diets were dictated by the availability of plant types. In montane regions of New Zealand, rabbit diets were mainly composed of native grass species from the Poaceae (Nordbury 1996) while in Kosciusko National Park they predominantly ate forbs (Leigh *et al.* 1987). The current findings are therefore consistent with the availability of monocotyledonous plants and herbs at the feeding height of rabbits in the study area.

Effect of browsing on vegetation and threatened flora

Fenced exclosure experiments demonstrated the positive effect on plant growth after the removal of quokka and rabbit. The evidence suggested that during the study period, quokka and to a lesser extent rabbit, was responsible for this browsing pressure. Invertebrate species can cause sporadic leaf damage in this community and would not have been excluded by the exclosures.

Slow growth rates were recorded in this montane vegetation, with the majority of species growing less than three centimetres during the one-year study. Consequently, for many species the recovery from browsing relative to their naturally slow growth rates may have been difficult to detect. Coupled with low statistical power, this would explain the lack of statically significant comparisons between individual plant species. However, when grouped by lifeform, perennial herbs grew significantly more in the absence of browsing, which is consistent with the occurrence of these species in the diets of both browsing fauna. The majority of other comparative fencing exclusion experiments report on changes over five to ten years duration. Interesting, a study of goat browsing in tropical montane habitats monitored periodically over three years, showed that the greatest change in cover of herbaceous species occurred in the first year (Scowcroft *et al.* 1987).

Three selected threatened flora showed significantly more growth and reproductive output in the absence of browsing. Images of quokka browsing a fourth threatened flora species, *Andersonia axilliflora*, were captured on a mountain near Bluff Knoll, but these were not included in the camera trapping analysis. Two threatened flora (*Leucopogon gnaphalioides* and *D. collina*) were recovered in the faeces of quokka even though they were relatively uncommon in the study site, each occurring in 12% of the quadrats outside the exclosures.

Interaction of threatening processes

The interaction of threatening processes has been observed in several other montane communities and is exemplified in the Montane Heath and Thicket TEC. Fire in Kosciusko National Park caused elevated rabbit populations that significantly inhibited recovery and perpetuated bare ground cover (Leigh *et al.* 1987). In comparably cool and moist subalpine regions of Tasmania, removal of vegetation cover caused increased expression of *Phytophthora cinnamomi* due to increased solar exposure and higher soil temperatures (Podger *et al.* 1989). Similarly, frequent vegetation removal through fire has been shown to increase the impact of *Phytophthora cinnamomi* in other habitats of the Stirling Range (Moore *et al.* 2015). The recent decline in the Montane Heath and Thicket TEC has mainly been attributed to short fire returns and *Phytophthora cinnamomi*, whereas the impacts of browsing have been largely overlooked. The present study indicates the significant contribution of browsing in slowing recovery after fire, particularly of some key threatened species. Additionally, a reduction in vegetation cover through browsing could be anticipated to create or prolong environmental conditions that are more conducive for disease.

CONCLUSIONS

Rabbit and quokka are browsing fauna present in the Montane Heath and Thicket TEC. Quokka are highly abundant and can be implicated from this study in impacts to at least five species of conservation significance including three threatened flora. Rabbits are less abundant and have an apparent dietary preference for monocotyledonous species under current conditions. Despite the generally slow growth of montane species, fenced exclusion experiments resulted in rapid increases in growth and/or reproductive output for species of conservation significance. Browsing by the native quokka is a natural ecosystem process that may not be in equilibrium due to alteration of the montane ecosystem by multiple threatening processes. For plant species with critically low population numbers the impact of browsing poses a threat to population persistence and undermines conservation recovery actions. Management of browsing by 1080 baiting alone will be insufficient to manage native resistant fauna, therefore protection of high value assets in wire exclosures or by other means is warranted.

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Appendix 1. Inventory of vascular species grouped by lifeform recorded in 24 quadrats on Bluff Knoll. Nomenclature, conservation status and voucher accession according to the Western Australian Herbarium (1998–). Frequency is the number of quadrats with taxon present. Epidermal peels of reference specimens were produced for common taxa (frequency >1 quadrat).

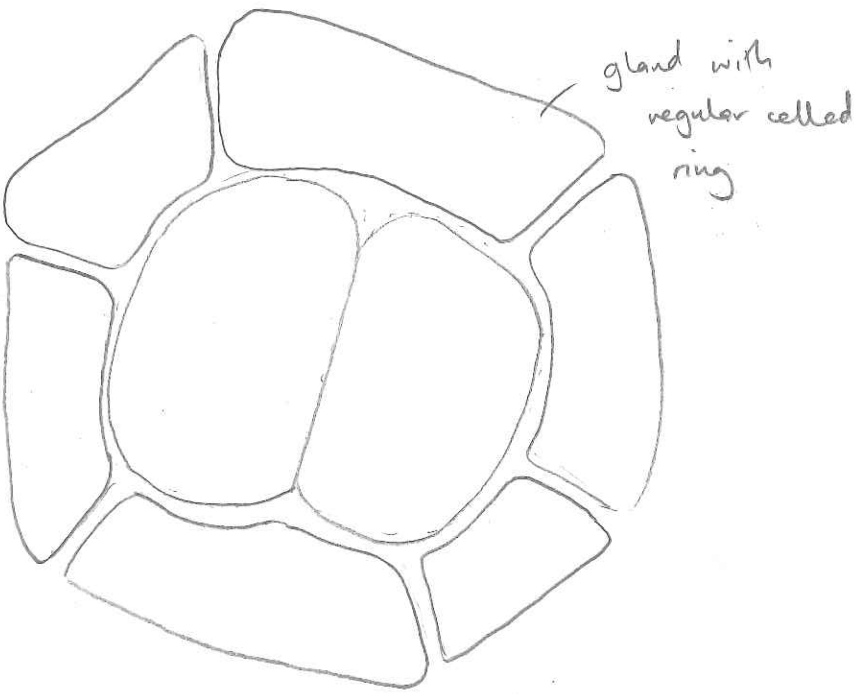
Taxon name grouped by life form	Conservation status	Frequency	Reference specimen for diet analysis	Herbarium voucher accession
Resprouting shrubs				
Astartea montana		6	*	04249437
Beaufortia decussata		1		08315086
Calothamnus montanus		17	*	04246454
Melaleuca thymoides		9	*	04273257
Taxandria floribunda		24	*	04208560
Taxandria parviceps		7	*	03129764
Xanthorrhoea ? drummondii		1		08084246
Seeding shrubs				
Acacia drummondii ssp *elegans*		1		04558537
Adenanthos filifolius	Priority three	6	*	04204891
Andersonia axilliflora	DRF	2	*	04246551
Andersonia echinocephala	Priority three	4	*	03152405
Aotus genistoides		5	*	04213505
Beaufortia anisandra		20	*	02348438
Darwinia collina	DRF	5	*	04136071
Dielsiodoxa tamariscina	Priority two	7	*	08322252
Kunzea montana		22	*	04243986
Latrobea colophona	DRF	6	*	00783757
*Leptomeria scrobiculata**		1		04329733
Leucopogon gnaphaliodies	DRF	7	*	03006042
Lysinema fimbriatum		4	*	04253132
Muiriantha hassellii	Priority four	1		04213424
Sphenotoma drummondii	DRF	1		01133934
Sphenotoma sp. Stirling Range (P.G. Wilson 4235)	Priority three	14	*	025669817
Perennial herbs				
Actinotus rhomboideus	Priority four	1		07464266
Amperea conferta	04243854	18	*	04243854
Boronia spathulata		11	*	
Dampiera loranthifolia		6	*	04135547
Platysace sp. Stirling (J.M. Fox 88/262)	Priority four	1		03542157
Stylidium ? diversiflolium		1		06859992
Stylidium sp. Bluff Knoll (S. Barrett s.n. 8/11/1994)	Priority two	5		04245997
Velleia foliosa		1		06376568
Xanthosia rotundifolia		14	*	03621820

Taxon name grouped by life form	Conservation status	Frequency	Reference specimen for diet analysis	Herbarium voucher accession
<u>Annual herbs</u>				
Caladenia sp.		1		
Cryptostylis ovata		3		
**Disa bracteata*		2		
Drosera huegelii		4		04273567
Drosera pulchella		4		04919327
Eriochilus helonomos		5		07851146
Thelymitra graminea		2		04136489
<u>Monocots</u>		21		
Amphipogon laguroides ssp *laguroides*		1		05137764
Anarthria prolifera		6	*	04204824
Desmocladus flexuosus		20	*	
Lepidosperma sp. Bluff Knoll robust (G.J. Keighery 12595)		1	*	04204522
*Rytidosperma setaceum**		1	*	
Schoenus efoliatus		20	*	04231953
Tetraria sp. Jarrah Forest (R. Davis 7391)		12		04258541
*Vulpia myuro*s forma *megalura*		3		051377556
<u>Climber</u>				
Billardiera drummondii		1		03017052

