

Studies in the genus *Riccia* (Marchantiales) from southern Africa. 12. *Riccia albolimbata* and the status of *R. albosquamata*, white-scaled species originally described by Arnell

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Keywords: Arnell, Marchantiales, *Riccia albolimbata*, *R. albosquamata*, white scales

ABSTRACT

Arnell's (1957, 1963) inadequate descriptions, poor drawings, mistakes in the text and key, as well as mixed collections, have all contributed to the confusion regarding the identity of his species *R. albolimbata* and *R. albosquamata*. Volk's collections (Arnell 1957) of the latter consist mostly of two white-scaled species in the same packet: one is *R. albolimbata* and the other is *R. argenteolimbata* Volk & Perold (Volk *et al.* 1988). Evidently Arnell used characters of both plants to describe *R. albosquamata*, although the type specimen, Volk 452, consists of only *R. albolimbata* (plus fragments of *R. atropurpurea* Sim and *R. trichocarpa* Howe). *R. albosquamata* is accordingly to be regarded as a taxonomic synonym of *R. albolimbata*.

UITTREKSEL

Arnell se (1957, 1963) onvoldoende beskrywings, swak tekeninge, foute in die teks en sleutel, sowel as gemengde versamelings, het almal bygedra tot die verwarring omtrent die identiteit van sy spesies *R. albolimbata* en *R. albosquamata*. Volk se versamelings (Arnell 1957) van laasgenoemde, bestaan meestal uit twee spesies met wit skubbe in dieselfde pakkie: die een is *R. albolimbata* en die ander een *R. argenteolimbata* Volk & Perold (Volk *et al.* 1988). Blykbaar het Arnell kenmerke van beide plante gebruik om *R. albosquamata* te beskryf, alhoewel die tipe-eksemplaar, Volk 452, alleenlik bestaan uit *R. albolimbata* (plus fragmente van *R. atropurpurea* Sim en *R. trichocarpa* Howe). *R. albosquamata* word derhalwe beskou as 'n taksonomiese sinoniem van *R. albolimbata*.

1. *Riccia albolimbata* S. Arnell, Mitteilungen aus der Botanischen Staatssammlung, München: 264 (1957); 1963: 25.

TYPE.—SWA/Namibia, 2117 (Windhoek): Farm Voigtland, bei Windhoek, gegen Ondekaremba, Kalkboden (–AB), 1956.02.12. Volk 11419 (PRE-CH 4232) (M!, holo., PRE!). 2217 (Windhoek): Binsenheimkamp (–CD), Volk 11080 (M!, PRE!, para.).

Thallus monoicous, perennial, in rosettes 15–20 mm across, or in crowded gregarious patches; medium-sized; furcate or bi-furcate, branches \pm symmetrical or one branch smaller, diversely divergent, ovate to oblong, up to 8.0 mm long, (1.5–) 1.8–2.2 (–3.0) mm broad, 2–2.5 times wider than thick; apex rounded, emarginate (Figures 1A; 2A); sulcus narrow and deep distally, disappearing in proximal parts, which are \pm flat or slightly concave (Figure 1D1–5); dorsally green and shiny, becoming white and spongy over sporangia; margins acute to subacute, flanks generally sloping obliquely upward and outward, green or brown to dark red; ventral surface flat to slightly rounded (Figure 1C, 1D1–5), green; when dry, margins inflexed with wavy hyaline/white scales covering most of dorsal surface (Figure 1B).

Anatomy of thallus: cells of dorsal epithelium emerging apically from groove in regular rows, hyaline, thin-walled, unistratose, dome-shaped or globose (Figures 1E; 2C), $\pm 45 \times \pm 50 \mu\text{m}$, each cell usually with a single corresponding column of assimilation cells

beneath, bulging upper walls sprinkled with calcium carbonate granules, cells soon collapsing, especially toward margins and more proximally (Figures 1E; 2D); air pores 4–5(–6)-angled, leading to air canals below (Figure 1F); assimilation tissue (chlorenchyma) about $\frac{1}{2}$ the thickness of thallus, cells short-rectangular, $\pm 50 \times 40\text{--}45 \mu\text{m}$, in columns of 6–8 (–10), enclosing 4–5-sided air canals (Figures 1F; 2E) which widen toward sides of branches (Figure 2B); storage tissue occupying lower $\frac{1}{2}$ of thallus, cells angular, size $\pm 55 \mu\text{m}$. Rhizoids mostly smooth, some tuberculate, 15–20 μm wide. Scales hyaline to white, base often flecked with brown or dark red, closely imbricate, undulating, large, 800–900 (–1200) $\times \pm 600 \mu\text{m}$ (Figure 1G), extending $\pm 150 \mu\text{m}$ above margin of thallus, rounded, edge mostly smooth, cells hexagonal to oblong-hexagonal in body of scale (Figures 1H; 2F), 55–100 $\times 35\text{--}55 \mu\text{m}$, marginally smaller, $\pm 25\text{--}40 \times 30\text{--}40 \mu\text{m}$, surface of cells often encrusted with calcium carbonate deposits, cell walls generally free of crystals. *Antheridia* with thick hyaline necks becoming white and thread-like, in one or two rows along middle of lobe. *Archegonia* with purple necks. *Sporangia* with about 300–450 spores each, overlying tissue turning white and spongy, disintegrating soon and leaving several capsules exposed along the longitudinal hollow. *Spores* 82–95 (–105) μm in diameter, yellow-brown to dark brown, semi-transparent to opaque, triangular-globular, polar, with wing narrow, 3.0–5.0 μm wide, often with pores at marginal angles, margin crenulate or finely eroded (Figure 3A); distal face with ornamentation quite variable, generally (7–) 10–12 angular to round areolae across (Figure 3B, C, D), 5.0–7.5(–10.0) μm wide, areolar walls varying from thin to thick, with raised papillae at nodes (Figure

