obscures the triradiate ridge. Spores covered, except for this apical prominence, with small spines'. He described gula as 'apical prominence' which 'although not always as elongated as in the type figures of *Triletes crassiaculeatus*[26] (p. 9, figure 28) is considerably larger in the fully developed spores of *Lepidostrobus allantonensis* than *L. dubius*'. This apical prominence is actually the germ tube, hence, it is not always of the same size as it depends on the degree of germination. It is possible that these megaspores found in fertile fructification of *L. monospora* and *L. dubius* might have germinated prior to their liberation from the sporangium – a rare and evolutionarily important phenomenon leading to the development of further advance stage, i.e. retention of megaspore in the megasporangium.

The nature of gula is not known[4]. This is not produced in any living heterosporous plants, although it can be compared with germinated megaspores. In our view 'gula' is a germ tube which emerges from the spore by rupturing the spore coat or the sexine for germination as is evident from the photographs and text-figures of gulate megaspores described by us[24] and various workers[27–29]. At the time when germination was taking place, these megaspores were preserved and fossilized. This view is strengthened by the fact that gula is always without ornamentation, is not always of the same length, and never produced in living plants because there it is designated as germ tube.

For evolving a simpler, logical and practical system of identification and classification based on the above points and major qualitative characters of megaspore organization and exinal characters, it is now necessary to reorganize and reclassify the megaspore genera described so far. In view of the above points, the group Lagenotriletes should be abolished and lageniculate/gulate megaspore taxa recorded so far should be merged in already described megaspore taxa only on the basis of exosporium and mesosporium characters, neglecting the presence or absence of the germ tube or gula, since the gula is nothing but a germ tube and gulate megaspores are germinated megaspores.

1. Zerndt, J., *Bull. Int. Acad. Pol. Sci. Lett. Ser.*, 1937, **3**, 1–78.
2. Potonié, R. and Kremp G., *Geol. Jahrb.*, 1954, **69**, 111–194.
3. Bharadwaj, D. C. and Tiwari, R. S., *Palaeontographica*, 1970, **129**, 1–70.
4. Pant, D. D. and Mishra, S. N., *Palaeontographica*, 1986, **198**, 13–73.
5. Bennie, J. and Kidston, R., *Proc. R. Phys. Soc., Edinburgh*, 1886, **9**, 82–117.
6. Reinsch, P. F., Neue untersuchungen über die mikrostruktur der Steinkohle des karbon, der Dyas und Trias. Leipzig, 1881.
7. Potonié, R. and Kremp, G., *Palaeontographica*, 1955, **98**, 1–136.
8. Bharadwaj, D. C., *Palaeontographica*, 1957, **101**, 73–125.
9. Schopf, J. M., Report of Investigations–No. 50, State Geological Survey, Urbana, Illinois, 1938, pp. 1–73.
10. Surange, K. R., Singh. P. and Srivastava, P. N., *Palaeobotanist*, 1953, **2**, 9–17.
11. Chaloner, W. G., *Ann. Mag. Nat. Hist. Ser. 12*, 1954, **7**, 81–91.
12. Zerndt, J., *Bull. Int. Acad. Pol. Sci. Lett. Ser.*, 1934, **1**, 1–56.
13. Chaloner, W. G., *J. Linn. Soc. Bot.*, 1968, **61**, 25–36.
14. Bharadwaj, D. C. and Venkatachala, B. S., *Palaeobotanist*, 1962, **10**, 18–47.
15. Dybova-Jachowicz, S. *et al.*, *Acta Palaeontol. Pol.*, 1979, **24**, 411–422.
16. Brack-Hanes, S. D., *Bot. Gaz.*, 1981, **141**, 294–304.
17. Scott, A. C. and King, G. R., *Rev. Palaeobot. Palynol.*, 1981, **43**, 107–133.
18. Spinner, E., *J. Micropalaeontol.*, 1983, **1**, 67–70.
19. Pant, D. D. and Srivastava, G. K., *Palaeontographica*, 1962, **111**, 79–81.
20. Chaloner, W. G., Leistikow, K. U. and Hill, A., *Rev. Palaeobot. Palynol.*, 1979, **28**, 117–136.
21. Mishra, S. N. and Tripathi, R. P., *Aspects Plant Sci.*, 1991, **13**, 163–169.
22. Tripathi, R. P. and Mishra, S. N., *J. Palaeontol. Soc. India*, 2001, **46**, 37–42.
23. Srivastava, A. K. and Tewari, R., *J. Palaeontol. Soc. India*, 2001, **47**, 93–96.
24. Tewari, R., Rajanikanth, A. and Jha, Neerja, *Palaeobotanist*, 2004, **53**, 35–50.
25. Pant, D. D. and Basu, N., *Rev. Palaeobot. Palynol.*, 1979, **28**, 203–223.
26. Zerndt, J., *Bull. Int. Acad. Pol. Sci. Lett. Ser. A*, 1931, 165–183.
27. Chaloner, W. G., *Ann. Bot.*, 1953, **17**, 263–293.
28. Dijkstra, S. J., *Meded. Geol. Sticht. N.S.*, 1955, **9**, 5–10.
29. Mortimer, M. G. and Chaloner, W. G., *Palaeontology*, 1967, **10**, 189–213.

