Table 1. *Honge* oil economics

Honge seeds have about 30 to 35% oil; up to about 27 to 28% oil can be expressed in crushers (say 25% for convenience of calculations)

Sample cost calculations

Cost of 4 kg of *honge* seeds (at average seasonal price)	Rs 20.00
Expelling charges (in large quantities)	Rs 4.00
Less return from selling 3 kg of cake	– Rs 12.00
Net cost of 1 kg of *honge* oil	Rs 12.00
Price of diesel in Kunigal (per litre)	Rs 19.30
Net cash outflow per kg of oil to the farmer if he uses seeds from his trees	Rs 4.00

The officials from the Karnataka Forest Department indicated that they have identified several high-yielding varieties of *honge* and are presently producing lakhs of seedlings every year. Other experts in forestry argued that it is possible to accelerate propagation of better varieties through cuttings or by grafting, gootying (air layering) and making use of greenhouses and mist chambers. One of the special features of the *honge* tree is its ability to withstand salinity.

Available numbers on yield (2500 kg of oil per hectare per year) and efficiency (4 kh per kg of oil in 1 MW generators) indicate that 10 million hectares of plantation could lead to a generation of 100 billion kWh of electricity or replace 25 million tonnes of diesel fuel. Cost of plantation at Rs 15,000 per hectare would amount to Rs 15,000 crores, most of which could come as voluntary contribution in kind from the farm sector to improve its own income.

Apart from *honge*, oils from other trees like neem and mahua have also been evaluated and are found to be potential diesel substitutes. These trees are hardy and already exist in very large numbers.

To conclude, tree-based oilseeds hold great promise to the rural sector to meet its energy and fertilizer requirements in adequate measure. The potential for consequent increase in primary production from land itself could reshape Indian economy to see better days. The path advocated being environmentally benign makes it even more interesting from a global point of view.

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SCIENTIFIC CORRESPONDENCE

On a long-lost endemic liverwort (Hepaticae) from India

While working on the diversity and distribution of liverworts (Hepaticae) in India, it has come to our notice that several of the taxa instituted and described earlier from the Indian subcontinent appear to have never been collected again since their original discovery and therefore, need due attention. *Isotachis indica* Mitt. – an endemic and threatened liverwort from India reportedly confined to a small pocket of Khasi hills, belongs to the same category. This species was instituted by Mitten[1] on the basis of collection made by J. D. Hooker from Khasi hills with a short diagnosis of the plant. Stephani[2] and Hatcher[3] also described *I. indica* in their world monograph, but provided only the vegetative details of the haplophase (gametophytic organization). Unfortunately, we also did not succeed in collecting *I. indica* from India, though a number of collections have been made in Khasi hills and neighbouring areas of eastern Himalayas during the past three decades or more. Although this species has been listed in Chopra's[4] and Parihar's[5,6] census of Indian liverworts based on earlier reports, it has never been reported from any other part of the globe – hence it is strictly endemic to India. During the study of type specimen obtained from the Farlow Herbarium, Massachusetts, USA, we came across some fruiting specimens of *I. indica* in the original collection of Hooker which seemingly escaped the attention of earlier workers, so far as the sporophytic phase is concerned. As this species appears to be highly vulnerable for extinction, we provide here an account of *I. indica* with details of the diplophase (sporophytic generation), exclusively based on the study of the type specimen.

Plants up to 45 mm long and nearly 4 mm broad with leafy axes and apices somewhat bent downwards, branches lateral intercalary. Stem rigid, up to 14 cells across diameter, differentiated into cortical and medullary zones, cortical cells thick-walled and arranged in 1–2 layers, medullary cells thin-walled, relatively larger than cortical cells. Leaves large, transversely inserted, incubously and imbricately arranged on stem, lower leaves distant, widely spreading, bilobed, sinus deep, anterior lobe large, antical leaf margin covering the stem and sometimes arching beyond the stem, lobes often bifid, dentate, dentition up to 22 in number, acute, 1–5 cells long, 2–3 cells broad at base, cells thin-walled, 24–60 μm × 12–28 μm towards apex, 32–52 μm × 16–28 μm towards base, cell wall surface striolate. Underleaves bilobed, lobes divergent, sinus deep and broad, lobes dentate, dentitions acute, rarely 2-celled at apex, up to 13 in number, 1–7 cells long and 1–6 cells broad at base, cells thin