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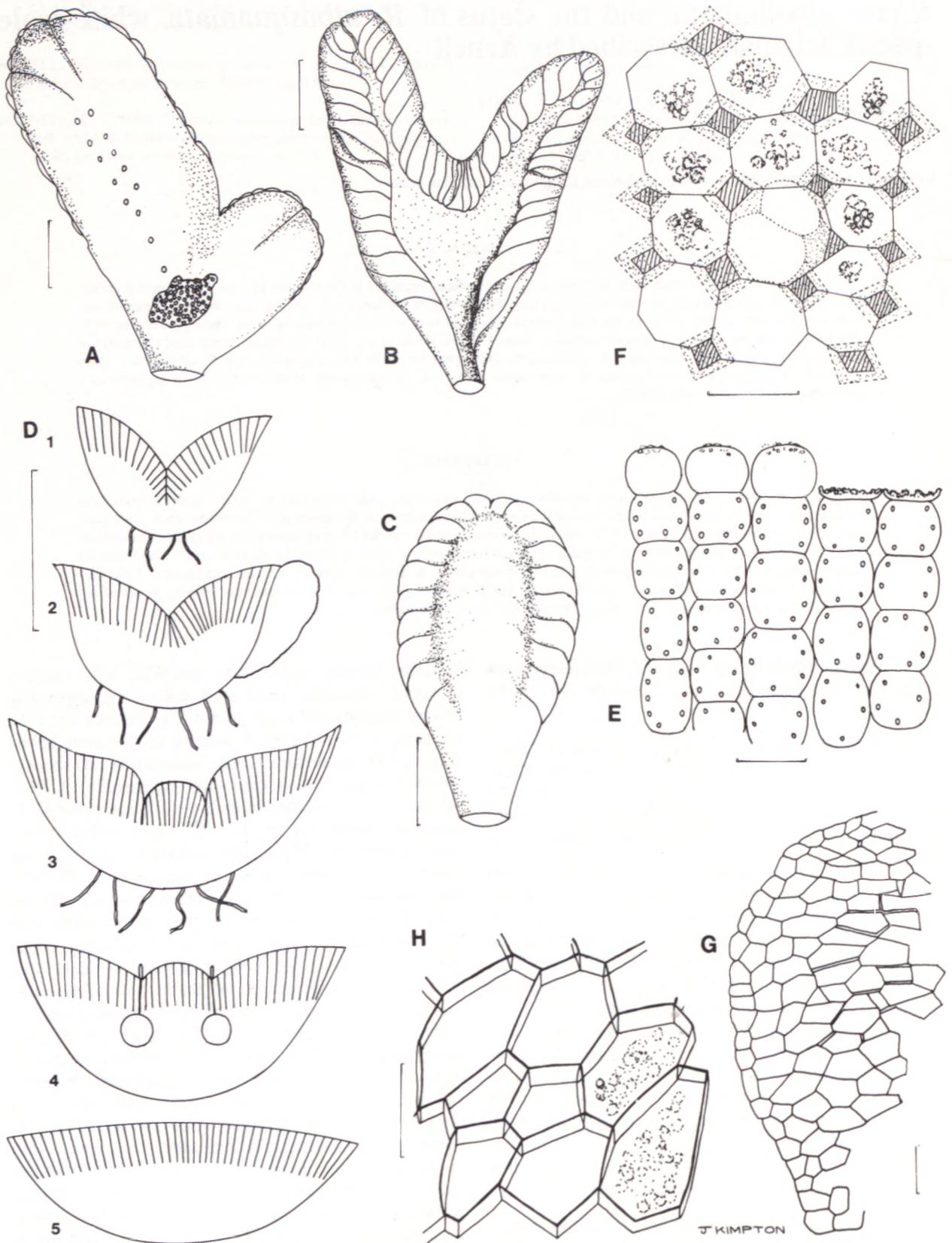


FIGURE 1.—*Riccia albolimbata* Arnell. Morphology and anatomy. A, fresh thallus; B, dry thallus; C, ventral view of thallus; D1–5, transverse sections of branch at different distances from the apex to older proximal part, *S. M. Perold 1380*; E, enlargement of transverse section through intact dorsal epithelial cells, capped with calcium crystals and showing narrow air canals in assimilation tissue; on right collapsed dorsal epithelial cells toward margin and larger air canals between columns of cells; F, epithelial cells with calcium crystals, air pores (hatched) overlying 4–5-sided air canals (dotted), as seen from above, *S. M. Perold 398*; G, scale; H, enlarged scale cells with calcium crystals, *S. M. Perold 803*. Drawings by J. Kimpton. Scale bar: A–D = 1 mm; E, F, H = 50 μ m; G = 100 μ m.