ACKNOWLEDGEMENTS. We thank Dr N. C. Mehrotra, Director, Birbal Sahni Institute of Palaeobotany, Lucknow for encouragement and permission to publish this paper.

Received 24 March 2006; revised accepted 7 July 2006

NEERJA JHA*
RAJNI TEWARI

Birbal Sahni Institute of Palaeobotany,
53 University Road,
Lucknow 226 007, India
**For correspondence.*
e-mail: neerjajha@yahoo.co.uk

Hot springs of Tawang and West Kameng districts of Arunachal Pradesh

The discovery of extreme environments has made more plausible search for life outside the earth, and even the possibility of panspermia (transport of life from one planet to other). The Eastern Himalayas are among one of the twenty-five biodiversity hotspots[1] identified worldwide in the biosphere as an area of great biological diversity and as one of the globally important ecoregions out of the two hundred regions which have been identified worldwide[2]. Arunachal Pradesh, with its climatic conditions, altitudinal variations and by its geographical position, occupies a major portion of eastern Himalayas and is a vast repository of resources of both ecological and economic importance and is a biodiversity-rich region in northeastern India. Arunachal Pradesh (83,789 km^2) highly endowed with diverse ecosystem lies in the confluence zone of Indo-Chinese,

Afro-Tropic and Indo-Malayan biogeographical realms[3] and the state comprises 15 districts with 26 major tribes. During our expedition we have located two hot springs, one in the Dirang area of west Kameng district and another in the Kitpi area of Tawang district (Figure 1). This correspondence gives an idea about the location, the vegetation around the springs, the belief of local people and the physiological parameters of the hot springs. These hot springs exhibit distinctive physiochemical properties such as high temperature and alkaline conditions. The chemical analysis of the water from the two hot springs is given in Table 1.

The first hot spring is in the Dirang area of West Kameng district, lying between 26°54′ and 28°01′N lat. and 91°30′ and 92°40′E long. It is bounded by Tibet in the North, Bhutan in the west and Tawang district of Arunachal Pradesh in the northwest, East Kameng district in the east and Sonitpur district of Assam in the south. It has an area of 7422 sq km. The hot spring of Dirang is located on the bank of river Dirang-chu at a height of 1495 m asl. Dirang hot spring is surrounded by river Dirang-chu on one side and by subtropical Pine forest on the other three sides. This vegetation occurs from 1000 m asl to 1800 m asl and is represented by *Pinus roxburghii*, *Pinus wallichiana*, *Pinus merkusii*, *Betula alnoides*, *Rhus javanica*, etc. Shrubby and herbaceous plant tiers are represented by species like *Eleagnus* spp. *Luculia* spp., *Rubus* spp., *Elsholtzia* spp., *Fragaria* spp., and *Rumex* spp.

The other hot spring (Kitpi hot spring) is situated in the Greng Khar village of Kitpi area of Tawang district. Kitpi area is approximately 20–25 km away from the main Tawang city. Tawang district lies between 27°22′ and 27°45′N lat. and 90°15′ to 90°45′E long. It covers an area of 2085 sq km and lies at an altitude of 3500 m asl. It is bounded by Tibet in the north, Bhutan in the south and west; and West Kameng district in the east. Kitpi hot spring is located in the bank on the river Jong at a height of 1850 m asl. It is bounded by the river Jong on one side and on the other three sides are by the temperate broadleaved forest. This vegetation is found between 1800 m and 2800 m. Vegetation which is represented by tall tree species like *Populus* spp., *Betula* spp., *Acer* spp., *Illicium* spp., etc. The middle portion is represented by species of *Rhododendron* spp., *Prunus* spp., and *Pyrus* spp.; the small tree species represented by *Berberis* spp., *Debregeasia* spp, *Rhododendron*, etc.; ground floor is occupied by the species *Polygonum* spp., *Potentilla* spp., *Thalictrum* spp., *Fragaria* spp., and *Houttuynia* spp.

