minima coincide on the summer solstice day. A similar coincidence happens on the winter solstice day at the Tropic of Capricorn.

Figure 9 shows a more realistic representation in polar coordinates, including additional azimuthal data for places from the equator to 60° lat., exhibiting interesting shape change of the Asr curve.

The Moti Masjid sundial, though a fine piece of art, has been useless for centuries and in wrong orientation. Because of its simple, single Asr curve, the dial is also significantly different from the one at Srirangapatna. Srirangapatna, being situated in the tropics, witnesses the Sun’s zenithal passage twice a year. The size of the lower part of the Asr curve beyond the cusp signifies how close the place is to the tropical lines. Since the Sun never reaches the zenith beyond the tropics, the lower part of the Asr curve disappears.

The Asr prayer time in Agra practically extends up to sunset. It is time for the fourth prayer-Maghrib at sunset. We could successfully determine the appropriate length 5.625 inches of the missing original gnomon of the sundial in Agra by carrying out computer simulations, followed by on-site observations to resolve a long-standing puzzle.

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Traditional knowledge of medicinal plants among the Thangal–Naga ethnic group of Manipur, India

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With a population of 4475 individuals, the Thangal–Naga of Manipur is one of the vulnerable schedule tribes in India. During the study, oral traditional knowledge for the treatment of ailments using wild medicinal plants by the ethnic group was documented. Forty-one ethnomedicinal plants from 40 genera and 28 families were reported during the semi-structured interviews of 70 locals. In total, 29 different ailments were treated using medicinal plants. Further, phytochemical analysis of 11 common medicinal plants revealed the presence of alkaloids, flavonoids, saponins, tannins, phenols, steroids, anthraquinones, coumarins, glycosides and terpenoids.

Keywords: Ethnomedicinal plants, ethnic groups, phytochemical analysis, Thangal–Naga, traditional knowledge.

THANGAL–Naga, also known as Koirao, is one of the endangered, small, tribal ethnic groups in India with a population of 4475 individuals, and represents 0.38% of Manipur’s tribal population. Today, there are only 11 villages in Senapati district of Manipur, viz. Angkailongdi,

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Table 1. Plants used in traditional medicine among the Thangal–Naga ethnic group