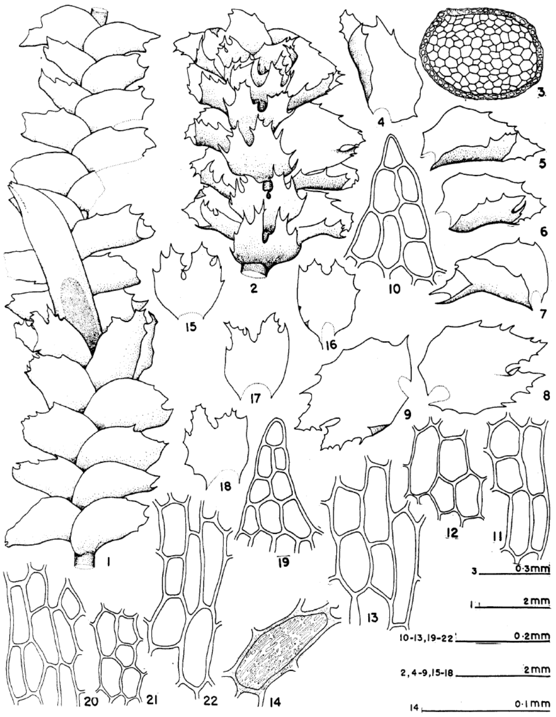

Figure 1. 1, Plant with perigynium, dorsal view; 2, Plant, ventral view; 3, T.S. of stem; 4–9, Leaves; 10, Apical cells of leaf; 11, Marginal cells of leaf; 12, Median cells of leaf; 13, Basal cells of leaf; 14, Striolate leaf cell wall surface; 15–18, Underleaves; 19, Apical cells of underleaf; 20, Marginal cells of underleaf; 21, Median cells of underleaf; 22, Basal cells of underleaf.

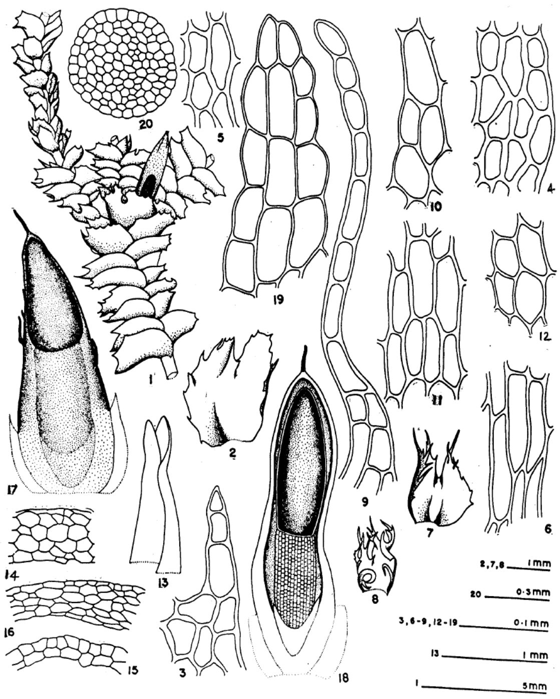

Figure 2. 1, Plant with perigynium, dorsal view; 2, Female bract; 3, Apical cells of female bract; 4, Marginal cells of female bract; 5, Median cells of female bract; 6, Basal cells of female bract; 7,8, Bracteoles; 9, Apical cells of bracteole; 10, Marginal cells of bracteole; 11, Median cells of bracteole; 12, Basal cells of bracteole; 13, Perigynium longitudinally cut open to show the union of perianth; 14, Portion of T.S. of perigynium at base; 15, T.S. of perigynium at apical portion; 16, Portion of T.S. of shoot calyptra; 17, Sporophyte within shoot calyptra; 18, L.S. of sporophyte; 19, Cells of perianth; 20, T.S. of seta.

walled, 32–52 μm × 24–28 μm towards apex, 64–144 μm × 24–64 μm in middle region, 64–144 μm × 24–64 μm towards margin and 48–100 μm × 12–24 μm towards the base.

