



RESEARCH ARTICLE

Comparative seedling morphology of four species of *Sida* (Malvaceae) from Tripura, India and their taxonomic implications

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Abstract

Comparative seedling morphology of four *Sida* species occurring in Tripura were investigated. Seedling characters (germination pattern, position of cotyledon, hypocotyl, epicotyl and paracotyledon and eophylls development) were found to be important and promising from the taxonomic as well as evolutionary point of view. These characters provide important diagnostic character of the species of the genus. Phenogram based on UPGMA method has been prepared and correlation between the characters of seedling of four *Sida* species were studied.

Keywords

Juvenile stage, *Sida*, Taxonomy, Tripura

Introduction

The 'seedling' is a young plant sporophyte and is a critical stage in life cycle of an individual (1). The term *seedling* includes very young individuals (2). Seedling characters like germination pattern, position of cotyledon, root, hypocotyl, epicotyl, eophylls and metaphyll are as reliable as floral character (3) and are very useful in better understanding of taxonomically difficult taxa (4). The study of seedling morphology has emerged as an essential discipline for taxonomic research at present. Now a days, there is world-wide loss of biodiversity because of random exploitation of natural resources by humans (5). If we can identify plants in their early stage then it will be helpful for conservation of natural resources which in turn shall help in conservation of biodiversity. Very less work has been done on seedling morphology in India, so in this study an attempt has been made to study seedling morphology of 4 species of the genus *Sida* occurring in Tripura. These are *S. acuta* Burm.f. *S. cordifolia* L, *S. cordata* (Burm.f.) Borss. Waalk. and *S. rhombifolia* L. which are variously used as medicine in different treatments. Barks and leaves of *S. acuta* are used in malaria. (6). Roots of *S. cordata* along with cow butter is applied locally to cure piles and relief from the pain. (7). *S. cordifolia* is used for asthma, bleeding piles, gonorrhoea and rheumatism (8). *S. rhombifolia* is used for cold and cough, headache and fever (8).

Materials and Methods

Mature seedling specimens of *S. acuta*, *S. cordata*, *S. cordifolia* and *S. rhombifolia* were collected. An extensive survey was done for seedlings samples from different localities of Tripura (Fig. 1.) Voucher specimen were photo-

graphed and preserved at Tripura University Herbarium (TUH)HHh. They were identified and compared with seedling raised from already identified seeds. At least seven to ten specimens of each seedling stage were studied from

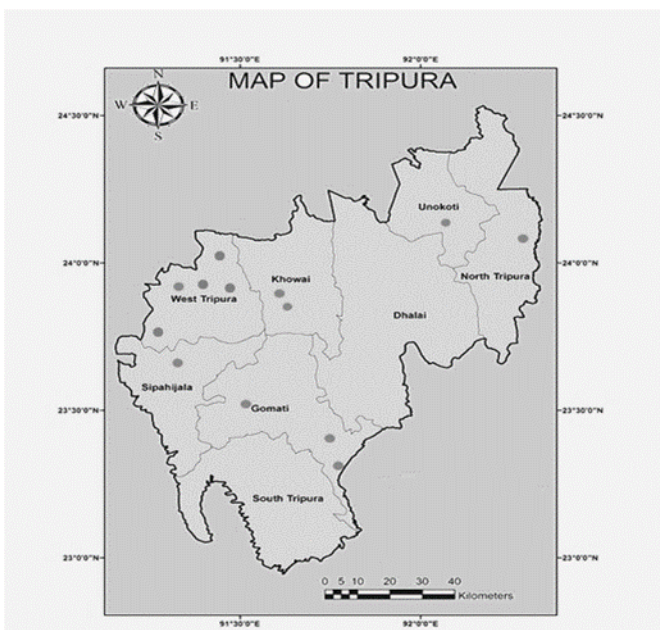


Fig. 1. Map of Tripura showing the different areas visited during the field survey.

various localities. Seedling morphological description were prepared (2-4, 9, 10). Artificial key was prepared for easy identification of investigated taxa in juvenile stage. UPGMA method was used to prepare phenogram using PAST software. Tap roots had been classified on the basis of measurement as reduced (< 2 cm), shortly elongating (2-4 cm) and elongating (>4 cm). Likewise Hypocotyl is classified as (< 1cm), shortly elongating (1-2 cm) and elongating (>2 cm) (3).