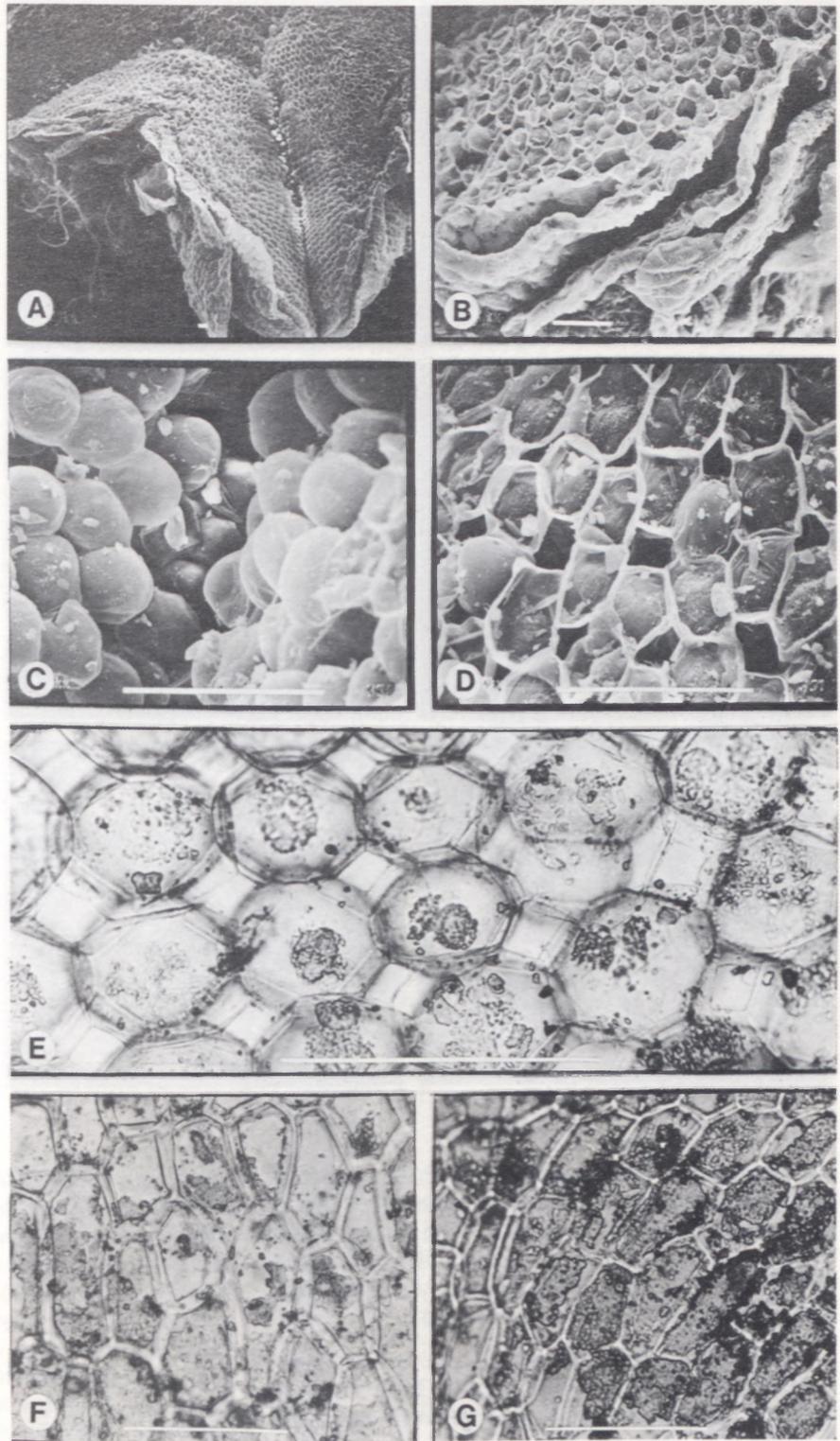


FIGURE 2.—*Riccia albolimbata* Arnell. Morphology and anatomy. A, dorsal view of apex and groove; B, large air pores near margin; C, globose dorsal cells intact at groove; D, collapsed dorsal cells around air pores; E, dorsal cells and air pores, *S. M. Perold 398*; F, scale cells, *Volk 11419*; G, scale cells, *Volk 452*. A–D, SEM micrographs; E–G, LM (light microscope) micrographs. Scale bar on A–G = 100 μ m. All SEM and LM micrographs by S. M. Perold.

3F), frequently only a few of the areolae over central area complete, and short, irregular ridges radiating outwards from central areolae and extending onto wing; proximal face with triradiate mark distinct and generally incompletely areolate, walls often thinning out or anastomosing to form irregularly branching ridges (Figure 3A, E). Chromosome number $n = 12$ (*Volk 81/204* p.p.); 16 (*Volk 81/160*); (*Volk 81/231b* as *R. albosquamata*); 24 (*Volk 81/164*) (Bornefeld 1984).

Different chromosome patterns within the same *Riccia* species, due to differential multiplication of individual

chromosomes, were reported by Bornefeld (1984) and termed 'nothopolyploidy'. Multiple chromosome numbers in some species (such as *R. albolimbata*) render chromosome numbers unsuitable as a diagnostic character (*Volk et al.* 1988).

R. albolimbata is widely distributed in the summer rainfall area of southern Africa and has been collected in South West Africa/Namibia and in Transvaal, Orange Free State and north-eastern Cape Province. It is apparently quite rare in Natal and central Cape and has not been found in the winter rainfall area of the north-western, western and south-western Cape (Figure 5).

