provide habitat for rare animal species. The significance of such investigations to determine diversity indices in host–parasite infrapopulation interdependence and commercial output assessment would, therefore, provide long-term benefits to the fish industry in the country. The present analysis has the potential to explain the hazardous role of human activity in dispersal of parasitic species. The factual occurrence of adult worms of *Rostellascaris* spp. in water bodies at different geographic locations provided further evidence of the completion of its life cycle within the aquatic body itself. Such parasitic organisms confirmed to the description of 'autogenic'[6] parasites which completed their life cycles exclusively in aquatic hosts and were confined to the aquatic ecosystem, constraining dispersal. As a result 'allogenic' species capable of using vagile hosts like birds and mammals were considered to be most widely dispersed, showing broader geographic distributions than autogenic parasites[16].

The present investigation is in striking contrast in *Rostellascaris* being clearly one of the most broadly distributed parasite genera in Indian fishes. This indicates possibility of inter-habitat transmission of this nematode genus to distant geographic locations by human activity, and not by any natural process, because although the Mandavi riverine system existed besides marine ecosystems at Goa, no inter-habitat transfer of *Rostellascaris* was observed either due to salinity gradient, host's behavioral response or due to a broader host specificity. Earlier too such a word of caution has been stressed[17] with regard to the power of human intervention to alter natural ecological processes.

1. Moller, H., *Int. J. Parasitol.*, 1987, **17**, 345.
2. Knudsen, R., Klemetsen, A. and Staldvik, F., *J. Fish Biol.*, 1996, **48**, 1256–1258.
3. Prejs, K., *Ekol. Pol.*, 1977, **25**, 2124.
4. Zullini, A., *Nematol. Medit.*, 1976, **4**, 1315.
5. Sindermann, C. J., *NAFO Sci. Coun. Stud.*, 1983, **6**, 6371.
6. MacKenzie, K., *Int. J. Parasitol.*, 1987, **17**, 345352.
7. Malhotra, Sandeep K. and Anas, M., *Prof. V. N. Capoor Commemoration Vol.*, Ankit Publ., 2001, pp. 4650.
8. Geetanjali, Malhotra Sandeep K., Ansari, Z. and Malhotra, A., *Environment and its Challenges* (ed. Kumar, A.), Soc. Env. Sci., 2002 (in press).
9. Malhotra, Sandeep K., *Environment and Applied Biology* (ed. Agarwal, V. P.)., Soc. Biosci., 1994, pp. 153161.
10. Bongers, T. and Ferris, H., *TREE*, 1999, **14**, 224227.
11. Millward, R. N. and Grant, N., *Mar. Pollut. Bull.*, 1995, **30**, 701703.
12. Lafferty, K. D. and Morris, A. K., *Ecology*, 1996, **77**, 1390.
13. Biserkov, V. and Kostadinova, A., *J. Helminthol.*, 1998, **72**, 267271.
14. Madhavi, R. and SaiRam, B. K., *ibid*, 2000, **74**, 337342.
15. Aho, J. M., in *Parasitic Communities: Patterns and Processes* (eds Esch, G. W., Bush, A. O. and Aho, J. M.), Chapman and Hall, London, 1990, pp. 157190.
16. Esch, G. W., Kennedy, C. R., Bush, A. O. and Aho, J. M., *Parasitology*, 1988, **96**, 519523.
17. Font, W. F., *J. Helminthol.*, 1998, **72**, 307309.

ACKNOWLEDGEMENTS.S.K.M. thanks the Indian Council of Agricultural Research, New Delhi for funding a major research project.

Received 16 July 2001; accepted 27 December 2001

GEETANJALI†
SANDEEP K. MALHOTRA‡
ANSHU MALHOTRA†
ZAKIR ANSARI*
ANIL CHATTERJI*

†*Parasitology Laboratory,*
Department of Zoology,
University of Allahabad,
Allahabad 211 002, India
**Division of Aquaculture,*
National Institute of Oceanography,
Dona Paula,
Goa 403 004, India
‡*For correspondence*

Vertebrate fauna from Panandhro lignite field (Lower Eocene), District Kachchh, western India