Dioecious? Only female plants available. Sporophyte enclosed in a typical stem perigynium. Perigynium cylindrical, up to 6 mm long, multistratose at base, 1–2 layered at apical portion with highly reduced perianth attached to inner surface of perigynium. Perigynium surrounded by 2 pairs of bracts and one pair of bracteole, bracts similar to vegetative leaves but larger in size, dentate, dentitions up to 1–5 cells long, 1–4 cells broad at base, cells thin-walled, 80–96 μm × 40–64 μm towards apex, 56–168 μm × 32–64 μm in middle region, 88–240 μm × 40–64 μm towards margin and 200–448 μm × 40–80 μm towards base; bracteole similar to underleaves, dentitions ciliate, up to 10 cells long, cells thick-walled, 64–280 μm × 40–80 μm towards apex, 80–200 μm × 40–80 μm towards margin, 96–224 μm × 32–72 μm in middle region, 80–200 μm × 48–112 μm towards base. Perianth highly reduced and lobed, each lobe with 1–3 dentitions, cells thin-walled, rectangulate, 44–88 μm × 20–40 μm. Shoot calyptra present within perigynium with unfertilized archegonia on outer surface. Shoot calyptra multistratose enclosing the sporophyte. Sporophyte immature-nearly mature with foot, seta and capsule. Foot embedded in the vegetative tissue, forming a collar around the basal portion of seta; seta long, massive, up to 14 cells across diameter, capsule ovoid with immature capsule wall, spores and elaters.

Specimen examined: FH 1339 C Typus *I. indica* Mitt., Herb. Ind. or Hook. Fil. & Thomson. Khasia Montium Reg. Trop., Alt.: 2–4000 pedigree, Leg.: J.D.H. and T.T.

Isotachis is remarkable in having typical *Isotachis*-type of perigynium[7] showing a highly reduced perianth as a small ring at its summit. It is suggested that this species be listed in the Red data book.

1. Mitten, W., *J. Proc. Linn. Soc.*, 1861, **5**, 89–128.
2. Stephani, F., *Species Hepaticarum*, Geneva, 1909, vol. III.
3. Hatcher, R. E., *Nova Hedwigia*, 1960–61, **2**, 573–608; **3**, 1–35.

4. Chopra, R. S., *J. Indian Bot. Soc.*, 1943, **22**, 237–259.
5. Parihar, N. S., *An Annotated Revised Census of Indian Hepatics*, University of Allahabad Studies (Botany Section), Senate House, Allahabad, 1961.
6. Parihar, N. S., Lal, B. and Katiyar, N., *Hepatics and Anthocerotes of India – A New Annotated Checklist*, Central Book Depot, Allahabad, 1994.
7. Schuster, R. M., *Hepaticae and Anthocerotae of North America, East of the Hundredth Meridian*, Columbia University Press, New York, 1966, vol. I.

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Vocal interactions, territoriality and fighting behaviour of the rhacophorid frog, *Philautus variabilis* (Gunther, 1858)

Variation in calling behaviour and acoustic characteristics of the mating calls are presumed to be important determinants of male mating success in anuran amphibians. Calling sites are established and territories are maintained primarily by vocal interaction by males[1–3]. Fighting and territoriality among anurans have been reported in both tropical and temperate species[2]. Fight appears to be costly in terms of time, energy and a risk of injury or death, which is thought to be the reason why most animals tend to settle the disputes with conventional displays such as exaggerated movements, repeated vocalizations or combination of both[4,5]. Selection appears to have favoured the evolution of displays that allow animals to resolve conflicts without fighting[6]. These displays are often used to assess the fighting ability of the opponents prior to the fight[5,7], thereby allowing animals to avoid potentially costly fights. Vocalizations may also be used as a reliable cue for such assessments in birds, mammals and frogs[8–10]. The best evidence that vocalization is used in assessment of fighting ability comes from experimental studies on deer[5] and anurans[7,11–13]. Studies on territoriality and fighting behaviour among Indian anurans are limited to *Rana limnocharias*[14].

