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Research Article

MORPHO-TAXONOMIC STUDIES ON GENUS *RADULA* DUMORT (RADULACEAE: HEPATICAE) FROM NAGALAND, NORTH EAST INDIA

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ABSTRACT
Three species of the genus *Radula* viz., *R. madagascariensis* Gottsche, *R. obscura* Mitt., *R. javanica* Gottsche have been reported for the for time from the state of Nagaland, North East India. Detailed hand drawing illustrations have been provided for its easy identification.

Key Words: *Radula, Hepaticae, Morpho-Taxonomic, Nagaland*

INTRODUCTION
The state of Nagaland lies in between 26° 60'N and 27° 40'N latitude and 93° 20' E and 95° 15'N E longitude of the equator. It is located in the extreme North Eastern part of India having an area ca 16,579 Square Kilometres. The state is rich in flora and fauna. Many biologists across the globe have worked on the higher angiospermic plants but the work done on lower groups of plants especially Hepaticae is fragmentary and scanty. The first published worked on bryology was done by Udar and Asthana (1985) where they have reported the occurrence of the genus *Anthoceros* for the first time from the state. Subsequently, Pant and Bhowmik (1997), Lal *et al.*, (2003), Chaturvedi and Chaturvedi (2007), Nath *et al.*, (2011), Chaturvedi and Eshuo (2012), Eshuo and Chaturvedi (2011a, 2011b, 2011c), Eshuo *et al.*, (2012), Chaturvedi *et al.*, (2011, 2011b, 2011c) have contributed the work on bryology in the state of Nagaland. There is no previous record on the occurrence of the genus *Radula* from the state and hence this is the first hand report on the occurrence of the genus *Radula*. In this present paper its deals with the occurrence of three species of genus *Radula* viz., *R. madagascariensis* Gottsche, *R. obscura* Mitt., *R. javanica* Gottsche which is the first comprehensive work on the family Radulaceae from the state of Nagaland, north east India.

MATERIALS AND METHODS
The fresh specimens of genus *Radula* Dumort. were collected from their natural localities from Kohima and Mokokchung districts, Nagaland (Map 1). The morphological characters were studied under Leica digital Stereo-zoom (S6D). The anatomical studies of stem, leave cells were studies under Leica digital Microscope (DM1000). The hand sections of stems and leaves were mounted in 30% aqueous solution of glycerin and observed under the Leica digital Microscope (DM1000). The photomicrographs and photomacrographs were taken under Leica digital Microscope (DM1000) and Leica stereo-zoom (S6D) respectively. The field photographs were taken with the help of Canon (SX120) digital Camera. The preserved specimens were deposited in the Department of Botany, Nagaland University.

Taxonomic Treatment
Key to the species of the genus *Radula*

1. Leaves strongly caducous, stem 8-9 cells cross, lobule 1/3 of the length of the lobe, trigones minute to tri-radiate.....*R. madagascariensis*
1a. Leaves not caducous, lobule 1/2 of the length of lobe, trigones nodulose.....2
2. Stem 6 cells across, lobule 1/2 as long as the lobe,.....*R. obscura*
2a. Stem 9-11 cells across, lobule 1/3 as long as the lobe,.....*R. javanica*

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Radula madagascariensis Gottsche. Abhandl. Naturwis. Verein (Bremen) 7: 349. 1882. (**Figure 1. Figures 1 – 11**)

Plants medium, light brown in dry herbarium, 25-40 mm long, 1-1.7 mm wide including leaves, irregularly branched, branching of Radula-type, intercalary-terminal; rhizoids scanty or few, rhizoid initial area convex, brown. Stem oval, brown, 151-153 x117-125 µm in diameter, 6-8 cells across, cortical cells 28-29 in radial rows, 9-22 x 7-15 µm, thick-walled, medullary cells larger than the cortical cells, 9-25 x 7-18 µm, thick-walled, trigonous. Leaves strongly caducous, often only the scar remain on the stem, slightly imbricate, ovate, 0.8-1.2 mm long, 0.8-1 mm wide, apex broadly rounded, entire, dorsal margin convex, covering 1/3 of the stem width; apical cells quadrate to rectangular, 15-29 x 9-14 µm, median cells 16-21 x 12-18 µm, sub-quadrate, polygonal, basal cells 17-32 x 16-20 µm, sub-quadrate, polygonal, thin-walled throughout, trigones, small, tri-radiate; gemmae absent, ocelli and vitta absent. Leaf lobule sub-rectangular, 1/3 length of the lobe, apex truncate, saccate, adaxial margin straight, 0.28-0.34 mm long, 0.2-0.3 mm wide. Androecia and gynoecia not seen.

