**Status of *Brachiolejeunea* (Spruce) Schiffn. in India**

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**Abstract.** The status of Indian *Brachiolejeunea* (Spruce) Schiffn. is discussed. The species described earlier under this genus belong to closely allied genera *Frullanoides* Raddi or *Trocholejeunea* Schiffn. *Frullanoides* Raddi is known only by *Frullanoides tristis* (Steph.) Van Slageren which has been discovered recently from Nilgiri hills (Tamil Nadu) and Nandi hills (Karnataka) in southern India. *Trocholejeunea* is represented by two species, *Trocholejeunea infuscata* (Mitt.) Verd. from eastern Himalayas and *Trocholejeunea sandvicensis* (Gott.) Mizut. from Palni hills (Tamil Nadu), south India and western Himalaya. Of these *Trocholejeunea sandvicensis* has been discovered for the first time from western Himalaya which also shows intracapsular spore germination of the *Lopholejeunea*-type. The scanning electron microscopic details of sporoderm of *Frullanoides tristis* and *Trocholejeunea sandvicensis* have been given.

**Keywords.** Bryophyta; Jungermanniales; Lejeuneaceae; *Brachiolejeunea*; *Frullanoides*; *Trocholejeunea*.

1. Introduction

The first Indian species of *Brachiolejeunea* (Spruce) Schiffn. sensu lato was described by Mitten (1861) as *Lejeunea infuscata* Mitt. from Sikkim and Khasi hills. It was later transferred to *Trocholejeunea* by Verdoorn (1934). Later, Stephani (1912–1917) described 3 species—*B. andamana* St. from Andaman, *B. wardiana* (Mitt.). St. from Himalaya and *B. levieri* Schiffn. from Sikkim Himalaya. Schiffner (1932) described *B. levieri* as *Trocholejeunea levieri* (St.) Schiffn. from Darjeeling and Kurseong. Verdoorn (1934) rightly treated *B. andamana* and *B. wardiana* as synonyms of *Ptychanthus striatus* (Lehm. et Lindenb.) Nees and *Mastigolejeunea repleta* (Tayl.) St., respectively, while *B. levieri* was treated under *Trocholejeunea infuscata* (Mitt.) Verd. Under the genus *Brachiolejeunea*, he described *B. sandvicensis* (Gott.) Evs. from Perumalmalai, Palni hills (see also Mizutani 1961). Herzog (1939), however, retained *B. levieri* and reported it from Darjeeling. He also described *B. aliculata* Herz. from Shembaganur (Herzog 1950) which seems to be the synonym of *B. sandvicensis*. Mizutani (1978) transferred this species (*B. sandvicensis*) to *Trocholejeunea* Schiffn.

It is thus evident that *Brachiolejeunea* and *Trocholejeunea* have been controversial genera for a long time. Schuster (1980) pertinently remarked "... it is difficult, if not impossible, to maintain the distinction between *Brachiolejeunea* and *Trocholejeunea* accepted by Verdoorn (1934) and, following him, Gradstein (1975) and others". Considering intrageneric diversity within *Brachiolejeunea* sensu lato, Schuster (1980) divided *Brachiolejeunea* into 3 subgenera—*Brachiolejeunea* (Spruce) Schiffn., *Plicolejeunea* Schust. and *Trocholejeunea* (Schiffn.) Schust., the last with sections *Pluriplicatae*, *Trocholejeunea* and *Sandvicensis*. Van Slageren (1985) raised the
subgenus *Plicolejeunea* to the generic rank as *Frullanoides* Raddi, and considered the other two subgenera also as distinct genera. According to him the 3 genera differ as shown in table 1.

Table 1 evidently shows that *Brachiolejeunea* is distinctly different from the other two genera particularly in sporophytic characters and convincingly merits a generic status. However, *Frullanoides* and *Trocholejeunea* are closely related as they do not possess sufficiently contrasting stable characters and therefore subject to controversy till more information in this regard is provided. But as the generic delimitation in Ptychanthoideae is difficult for many taxa due to variability and plasticity in various characters, the generic status could be drawn only after judging the over all features and taking them into consideration we agree with Van Slageren’s (1985) treatment which has been adopted in the present communication.