Philautus variabilis is a small-sized rhachophorid frog distributed in many parts of the Western Ghats[15,16] which exhibits direct development[17]. Male frogs call from bushes and small trees (Figure 1 *a*) and emit advertisement and aggressive calls[16]. Males commonly compete for calling sites and get involved in vocal interactions. In the present study, we describe vocal interaction, territoriality and fighting behaviour of *P. variabilis*.

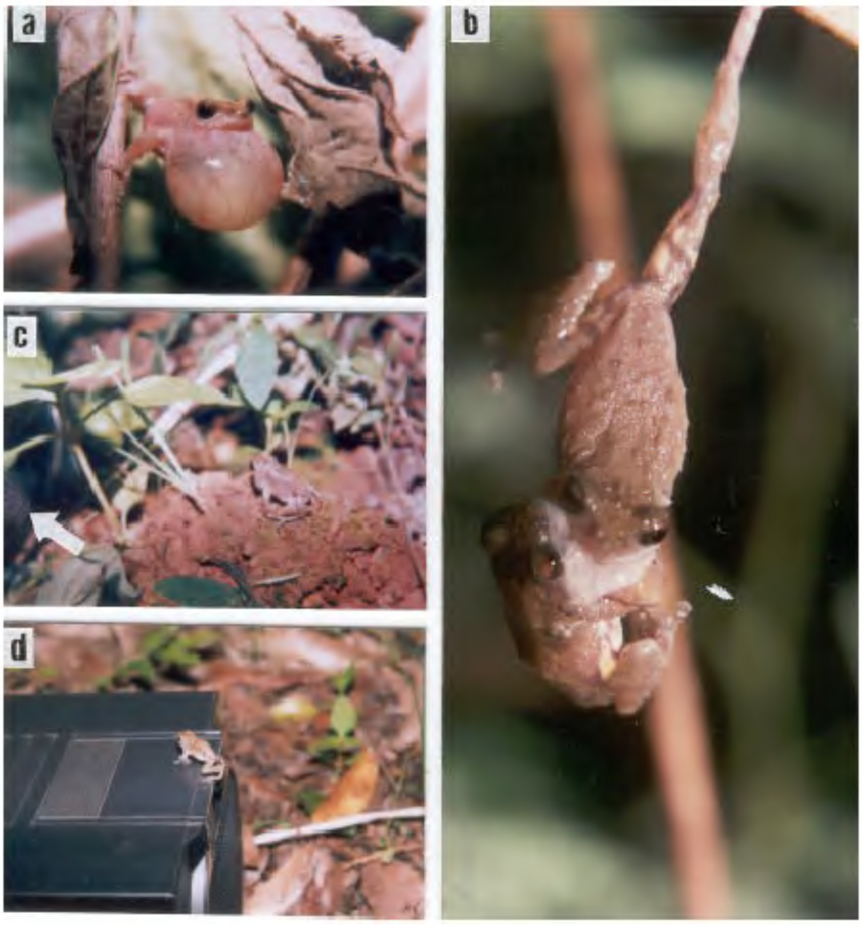

Figure 1. ***a***, Male *P. variabilis* calling from a tree branch. Note the single subgular vocal sac; ***b***, Fighting between two males. A male obstructing the vocal sac and dislodging the opponent from the tree branch; ***c***, Male frog approaching the speaker and emitting aggressive call during playback experiment (arrow mark shows the speaker); ***d***, Male frog mounted on the speaker after attacking it (photos: GGK).