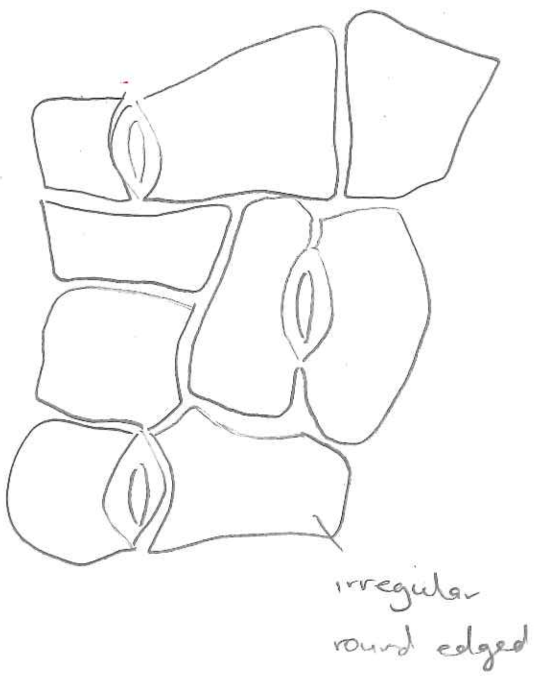
Ellen Peak collection*

Kunzea montana

- small stomata - 24 / 100x view numerous
- large oil glands / both sides



Oil gland x 100

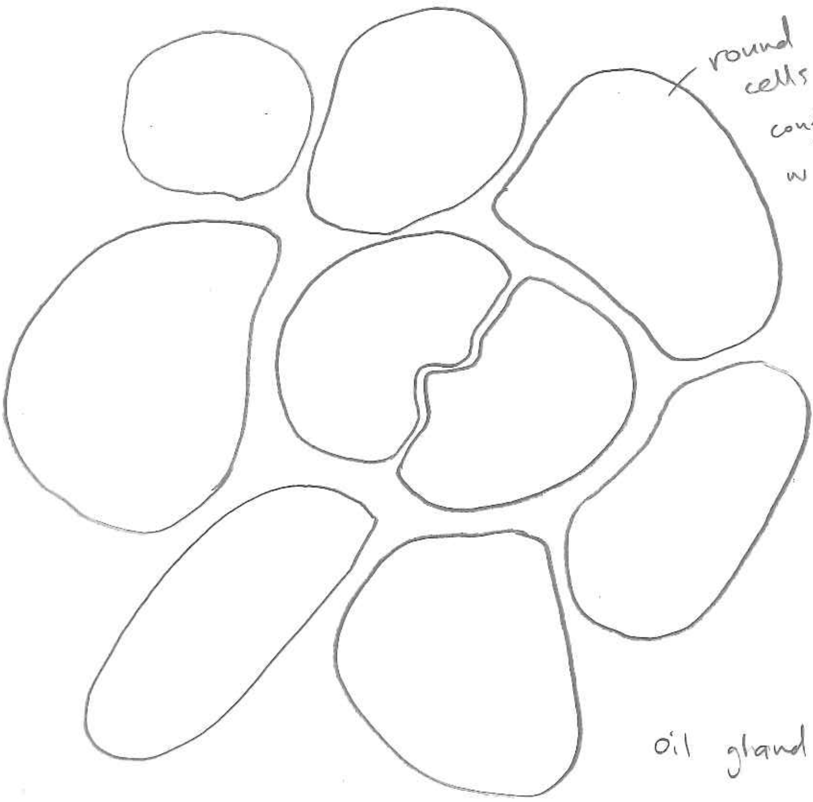


Stomata x100

Calothamnus montanus x40

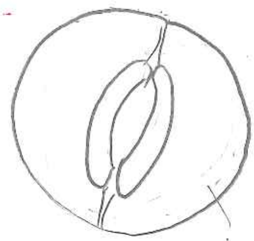
Calothamnus montanus – stomata 6 per x40 view