The soils in the surrounding areas of the two hot springs are rocky and sandy; a

Table 1. Chemical parameters of the water collected from the hot springs of Arunachal Pradesh

Parameters	Hot spring 1 (Dirang)	Hot spring 2 (Tawang)
pH	8.10	8.16
Temperature	40°C	43°C
Total hardness ($CaCO_3$)	162.51	204.1
Ca^{2+}	97.9	122.8
Na^{2+}	269.5	88.2
K^{+}	4.6	4.4
Conductivity	1853.7	979.1
Total alkalinity	56	216
SO_4^{2-}	56.4	60.6
Cl^{-}	40.4	44.6

Concentrations in mg/l: Wet chemical method[4].

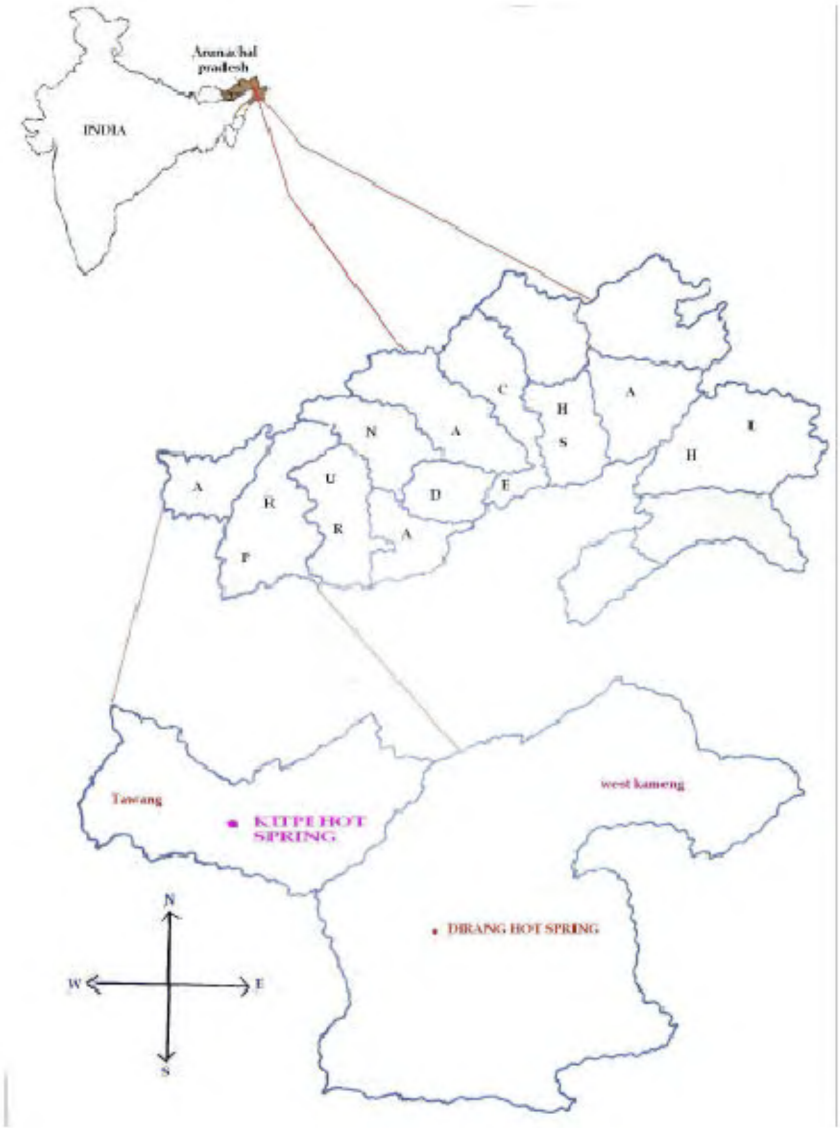

Figure 1. Map showing the location of the hot springs.

high degree of acidity is in the soil, which may be attributed to heavy rainfall.

Monpa, Miji, Sherdukpen and Aka tribes inhabit West Kameng; Tawang district is inhabited by Monpa tribe. The Monpa and Sherdukpen are Buddhist by religion. Aka and Miji worship Donyo–Polo (Moon–Sun god) and Nature. Monpa, Sherdukpen, Miji and Aka tribes take holy bath in these hot springs in the belief that their sins will get washed away. They also take a dip in the water for 1–3 h for healing any kind of skin disease.

The ecosystem of the hot springs of Tawang and Dirang districts of Arunachal Pradesh can serve as a source for bioprospecting of novel microorganisms like thermophiles that are stable under high temperature and have the potential for further exploration.