Habitat: Plants grows on moist rocks (saxicolous) or epiphytic (corticolous) in association with *Plagiochila* sp., *Trocholejeunea* sp., *Heteroscyphus* sp., *Ptychanthus* sp. and Mosses at 1500 – 1700 m ASL at Jakhama: KE 10227: 08.08.2010.

Range: India, Nepal, Java, Sumatra, Indonesia, Sri Lanka, Madagascar, Mauritius Island.

Distribution in India: *Eastern Himalaya*: West Bengal-Darjeeling, Meghalaya-Mawphlong, Sikkim, **Nagaland**.

Radula obscura Mitt. Journ. Proc. Linn. Soc. London 5: 107. 1861.

(**Figure 2. Figures 1-12**)

Plants small to medium, whitish green to light green, light brown in dry herbarium, 8-12 (-15) mm long, 1-.15 mm wide including leaves, branched, branching irregular, intercalary, terminal, branching of *Radula*-type. Rhizoids hyaline, and at the base of the lobule base. Stem circular, 62 x 65 µm in diameter, 4 cells across, cortical cells 11-13 in radial rows, thick walled, 6.3-12.7 x 7.6-11.7 µm in diameter, medullary cells thick walled, trigonous, 9.2-13 x 5.8-11.2 µm in diameter. Leaves distant to slightly imbricate, retuse, entire, oblong ovate, 0.7-1.0 mm long, 0.6-0.78 mm wide, apex broadly rounded; cells trigonous, triangular to nodulose trigones; apical cells 12-23 µm long, 8-14 µm wide, sub-quadrate, to sub-rectangular; median cells sub-quadrate to polygonal, 11-18 µm long, 8-13 µm wide; basal cells sub-quadrate to rectangular, 14-23 µm long, 10-20 µm wide; epidermal cells quadrate to rectangular, 8-18 µm long, 7-13 µm wide. Leaf lobule sub-quadrate, persistent, saccate, almost 1/3 of the leaf length, 0.3-0.34 mm long, 0.14-0.2 mm wide, apex truncate and obtuse, adaxial margin sinuate to straight. Oil bodies large, one per cell, finely to coarsely segmented, 11-17 x 6-11.5 µm in diameter. Androecia and gynoecia not seen.

Habitat: Plants grows on bark (corticolous), on leaves (foliicolous) in association with *Plagiochila* sp., *Trocholejeunea* sp. and Mosses at 1900-2600 m asl at Khuzama: KE 10245, 10253: 05.0.8.2010 and Khonoma: KE 10420: 19.03.2010.

Range: India, Taiwan, Indonesia, Philippines, Thailand, Nepal, Sri Lanka (Mitten, 1861; Yamada, 1979; Udar & Kumar, 1984; Singh & Nath, 2007; Singh & Singh, 2009).

Distribution in India: *Western Himalaya*: Himachal Pradesh, Uttarakhand; *Eastern Himalaya*: West Bengal, Meghalaya, **Nagaland**; *South India*: Tamil Nadu.

Radula javanica Gottsche in Gottsche, Lindenb. et Nees, Syn. Hep.: 257. 1845. **(Figure 3. Figures 1 – 14)**