In view of the above treatment (Van Slageren 1985) the genus *Brachiolejeunea* is altogether lacking in India and *Trocholejeunea* is represented by *T. infuscata* (Mitt.) Verd. and *T. sandvicensis* (Gott.) Mizut. and *Frullanoides* by *F. tristis* (Steph.) Van Slageren, the latter recently discovered from Nilgiri hills (Tamil Nadu) and Nandi hills (Karnataka), south India. *T. sandvicensis*, earlier known from Palni hills (south India) has an extended range in the Himalaya. Intracapsular spore germination has been described for the first time in *T. sandvicensis*. The scanning electron microscopic (SEM) details of sporoderm pattern for Indian plants of *F. tristis* and *T. sandvicensis* have also been provided.

### Table 1.

<table>
<thead>
<tr>
<th>Characters</th>
<th><em>Brachiolejeunea</em></th>
<th><em>Frullanoides</em></th>
<th><em>Trocholejeunea</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigmentation</td>
<td>without secondary pigments</td>
<td>with secondary pigments</td>
<td>without secondary pigments</td>
</tr>
<tr>
<td>Stem</td>
<td>cortex thick-walled and medulla thin-walled or outer medulla and cortex thickened and inner medulla thin-walled</td>
<td>medulla thick-walled cortex thin-walled</td>
<td>cortex and medulla more or less equally thick-walled</td>
</tr>
<tr>
<td>Dorsal merophyte</td>
<td>in straight line <em>Frullania</em>-type</td>
<td>zig-zag <em>Both Frullania and Lejeunea</em>-type</td>
<td>in straight line <em>Both Frullania and Lejeunea</em>-type</td>
</tr>
<tr>
<td>Branching</td>
<td><em>Frullania</em>-type</td>
<td><em>Both Frullania</em> and <em>Lejeunea</em>-type</td>
<td><em>Both Frullania</em> and <em>Lejeunea</em>-type</td>
</tr>
<tr>
<td>Underleaf Lobule</td>
<td>1-4 toothed tristratose</td>
<td>3-11 toothed bistratose</td>
<td>2-4 toothed bistratose</td>
</tr>
<tr>
<td>Perianth</td>
<td>with 0-1 (-2) ventral plicae</td>
<td>with 2-5 ventral plicae</td>
<td>with 2-5 ventral plicae</td>
</tr>
<tr>
<td>Subfloral innovation</td>
<td><em>Jubula</em>-type</td>
<td><em>Jubula</em>-type</td>
<td><em>Frullania</em>-type</td>
</tr>
<tr>
<td>Seta</td>
<td>articulate</td>
<td>articulate</td>
<td>not articulate</td>
</tr>
<tr>
<td>Seta in cross-section</td>
<td>16 + 4 celled suberect</td>
<td>16 + 4 celled curving outwardly</td>
<td>(16-32)+(8-16) celled curving outwardly</td>
</tr>
<tr>
<td>Valve of the capsule at dehiscence</td>
<td>nodular</td>
<td>fenestrate</td>
<td>fenestrate</td>
</tr>
<tr>
<td>Inner layer of capsule wall</td>
<td>irregularly elongated with wall thickenings only</td>
<td>isodiametric with well developed spiral</td>
<td>isodiametric with well developed spiral</td>
</tr>
<tr>
<td>Spores</td>
<td><em>Lejeunea</em>-type</td>
<td><em>Lopholejeunea</em>-type</td>
<td><em>Lopholejeunea</em>-type</td>
</tr>
<tr>
<td>Elaters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sporeling</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Taxonomic description