| Scientific name, family and voucher number | Vernacular name (Thangal) | Habit | Parts used | Ailment treated and other uses | Preparation/ formulation | Routes of administration | Edible use |
|-------------------------------------------|--------------------------|-------|------------|--------------------------------|-------------------------|--------------------------|------------|
| Acanthaceae                               |                          |       |            |                                |                         |                          |            |
| Phlogacanthus thyrsiformis Nees BP-2019/22 | Tamphanggan Shrub Lf     |       | Lf         | Cold                           | Boiled Juice            | Oral/ inhalation/bath    | Fw as kanghou; Lf as chutney |
| Anacardiaceae                             |                          |       |            |                                |                         |                          |            |
| Rhus semialata Murray BP-2019/07          | Khama Tree Fr            |       | Fr         | Gastric problem                | Decoction               | Oral                     | Fr as raw  |
| Apiaceae                                  |                          |       |            |                                |                         |                          |            |
| Centella asiatica (L.) Urb. BP-2019/30    | Jopikonggan Herb Wp      |       | Wp         | Stomach problems, blood purifier, enhanced eyesight | Decoction               | Oral                     | Wp as kangsu and chamfut |
| Eryngium foetidum L. BP-2019/14          | Majangnikkhom Herb Lf    |       | Lf         | Epilepsy, paralysis and high blood pressure | Paste/decoction/ fresh  | Topical/oral              | Lf as spice |
| Apocynaceae                               |                          |       |            |                                |                         |                          |            |
| Ruellia serpentina (L.) Benth. ex Kurz BP-2019/12 | Parisaikoi Herb St      |       | St         | Skin infection                 | Paste                   | Topical/ massage         | –          |
| Asteraceae                                |                          |       |            |                                |                         |                          |            |
| Eupatorium adenophorum Spreng. BP-2019/37 | Japan phana Herb Ts, Lf |       | Ts, Lf     | Cuts and wounds                | Paste                   | Topical                  | –          |
| Ageratum conyzoides (L.) L. BP-2019/08    | Majangmi phana Herb Lf  |       | Lf         | Cuts and wounds                | Paste                   | Topical/oral              | –          |
| Artemisia nilagirica (C.B. Clarke) Pamp. BP-2019/01 | Tampitangou Herb Lf, Ts |       | Lf, Ts    | Dysentery                      | Fresh/juice             | Topical/oral              | –          |
| Gynura cusimbua (D.Don) Moore. BP-2019/35 | Leishak phana Herb Lf   |       | Lf         | Gastric problem and cleansing of stomach | Decoction               | Oral                     | Fr as chutney |
| Spilanthes acmella (L.) L. BP-2019/06     | Shagitla Herb Fw         |       | Fw         | Toothache and gastric problems | Fresh                   | Oral                     | –          |
| Oroxylum indicum (L.) Kurz. BP-2019/41    | Chakko Tree Br, Fr       |       | Br, Fr     | Piles and cancer               | Juice                   | Oral                     | Fr as fresh |
| Caricaceae                                |                          |       |            |                                |                         |                          |            |
| Carica papaya L. BP-2019/26               | Koigithei Tree Lf        |       | Lf         | Headache, gastric and stomach problems | Decoction               | Oral                     | Fr as fresh |
| Cucurbitaceae                             |                          |       |            |                                |                         |                          |            |
| Momordica charantia L. BP-2019/17         | Khalaganei Climber Lf    |       | Lf         | Flu and cold                   | Decoction               | Oral                     | Fr as chutney or boiled; Lf as fresh |
| Echinocystis lobata (Michx) Torr. & A. Gray BP-2019/18 | Ram githei phana Climber Wp |       | Wp         | Jaundice                       | Decoction               | Oral                     | –          |
| Cyperaceae                                |                          |       |            |                                |                         |                          |            |
| Fairena umbellata Rottb. BP-2019/33       | Ngi Herb Rt              |       | Rt         | Fever, swelling of arms, legs and stomach problem | Decoction               | Oral                     | –          |
| Lamiaceae                                 |                          |       |            |                                |                         |                          |            |
| Mentha spicata L. BP-2019/23              | Nungsit pari Herb Lf, Ts |       | Lf, Ts     | Stomach problems               | Decoction               | Oral                     | Ts as flavouring agent |
| Ocimum canum Sims. BP-2019/09             | Hopae Herb Lf, Ts        |       | Lf, Ts     | Headache                       | Decoction               | Oral                     | Ts as flavouring agent |
| Lauraceae                                 |                          |       |            |                                |                         |                          |            |
| Cinnamomum verum J. Presl BP-2019/02     | Sangleikoi Tree Br       |       | Br         | Cough, pain/ itching           | Juice/fresh             | Oral/topical             | Br as spice |
| Liliaceae                                 |                          |       |            |                                |                         |                          |            |
| Allium hookeri Thwaites BP-2019/32        | Sanamnamchenga Herb Lf   |       | Lf         | Deworming                      | Paste                   | Topical/ massage         | Wp as chamfut and as chutney |
| Allium sativum L. BP-2019/15              | Sanamriba Herb Lf        |       | Lf         | High blood pressure, cough and cold | Juice                   | Oral                     | Bl as spice |

(Contd)
Table 1. (Contd)

