Geneclean (Bio 101, Inc, USA). 1 µl of this DNA was used to perform microsatellite amplification at 3 feline CA repeat loci[8], Fca 45, Fca 77 and Fca 126. Mitochondrial D loop amplification was performed using feline-specific primers[9] and the amplified product was purified using Geneclean and directly sequenced using Cyclist manual PCR sequencing kit (Stratagene, USA).

The procedure described was effective in amplifying the feline microsatellites and mitochondrial DNA from all the scat samples tested. Three feline-specific microsatellites were amplified successfully from the DNA extracted from dried scats of Asiatic lions and Indian tigers. The PCR products matched exactly with the microsatellites amplified from blood of animals (Figure 1). Mitochondrial D loop region of approximately 1 kb was also amplified using feline-specific primers (Figure 2) and the product was directly sequenced. The sequence of DNA, including the unique repetitive stretch from scat, matched exactly with the sequence of DNA from the blood of Asiatic lions as shown in Table 1. The use of PVPP effectively removes the PCR inhibiting polyphenols by hydrogen bonding. Earlier procedures used PVPP along with high concentrations of EDTA. EDTA chelates the heavy metal ions which degrade DNA during boiling but high concentrations of it necessitate dilution for further enzymatic reactions like PCR. As the amount of animal DNA is extremely low in scat samples, dilution to this extent does not permit PCR amplification. The role of chelex is that of EDTA but as it is insoluble, effective removal is ensured. Glass milk further facilitates the removal of impurities and also reduces the loss of DNA during handling. The minimal transfer between tubes and the reduced handling time involved in this procedure prevent cross contamination and allow the processing of a large number of samples. This procedure could also be used to amplify plant DNA, using plant-specific PCR primers, which would shed light upon the dietary behaviour of the animals tested. We are planning to employ this technique for large scale sampling and genetic analysis of wild Asiatic lions and Indian tigers. This technique can also be used in the medical field for non-invasive diagnosis.

1. Khoshoo, T. N., *Curr. Sci.*, 1988, **74**, 13–14.
2. Hoss, M., Kohn, M., Pääbo, S., Knauer, F. and Schröder, W., *Nature*, 1992, **359**, 199.
3. Constable, J. J., Packer, C., Collin, D. A. and Pusey, A. E., *Nature*, 1995, **373**, 393.
4. Boom, R., Sol, C. J., Salimans, M. M., Jansen, C. L., Wertheim van Dillon, P. M. and van der Noordaa, J., *J. Clin. Microbiol.*, 1990, **28**, 495–503.
5. Kohn, M., Knauer, F., Stoffella, A., Schröder, M. and Pääbo, S., *Mol. Ecol.*, 1995, **4**, 95–103.
6. Sidransky, D., Tokimo, T., Hamilton, S. R., Kinzler, K. W., Levin, B., Frost, P. and Vogelstein, B., *Science*, 1992, **256**, 102–105.
7. Steiner, J. J., Poklemba, C. J., Fjellstrom, R. G. and Elliott, L. F., *Nucleic Acids Res.*, 1995, **23**, 2569–2570.
8. Menotti-Raymond, M. and O'Brien, S. J., *J. Hered.*, 1995, **86**, 319–322.
9. Hoelzel, A. R., Lopez, J. V., Dover, G. A. and O'Brien, S. J., *J. Mol. Evol.*, 1994, **39**, 191–199.

ACKNOWLEDGEMENTS. We thank Dr S. Patil and Dr Shivaji of CCMB and Dr Navin Kumar of the Nehru Zoological Park, Hyderabad for providing the scat samples. This work was supported by a grant from Central Zoo Authority to L.S.