2.1 Frullanoides Raddi


Plants brownish in colour, irregularly branched by Lejeunea-type or Frullania-Ptychanthus-type (first leafy appendage) on a branch is a bilobed underleaf of branching. Stem in cross-section (0.15–0.20 mm in diameter) with 18–20 cortical cells and 35–40 slightly smaller medullary cells, both cortical and medullary cells thick-walled with distinct trigones. Leaves imbricated, widely spreading, slightly squarrose, ovate, ovato-oblong, 0.85–1.00 mm long, 0.51–0.69 mm wide, entire-wavy at margin, antical margin convex, postical margin slightly incurved at about middle, also often revolute along with apex, apex rounded, obtuse, or rarely subacute, cells arranged in diverging rows, with distinct cordate trigones and intermediate nodular thickenings, basal cells 24–36 × 24–28 μm, median cells 20–32 × 16–20 μm, marginal cells 12–20 × 12–16 μm, lobule ovate 1/2 or slightly more than 1/2 of the lobe length, 0.30–0.51 mm long, 0.27–0.33 mm wide, with 4–7 marginal teeth of 2–3 cells in height and 1–2 cells in width. Underleaves imbricated, slightly auriculate at base with usually arched or rarely sinuate insertion, slightly longer than wide, or as long as wide, 0.48–0.51 mm long, 0.41–0.48 mm wide, margin entire-wavy, apex rounded, rhizoids rare. Female inflorescence terminal on an elongated branch with two subfloral innovations of Radula-Jubula-type (in which first appendage on the branch is underleaf) bractlobe ovate or oblong, 1.12–1.47 mm long, 0.64–1.00 mm wide, margin entire-wavy, apex subacute or rounded, lobule almost rectangular more than 1/2 of the lobe length, 0.40–0.67 mm long, 0.16–0.24 mm wide, adnate with the lobe or slightly extending beyond the keel, keels with variously shaped appendages; bracteole almost 1/2 of the perianth length, somewhat rectangular, 0.83–0.89 mm long, 0.57–0.59 mm wide, with entire-wavy margin, apex rounded or truncate; perianth oblong, ca 1.85 mm long, 0.70 mm wide, isoplicate, plicae 10, wide and smooth. Seta in cross-section with 16 peripheral and 4 central cells. Capsule wall bistratose, outer layer with sinuate-nodular thickenings, inner layer with fenestrate thickenings on inner tangential walls and sinuate thickenings on radial wall. Spores green, variously shaped, 48–60 μm in diameter or 60–80 × 44–52 μm, ornamented with small papillae and few 'rosettes' of spines. Elaters trumpet shaped, 400–480 mm long, 16–24 mm wide, with 1 (–2) spiral thickening bands.

2.1b Specimens from India examined: LWU No. 128 SE/72, Loc.: Near Naduvattam (Mysore road), Nilgiri hills (alt. ca 1982 m), Tamil Nadu, south India, Dt.: January 3, 1972, Leg.: R Udar and party. LWU No. 7101/83, Loc.: Mukurty, Ootacamund (alt. 2500 m), Tamil Nadu, south India, Dt.: September 27, 1983, Leg.: R Udar and party. LWU No. 7501/83, 7523/83, Loc.: Near Kodai lake, Kodaikanal (alt. 2500 m), Tamil Nadu, south India, Dt.: September 30, 1983, Leg.: R Udar and party. LWU No. 7539/83, Loc.: Shembaganur, Kodaikanal (alt. 2500 m), Tamil


2.1a Specimens from other countries examined: JE H208/8, NICH 242111 (Isotype) *Brachiolejeunea poeltii* Mizut. et Grolle. Loc.: Nepal, Leg.: Poelt, Dt.: 1962, Det.: Mizut. and Grolle, G 739 Type *Frullanoides tristis* (St.) Van Slageren (Brachiolejeuna
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2.1d Distribution: India (Tamil Nadu), Angola, Brazil, Burundi, Colombia,
Cameroun, Costa Rica, Cuba, Ethiopia, Gâlapagos Islands, French Guiana Honduras, Jamaica, Madagascar, Nepal, Nigeria, Peru, Panama, Puerto Rico, Rwanda, South Africa, Sierra Leone, Tanzania, Venezuela and Zaire.