| Scientific name, family and voucher number | Vernacular name (Thangal) | Habit | Parts used | Ailment treated and other uses | Preparation/formulation | Routes of administration | Edible use |
|-------------------------------------------|--------------------------|-------|------------|-------------------------------|-------------------------|--------------------------|------------|
| Lythraceae Punicia granatum L. BP-2019/20 | Pulangtheikoi Tree Rt Dysentery Juice Oral | Fr as fresh |
| Meliaceae Azadirachta indica A. Juss. BP-2019/04 | Neemkoi Tree Lf Fever and cough Decoction Oral | – |
| Mimosaceae Mimosa pudica L. BP-2019/40 | Kajakpi phana Herb Wp Piles and stone problems Decoction Oral | Fr as singju and iromba; Fw as singju |
| Parkia javanica Merr. BP-2019/34 | Kajongtakkoi Tree Fr Diarrhoea and dysentery Boiled juice Oral | |
| Musaceae Musa paradisiaca L. BP-2019/39 | Poitheikoi Tree Fr Diarrhoea Fresh Oral | Fw as fried item; St as iromba; Fr as fresh |
| Myristicaceae Myristica lanifolia Roxb. BP-2019/25 | Ripkoi Tree Lf Cuts and wounds Paste Topical/massage | – |
| Oxalidaceae Oxalis corniculata L. BP-2019/29 | Pit Herb Lf Indigestion and gastric problem Decoction Oral | Lf as kangsoi |
| Plantaginaceae Plantago major L. BP-2019/38 | Kapatnougan Herb Lf Blood clot and boils Paste Topical/massage | Lf in iromba |
| Poaceae Cynodon dactylon L. BP-2019/05 | Phlim Herb Wp Fever and typhoid Juice Oral | – |
| Rosaceae Rubus ellipticus Sm. BP-2019/03 | Machikthei Shrub Rt Diarrhoea Juice Oral | Fr as fresh |
| Rubiaceae Meyna laxiflora Robyns BP-2019/36 | Habitheikoi Tree Lf Swelling of the body Decoction Oral | Lf as fresh in singju; Fr as dried |
| Paederia foetida L. BP-2019/19 | Beireng Climber Lf Bone fracture Paste Massage/topical | – |
| Rutaceae Citrus limon (Linn.) Burm. f. BP-2019/10 | Champra Shrub Fr Fever Fresh Massage | Fr as fresh |
| Zanthoxylum acanthopodium DC BP-2019/27 | Ngangtheikoi Tree Fr Toothache Fresh Oral | Fr in chutney; Lf as spice |
| Sapindaceae Sapindus mukorossi Gaertn. BP-2019/13 | Talumthei Tree Fr Fever and deworming Juice Topical/massage | – |
| Sauururaceae Houttuynia cordata Thunb. BP-2019/31 | Dana Herb Wp, Rz Muscle cramp, eye and skin irritation, measles, stomach ulcers Decoction/ juice Oral | Lf as fresh spice |
| Solanaceae Solanum torvum Sw. BP-2019/11 | Khukthei Shrub Fr Fever and typhoid Juice Oral | Fr as chutney |
| Verbenaceae Clerodendrum colebrookianum Walp. BP-2019/24 | Pokdomna Tree Lf Blood pressure Decoction Oral | Lf as curry |
| Zingiberaceae Alpinia galangal (L.) Willd. BP-2019/21 | Jaikhaba Herb Rz Cough and diarrhoea Paste/deworming Paste | Topical/oral Rz as spice |
| Curcuma longa L. BP-2019/28 | Marenggai Herb Rz Swelling of the body Sore throat Fresh | Topical/massage Rz as spice |
| Zingiber officinalis Roscoe BP-2019/16 | Saraikaga Herb Rz | |

Br, Bark; Fr, Fruits; Fw, Flowers; Lf, Leaves; St, Stem; Ts, Tender shoots; Rt, Roots; Rz, Rhizomes; Wp, Whole plants.
Katomei Makeng, Makeng Cheijinba, Ngaihang, Mapao Thangal, Mayangkhang, Ningthouham, Thangal Surung, Tumnoupokpi, Yaikongpao and Takaimei where Thangal habitations are found. Traditionally, Thangals are agriculturists and horticulturists with experience in jhum cultivation. The womenfolk are mostly skilled weavers making indigenous hand-woven clothes. They have lived with the sustainable use of forest and plant resources, such as wild edible plants, timber, fruits, medicinal herbs, flowers, orchids, etc. and depend on them directly or indirectly for their livelihood.

Like the major ethnic groups of Manipur, Thangals have acquired the traditional knowledge of using plants for healing different ailments since generations. They have maintained their own ethnic identity, customs, beliefs, faith and tradition. However, the indigenous traditional ways are disappearing from the society under the influence of modernization and industrialization. Today, lack of proper documentation has resulted in the disappearance of important ethnomedicinal knowledge from different indigenous ethnic groups, where the age-old traditions are being replaced by modern allelopathic practices. Therefore, there is an urgent need to update the traditional knowledge of these ethnic groups.

In this study, the ethnomedicinal knowledge was collected from 11 Thangal-inhabiting villages of Senapati district during 2018–19. Information on ethnomedicinal plants such as local name, ailments treated, plant parts used, preparation methods and administration routes was collected using semi-structured interviews. Voucher specimens collected were identified with the help of experts and the available literatures. The scientific name and family were cross-checked using the PlantList (www.theplantlist.org) of the Royal Botanic Garden, Kew, UK. Voucher specimens (BP-2019/01 to BP-2019/41) were then deposited in the Department of Forestry and Environmental Science, Manipur University. Eleven common medicinal plants (Cynodon dactylon and Centella asiatica whole plant, Oroxylum indicum and Cinnamomum verum bark, Eupatorium adenophorum and Ageratum conyzoides leaves, Musa paradisiaca and Solanum torvum fruits, Alpinia galanga and Curcuma longa rhizomes and Spilanthes acmella flowers) were collected and qualitative analysis of the phytochemicals was performed (water extract).