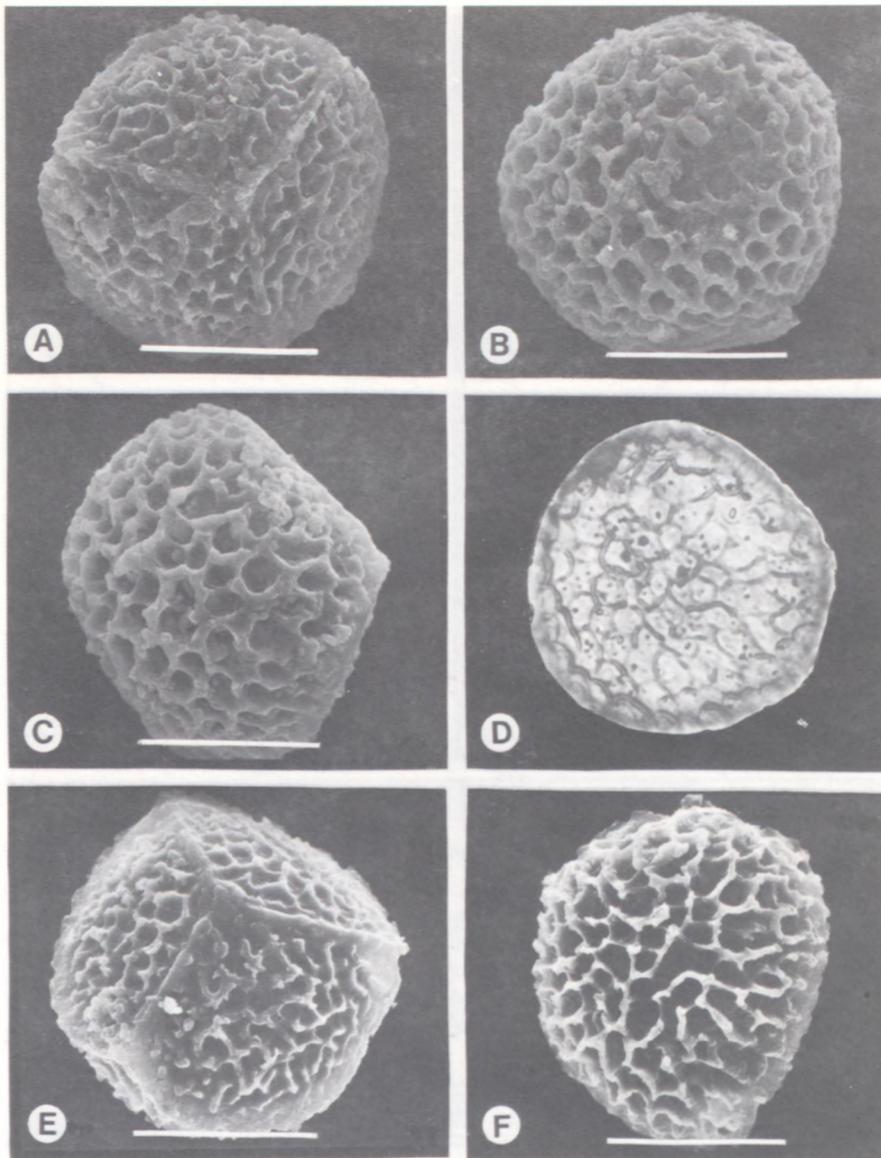


FIGURE 3.—*Riccia albolimbata* Arnell. Spores. A, proximal face; B, distal face; C, side view of distal face; D, distal face, Volk 11419, holotype, (spores from disintegrated sporangium at base of thallus); E, proximal face; F, distal face, Volk 11080, paratype. A–C, E, F, SEM micrographs; D, LM (light microscope) micrograph. Scale bar on A–C, E, F = 50 μm ; diameter of spore on D, $\pm 100 \mu\text{m}$.

It often grows on rocky outcrops, on shallow, calcareous soil at an alkaline pH, and on loamy soil between tufts of grass, sometimes in association with other *Riccia* species, e.g. *R. atropurpurea* Sim, *R. okahandjana* S. Arnell, *R. trichocarpa* Howe, *R. argenteolimbata* Volk & Perold and rarely with *Marchantia* spp.

Arnell (1957, 1963) reported *R. albolimbata* to be dioicous, but it is definitely monoicous (Table 1). There are other inaccuracies in his description as well: with branches 7×2 mm, it is not truly 'minor', but medium-sized; the dorsal colour of the thallus is green when fresh, not 'pale green'; the scale cells are not 'almost quadratic', except occasionally at the margins: in the body of the scale they are oblong-hexagonal (he also described the cell shape as 'generally hexagonal' (Arnell 1957, at the bottom of p. 266), mistakenly referring to it as *R. albomarginata*, as explained below), and their cell sizes at $55\text{--}100 \times 35\text{--}55 \mu\text{m}$ are usually somewhat larger than the $30 \times 30\text{--}40 \times 60 \mu\text{m}$ he reported; the scale cell walls are hardly thinner than in *R. albosquamata* [in both, the vertical walls are frequently visible (Figures 1 G, H and 2F, G which illustrate only *R. albolimbata*)]. The surfaces of the scale cells are often encrusted with calcium carbonate, but he did not men-

tion it, only referring to it under *R. albosquamata*. In *R. albolimbata* spores, he described the wing as incomplete, but it could have been partly folded inwards or partly obscured, as his illustrations (Arnell 1957, Figure 2; 1963, Figure 14) suggest. Although there are generally papillae arising from the areolar nodes, he stated that they were without papillae; his illustrations show ± 12 areolae across the distal face, but it has been found that the ornamentation shows a good deal of variability, with the areolae often incompletely separated, and hence fewer in number (Table 2). The inner face, however, clearly has 'irregular, thin lamellae' as described by him.

In his key to the *Riccia* species (pp. 13–16), *R. albolimbata* has been left out and *R. albomarginata* is listed twice, at Nos 7 and 11. On p. 14, at No. 11, *R. albomarginata* must be replaced by *R. albolimbata*, and also on p. 25, as he is comparing *R. albosquamata* with *R. albolimbata* (and not with *R. albomarginata*!). In the couplet (i) and (ii) on p. 14, part of the first sentence must be transposed, to correspond with his information in the text, viz. 'with a deep and sharp furrow' belongs with the information about *R. albolimbata* and 'slightly concave' refers to his description of the dorsal surface of

TABLE 1.—Comparison of Arnell's data on *Riccia albolimbata* and *R. albosquamata*. Observations and/or comments on type and other specimens by author