Results and Discussion

Sida acuta Burm. F. Fl. Indica, 147. 1768. (Fig. 3.)

Vernacular names

Berela, Ban Methi, Kureta, Urusia, Morong, Baitali.

Fruit and Seed morphology

Fruit schizocarp, globose/ disc shaped, mericarps 6-10, more or less trigonous, surface rough with two awns, size $\pm 0.50-0.90 \times \pm 0.40-0.60$ cm, weight $\pm 0.0150-0.0230$ g, colour brown, apex beaked, base rounded, length/breadth ratio 1.4. Seeds ovoid, trigonous, size $\pm 0.30-0.50 \times \pm 0.20-0.30$ cm, acute apex, rounded base, glabrous, seed colour brown, weight $\pm 0.00210-0.0030$ g, hilum position basal, hilum colour brown, length and breadth ratio 1.6 per fruit 5-8 seeds.

Morphological description of seedling: (Up to 6th leaf stage)

Germination pattern phanero-epigeal foliaceous (PEF). Roots are tap, not branched, $\pm 1.20-5.20 \times \pm 0.10-0.20$ cm, elongating, brown, soft, root tip brown. Hypocotyl epigeous, $\pm 2.0-4.80 \times \pm 0.050-0.10$ cm, green, terete, hairy, elongating, soft. Paracotyledon epigeous, two, opposite and

equal, petioles present, petiole size $\pm 0.20-0.60 \times \pm 0.050-0.10$ cm, terete, petiole surface hairy, stipules absent, leaf elliptic, size $\pm 0.50-1.20 \times \pm 0.60-1.20$ cm, obtuse base, obtuse apex, entire margin, pinnate venation, 1 primary vein, venation prominent, secondary veins prominent, eucamp-todromous venation, texture soft, colour green, blade surface glabrous both surfaces, symmetric lamina. Epicotyl green, moderately woody, surface hairy, size $\pm 1.20-1.80 \times \pm 0.10-0.20$ cm. First 2 leaves simple, alternate, soft, stipules absent, petioles present, petiole size $\pm 0.30-0.60 \times \pm 0.050-0.10$ cm, terete, petiole surface hairy, leaf ovate/ elliptic, size $\pm 2.0-3.90 \times \pm 1.30-2.50$ cm, base cuneate, apex obtuse, margin serrate, palmate venation, 5 primary veins, actinodromous venation, veins prominent, blade hairy, base balance symmetric. Next leaves alternate, soft, stipules present, petioles present, simple, lamina ovate, cuneate base, acute apex, serrulate margin, palmate venation, actinodromous, irrespective of dimensions other seedling traits are almost similar to eophylls.

Sida cordata (Burm.f.) Borss.Waalk.in Blumea 14: 182. 1966. (Fig. 3.)

Vernacular names

Jhunka, Jop, Pitberela, Longsham.

Fruit and Seed morphology

Fruit schizocarp, mericarp 5, awn less, nearly globose, size $\pm 0.30-0.60 \times \pm 0.30-0.50$ cm, weight $\pm 0.0060-0.0150$ g, surface hairy, colour brown, apex truncate, base rounded, length/breadth ratio 1.125. Seed shape ovoid, size $\pm 0.20-0.250 \times \pm 0.10-0.20$ cm, obtuse apex, obtuse base, seed glabrous, weight $\pm 0.00130-0.00180$ g hilum position basal, hilum colour brown, length and breadth ratio 1.5 seeds 1 per mericarp and 5 per fruit.