small



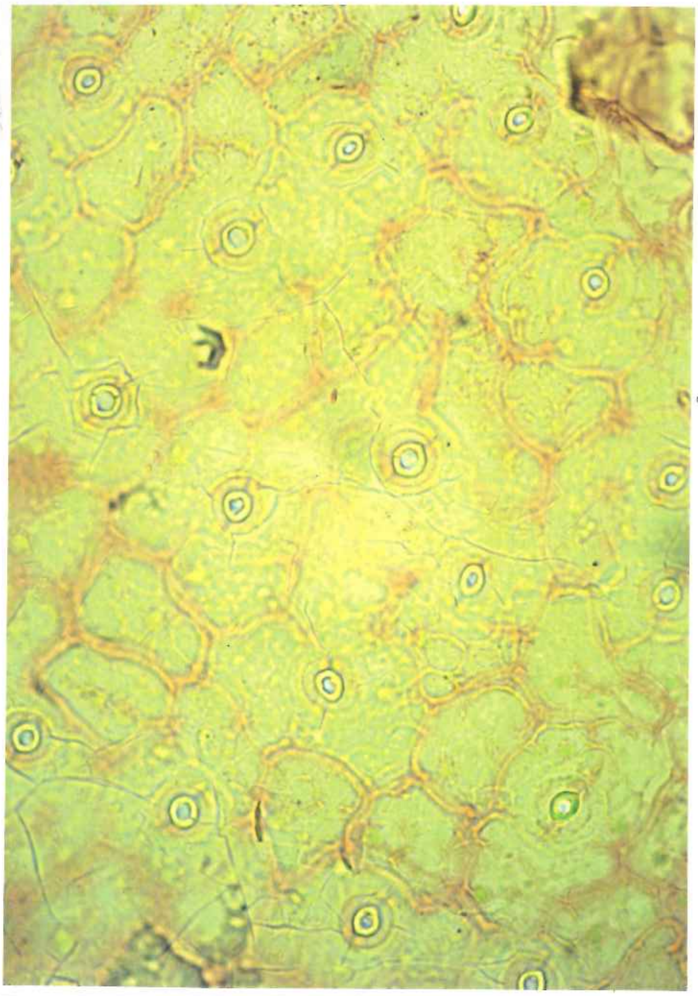
round cells continuous with surrounding

oil gland x 40

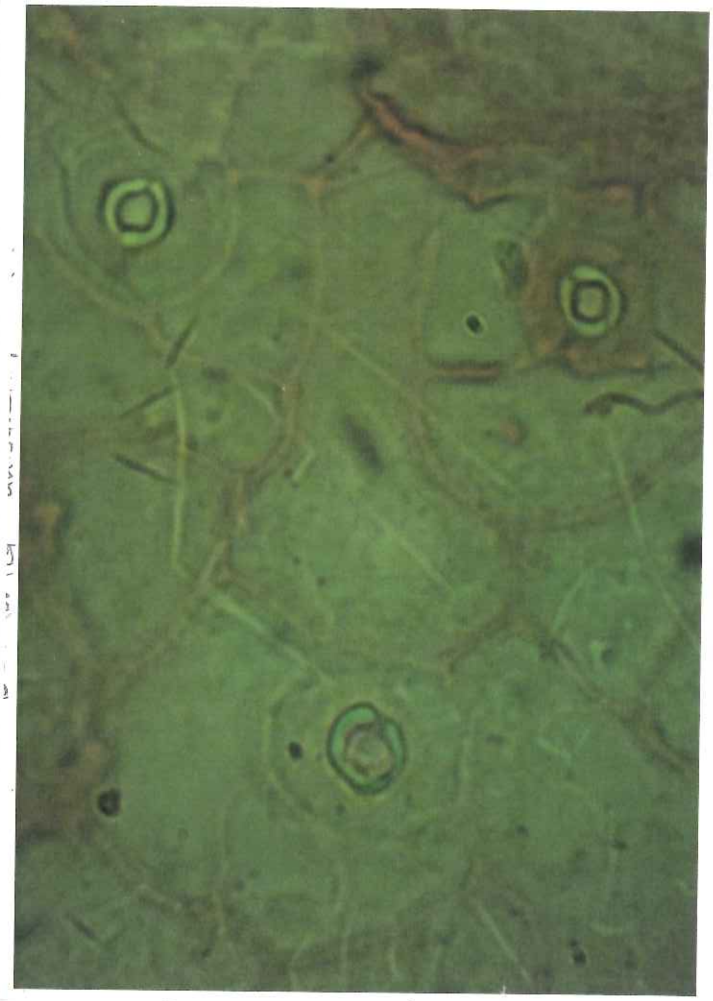


circular guard cells

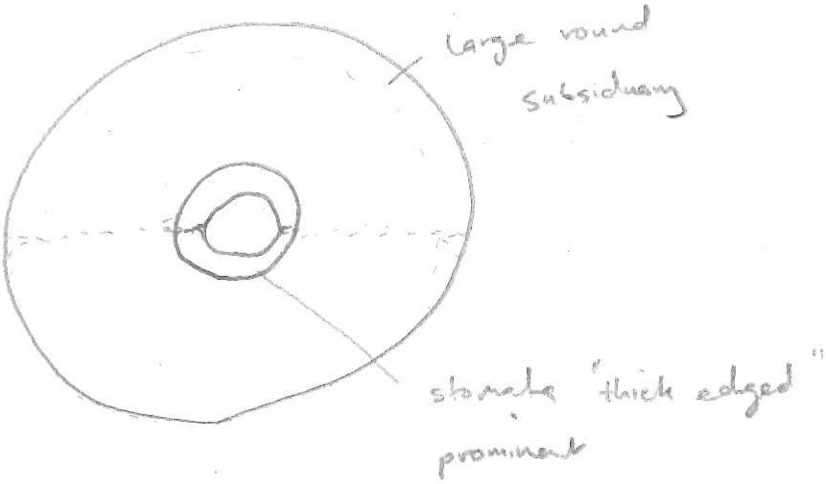
stomata x40



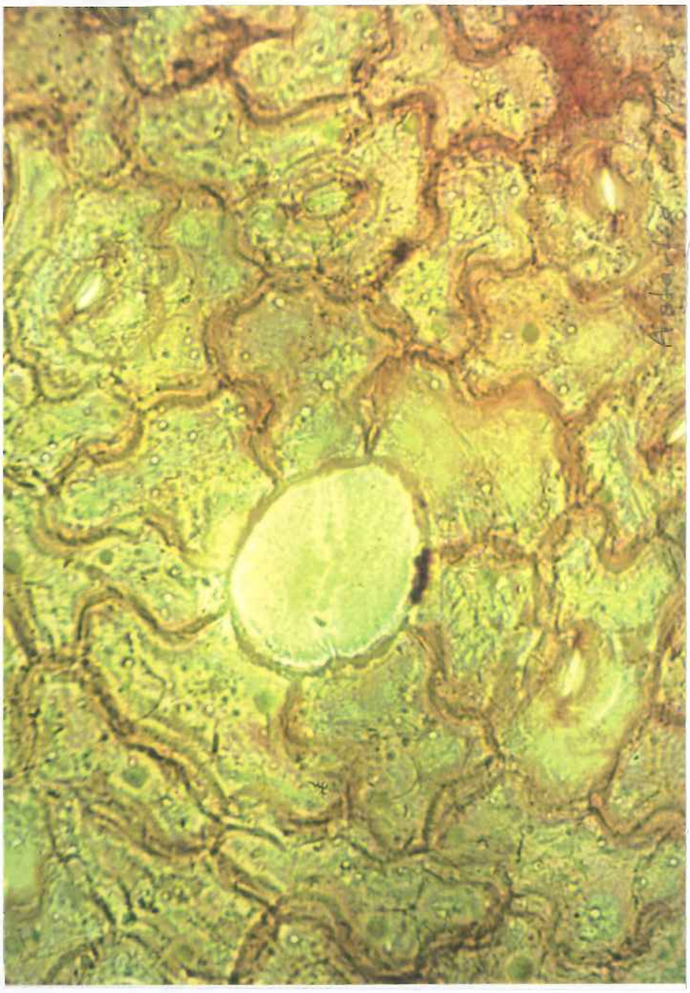
Beaufortia anisandra x 40



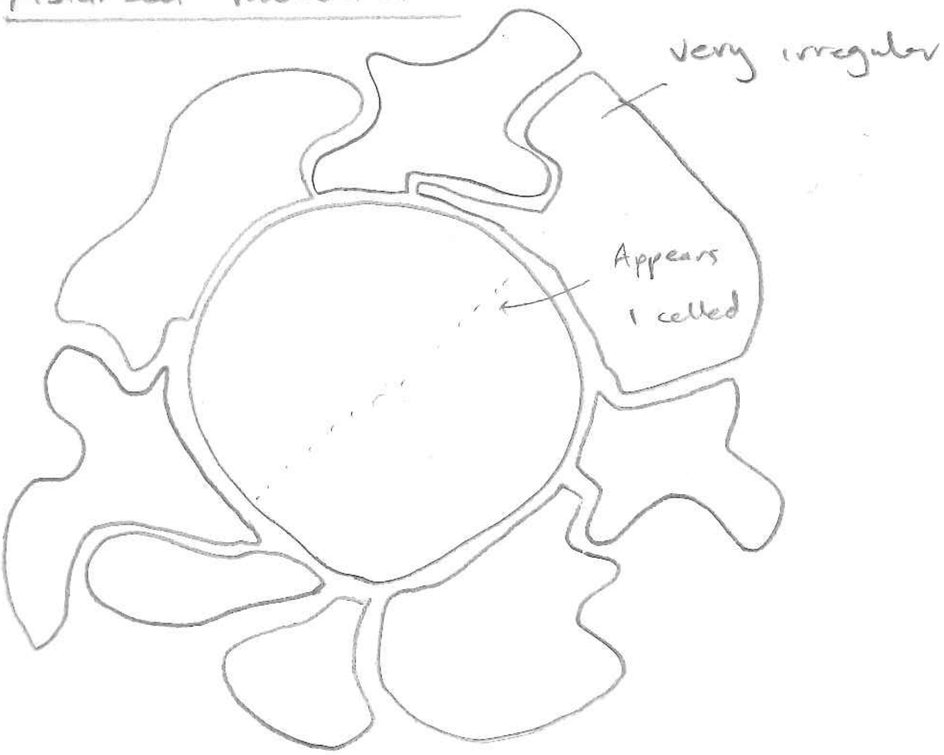
Beaufortia anisandra - 30 stoma x 40 view
5 " x 100 "