PATTABHIRAMAN SHANKARANARAYANAN*
LALJI SINGH*,†

**Centre for Cellular and Molecular Biology, Uppal Road, Hyderabad 500 007, India*
†Centre for DNA Fingerprinting and Diagnostics, Centre for Cellular and Molecular Biology, Hyderabad 500 007, India

Rapid land building activity along Vedaranniyam coast and its possible implications

The great Indian epic 'Ramayana' says that 'Lord Rama' has tried to cross over the Bay of Bengal so as to reach Sri Lanka from India from three points along the southeastern fringe of the Indian coast. Firstly, he is said to have tried to cross from Vedaranniyam which is mythologically called as 'Kodiyakkarai', secondly from Manamelkudi and finally crossed over to Sri Lanka from Rameswaram Island (Figure 1), as the former two coastal locations were widely separated from Sri Lanka by Bay of Bengal and the Rameswaram Island was nearer to Sri Lanka during that period. But, the recently acquired satellite data shows the huge accretion of sediments and rapid land building activity off Vedaranniyam coast (Figures 2 and 3). The geomorphic interpretations carried out using IRS 1A imagery and ^{14}C and archaeological dating of such geomorphic features have shown that such ongoing sediment accretion phenomena off Vedaranniyam nose might in future connect the Vedaranniyam part of Indian peninsula with Jaffna peninsula of Sri Lanka if the sediment accumulation continues unabated. The sediment accretion in this area, therefore, requires detailed studies particulaly in the context of the contemplated 'Sethusamudram Project' for navigation through the Palk strait (Figure 1).

The Vedaranniyam area forms a spectacular triangular shaped coast in the southeastern part of India (Figures 1 and 2). The IRS 1A satellite data (Figure 2) shows rows of beach ridges (palaeo beaches) along a coastal length of 31 km from Chettipulam in the NNW to Kodiyakkarai in the SSE. The digitally processed IRS 1A image (band 2, density sliced data) of 1990 shows offshore sand bars upto 27 km southeast of Vedaranniyam nose (Point Calimere) inside the sea (2, Figure 3).

Shell samples were collected from 1.2 to 3 m depth from four beach ridge complexes from NNW to SSE, at Chettipulam,

Maranganallur, Tettagudi and Kodiyakkarai which are respectively 32 km, 22 km, 19 km and 1 km from the present day coast (Figure 2).

Existence of beach ridges upto Chettipulam indicates that the sea might have been upto Chettipulam and regressed to Kodiyakkarai in the recent past. ^{14}C dating of beach ridge at Chettipulam (1, Figure 2) shows an age of 6085 ± 223 y.B.P., at Maranganallur (2, Figure 2) 5646 ± 223 y.B.P., Tettagudi (3, Figure 2) 3570 ± 205 y.B.P. and Kodiyakkarai (5, Figure 2) 1020 ± 80 y.B.P. The Vedaraneswarar temple located over the beach ridge at Vedaranniyam (4, Figure 2) suggests an approximate age of 1300 y.B.P. (7th century A.D) to the ridge here[1]. The density slicing of IRS 1A band 2 data shows that the offshore bars have developed up to 27 km inside the sea (2, Figure 3), and as this data was obtained in 1990, it is reasonable to assume the same age to these offshore bars.

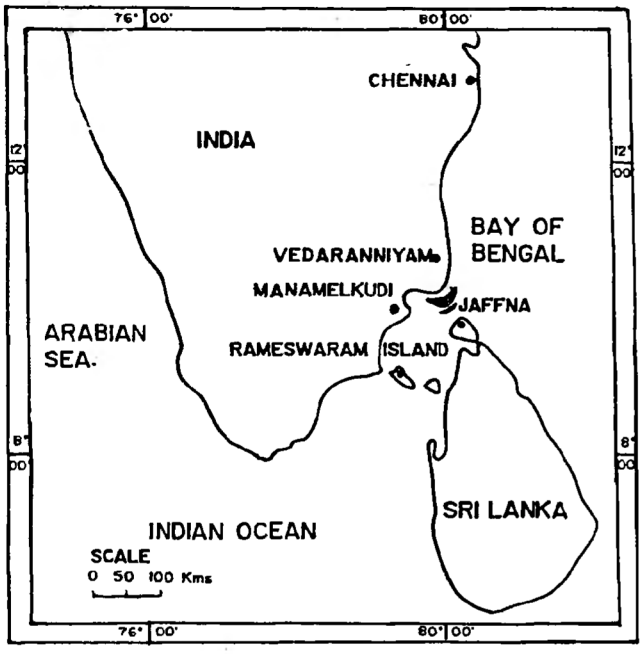

Figure 1.