Plants light green to yellowish green, upto 25 mm long, 1.8-2 mm wide including leaves, irregularly branched, pinnately branched, branching of Radula-type; rhizoids numerous, fasciculate, arises in the middle, rhizoid-initial area slightly inflated. Stem in cross section ovoid, 150-181 x 120-130 µm in diameter, 9-11 cells across, cortical cells thick-walled, 9-18 x 8-14 µm, medullary cells thick-walled, 11-23 x 10-17 µm, trigonous, trigones large. Leaves loosely imbricate to contiguous, widely spreading, lobe ovate, 1-1.2 mm long, 0.9-1.1 mm wide, apex rounded, margin entire; lobe apical cells 9-16 x 7-12 µm,

median cells 16-21 x 11-17 µm, cells isodiametric, basal cells 20-30 x 16-21 µm, cells thin-walled throughout, trigones small, intermediate thickenings absent. Cuticle nearly smooth; ocelli and vitta cells absent. Oil body 1 per cell, or rarely 2 at basal cells, large, oblong, spherical, 11-22 x 8-13 µm in diameter, finely to coarsely segmented. Lobule quadrate, nearly flattened, 0.4-.05 mm long, 0.35-.48 mm wide, apex truncate, adaxial margin straight, entire, smooth, 1/3 as long as the lobe, base covering 1/2-2/3 of the stem width. Gemmae absent or sometime present. Androecia and gynoecia not seen.

Habitat: Plants grows on the tree trunk (corticolous) in association with *Heteroscyphus* sp., *Lejeunea* sp., *Metzgeria* sp. and Mosses at 1200-1650 m ASL at Longkhum: KE 10519: 14.04.2012.

Range: China, Japan, India and widely distributed in tropics and subtropics of South Eastern Asia and pacific islands (Zhu & So 2003; Singh & Nath 2007; Singh & Singh 2009).

Distribution in India: *South India*: Tamil Nadu-Nilgiri Hills; *Eastern Himalaya*: Meghalaya**; Nagaland**.

RESULTS AND DISCUSSION

Discussion

All the three species of the *Radula* are Asiatic plants and they have been widely distributed in these regions of the globe. In the present investigation, two species viz., *Radula obscur*a and *Radula javanica* is mostly widely distributed in India as compare to *R. madagascariensis* which is reported only in the eastern Himalayan region . All the three species are reported for the first time from the state of Nagaland.

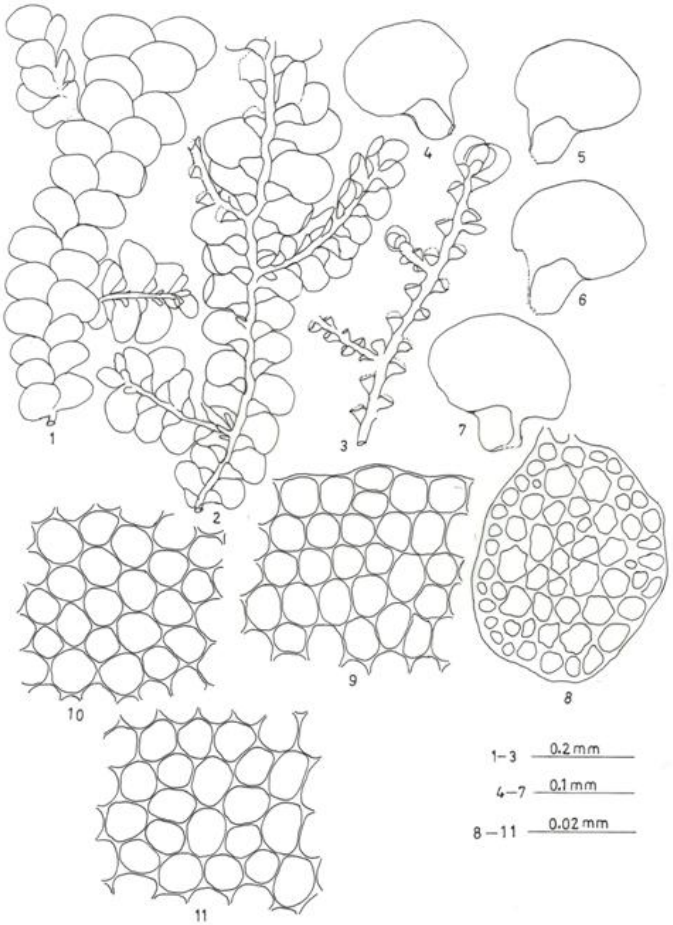

Figure 1. ***Radula madagascariensis*** Gottsche, Figures 1-11.

Figures 1-3. Plant showing habit, 1- plant in dorsal view, 2- plant in ventral view, 3- plant showing denuded leaves; 4-7. Leaves; 8. Cross section of the stem; 9. Leaf apical cells; 10. Leaf median cells; 11. Leaf basal cells.