Morphological description of seedling: (Up to 6th leaf stage)

Germination pattern phanero-epigeal foliaceous (PEF). Roots are tap, branches present, size $\pm 2.0-4.50 \times \pm 0.10-0.30$ cm, short elongating, colour creamish white, moderately woody, root tip colour white. Hypocotyl epigeous, size $\pm 1.40-2.50 \times \pm 0.050-0.20$ cm, colour dark brown/ brownish green, terete, surface hairy (long white hairs), shortly elongating, woody. Paracotyledon epigeous, two, opposite and equal, petioles present, petiole surface hairy, petiole terete, stipules absent, ovate leaf, size $\pm 0.40-0.60 \times \pm 0.40-0.50$ cm, base obtuse, acute apex, margin entire, palmate venation, 3 primary veins, veins prominent, actinodromous venation, texture soft, colour green, surface glabrous, base balance symmetric,. Epicotyl colour green, woody, terete, surface hairy, size $\pm 0.60-0.80 \times \pm 0.10-0.20$ cm. First 2 leaves simple, alternate, soft, stipules present, petioles present, petiole size $\pm 0.50-1.20 \times \pm 0.050-0.070$ cm, terete, surface hairy, leaf elliptic, size $\pm 1.20-1.60 \times \pm 1.30-1.50$ cm, base cordate, apex acute, margin serrate, palmate venation, veins prominent, 5 primary veins, actinodromous venation, hairy, base balance symmetric. Next leaves alternate, texture soft, stipules present, petioles present, hairy, simple, lamina elliptic, cordate base, acute apex, serrate margin, palmate venation, actinodromous,