In contrast to the Middle Eocene vertebrates, our knowledge of Lower Eocene vertebrate fossils from India is extremely poor. This hampers biogeographic evaluation in a geodynamic context, particularly in regard to the mammalian evidence. The few known occurrences of pre-Middle Eocene vertebrates include those from the Subathu Formation of Himalaya[13], from sediments associated with the Palana lignite in Bikaner[4] and, more recently, an otolith fauna from a lignite field near Surat[5]. During our recent fieldwork in Kachchh, we succeeded in locating a rich occurrence of fossil vertebrates in the well-known open cast lignite mines at Panandhro. The ossiferous outcrops are located in an operational mine (HD Mine) in the Panandhro lignite field and consist of grey silty shales occurring near the top of the lignitic sequence (Figure 1). These backswamp deposits form part of the Naredi Formation, dated as Early Eocene, mainly on the basis of benthic foraminifers[6]. The sequence is capped by red lateritic clays.

The recovered fauna comprises fishes, turtles, snakes, crocodiles and mammals, and a checklist with tentative identifications is given in Table 1. Fishes include a fragmentary skull of catfish, and hundreds of isolated teeth, spines and vertebrae belonging to sharks and rays. The skull, though smaller in size, appears to be conspecific with *Arius kutchensis*, already known from the Eocene of Kachchh[7]. The most common fish fossils are the isolated teeth and spines of *Myliobatis*. Both lateral and median teeth are present in the collection and are characterized by smooth hexagonal coronal surface and longitudinal grooves on the basal surface of the root. Associated with rays are a large number of shark teeth. *Galeocerdo*, characterized by a large

principal cusp and serrations on both anterior and posterior margins, is the most common shark.

Reptilian remains include approximately 50 well-preserved procoelous vertebrae of snakes, representing both caudal and trunk regions. Their affinities have yet to be worked out, but it is important to note that they represent the oldest record of fossil snakes from the Indian Tertiary. The crocodilian material, referred to as Crocodylidae, consists of approximately 30 isolated teeth and several vertebrae. Turtles, represented by a large number of carapace fragments, are tentatively referred to as the Trionychidae. Recovered specimens include costals bearing spines.

Although meagre, the most important component of the Panandhro collection is the fragmentary teeth of mammals. Of the six specimens, the most diagnostic is a left P1/(RUSB 2590, Figure 2 *s*). The tooth is long (18.9 mm) and narrow (5.9 mm), and has a single, strongly curved root. The apex of the tooth is broken, but it was triangular in labial view, with a complete cingulum, and strong anterior and posterior crests. This specimen matches in size and shape the maxilla of the type specimen of the recently described diminutive whale *Kutchicetus minimus* from the Middle Eocene of Kachchh[8], and is not similar to any of the other whales known from Kachchh. A left upper canine (RUSB 2579, Figure 2 *o*) has a circular cross-section, lingual cingulum and crenulated enamel lingually. At its base, it appears to match the crown of the isolated canine of *Kutchicetus*. It is important to note that the presence of

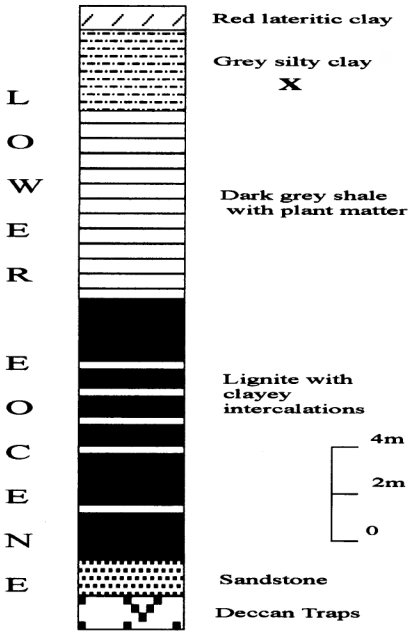

Figure 1. Lithostratigraphic section at the HD mine, Panandhro lignite field, District Kachchh. Vertebrate-bearing level is marked by **X**.

Table 1. Faunal list based on tentative identifications

Pisces	*Arius*, *Myliobatis* sp., *Galeocerdo* sp., *Galeorhinus* sp., *Isurus*
Serpentes	Indet.
Crocodilia	Crocodylidae indet.
Chelonia	Trionychidae indet.
Mammalia	Cetacea (*Kutchicetus minimus*?)