Figure 2.

The ^{14}C dates evaluated for the beach ridges show that the sea has gradually regressed due to the rapid accumulation of sediments and the development of cuspate landforms in between Chettipulam and Kodiyakkarai during these 6000 years. Our data has shown that the sea has regressed by 10 km in 439 years from Chettipulam to Maranganallur, by 4 km in 2076 years from Maranganallur to Tettagudi, by 8 km in 2270 years from Tettagudi to Vedaranniyam, by 8 km in 220 years from Vedaranniyam to Kodiyakkarai and by 28 km in 1020 years from Kodiyakkarai to present day offshore bars. These show that the beach ridges have grown at the approximate rate of 23 m/y (metres/year) from Chettipulam to Maranganallur, 2 m/y from Maranganallur to Tettagudi, 3.5 m/y from Tettagudi to Vedaranniyam, 36 m/y from Vedaranniyam to Kodiyakkarai, 27.5 m/y from Kodiyakkarai to the recently developed offshore bars of 1990. The above observations show that there is no strict linear relation between the rate of sediment accretion and the time period. Infact, under such dynamic coastal regimes, linear relationship cannot be expected because of varying degrees and duration of the fluvial and physical oceanographic processes. But, however in average (excluding Maranganallur to Tettagudi and Tettagudi to Vedaranniyam) the land building activity is around 29 m/y and if this accretion rates maintained Vedaranniyam nose will get connected to Jaffna peninsula, just 12 km from the offshore bars (2, Figure 3), in another 400 years. Regionally from Chettipulam to present day offshore bars, the land has grown to a distance of 58 km in 6085 years, at an average rate of 10 m/y. At this rate the offshore bars will provide a land con-

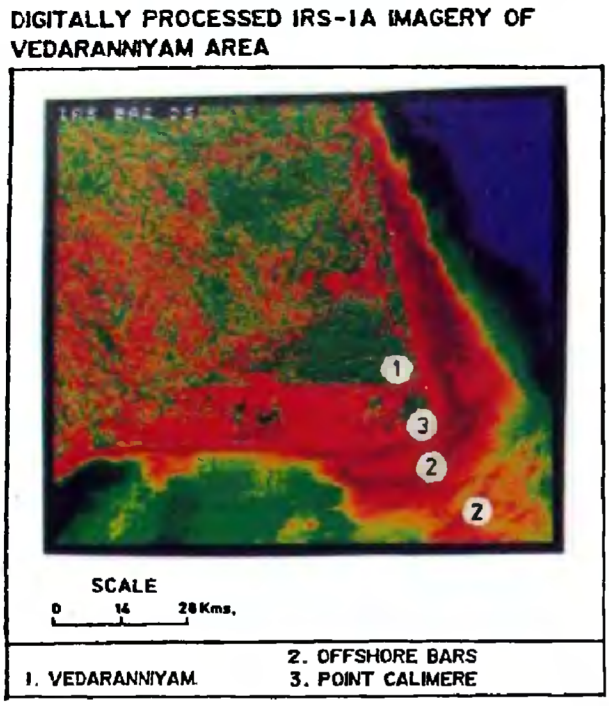

Figure 3. Digitally processed IRS 1A imagery of Vedaranniyam area.