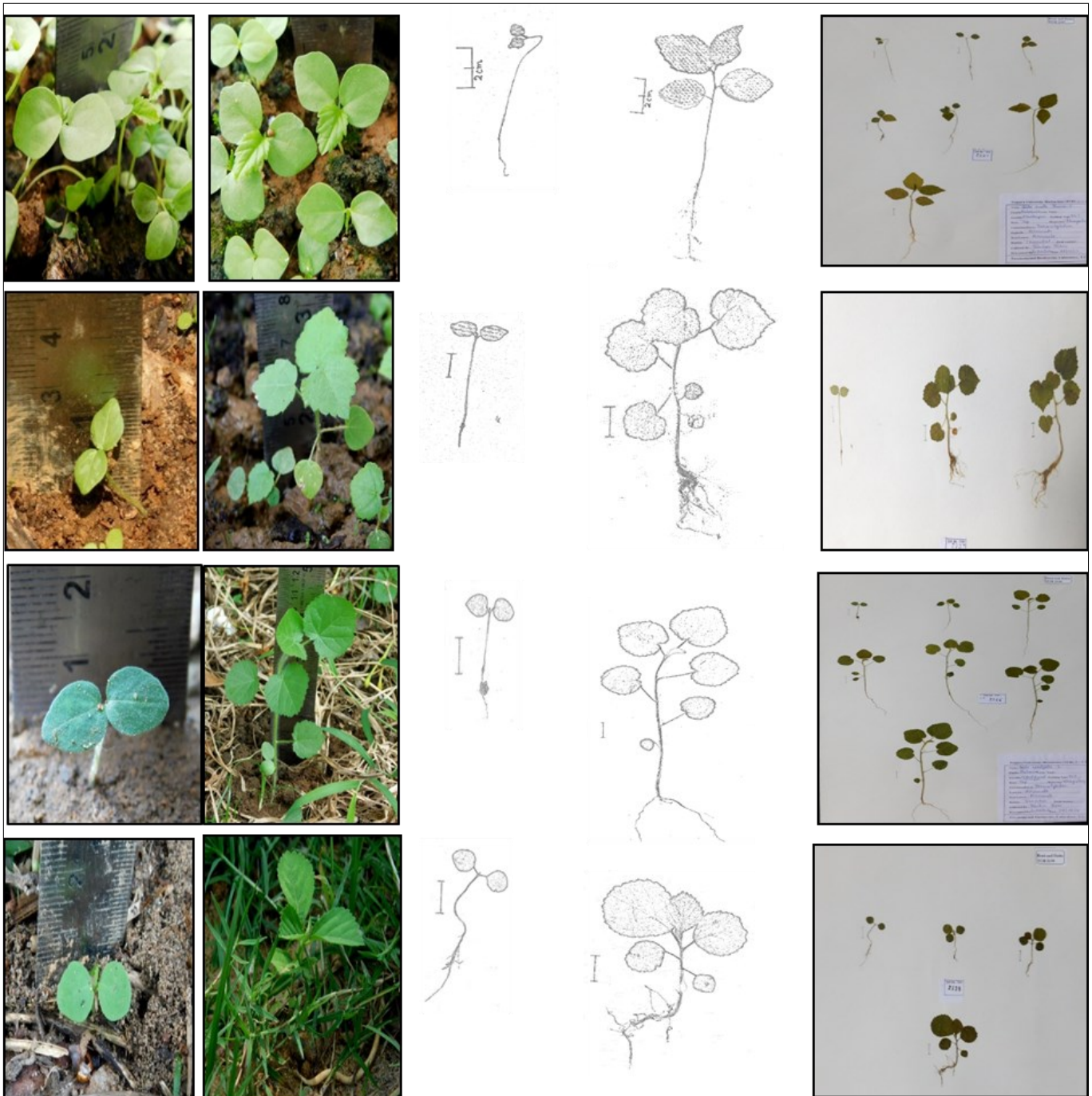


Fig. 3. 1(a-e) *S. acuta* (a). Paracotyledon stage (b) Mature seedling stage (c-d) Sketches of seedling (e) Dried herbarium specimen with different seedling stages. **2(a-e)** *S. cordata* (a). Paracotyledon stage (b) Mature seedling stage (c-d) Sketches of seedling (e) Dried herbarium specimen with different seedling stages **3(a-e)** *S. cordifolia* (a). Paracotyledon stage (b) Mature seedling stage (c-d) Sketches of seedling (e) Dried herbarium specimen with different seedling stages. **4(a-e)** *S. rhombifolia* (a). Paracotyledon stage (b) Mature seedling stage (c-d) Sketches of seedling (e) Dried herbarium specimen with different seedling stages.

irrespective of dimensions other seedling traits are almost similar to eophylls.

***Sida cordifolia* L.** Sp. Pl. 2: 684.1753. (Fig. 3.)

Vernacular names

Berela, Heart-Leaf Sida, Bor Sonborial, Badiyalaka, Bala, Baladhya.

Fruit and Seed morphology

Fruit schizocarp, mericarps 8-10 flattened, trigonous, two hairy awns at the apex, globose, size $\pm 0.70-0.90 \times \pm 0.30-0.80$ cm, weight $\pm 0.0290-0.0570$ g, surface hairy, smooth, colour brown, apex acute, apex two awned, base rounded, length/breadth ratio 1.45. Seeds are ovate, size $\pm 0.50-$

$0.70 \pm 0.20-0.30$ cm, obtuse apex, rounded base, weight $\pm 0.0040-0.0045$ g, rough surface, seed colour brown, hilum position basal, hilum colour brown, length and breadth ratio 2.4, per fruit 9 to 10 seeds.