2.1e **Discussion:** In *Frullanoides tristis* obtained from different herbaria, the leaves generally have acute or subacute apices. However, in Indian plants they are mostly obtuse or rounded (figures 1, 3). Van Slageren (1985) described the apex varying from rounded to blunt to (occasional) minutely apiculate in this taxon. His consideration of *Brachiolejeunea poeltii* Mizut. et Grolle as synonym of *F. tristis* seems reasonable.
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2.2 Trocholejeunea Schiffn.

2.2a Key to the Indian species of Trocholejeunea:

1. Leaf-lobes with postical margin straight, long axis of lobule parallel with the long axis of lobe, lobular teeth 2 (–3) in number . . . . T. sandvicensis.
2. Leaf-lobes with postical margin curved or bowed, long axis of lobule almost at right angle to the long axis of lobe, with 2 lobular teeth . . . T. infuscata.


Plants green in colour, irregularly branched by Frullania-Ptychanthus or Lejeunea-type of branching. Stem in cross-section (0.10–0.15 mm in diameter) with 12–13
cortical and 15–16 slightly smaller medullary cells, both cortical and medullary cells almost thin-walled with inconspicuous trigones. Leaves usually imbricated widely spreading, sometimes slightly squarrose, lobe 0.82–1.04 mm long, 0.59–0.85 mm wide, ovate with entire margin, antical margin convex, postical margin almost straight, apex rounded, cells arranged in diverging rows, with distinct cordate trigones and intermediate nodular thickenings, basal cells 24–52 × 20–32 μm, median cells 28–44 × 24–36 μm, marginal cells 20–28 × 12–20 μm; oil-bodies several in each cells at middle and base of the lobe, rounded (1–2 μm in diameter) oval, elliptical or rod-shaped (2–4 × 1 μm), homogeneous, lobule ovate, slightly less than 1/2 of the lobe length, 0.35–0.40 mm long, 0.25–0.32 mm wide, ovate, ovate-quadrilateral, with 2 (–3) marginal teeth of the cell in height. Underleaves imbricated, wider than long, 0.41–0.56 mm long, 0.48–0.73 mm wide, with entire margin and rounded apex, rhizoids present at the base. Female inflorescence terminal on an elongated branch, usually with one subfloral innovation of the Radula-Jubula-type, bract-lobe almost equal to leaf-lobe in size, 0.72–1.13 mm long, 0.51–0.97 mm wide, ovate or obovate, dimorphic (one bract without lobule), margin entire, apex obtuse-rounded; bracteole larger than underleaf, slightly less than the length of the perianth, 0.72–0.74 mm long, 0.61–0.64 mm wide; perianth 0.80–1.0 mm long, 0.60–0.80 mm wide, 10 plicate, plicae unequal wide and smooth. Seta in cross-section with 16 peripheral and 12 central cells. Capsule wall bistratose cells of the outer layer with sinuate-nodular thickenings, cells of the inner layer with fenestrate thickenings on inner tangential wall and sinuate-nodular thickenings on radial walls. Spores with minute papillae and
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(rosettes' of spines, germination in-situ, Lopholejeunea-type, protonema few-celled, primary leaves ovate. Elaters trumpet shaped 400–800 mm long, 16–24 mm wide, with 1 (–2) spiral thickening bands.


2.2e Distribution: India (Tamil Nadu, Uttar Pradesh), Central Pacific, continental south eastern Asia, Hawaii, Japan, Sri Lanka and Taiwan.

2.2f Discussion: Some stages of in-situ spore germination (figures 40–46) answering to Lopholejeunea-type of spore germination (see Fulford 1956) have been observed. A few-celled protonema is first formed with in the exospore (figures 45, 46). The leafy shoot from this protonema bears ovate primary leaf (figures 45, 46), saccate inflated Juvenile leaf (figure 46) and narrow, ovate, underleaf (figure 46).