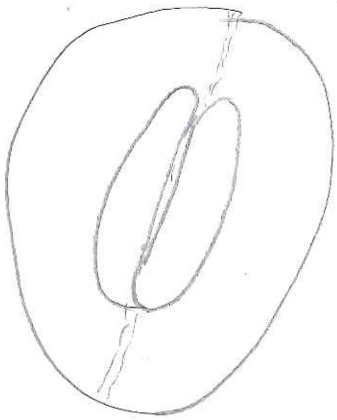
Stomata x100

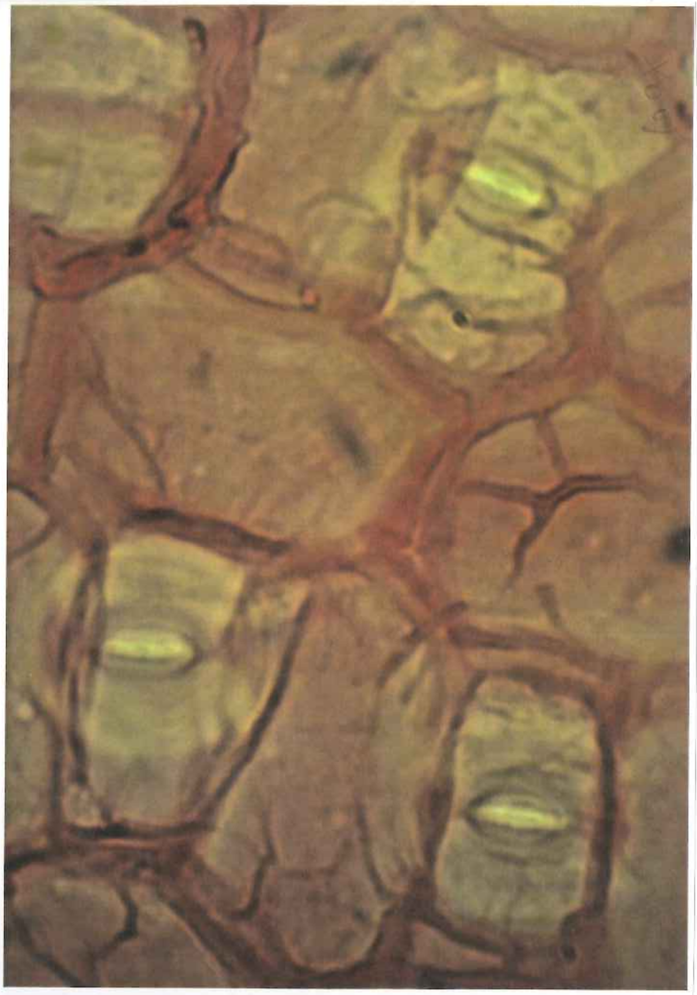


Astartea montana



Oil gland x40

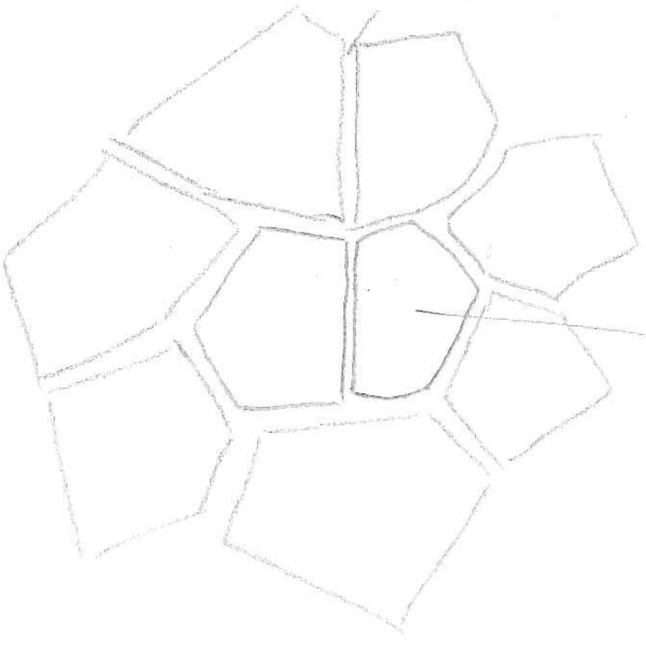




Taxandra floribunda x40

Taxandra floribunda   stomata 3 x 100 view

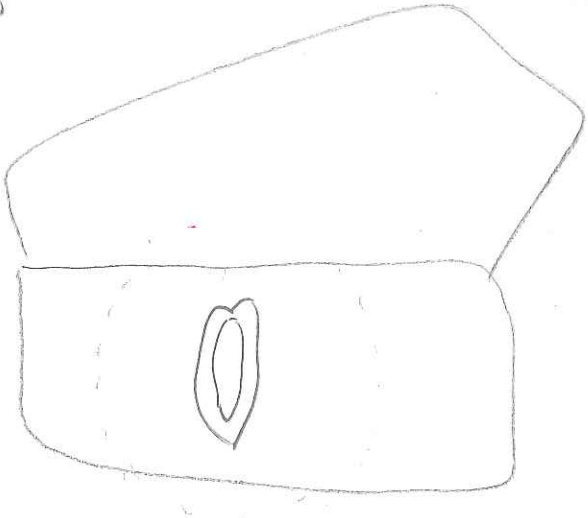
very thick walls



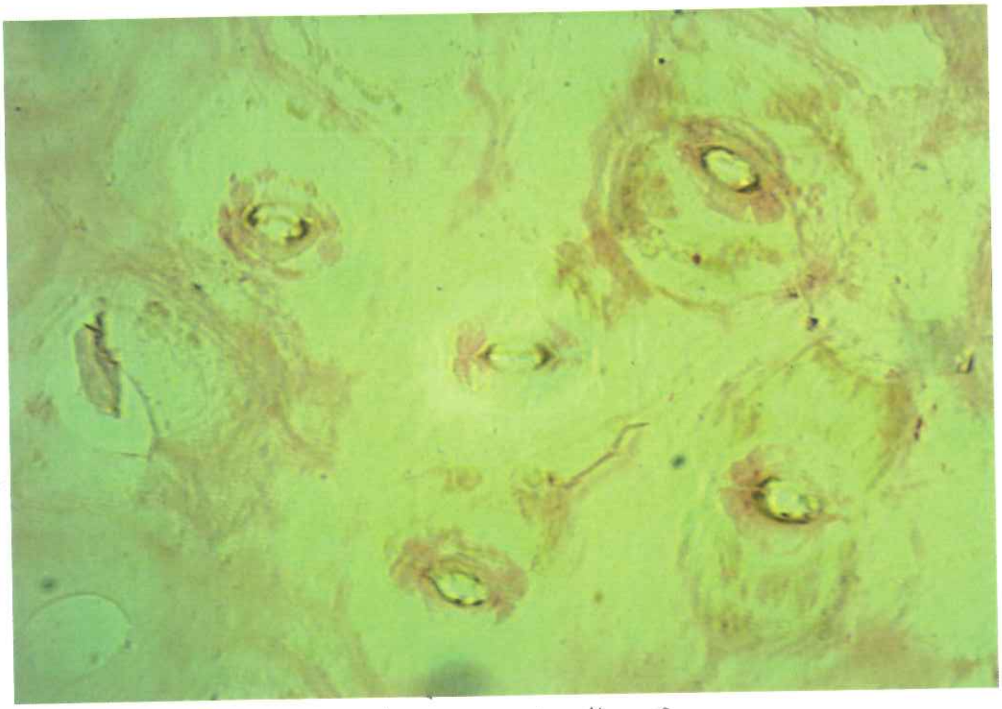
gland cells small

~ same as surrounding square edges

Oil Gland x 40



stomata x100
small indistinct



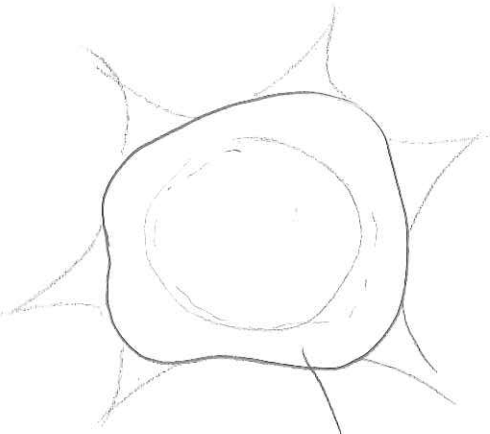
Xanthosia rotundifolia x40

Xanthosia rotundifolia

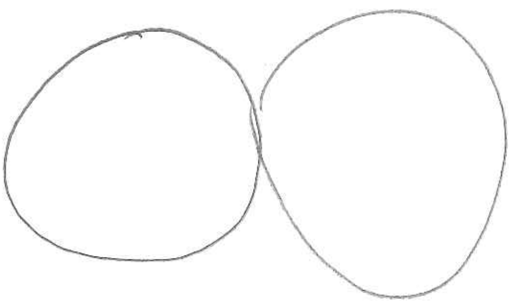
stomata 5x 40 view

Protrudes surface

Surface cells