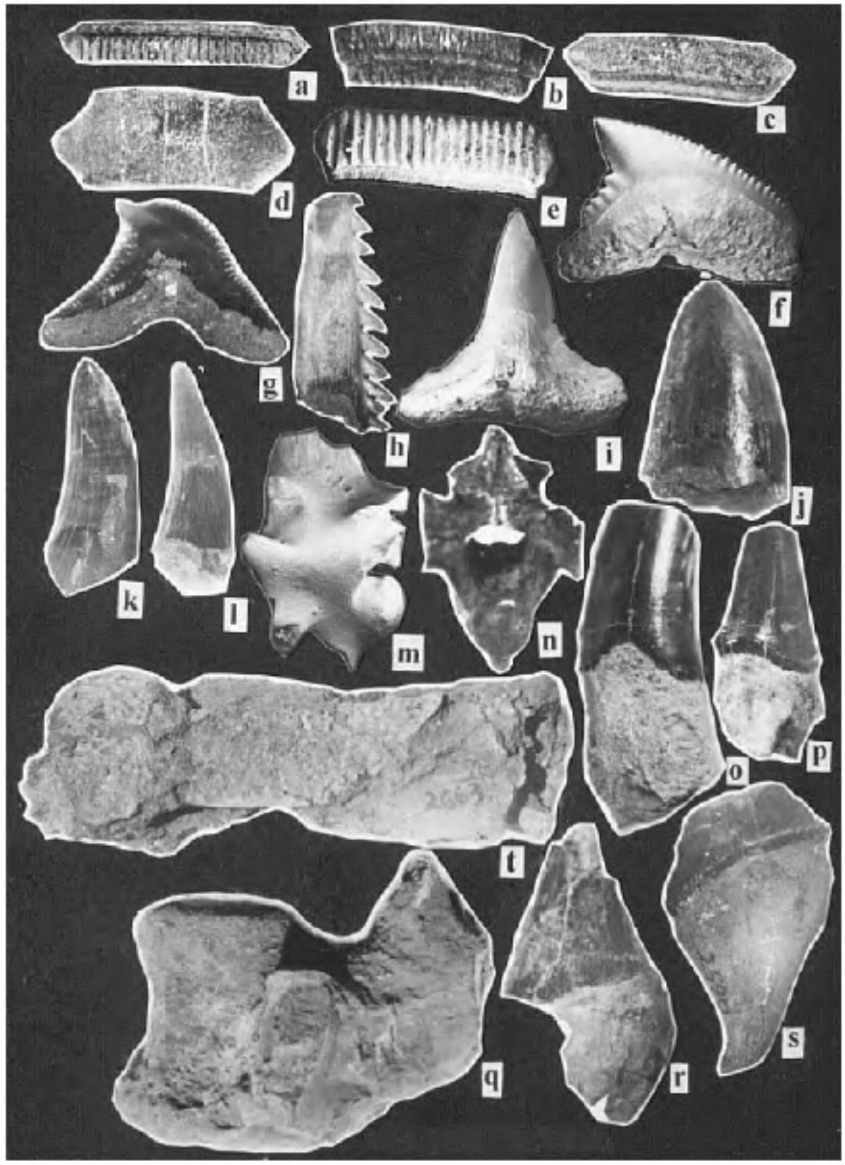

Figure 2. Vertebrates from Panandhro lignite mine. ***a***, (× 4); ***b***, (× 3); ***c***, (× 3); ***d***, (× 3.5); ***e***, (× 4); ***h***, (× 1.5) *Myliobatis* sp. isolated teeth and spine (RUSB 301305, 306); ***f***, (× 3) *Galeocerdo* isolated tooth (RUSB 307); ***g***, (× 3) Selachii indet. isolated tooth (RUSB 308); ***i***, (× 4.5) *Isurus* sp. isolated tooth (RUSB 309); ***j***, (× 3); ***k***, (× 3); ***l***, (× 3); ***q***, (× 0.75) Crocodylidae indet. isolated teeth and vertebra (RUSB 310313); ***m***, (× 5); ***n***, (× 3.5) Serpentes indet. vertebrae (RUSB 314, 315); ***o***, (× 2); ***p***, (× 3); ***r***, (× 3); ***s***, (× 2) *Kutchicetus minimus*? isolated mammal teeth (RUSB 2579, 2589, 2578, 2590); ***t***, (× 0.75) *Arius kutchensis* fragmentary skull (RUSB 316).