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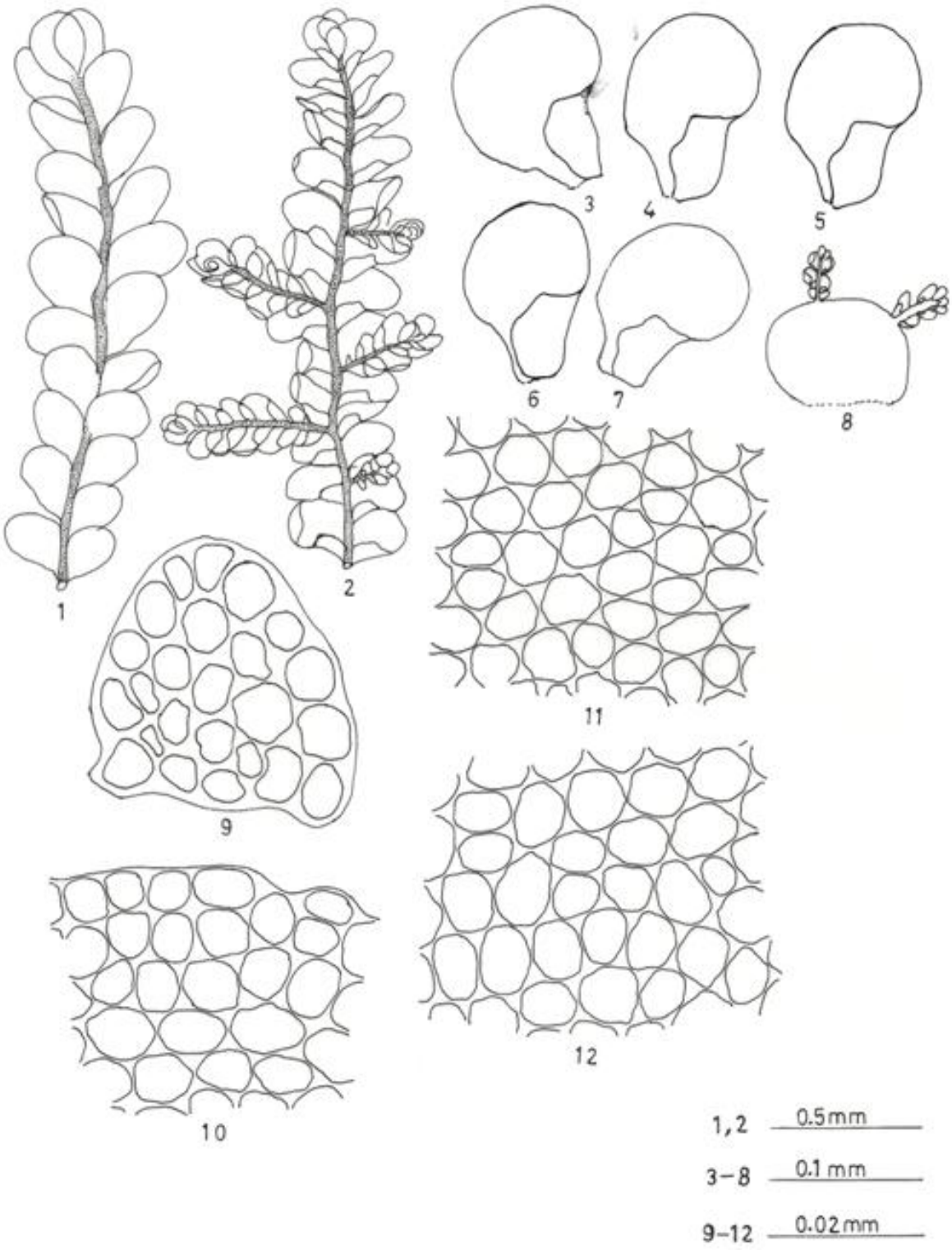

Figure 2. ***Radula obscura*** **Mitt. Figures 1-12**
Figures 1-2. Plants showing habit, 1- plant in dorsal view and 2- plant in ventral view; 3-7. Leaves; 8. Leaf showing young plants from the leaf ocelli; 9. Cross section of the stem; 10. Leaf apical cells; 11. Leaf median cells; 12. Leaf basal cells.