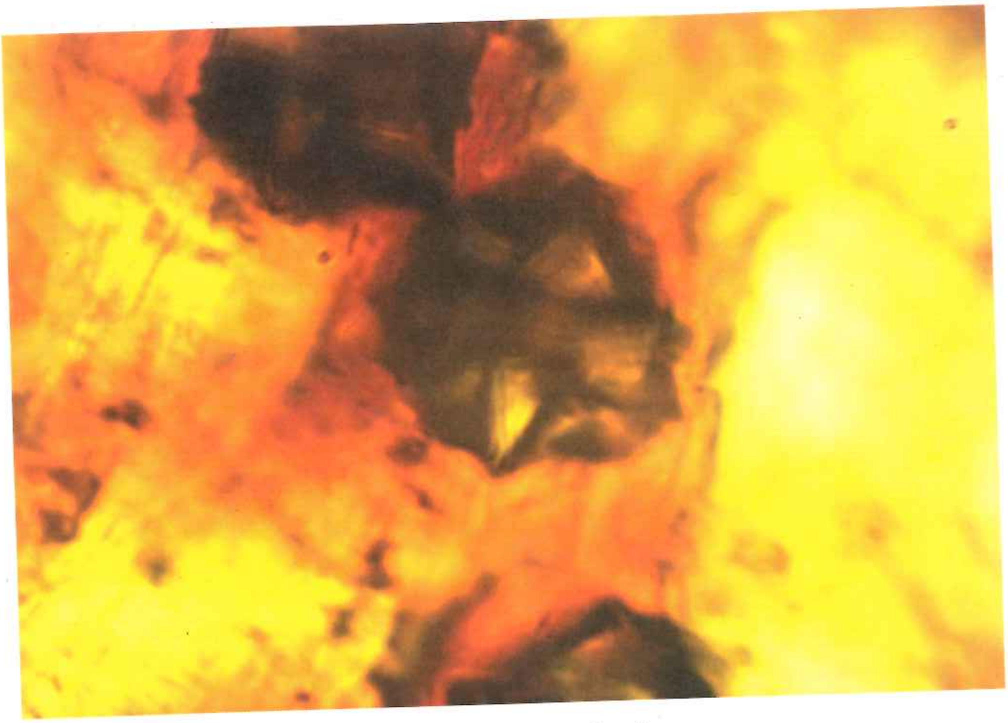


sometimes black



distinct round

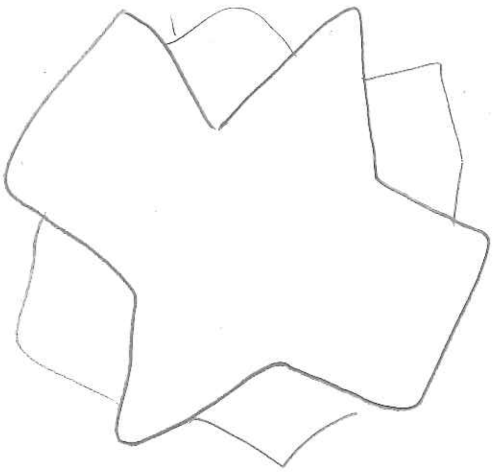
Papillae x40



Amperea conferta x100

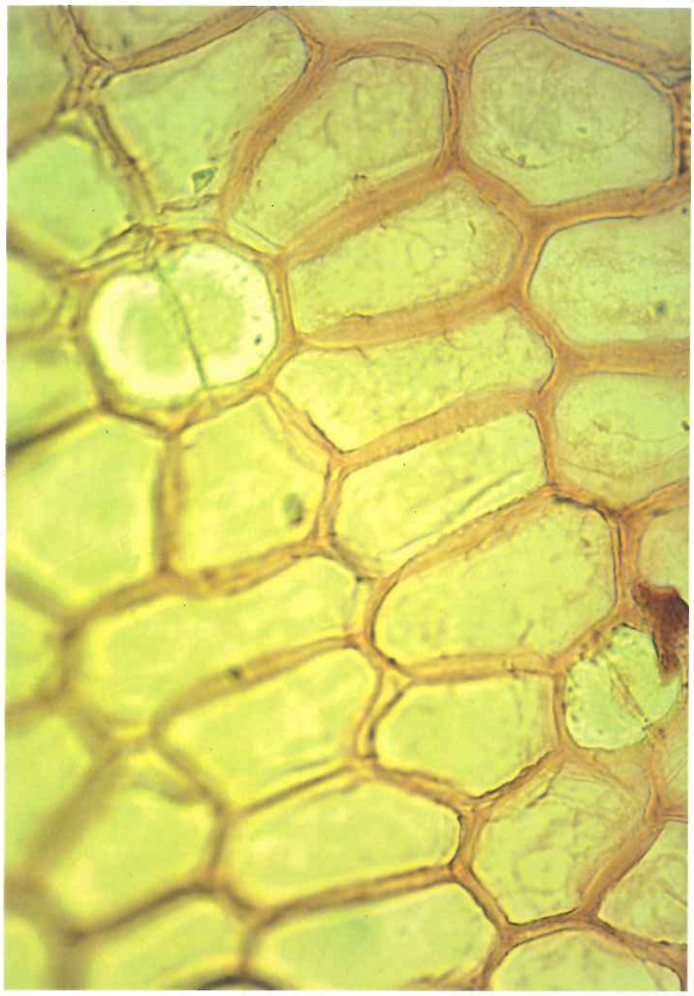
Amperea conferta

star shaped clusters on surface



Hair cluster x100

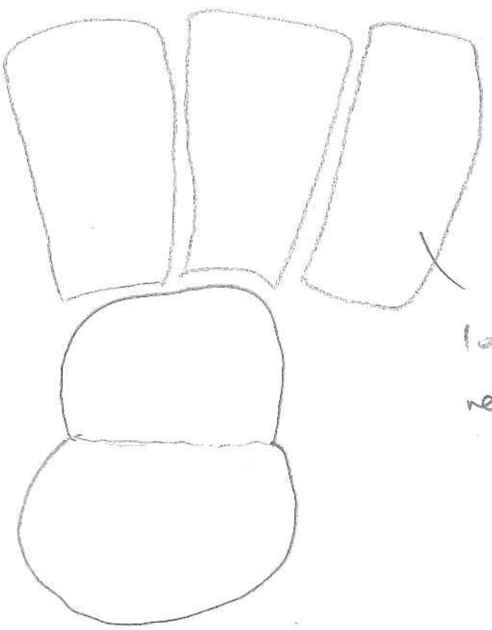
Darwinia collina x 40



Darwinia collina

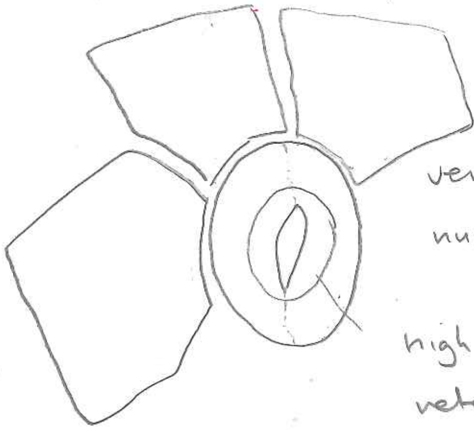
stomata 10± /×40 view

Adaxial - glands only

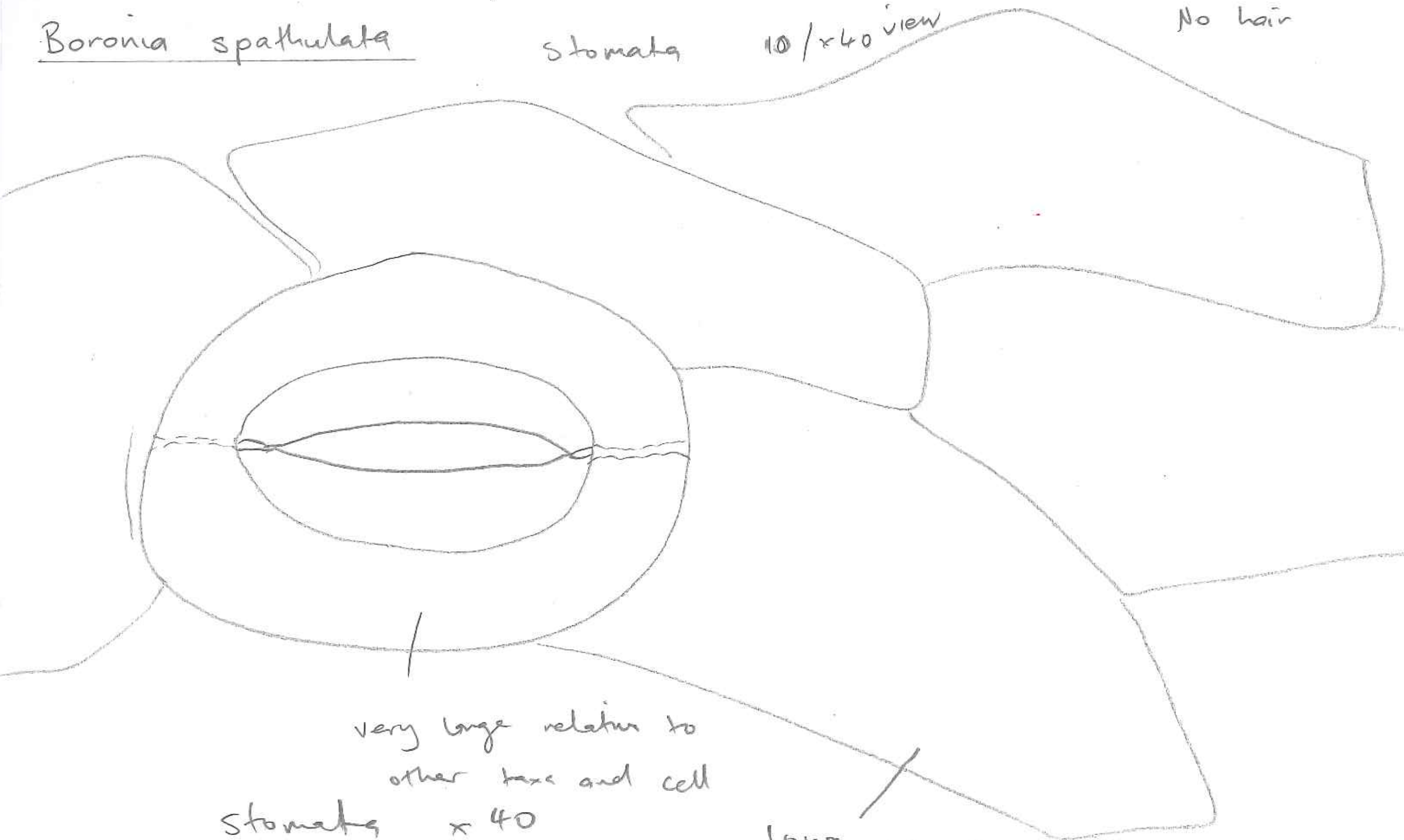


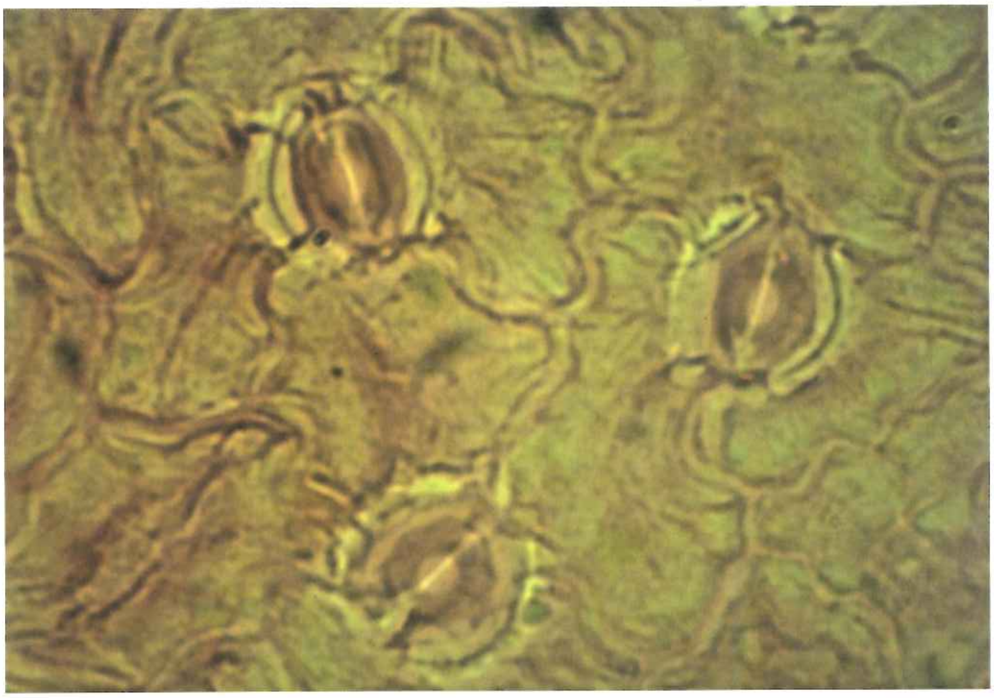
gland × 40

Abaxial - stomata + glands



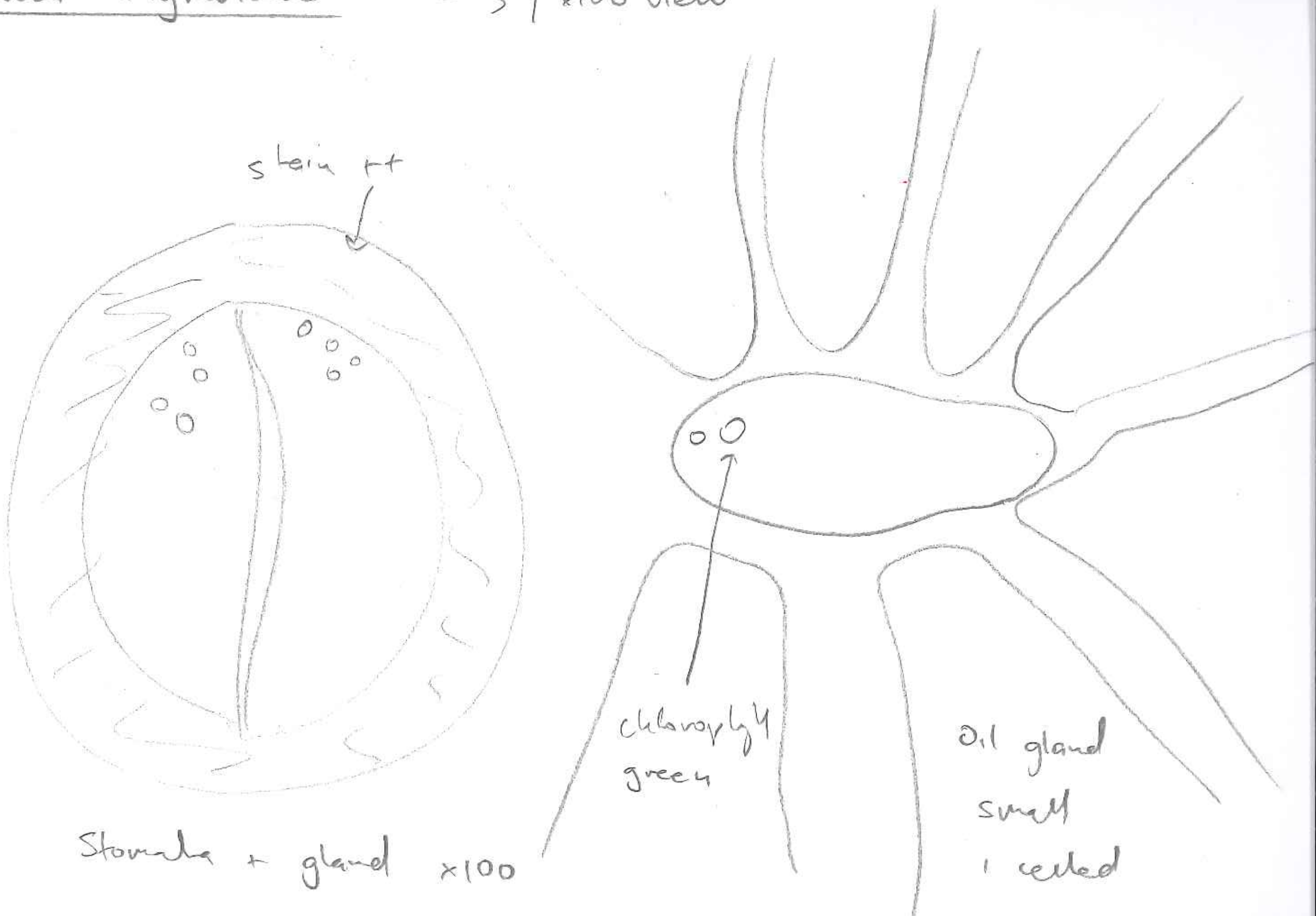
Boronia spathulata stomata 10/x40 view No hair