	<i>R. albolimbata</i>		<i>R. albosquamata</i>	
	Arnell	Perold	Arnell	Perold
Substrate		Brown soil		Finely textured, gray soil with calcium content ± 5 times higher than that of <i>Volk 11419</i> (LINK X-ray Microanalysis)
Sex	Dioicous	Monoicous	Monoicous	Monoicous
Colour	Pale green, shiny when fresh; colourless and 'spongy' over archegonia	Dry specimens white	White, shiny when fresh	White
Size	7 X 2 mm	Up to ± 7 mm long, 1.6–1.8 mm wide, 0.9 mm thick	5 mm long	Up to 5 mm long, segments 3 mm long, 1.3(–1.6) mm wide, 0.9 mm thick
Width: thickness	2–3 times broader than thick	1.6–2 times broader than thick	3 times broader than thick	1.4–1.6 times broader than thick
Branching	Bifurcate	Bifurcate	Dichotomously branching, with one branch longer	Bifurcate
Segment shape	Ovate	Broadly ovate		
Apex	Subacute	Rounded		
Groove	Deep and sharp, except proximally plano-convex, lateral parts of dorsal surface convex	Deep and sharp apically, concave proximally	Slightly concave dorsally	Apically grooved, proximally concave, frequently with \pm bulging sporangia
Margin	Subacute	Acute to subacute	Sharp, thin and scale-like	Could not be verified
Flanks	Obliquely ascending at 45–60°	Steep in old, long dried herbarium specimens, mostly oblique when fresh but degree possibly somewhat affected by shade and moisture conditions	Perpendicular, almost straight in upper $\frac{2}{3}$, arched in ventral $\frac{1}{3}$	Presumably referring to <i>R. argenteolimbata</i>
Epithelium	Cells thin-walled, upper wall subspherical	Collapsed, except in groove at apex	Thin-walled, \pm cubic, 20 μ m, soon destroyed	Presumably referring to <i>R. argenteolimbata</i>
Scales	Large, exceeding margin of thallus, entire, rounded, imbricate, cells thin-walled, almost quadratic, 30 X 30 to 40 X 60 μ m	1 200 X 700 μ m, cells in body of scale hexagonal, up to 100 X ± 35 μ m, wavy, hyaline; in other specimens white with calcium deposits	Large, imbricate, white with pale purple base, widely exceeding margin of thallus, margin entire, rounded, like scales of <i>R. limbata</i> , cells large, 50 X 70 μ m, thick-walled, lumen \pm filled of (sic) fine granules	Presumably referring to <i>R. argenteolimbata</i> ; scales in <i>Volk 452</i> , 850–1 000 X 550 μ m, cells oblong-hexagonal, 60–75 X 37 μ m, not thicker-walled, white, heavily encrusted with overlying calcium deposits, perhaps due to much higher calcium content in substrate
Spores		(See Table 2)		(See Table 2)
Diameter	80–100 μ m	Yellow-brown to dark brown	70–80 μ m	Yellow-brown to nearly black
Colour	Brown	Partly folded or obscured	Dark brown	
Wing	Incomplete	± 12 areolae across distal face, as illustrated in drawing by Arnell (variable)	2–4 μ m	5–7.5 μ m
Outer face	Foveolae 8–10 μ m wide, rounded, without papillae, thin reticulum	Irregular, thin lamellae	Irregularly areolate, 7–8 areolae in diameter, (8–10–12 μ m wide, 'processes of reticulum as spines in the wing')	Areolae frequently incompletely separated and hence fewer in number
Inner face	Irregular, thin lamellae		Not described or illustrated	Irregular thin lamellae

TABLE 2.—Comparison of measurements of spores from the type specimens of *Riccia albolimbata* (Volk 11419) and *R. albosquamata* (Volk 452: only the white-scaled portions). A minimum of 10 spores examined from each sporangium

	Spore diameter in μm	No. of areolae across distal face	Areolar width in μm	Wing width in μm
<i>R. albolimbata</i> (Volk 11419)				
1. Disintegrated sporangium at base of thallus	87–92	9–12	5,0–7,5	3,0–5,0
2. Disintegrated sporangium beneath thallus	92–95	7–9	7,5–12,0	5,0
3. Disintegrated sporangium in soil	82–95	8,9	7,5–10,0	5,0
<i>R. albosquamata</i> (Volk 452)				
1. Sporangium in small thallus	77–90	8–10	7,5–10,0	5,0–7,0
2. Sporangium in larger thallus	85–100	8–19	7,5–12,5	7,0
3. Sporangium \pm midway along length of lobe	70–90	9,10	5,0–10,0	3,0–5,0
4. Sporangium at base of thallus	75–90	10–12	5,0–7,5	5,0–7,0
5. Sporangium in small, loose thallus (yellow-brown spores)	95–100	10–12	7,5–10,0	7,5
6. Small sporangium (black, \pm poorly preserved spores)	77–80	\pm 10	\pm 5,0–7,0	5,0

R. albosquamata. It has now, however, become clear that the dorsal surface of *R. albolimbata* is only apically deeply grooved, and flat to somewhat concave proximally, whereas that of the other white-scaled species in these Volk collections, *R. argenteolimbata* (Volk *et al.* 1988), is deeply grooved along the entire length of the thallus.

Besides the types, there are fortunately several other fairly good specimens of *R. albolimbata* with spores [Volk 11080 (M!, PRE!), 11401 (M!), 11705 (PRE!) and 11946 (M!, PRE!)], identified by Arnell, to enable one to form a clear concept of the characters of this species. Volk 11967 (PRE!), is possibly a large plant of *R. atropurpurea*, judging by the spore ornamentation, but the thalli are broken up and it is difficult to make a definite decision about its identity. In notes found with some of Duthie's collections from Fauresmith and Middelburg (Cape) and now identified as *R. albolimbata*, she referred to them as the 'Doornberg' species, thus clearly indicating that she recognized them as belonging to a distinct species. Regrettably, she made no attempt to describe it.

R. albolimbata is closely similar to *R. albornata* Volk & Perold (Volk *et al.* 1988), but the former often grows in rosettes, the dorsal tissue covering the sporangia turns chalk-white and spongy, its scales are somewhat smaller and the spore ornamentation is coarser. Furthermore, the distribution ranges of the two species do not appear to overlap, except for two localities at Middelburg and Britstown, in the central Cape, and a doubtful one in northern South West Africa/Namibia.