Kutchicetus in the backswamp deposits of Kachchh is consistent with the available data on its vertebral column, which indicates that this animal represents a primitive pattern of locomotion in the evolutionary transition of whales from land to sea[8]. The swimming mode of *Kutchicetus* probably resembled that of otters and the animal clearly lacked locomotor adaptations for deep-sea environments.

Summing up, the present discovery of a diverse Lower Eocene vertebrate fauna marks the success of a long-continued search in Kachchh. Recently, from a broadly coeval (Ypresian) coal mine near Quetta in Pakistan, a land mammal has been described[9]. The fact that the Kachchh fauna includes a few cetacean teeth is particularly significant, as it indicates that the origin and early evolution of whales (and possibly also sirenians and proboscideans) are documented in the Eocene Tethyan realm of the Indian subcontinent. However, the existing collections need to be enlarged both taxonomically and anatomically in order to make any meaningful evaluation of this fauna. Because these important outcrops are located inside the mine and may be destroyed by ongoing mining activities, intensive prospecting for vertebrates needs to be undertaken on a regular basis.

1. Sahni, A. and Kumar, K., *J. Palaeontol. Soc. India*, 1981, **23**, 132–135.
2. Kumar, K. and Loyal, R. S., *ibid*, 1987, **32**, 60–84.
3. Bajpai, S. and Gingerich, P. D., *Proc. Natl. Acad. Sci. USA*, 1998, **95**, 15464–15468.
4. Paliwal, B. S., *Curr. Sci.*, 1999, **76**, 1536–1538.
5. Samant, B. and Bajpai, S., *ibid*, 2001, **81**, 758–759.
6. Biswas, S. K., *J. Palaeontol. Soc. India*, 1992, **37**, 129.
7. Sahni, A. and Mishra, V. P., *Monogr. Palaeontol. Soc. India*, 1975, **3**, 148.
8. Bajpai, S. and Thewissen, J. G. M., *Curr. Sci.*, 2000, **79**, 1478–1482.
9. Gingerich, P. D., Abbas, S. G. and Arif, M., *J. Vertebr. Paleontol.*, 1997, **17**, 629–637.

ACKNOWLEDGEMENTS.We extend our sincere thanks to Prof. Ashok Sahni for his constant encouragement. Financial support provided by the Department of Science and Technology, New Delhi and the National Geographic Society, Washington DC is thankfully acknowledged.

Received 21 July 2001; revised accepted 27 December 2001

SUNIL BAJPAI[†]*
J. G. M. THEWISSEN[‡]

[†]*Department of Earth Sciences, Indian Institute of Technology, Roorkee 247 667, India*
[‡]*Department of Anatomy, Northeastern Ohio Universities College of Medicine, Rootstown, OH 44272, USA*
**For correspondence*
e-mail: sunilfes@iitr.ernet.in

MEETINGS/SYMPOSIA/SEMINARS

A Two-Day Workshop on Avenues of New Drug Discovery in the New Millennium

Date: 23–24 March 2002
Place: Ahmedabad

Topics include: Molecular diversity, lead development and strategy of drug design; Quantitative structure activity relationship (QSAR) and computer-aided drug design (CADD); New targets for therapeutic intervention: DNA to drugs; Recent trends in the drug development in specific therapeutic areas such as obesity, allergy, anti-hyperlipidaemic agents, diabetes, antimicrobial agents, etc.

Contact: B.V. Patel PERD Centre
Thaltej–Gandhinagar Highway
Thaltej
Ahmedabad 380 054, India
Tel: 079-7439375
Fax: 079-7450449
E-mail: perd@wilnetonline.net

Environmental Education-21: Conference on Environmental Education for developing Practical Strategies on Sustainable Future (Special Emphasis on Rio + 10)

Date: 26–28 April 2002
Place: Agra, India

Topics include: Environmental education and sustainable development; Environmental education and local agenda-21; Global warming and climate change; Bio-diversity conservation and sustainable development; Wetland conservation and water resources; Environmental education and Rio + 10.

Contact: Dr Desh Bandhu
President
Indian Environmental Society
U-112 (3rd Floor)
Vikas Marg, Shakarpur
Delhi 110 092, India
Tel: 91-011-222 3311, 245 0749, 204 6823/24
Fax: 222 3311
E-mail: iesenro@del2.vsnl.net.in
Web site: iesglobal.org