Morphological description of seedling: (Up to 6th leaf stage)

Germination pattern phanero-epigeal foliaceous (PEF). Roots are tap, not branched, size $\pm 1.10-2.50 \times \pm 0.10-0.20$ cm, reduced, colour white/brown, soft, surface hairy, root tip colour white/ brown. Hypocotyl epigeous, size $\pm 2.0-3.0 \times \pm 0.10-0.20$ cm, colour whitish green, terete, surface very hairy, elongating, soft. Paracotyledon epigeous, two, opposite and equal, symmetric, petioles present, petiole size

$\pm 0.20-1.20 \times \pm 0.10-0.20$ cm, terete, petiole hairy, stipules absent, ovate leaf, size $\pm 0.50-1.50 \times \pm 0.40-1.0$ cm, base cordate, acute apex, margin entire, palmate venation, 3 primary veins, venation prominent, secondary veins prominent, acrodromous venation, texture soft, colour green, blade hairy, symmetric lamina. Epicotyl colour green, soft, surface hairy, size $\pm 0.80-1.450 \times \pm 0.10-0.20$ cm. First 2 leaves simple, alternate, soft, stipules absent, petioles present, petiole size $\pm 1.20-1.50 \times \pm 0.10-0.20$ cm, terete, petiole surface hairy, leaf ovate, size $\pm 1.50-2.40 \times \pm 1.20-2.10$ cm, base cordate, apex rounded, margin serrate, palmate venation, 5 primary veins, actinodromous venation, veins prominent, hairy, base balance symmetric. Next leaves alternate, texture soft, stipules present, petioles present, petiole hairy, terete, simple, lamina ovate, cordate base, rounded apex, serrate margin, venation actinodromous, irrespective of dimensions other seedling traits are almost similar to eophylls.

Sida rhombifolia L., Sp. Pl. 2: 684. 1753. (Fig. 3.)

Vernacular names

Lal Berela, Mahabala, Svetbarela, Boriala, Sahadeva, Uhal ukabi, Queensland hemp.

Fruit and Seed morphology

Fruit schizocarp, semi globose, mericarps flattened, 7-10, dehiscent, size $\pm 0.40-0.70 \times \pm 0.40-0.60$ cm, weight $\pm 0.0110-0.0260$ g, surface glabrous, colour brown, apex awned, base obtuse, length/breadth ratio 1. Seeds reniform, size $\pm 0.20-0.210 \times \pm 0.150-0.20$ cm, obtuse apex, rounded base, weight $\pm 0.020-0.0250$ g, glabrous surface, seed colour black, hilum position basal, hilum colour brown, length and breadth ratio 1.14, per fruit 6 to 7 seeds.

Morphological description of seedling: (Up to 6th leaf stage)

Germination pattern is phanero-epigeal foliaceous (PEF). Roots are tap, not branched, size $\pm 1.40-2.50 \times \pm 0.10-0.20$ cm, short elongating, colour light brown, soft, root tip colour brown. Hypocotyl epigeous, size $\pm 1.40-2.10 \times \pm 0.10-0.20$ cm, colour light green, angular, surface hairy, reduced, soft. Paracotyledon epigeous, two, opposite and equal, symmetric, petioles present, petiole size $\pm 0.20-0.40 \times \pm 0.050-0.10$ cm, terete, petiole hairy, stipules absent, ovate leaf, size $\pm 0.40-0.60 \times \pm 0.60-1.20$ cm, base obtuse, apex obtuse, margin entire, pinnate venation, 1 primary vein, venation prominent, secondary veins prominent, craspedodromous venation pattern, texture soft, colour green, blade glabrous, symmetric lamina. Epicotyl colour green, soft, hairy, size $\pm 0.40-0.60 \times \pm 0.10-0.20$ cm. First 2 leaves simple, alternate, soft, stipules absent, petioles present, petiole size $\pm 0.10-0.30 \times \pm 0.050-0.100$ cm, terete, petiole surface hairy, leaf elliptic/rhomboidal, size $\pm 1.0-2.60 \times \pm 1.0-2.50$ cm, obtuse base, rounded apex, serrate margin, pinnate venation, 1 primary vein, eucamptodromous venation, veins prominent, surface of blade glabrous, base balance symmetric. Next leaves, alternate, texture soft, stipules present, petioles present, petiole surface hairy, terete, simple, lamina elliptic, obtuse base, rounded apex, serrate margin, eucamptodromous, irrespective of dimensions

other seedling traits are almost similar to eophylls.