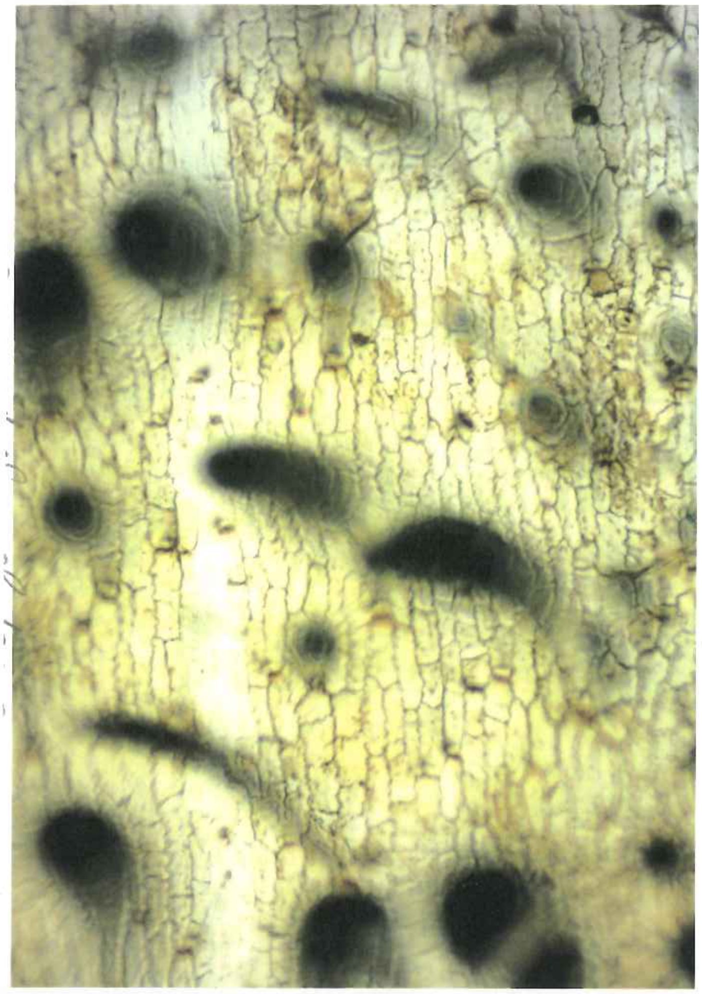


Melaleuca thymoides x100

Melaleuca thymoides - 3 | x100 view



Stomata + gland x100



Leucopogon gnaphalioides ×10

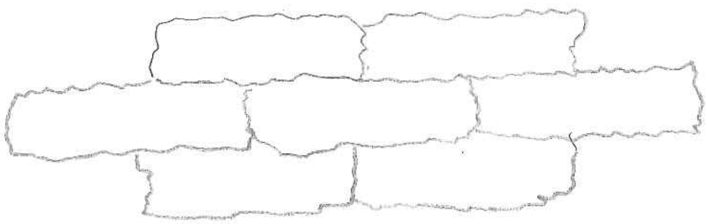
Leucopogon gnaphalioides

poor specimen

Adaxial - hairless
- stomata

Abaxial - long hairs

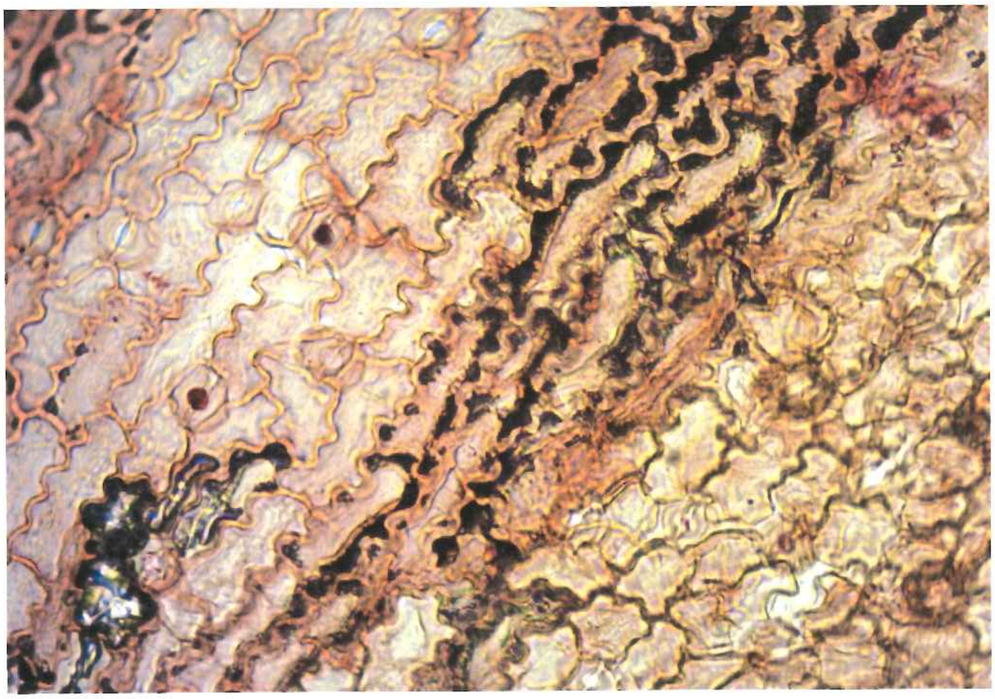
many small stomata
irregular arrangement