R. albida Sull., described by Frye & Clark (1937) as having a white, spongy dorsal surface (which they called 'calcified'), differs in other respects from *R. albolimbata* by being a small plant, 2–4 mm long and 1,1 mm wide; the ventral scales are minute and the spores nearly smooth. Na-Thalang (1980) regarded *R. austinii* Steph., *R. albolimbata* S. Arnell, *R. albosquamata* S. Arnell and *R. albomarginata* Bisch. as species closely related to *R. lamellosa* Raddi. However, *R. albomarginata* belongs to section *Pilifer* Volk, which is endemic to South Africa and is characterized by a dorsal epithelium of loose cell pillars (Volk 1983). *R. lamellosa* [= *R. austinii* (Müller 1954)], is a larger plant with thallus

lobes up to 20 mm long and with a somewhat different spore wing and spore ornamentation (Jovet-Ast 1986), neither has it been recorded from southern Africa.

2. *Riccia albosquamata* S. Arnell, Mitteilungen aus der Botanischen Staatssammlung, München: 266 (1957); 1963: 25.

TYPE.—SWA/Namibia, Damaraland, 1918 (Grootfontein): Neitsas, am Rande einer Kalkpfanne (–CA), 1956 Volk 452 p.p. (M!, holo.). 2017 (Waterberg): OTJ147 (–CA), Volk 881 p.p. (M!, PRE!, para.).

Arnell (1957, 1963) recognized two species, *R. albolimbata* and *R. albosquamata* on the basis of the following (see also Table 1):

- (i) the monoicism or dioicism of the plants;
- (ii) the so-called differences in the colour, size and branching of the thalli;
- (iii) differences in the shape of the dorsal groove, margins and flanks;
- (iv) the thin-walled subspherical or cubic-shaped dorsal epithelial cells;
- (v) the hyaline or white-spotted scales with, respectively, thin or thick cell walls;
- (vi) the different 'texture' of the spores, i.e. \pm 12–14 areolae across the diameter, forming a reticulum without papillae, in his spore drawing [Table I, Figure 2 (1957), Figure 14 (1963)], as opposed to 7–8 areolae across the spore diameter [Table II, Figure 1 (1957), Figure 15 (1963)], with 'processes of the reticulum (projecting) as spines in the wing'.

The holotype collection of *R. albosquamata*, Volk 452, is a mixed gathering which also contains *R. trichocarpa* Howe and *R. atropurpurea* Sim and several branches of a white-scaled species. Detailed investigations of the white-scaled material resulted in the following findings: the plant appears to be monoicous, as *R. albolimbata* was also found to be, and the branching, shape and size of the lobes fall within the normal range for *R. albolimbata*. The material is, of course, no longer fresh and green and dorsally it has turned whitish. The groove is only distinct apically, flattening out and becoming slightly concave proximally. The margins are subacute, the flanks are steeper and less sloping than

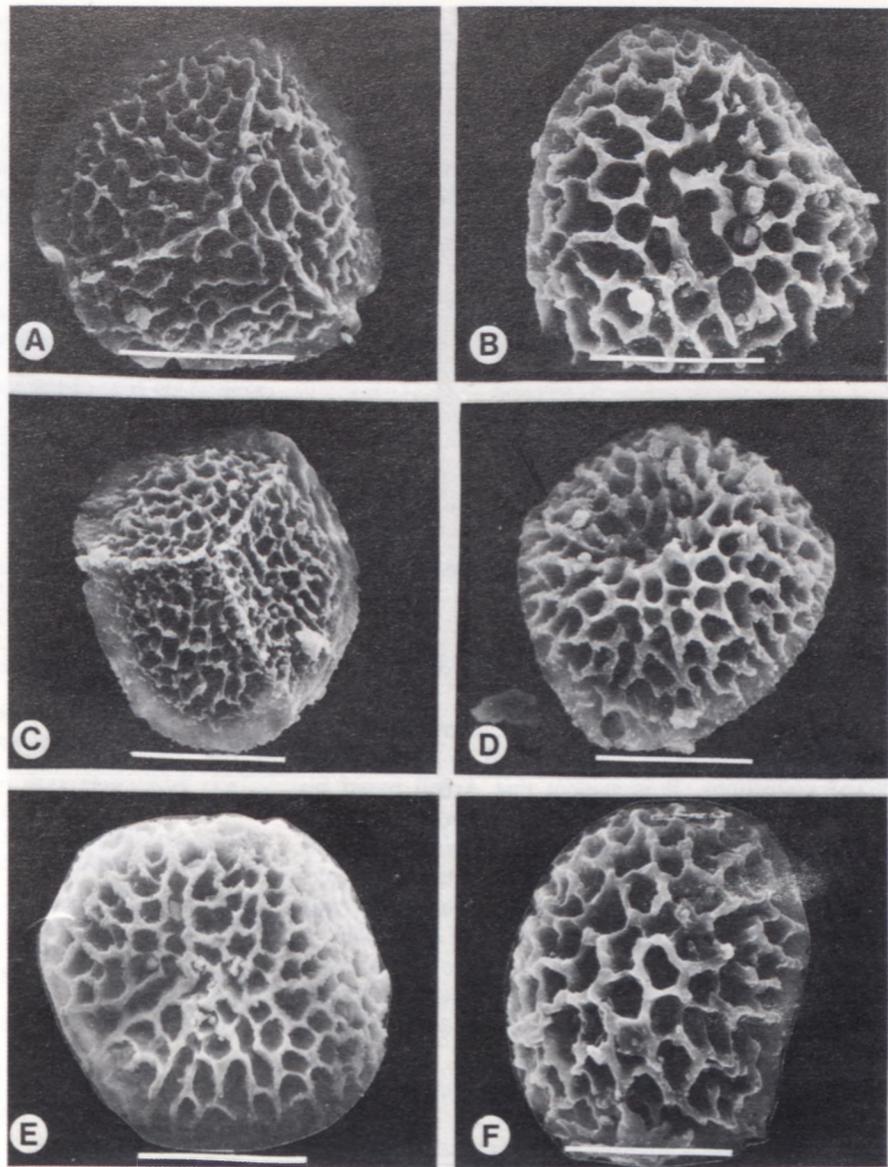


FIGURE 4.—*Riccia albosquamata*, Volk 452, holotype. Spores. A, proximal face; B, distal face (spores from sporangium in larger thallus); C, proximal face; D, distal face (spores from sporangium at base of thallus); E, distal face (spores from small, loose thallus); F, distal face (spores from small thallus). A–F, SEM micrographs. Scale bar on A–F = 50 μ m.