1. Myers, N., Muttermier, R. A., da Fonseca, G. A. B. and Kent, J., *Nature*, 2000, **403**, 853–858.
2. Olson, D. M. and Dinerstein, E., *Conserv. Biol.*, 1998, **12**, 502–515.
3. Roy, S. P. and Behera, M. D., *Curr. Sci.*, 2005, **88**, 250–256.
4. APHA, *Standard Methods of Examination of Water and Wastewater*, American Public Health Association, American Water Works Association and the Water Environment Federation 1998, p. 1220.

ACKNOWLEDGEMENTS. We thank DRDO for financial support and Dr S. N. Dube, Director, Defence Research Laboratory for suggestions and encouragement.

Received 5 November 2005; revised accepted 6 May 2006

LIMPON BORA[1,*]
A. KAR[1]
I. BARUAH[1]
M. C. KALITA[2]

[1]*Defence Research Laboratory, Tezpur 784 001, India*
[2]*Department of Biotechnology, Gauhati University, Guwahati 781 014, India*
**For correspondence*
e-mail: limponbioera@rediffmail.com

Anthropogenic input in Asian mega tsunami (2004) disaster along Tamil Nadu Coast, India

As the Tsunami Warning System (TWS) being contemplated by the South Asian territorial nations can only help in evacuating the coastal people on receiving the forewarning, the concept of tsunami vulnerability mapping is gaining equal momentum, since only this can suggest measures for also protecting coastal installations. Though geoscientists have made varied observations attributing the differential and preferential tsunami inundations along Tamil Nadu coast during the 2004 tsunami to coastal geometry[1], tectonics[2] and geomorphology[3,4], the present observations made in certain worst-affected areas of Tamil Nadu coast like Devanampattinam (A), Tirumullaivasal (B) and Nagapattinam (C) located amidst the fluvio-marine and marine landforms (D, Figure 1 *a*) show that improper development by humans has significantly contributed to tsunami inundation. Hence anthropogenic input warrants attention while framing strategies for tsunami mitigation.

Devanampattinam village (1) (Figure 1 *b*, *e* and *f*) is located on an elevated palaeo beach ridge (2) with well defined drainage channels of Ponnaiyar (3), Gadilam (4), a swale (5) on its three sides and thin beach (6) to its east. The eastern slope of the beach ridge (7) has been flattened to develop a beach resort (Figure 1 *c*). During the recent tsunami, the waves (8) have directly gushed into the village, rolling over the flattened beach ridge, and inundating the eastern slope as well as the village. Direct gushing of the tsunami waves over the beach ridge and the village is well-manifested in the form of westerly-deflected plants and bushes found to the east of the village (Figure 1 *d*). While beach ridges of the same elevation range with or without villages on them, were not affected in other parts of Tamil Nadu, the massive disaster at Devanampattinam despite well-defined drainage channels all around indicates that it is mainly due to the destabilization of beach ridges for beach resort development.

The Tirumullaivasal settlement (9) located on the northern bank of Uppanar river (10), is another area badly affected by the tsunami. The east-northeasterly-oriented sandbars (11) and meander scars (12) seen to the south of the village show that such original east-northeasterly flowing river might have been pushed towards southerly due to the growing settlements in the north. At the same time, nine-month northerly-moving vibrant littoral currents[5] (13) would not have allowed the river to shift towards southerly and hence, the river might have taken a 90° left-angled turn, enveloping the village and laid its mouth (14) to the east of the village. Littoral currents have subsequently built bay mouth bars (15) at its mouth. Thus, as the village is now positioned right at the mouth of the river, the ferocious waves (16) have gushed through the river mouth and destroyed the village. Had the village not been established abutting the river at its northern bank, neither the river flow would have been modified nor the new river mouth would have been formed facilitating direct entry of waves into the village, causing such a major disaster.

Nagapattinam township (17), the yet another severely affected region during the tsunami, is located on the northern bank of the northeasterly flowing river (18), which is also called the Uppanar river. The original river mouth has been closed by a concrete wall (19) and the river has been diverted towards northerly (20) all along the eastern fringe of the township and west of the coast, and made to open its mouth (21) just east of the town for harbour purposes. Thus the waves (22), unable to enter the original sealed river mouth, took advantage of the river mouth – river bed system and gushed onto the settlements and inundated the entire area, leaving only the central part of the town.

Thus, the observations made in the above three worst-affected areas show that the disaster was of such colossal magnitude only because of the improper developmental practices carried out without understanding coastal morphology and morphological processes. These ob-