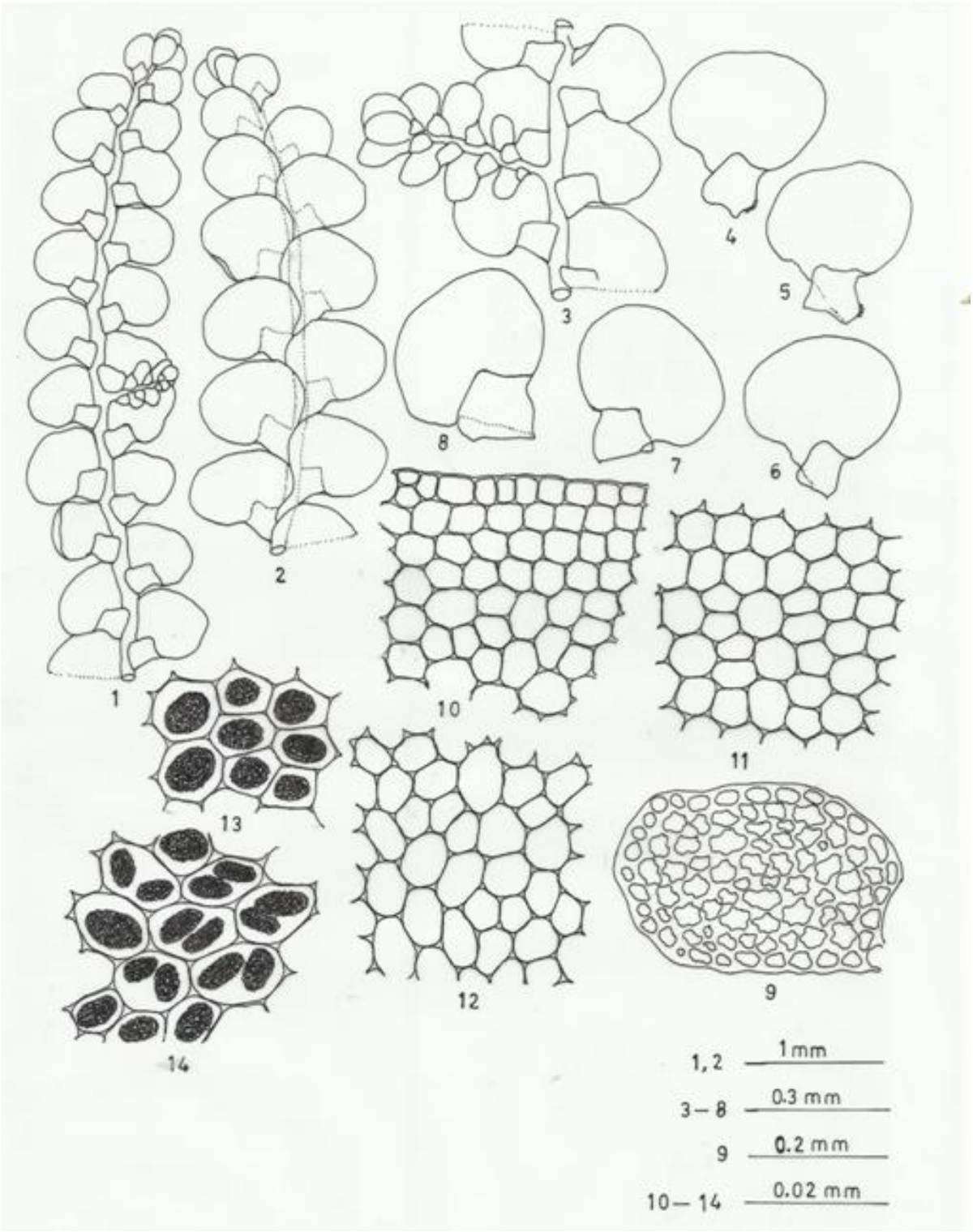

Figure 3. ***Radula javanica*** **Gottsche. Figures 1-14**
Figures 1-3. Plants showing habit, 1- plant in ventral view, 2- plant in dorsal view, 3- enlarge ventral view; 4-8. Leaves; 9. Cross section of the stem; 10. Leaf apical cells; 11. Leaf median cells; 12. Leaf basal cells; 13-14. Oil bodies.