usual and the ventral surface is convex. The dorsal epithelial cells have collapsed, but the pores are 4–5-angled, the latter not commented on by Arnell. The scales are white with a reddish purple base, imbricate, large, 850–1000 \times \pm 550 μ m, and extend above the margin of the thallus; the cells are \pm 60–75 \times 35 μ m (Arnell reported 70 \times 50 μ m), calcium carbonate granules cover the cell surfaces and do not fill the cell lumens as stated by Arnell. The cell walls are not truly thicker either (Figure 2G). The spores were found to be 70–100 μ m in diameter (Table 2) (Arnell reported 70–80 μ m), yellow-brown to dark brown, triangular-globular, polar, with the wing (3–)5(–7) μ m wide, sometimes with radial folds, pores at the marginal angles and the margin crenulate (Figure 4A); distal face with 8–10 (–12) areolae across (Figure 4B, D, E, F), (5,0–) 7,5–12,5 μ m wide and often incomplete; sometimes the branched ridges over the centre of the face are more prominent (Figure 4B, F), as also seen in Arnell's figure. The smaller number of slightly wider areolae Arnell described and illustrated for *R. albosquamata* spores, namely 7 or 8 as opposed to \pm 12 he illustrated for *R. albolimbata* spores, are due to several areolae being incompletely separated and becoming confluent. Papillae

project from the areolar nodes as in *R. albolimbata* spores. Arnell made no mention of the proximal face, but with thin, irregular ridges and a distinct triradiate mark (Figure 4A, C), it is indistinguishable from that of *R. albolimbata*.

I therefore conclude that the white-scaled branches included in the type gathering of *R. albosquamata* represent *R. albolimbata*. I hereby sink *R. albosquamata* S. Arnell under *R. albolimbata* S. Arnell, because the type collection of *R. albolimbata* represents only one species and the description refers to only one species, whereas *R. albosquamata* is based on a mixed type collection and its description is based on different species.

The identification of the other specimens which Arnell placed under *R. albosquamata* are as follows: Volk 453 (M, PRE!): the PRE specimen contains only *R. trichocarpa*; Volk 881 (paratype) (M!, PRE!): *R. albolimbata* and *R. argenteolimbata* Volk & Perold; Volk 883 (M!, PRE!): *R. albolimbata*, *R. argenteolimbata* and *R. atropurpurea* Sim; Volk 11906 (M!): *R. argenteolimbata*, *R. okahandjana* S. Arnell, *R. trichocarpa* and *R. atropurpurea*; Volk 12744 (M!, PRE!): *R. albolimbata* and an unidentified *Riccia* species. None of these white-scaled

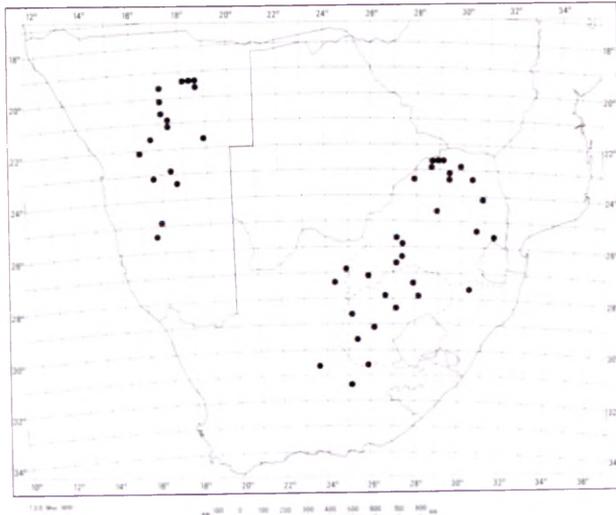


FIGURE 5.—Distribution map of *R. albolimbata* in southern Africa.

specimens, except for the unidentified fragment of *Volk 12744* and *Volk 452*, have spores.

It will be noticed that three of the above specimens also contain *R. argenteolimbata* Volk & Perold in the mixed collections. It is evident that Arnell based his description of *R. albosquamata* on the two white-scaled species, *R. albolimbata* and *R. argenteolimbata*, using characters from both. The references to 'thin and scale-like' margins, perpendicular sides, white scales with pale purple bases 'resembling the scales of *R. limbata* in shape and size' and presumably the 'cubic' dorsal cells, indicate that he referred to the *R. argenteolimbata* part of the collections, whereas the 'concave dorsal face' of the thallus and the spores with a wing (i.e. polar), are *R. albolimbata* characters; *R. argenteolimbata* has a long, sharp dorsal groove and the spores are wingless and apolar, its thallus is compact and the dorsal air pores are mostly triangular, but he did not note this. To give Arnell the credit due to him, he obviously recognized that there were two white-scaled species present, but he failed to distinguish clearly between them. As concluded above, *R. albosquamata* is a taxonomic synonym of *R. albolimbata*; *R. argenteolimbata* has been described as a new species (Volk *et al.* 1988).