Artificial key to the investigated species

- 1a. Paracotyledon ovate2
- 1b. Paracotyledon elliptic*S. acuta*
- 2a. Eophylls ovate or elliptic 3
- 2b. Eophylls rhomboidal*S. rhombifolia*
- 3a. Eophylls and subsequent leaves elliptic*S. cordata*
- 3b. Eophylls and subsequent leaves ovate*S. cordifolia*.

During this study it has been found that all 4 studied *Sida* species have Phanerocotylar Epigeal Foliaceous (PEF) germination pattern which advantageous over other types of germination because they generally grow fast when exposed light (11). Multivariate phenetic analyses have been used for interpreting results of taxonomic studies. (12). Seedling characters are often distinctive at the species level. They can correlate with the data from other. (13). Seedling characters like nature of root, germination pattern, hypocotyl, epicotyl, paracotyledons and eophylls has been considered for this study.

Roots of *S. acuta* is elongating, *S. cordata* and *S. rhombifolia* have short elongating roots and *S. cordifolia* have reduced type of roots. Hypocotyl of *S. acuta* and *S. cordifolia* are elongating, short elongating for *S. cordifolia* and reduced for *S. rhombifolia*. All *Sida* species have ovate paracotyledon except *S. acuta*. Eophylls of all *Sida* species are elliptic but *S. cordifolia* have ovate shape. Artificial key based on these seedling characters has been constructed which is useful for the identification of plants in their early life cycle stage.

Using UPGMA method a phenogram has been constructed (Fig. 2) to establish correlation between the *Sida* species. Phenogram shows all four *Sida* species are closely related and are present in one cluster. *S. rhombifolia* and *S. cordifolia* are more closely related to each other. *S. rhombifolia* and *S. cordifolia* are more closely related to *S. cordata* than related to *S. acuta*.

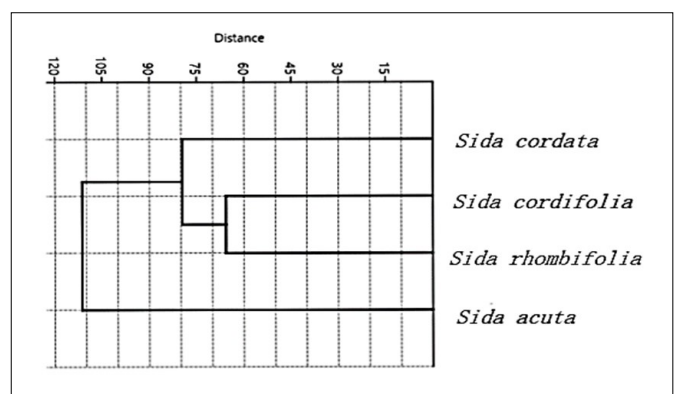


Fig. 2. Phenogram based on UPGMA method.

Conclusion

This work shows that seedling character of all *Sida* species are related to each other but still we can identify different *Sida* seedlings. The artificial key is extremely useful for identification of plants in their early stage and it can be helpful in restoration of plants. These types of study are

extremely useful for safeguarding of biodiversity as we can identify plants in their early stage of life cycle and can relocate them to a favourable condition. These are also helpful in establishing the phenetic relationship among plants. The artificial key prepared on the basis of seedling morphological study is completely a new initiative for the early identification of plants. The phenogram presented in this study for the phenetic analysis of the *Sida* species is the first report of implication of seedling morphological character in Tripura. Seedling morphology in *Sida* can be used as very useful tools for identifying the species.

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Authors contributions

RR has done the field survey and written the manuscript and BKD has supervised the work and reviewed the article.

Compliance with ethical standards

Conflict of interest: The authors declared no conflict of interest with respect to the research, authorship and publication of this article.

Ethical issues: None

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