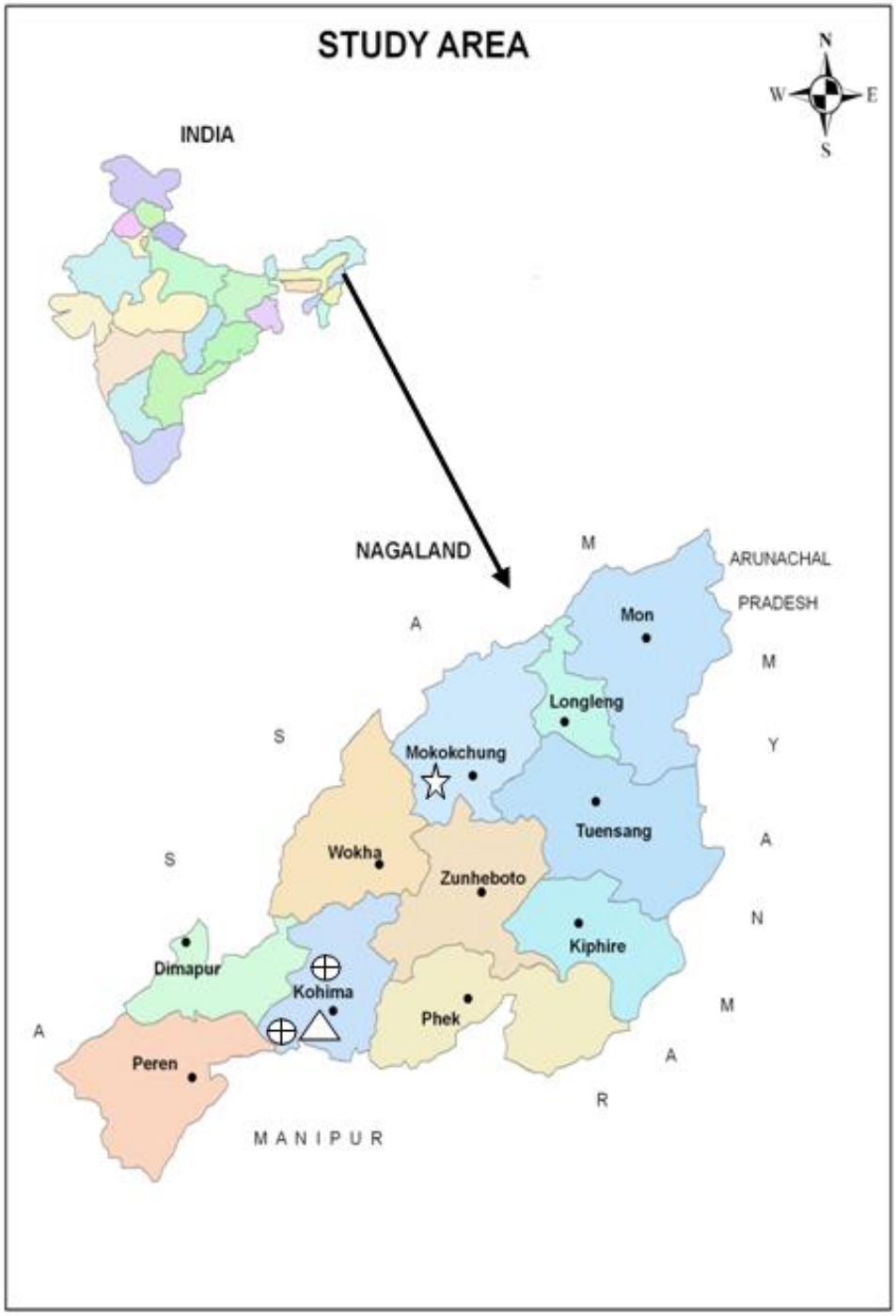

Figure: Map showing the distribution of genus *Radula* in Nagaland

☆ **= Distribution of *Radula javanica* Gottsche**

⊕ **= Distribution of *R. obscura* Mitt.**

△ **= Distribution of *R. madagascariensis* Gottsche**

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