Among the 70 locals included in the ethnobotanical survey, 80% were men and 20% were women. A great disparity was noticed in the distribution of the traditional
Table 2. Phytochemical screening of common medicinal plants

| Phytochemicals          | Cynodon dactylon | Centella asiatica | Oroxylum indicum | Cinnamomum verum | Eupatorium adenophorum | Ageratum conyzoides | Musa paradisiaca | Solanum torvum | Curcuma longa | Alpinia galangal | Spilanthes acmella |
|-------------------------|------------------|-------------------|------------------|------------------|-----------------------|---------------------|-----------------|---------------|--------------|----------------|------------------|
| Flavonoids              | +                | -                 | -                | -                | -                     | -                   | -               | -             | -             | -                | -                |
| Tannins                 | -                | +                 | -                | -                | -                     | -                   | -               | -             | -             | -                | -                |
| Phenols                 | -                | -                 | +                | -                | -                     | -                   | -               | -             | -             | -                | -                |
| Terpenoids              | -                | -                 | -                | +                | -                     | -                   | -               | -             | -             | -                | -                |
| Steroids                | -                | -                 | -                | -                | +                     | -                   | -               | -             | -             | -                | -                |
| Saponins                | +                | -                 | -                | -                | -                     | -                   | -               | -             | -             | -                | -                |
| Anthraquinones          | -                | -                 | -                | -                | -                     | +                   | -               | -             | -             | -                | -                |
| Coumarins               | -                | -                 | -                | -                | -                     | -                   | -               | -             | -             | -                | -                |
| Glycosides              | -                | -                 | -                | -                | -                     | -                   | -               | -             | -             | -                | -                |
| Alkaloids               | -                | -                 | -                | -                | -                     | -                   | -               | -             | -             | -                | -                |

Figure 3. Photographs of common medicinal plants. a, Mentha spicata; b, Carica papaya; c, Ageratum conyzoides; d, Centella asiatica; e, Gymnura cusimba; f, Eupatorium adenophorum; g, Momordica charantia; h, Mimosa pudica; i, Eryngium foetidum.

knowledge between the sexes, where the tradition is a male-inherited system. Moreover, the healers mostly belonged to the aged population of the community with the younger generation favouring modern methods of treatment. During knowledge transmission, elders usually pass on the information and treatment processes to their near ones orally, thus restricting the number of individuals with the said knowledge. This is a common tradition observed in different indigenous groups. In total, 41 species from 40 genera and 28 families were documented (Table 1). A. conyzoides, E. adenophorum, C. asiatica, C. dactylon, O. canum, P. thyrsiformis, P. major, S. torvum and Z. officinale were commonly recommended by the healers. The maximum use reports were found for treating ailments such as gastric and stomach problems, fever, diarrhoea and dermatological problems due to their greater prevalence in the region. The common preferred species belonged to families Asteraceae, Zingiberaceae, Lamiales, Rubiaceae, Apiaceae, Liliaceae and Cucurbitaceae. Moreover, herbs were the major ethnomedicinal source, which explains the rich herbaceous species wealth of the region. The traditional healers generally used nine different plant parts during the preparation of crude drugs (Figure 2a). The maximum use was reported for leaves (19 species), as the collection was easier and resources were available in large volumes compared to other parts. Moreover, the harvest of the leaves can cause minimum damage compared to other parts from the conservation point of view. Likewise, the parts were prepared under five categories and the crude drugs administered via five routes (Figure 2b and c). The healers were well aware of the preparation methods and routes for administration, so that maximum efficiency could be achieved for the drug. Further, it was observed that most of the drugs were administered orally as it was the most effective means, which is similar to numerous findings. Moreover, 27 species from 26 genera and 21 families were consumed in the local households in traditional cuisines (Table 1 and Figure 3). Phytochemical analysis of the 11 ethnomedicinal plants showed the presence of flavonoids, tannins, phenols, terpenoids, saponins, coumarins, anthocyanin, anthraquinones, glycosides, alkaloids and steroids (Table 2). The analysis supports the selection of a particular species by the healers for traditional medicine. Thus,
the present study highlights the rich, disappearing, traditional ethnomedicinal knowledge which is scattered in oral form within the Thangal–Naga ethnic group of Manipur. Such knowledge needs proper documentation for use, preservation and protection.

Conflict of interest. Authors declare no conflict of interest.

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