long parallel
rectangular cells

veins = 4-5 per ×10 view
lighter coloured cells

leaf margin hairy ++

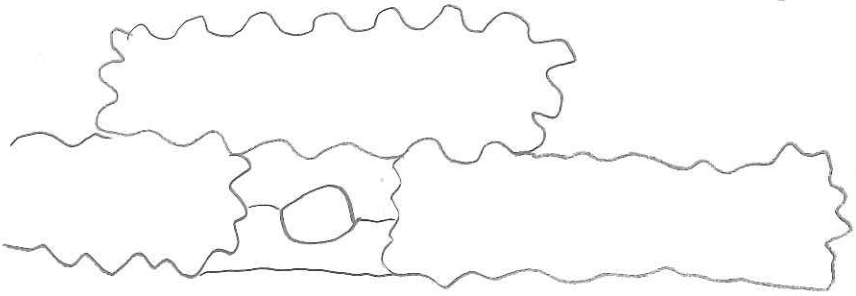


Dielsiodoxa tamaricina x40

Dielsiodoxa tamariscina

parallel veins

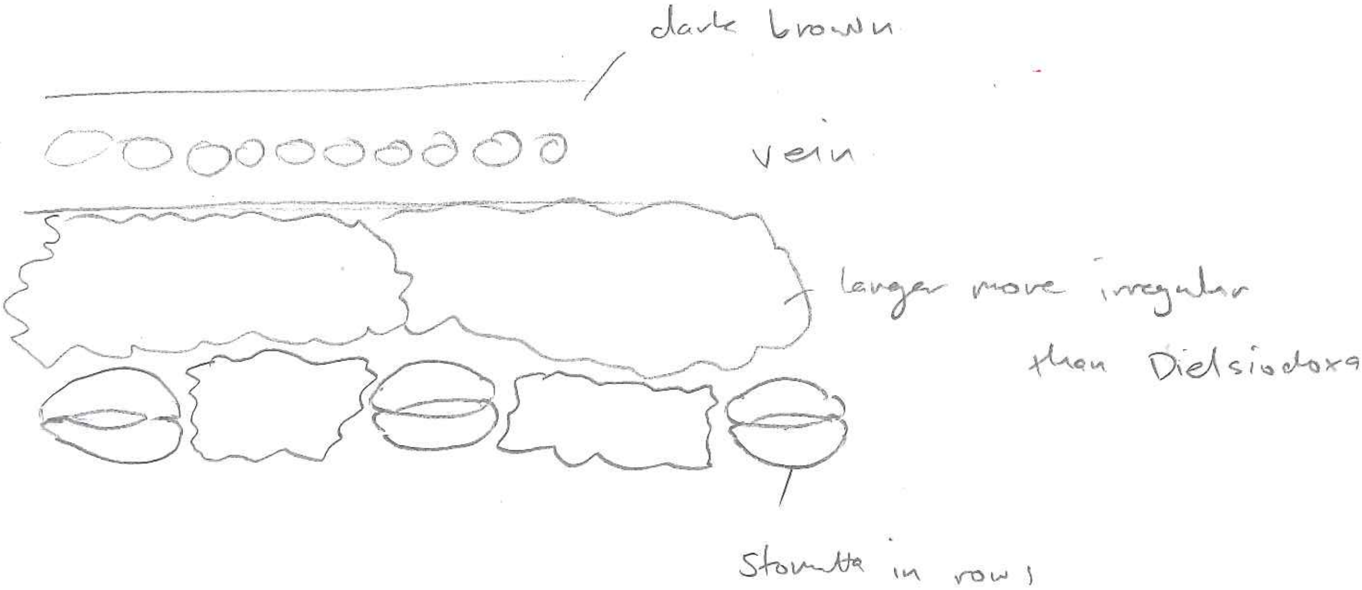
strongly irregular margin



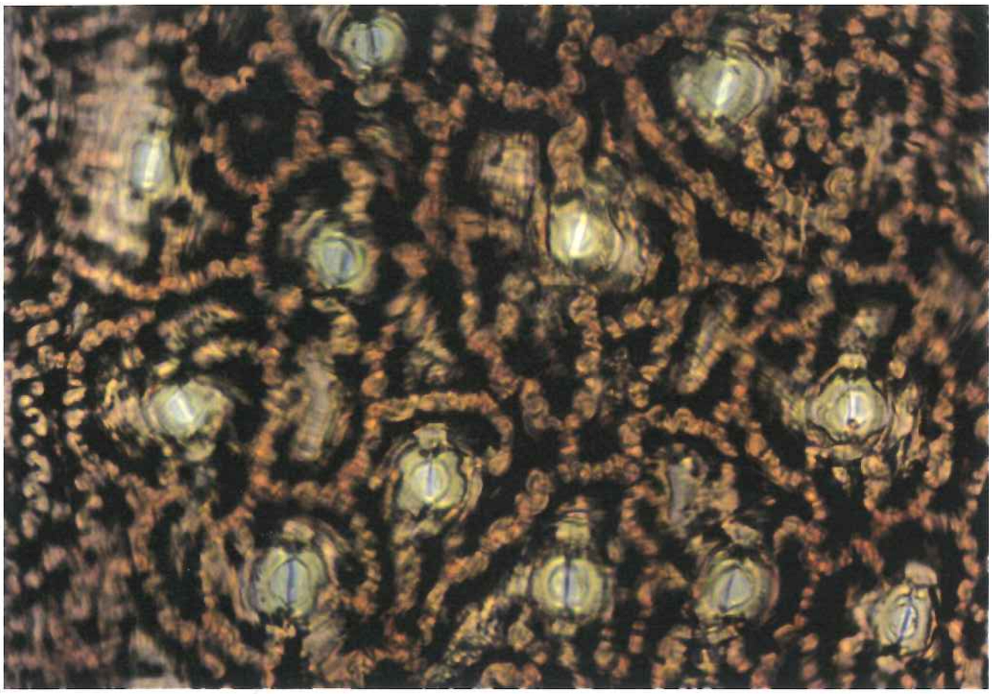
embedded stomata in rows

Sphenotoma sp. Stirling x40

Sphenotoma sp. Stirling

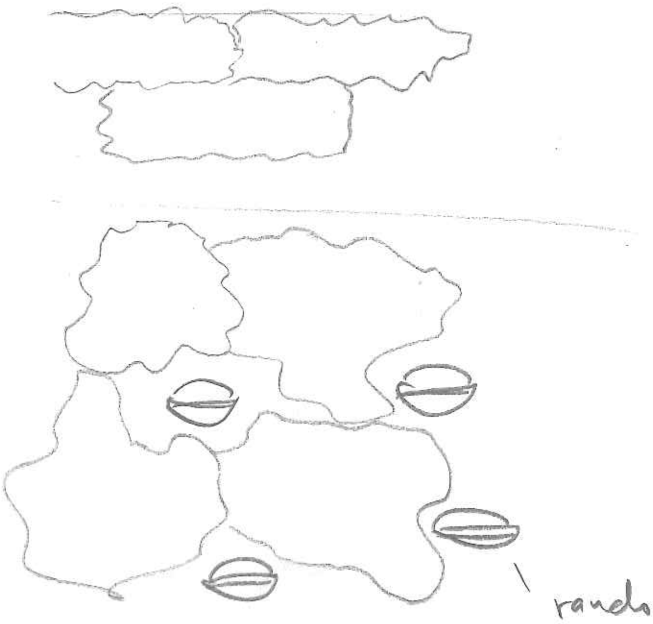


x 40



Andersonia axilliflora x40

Andersonia axilliflora



Vein = irregular cells in ||

Surface = irregular in irregular

stomata parallel but not in rows

random but in line

x40

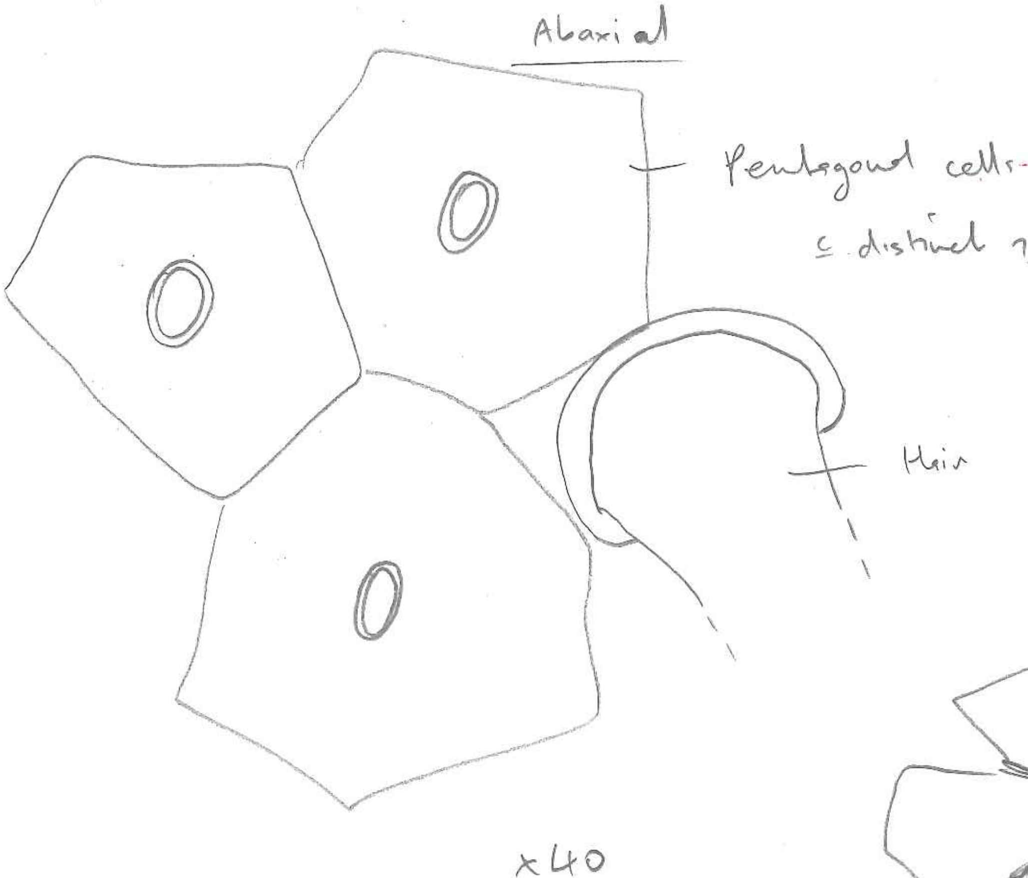