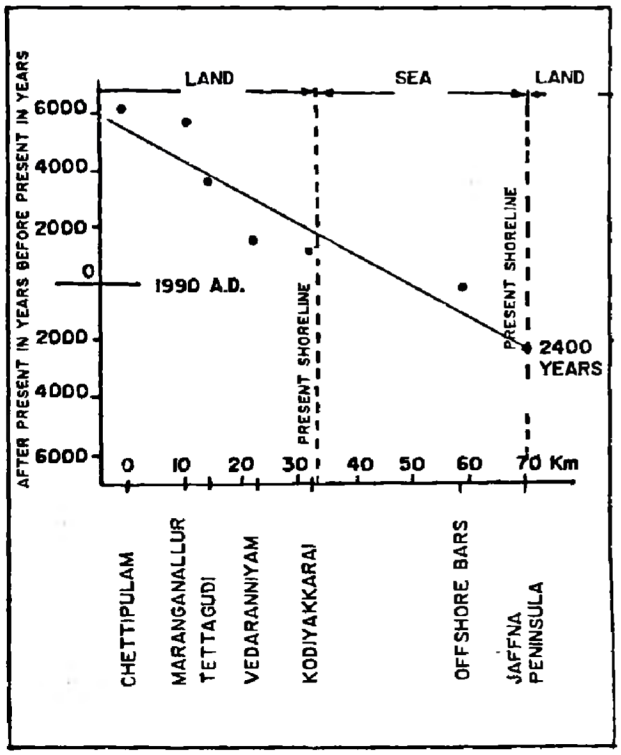

Figure 4.

nection with Jaffna peninsula in another 1200 years. The graphical projection of the locations of the beach ridges versus their ages has shown a coarse linear relationship indicating that the Vedaranniyam nose will get connected with Jaffna peninsula in another 2400 years (Figure 4).

The sediment building activity due to littoral currents seems to be very rapid in this area with the rate of 29 m/y and hence there is a possibility for such land building/connection in another 400 years. Ramasamy and Balaji[2] on the basis of satellite imagery interpretation have identified that the Mio-Pliocene sandstone of Vedaranniyam area is undergoing an upliftment in post Mio-Pliocene period. Ramasamy *et al.*[3] have observed an anticlockwise rotational migration of Cauvery river in the area north and northwest of Chettipulam-Kodiyakkarai during 2300–750 y.B.P. and attributed this to the ongoing upliftment of Mio-Pliocene sandstone and the resultant sediment accretion in Chettipulam-Kodiyakkarai area. Ramasamy and Karthikeyan[4] have observed further geomorphic and hydrogeochemical anomalies favouring ongoing land emergence in Vedaranniyam area. It is obvious therefore, that the tectonic upliftment has contributed substantially for such sediment accretion brought by littoral currents in Kodiyakkarai–Jaffna peninsular sector and hence it can be confidently said that Vedaranniyam land segment will get connected with Jaffna peninsula ultimately.

1. Venkatarajulu, S., Ph D thesis, Bharathidasan University, Tiruchirapalli, (unpubl.), 1994, p. 160.
2. Ramasamy, SM. and Balaji, S., *Int. J. Remote Sensing*, 1995, **4**, 2800–2832.
3. Ramasamy, SM., Balaji, S., Venkatasubramanian, V. and Paul, M. A., *INTERFACE, Bull. NRSA Data Centre*, 1995, **6**(4), 5–6.
4. Ramasamy, SM. and Karthikeyan, N., *Geo Carto Int. J.*, 1997 (in press).

SM. RAMASAMY
D. RAMESH
M. A. PAUL
SHEELA KUSUMGAR[†]
M. G. YADAVA[†]
A. R. NAIR[‡]
U. K. SINHA[‡]
T. B. JOSEPH[‡]

Centre for Remote Sensing,
Bharathidasan University,
Tiruchirapalli 620 024, India
[†]*Radio Carbon Dating Laboratory,*
Physical Research Laboratory,
Ahmedabad 380 009, India
[‡]*Isotope Division,*
Bhaba Atomic Research Centre,
Mumbai 400 085, India