SPECIMENS EXAMINED

SWA/NAMIBIA.—1917 (Tsumeb): Farm Kumkuaus (–CA), *E. Retief 1459* (PRE). 1918 (Grootfontein): Ossa, on dolomite (–AC), *Volk 81-146* (M. PRE); Gaikos (–A) *Volk 84-703* (M. PRE); Neitsas (–BC), *Volk 452* (M). 2017 (Waterberg): Oros 98 (–AA), *Hoffmann PRE-CH 4516* (PRE); OTJ 147 (–CA), *Volk 881* p.p., 883 p.p. (M. PRE); Wilhelmstal (–CD), *Volk 84-717, 84-721* (M. PRE). 2116 (Okahandja): Erichfelde, auf Kalk (–DA), *Volk 11946* (M. PRE). 2118 (Steinhausen): Gobabis, Farm Sturmfeld (–DB), *Toelken 5558* (PRE). 2216 (Otjimbingwe): OM 37 Otjua (–AA), *Volk 81-115* (M. PRE). 2217 (Windhoek): Rietfontein, on calcareous crust (–CD), *Volk 81-265* (M. PRE); Binsenheimkamp (–CD), *Volk 11080* (M. PRE); Wilhelmstal (–CD), *Volk 84-717* (M. PRE). 2316 (Nauchas): Farm Naos, on calcareous crust (–BA), *Volk 81-200* (M. PRE). 2317 (Rehoboth): Gravenstein (–BC), *Volk 11705* (M. PRE). 2416 (Malta-hohe): MAL 98 (–DD), *Volk 01254a* (M). 2516 (Helmeringhausen): Duwisib (–BC), *Volk 12744* p.p. (M. PRE).

TRANSVAAL.—2228 (Maasroom): Alldays, 55 km W of, on calcareous soil (–DA), *S. M. Perold 770* (PRE); Gregory Halt (–DA), *S. M. Perold 737* (PRE); 38 km W of Alldays (–DB), *S. M. Perold 759* (PRE); Bulkop, on calcareous soil (–DC), *S. M. Perold 793-795* (PRE). 2229 (Waterpoort): Chasa (?), Limpopo River, precise locality

unknown, *Stephansen 5393* (BOL); 4 km W of Alldays, Farm Bavaria (–CA), *S. M. Perold 733* (PRE); Wylie's Poort (–DD), *S. M. Perold 803* (PRE). 2327 (Ellisras): Villa Nora, 29 km NW of Farm Franschoek (–BD), *Smook 4231* (PRE). 2329 (Pietersburg): Vivo, 15 km N of (–AB), *S. M. Perold 725* (PRE); Dendron, 25 km S of (–AD), *S. M. Perold 719* (PRE). 2330 (Tzaneen): Lebowa Ga-Modjadji (–AD), *Glen 1400, 1404* (PRE). 2428 (Nylstroom): between Groenvallei and Roedtan, Farm Zoetkoppies (–DB), *S. M. Perold 339* (PRE). 2430 (Pilgrim's Rest): Phalaborwa, Farm Parsons 155, next to Olifants River (–BB), *Venter 12197* (PRE). 2527 (Rustenburg): 14 km N of Rustenburg, on calcareous soil (–CA), *S. M. Perold 222, 228* (PRE); Maanhaarrand, on soil at streamside (–CD), *S. M. Perold 454* (PRE). 2530 (Lydenburg): Sudwala, on earth bank (–BC), *S. M. Perold 398* (PRE). 2531 (Komatipoort): Kaapmuiden, Kaapse plateau (–CB), *Vogel T136* (Mainz). 2627 (Potchefstroom): Wonderfontein-spruit, 6 km N of Carltonville (–AD), *S. M. Perold 1026* (PRE); Gerhardminnebron (–CA), *Ubbink 1156* (PUC); Venterskroon (–CA), *Ubbink 1291* (PUC). 2725 (Bloemhof): Wolmaransstad, Farm Leeufontein (–BB), *A. E. van Wyk 5753* p.p. (PRE).

NATAL.—2730 (Vryheid): Burgers Pass (–CB), *S. M. Perold 699* (PRE).

O.F.S.—2726 (Odendaalsrus): Odendaalsrus (–DC), *Smook 6583a*; 6584 p.p. 2727 (Kroonstad): Heilbron, at stream, N of town (–BD), *S. M. Perold 1369* (PRE). 2728 (Frankfort): Wonderfontein-spruit, 40 km from Bethlehem on road to Lindley (–CC), *S. M. Perold 1365* p.p.; 1366 (PRE). 2825 (Boshof): Farm Goedehoop (–CA), *Volk 81-204* p.p., 81-210 (M. PRE). 2827 (Senekal): Allemanskraal, plateau near caravan park (–AC), *Volk 81-041, 81-231* p.p., 81-214 p.p., 84-653 (M. PRE). 2925 (Jagersfontein): Fauresmith (–CB), *Duthie 5441C, 5445, 5449* (BOL). 2926 (Bloemfontein): Bloemfontein (–AA), *Duthie 5507, 5519* (BOL); Eagle's Nest (–AA), *Geo. Potts CH 1010, CH 1036b* (PRE); *Henrici CH 3741* p.p. (PRE); *Volk 81-289* p.p. (M. PRE). 3025 (Colesberg): H. F. Verwoerd Dam, watercourse (–CB), *S. M. Perold 950, 951* (PRE).

CAPE.—2624 (Vryburg): 8 km E of Vryburg (–DD), *S. M. Perold 1380* (PRE). 2724 (Taung): Reivilo, Farm Sebete Tsapitse 899 (–AD), *Venter 12457* (PRE). 2823 (Griekwastad): precise locality unknown, *Wilman 5517* (BOL). 3023 (Britstown) Britstown (–DA), *Duthie 5469* (BOL). 3125 (Steynsburg): Middelburg, Doornberg (–AC), *Duthie 5110, 5438* (BOL).

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