Andersonia echinocephala x40

Andersonia echinocephala

vein = parallel irregular cells

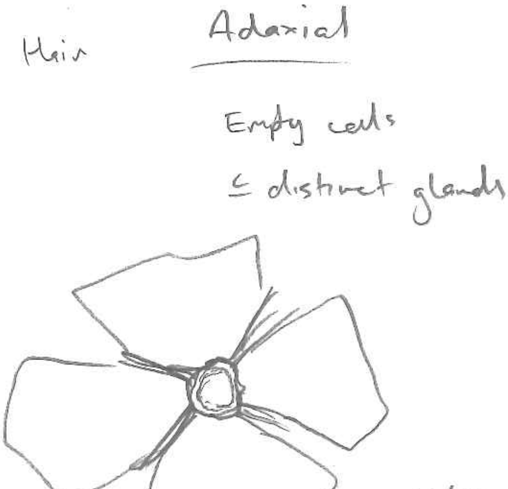
surface = nearly identical to Ae

Aotus genistoides



Adaxial

Empty cells
c distinct glands

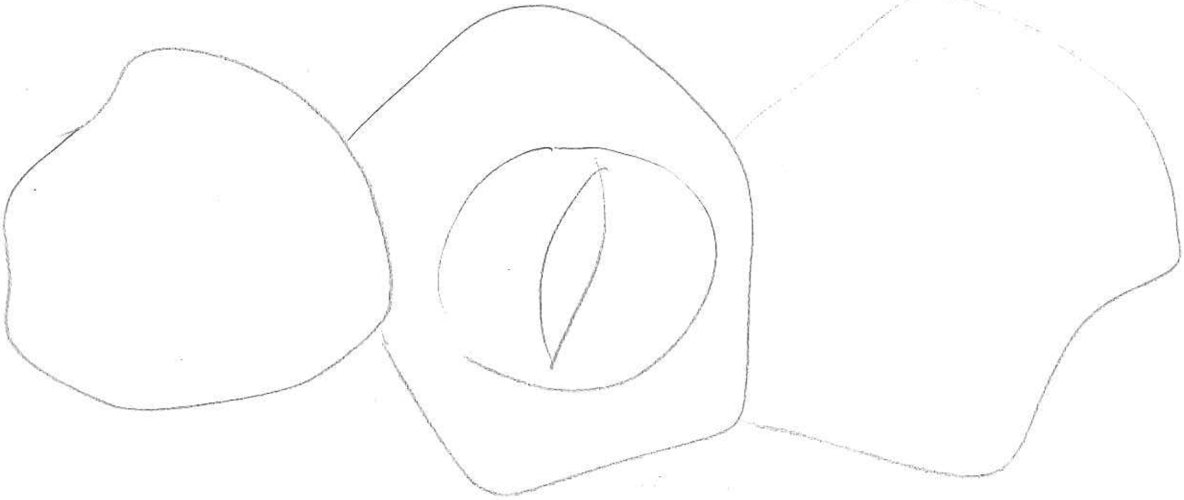


Latrobea colophona x10

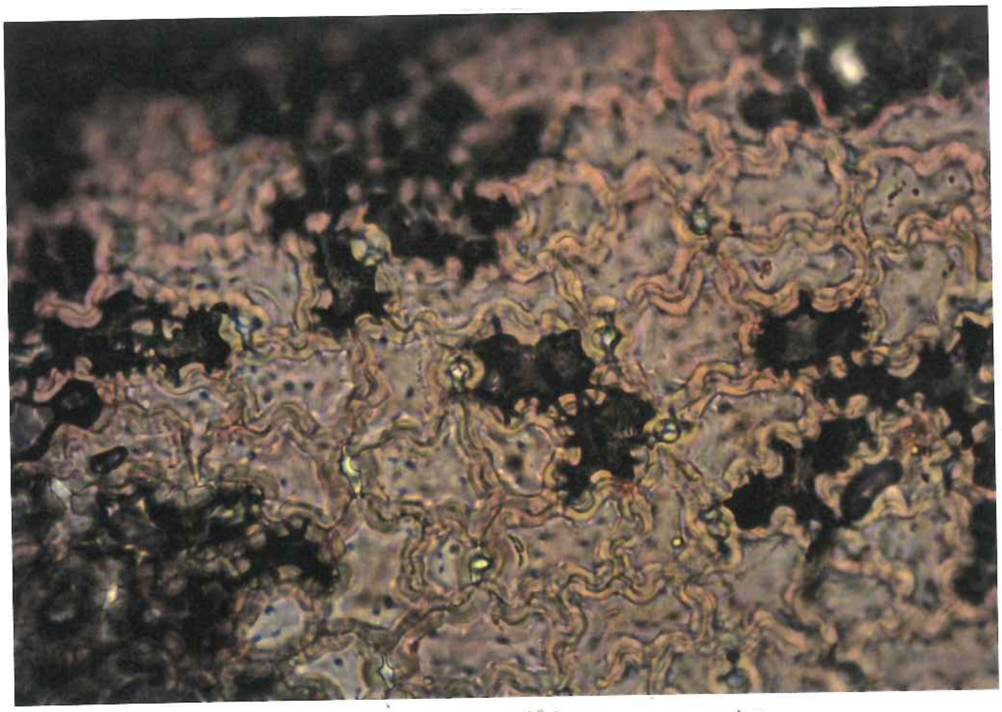
Latrobea colophona

poor image

- Long thin hairs
- irregular stomate



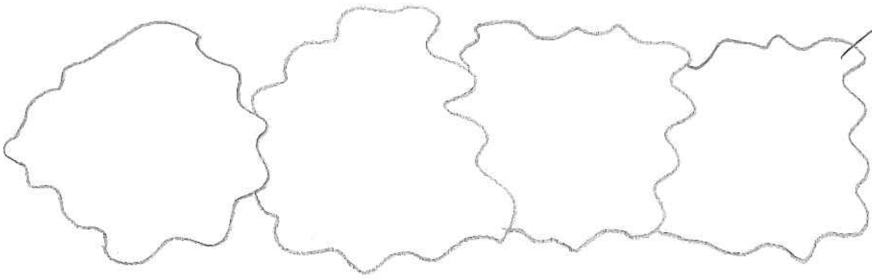
x 10

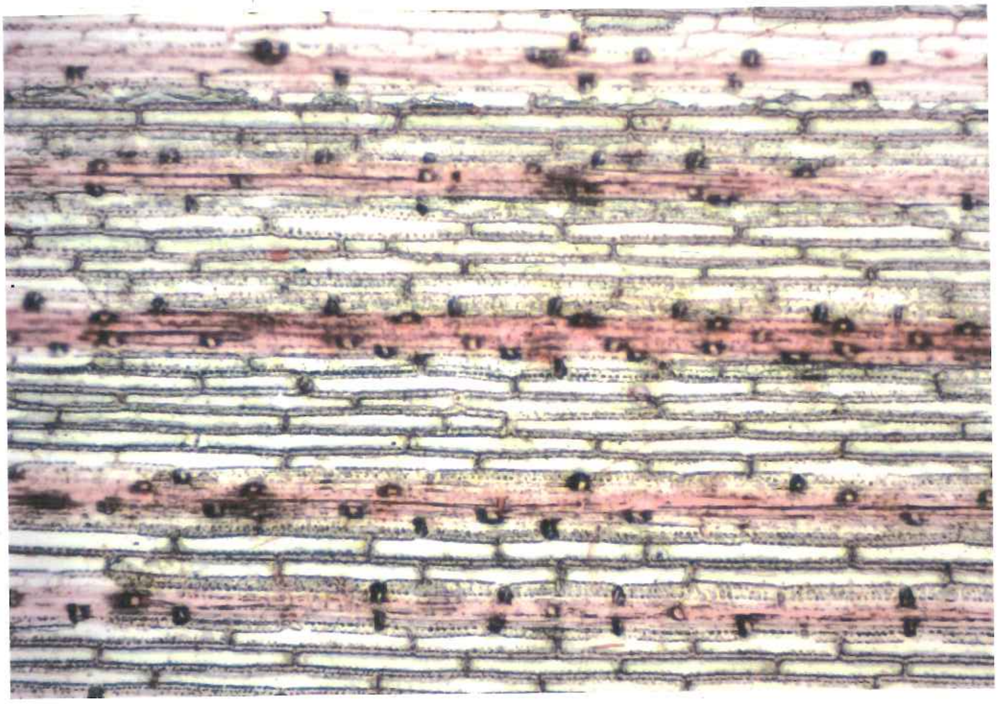


Lysinema ciliatum x40

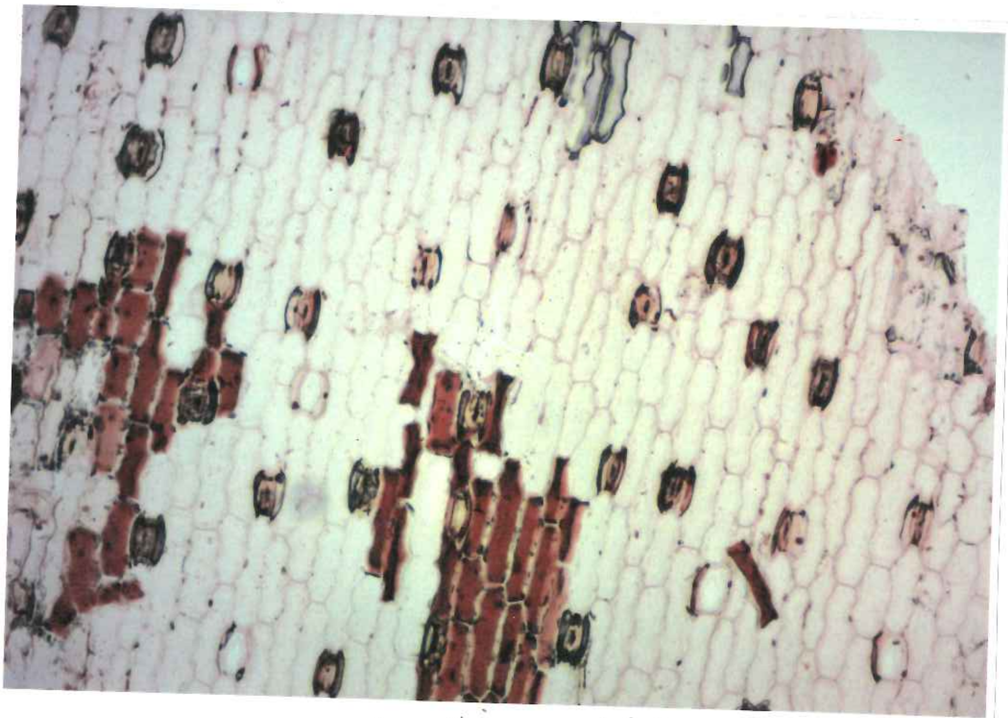
Lysinema ciliatum

- no veins
- irreguler cells typical of Ericaceae





Poaceae x10



Anarthria prolifera x10

Schoenus sp. Stirling ×10