Plants brown, irregularly branched by *Frullania-Ptychanthus*-type of branching. Stem in cross-section (0.14–0.16 × 0.19–0.21 mm) with 18–20 (–23) cortical cells and 35–40, almost equal sized and less thickened medullary cells with inconspicuous trigones. Leaves imbricated, widely spreading, falcate, lobe 0.96–1.02 mm long, 0.64–0.69 mm wide, ovate with entire margin, antical margin convex, postical margin strongly incurved at the end of the keel, apex obtuse, often incurved, cells arranged in diverging rows distinct cordate trigones and intermediate nodular thickenings, basal cells 28–50 × 16–28 μm, median cells 32–40 × 20–28 μm, marginal cells 8–20 × 12–20 μm; oil-bodies several in each cell at middle and base, rounded (2.2–4.4 μm in diameter), oval or rod-shaped (4.4–11.0 × 1.1–2.2 μm) with refracting granule, homogeneous; lobule ovate, slightly less than 1/2 of the lobe length, 0.43–0.57 mm long, 0.25–0.27 mm wide, with two teeth of (1–) 2–3 cells in height, often bend inwardly. Underleaves imbricated, slightly wider than long, 0.64–0.73 mm long, 0.68–0.81 mm wide, with entire but revoluted margin, apex rounded, rhizoids rare. Gynoecia and androecia not seen.

2.2h Specimens from India examined: LWU No. 3106/77, 3118A/77, Loc.: On way to Nathula pass, Sikkim (alt. ca 2,000 m), Dt.: December 28, 1977, Leg.: S C Srivastava, U S Awasthi and A Kumar. LWU No. 3233A/77, 3233B/77, Loc.: Kalimpong, West Bengal (alt. ca 1,000 m), Dt.: December 29, 1977, Leg.: S C Srivastava, U S Awasthi and A Kumar. LWU No. 3284A/77, Loc.: Llyod Botanic Garden, Darjeeling (alt. ca 2,000 m), Dt.: December 31, 1977, Leg.: S C Srivastava, U S Awasthi and A Kumar. LWU No. 5351/72, Loc.: Tiger hill, Darjeeling (alt. ca 2,500 m), Dt.: January 2, 1978, Leg.: S C Srivastava and party.


2.2j Distribution: India (eastern Himalaya), Nepal, Sri Lanka.

2.2k Discussion: Plants of *T. infuscata* were collected repeatedly from several sites in eastern Himalaya but they were found only in sterile condition. Even the specimens (G 15564, G 19970 and G 19984) obtained on loan from conservatoire et Jardin Botanique were also sterile.

The leaf-lobule which lies almost at right angle to the leaf-lobe and consequently the postical margin of the leaf-lobe is not straight (figures 50, 51) in *T. infuscata* and thus differs from *T. sandticensis* which has straight postical margin of the lobe (figure 24). Further, the lobule in *T. infuscata* has 2 teeth of (1–) 2–3 cells in height (figure 55) while in *T. sandticensis* it has 2–3 teeth of one cell in height (figure 29).
2.3 **SEM analysis of the spores of Fullanoïdes and Trocholejeunea spp.**

Earlier Udar and Awasthi (1983) described SEM details of spores of *Dicranolejeunea* (Spruce) Schiffn., *Schiffneriolejeunea* Verd. and *Spruceanthus* Verd. Van Slageren and Berendsen (1985) investigated the sporophytic features of Ptychanthioideae under SEM and depending on the sporoderm pattern categorised the taxa into 3 groups having capsule wall with fenestrate thickening on inner layer of cells.

1. Spinulate spore type (present in *Acrolejeunea, Frullanoides, Marchesinia, Ptychanthus, Schiffneriolejeunea Spruceanthus, Trocholejeunea* and *Thysenanthus*).
2. Verrucate spore type (present in *Archilejeunea*).
3. Baculate-Spinulate spore type (present in *Caudalejeunea* and *Mastigolejeunea*). The taxa having capsule wall with nodular type of thickening on inner layer of cells are highly variable with regard to sporoderm pattern which in this group serves to distinguish genera or even species.

The spores of *Frullanoides* and *Trocholejeunea* are spinulate type and thus more or less identical. However, the two species investigated (one of each genera): *F. tristis* and *T. sandvicensis* show some difference in the tip of the spine which is comparatively more fringed in *F. tristis* (figures 59, 60) and less so in *T. sandvicensis* (figures 57, 58).

2.4 **Current status of the Indian taxa described earlier**


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