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Cover picture

The discovery of deep-sea sulphide ore deposits during a submersible diving investigation of the East Pacific Rise is reported on p. 523.

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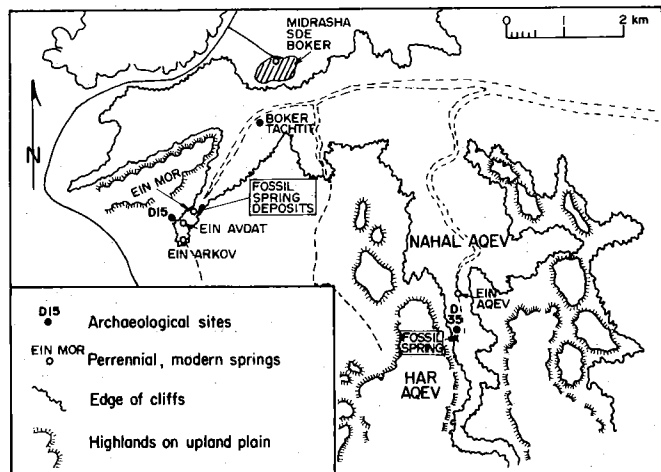


Fig. 1 Map of Nahal Zin showing locations of dated sites. Nahal Mor is the canyon in which Ein Mor and Ein Avdat are located.

also closely resemble the lithic technology of site Rosh Ein Mor (D 15), situated on the canyon rim above Nahal Mor.

The lowest layer of the travertine mound (Fig. 2A) was deposited $258,000 \pm 66,000$ yr BP, whereas three dates from layer B give an average age of $211,000 \pm 19,000$ yr BP. Layer C is undated. From layer D, two samples were obtained, one with an apparent age of $85,000 \pm 10,000$ yr BP (including a small correction for common ^{230}Th) and another (76NZ1) giving an age of $74,000 \pm 5,000$ yr BP. Unfortunately, both the artefact-bearing layer and the top layer (E) are too heavily contaminated with limestone fragments to permit dating. The artefact-bearing layer, which seems stratigraphically to be either of the same age or slightly younger than layer D, was therefore deposited at about $80,000 \pm 10,000$ yr BP. We infer that this was the time of occupation of site D 35, the location of which was presumably determined by the proximity of the spring¹². The site may have been abandoned when flow from the springs ceased.

Further downstream in Nahal Aqev, the active spring of Ein Aqev is now depositing travertine on the steep walls of a box canyon. Older deposits a few metres downstream on the west side of the canyon mark earlier stages in the headward recession of the canyon. A sample from the surface of these deposits (76NZ8) shows that the spring was active $12,200 \pm 700$ yr BP; from the thickness of the deposits we infer that deposition started a few thousand years before that date, $\sim 15,000$ yr BP. This was close to the time of occupation of the nearby Upper Palaeolithic site D 31 (Ein Aqev), ^{14}C -dated at from 18,000 to 17,000 yr BP¹³.

These results, as well as providing the first absolute date for the early Levantine Mousterian culture, demonstrate the potential of $^{230}\text{Th}/^{234}\text{U}$ dating of travertine in establishing an absolute time scale in archaeology.

Research was supported by grants from the National Geographic Society and the National Research Council of Canada. The archaeological and geological studies related to this paper were carried out under NSF grants GS-2860X1 and GS-42680.

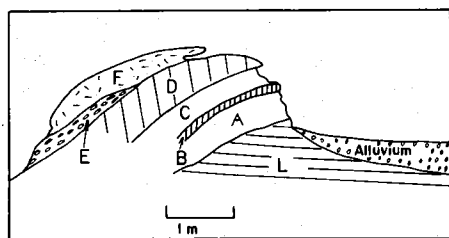


Fig. 2 Cross-section of fossil spring mound in Nahal Aqev. Layers A to D: travertine; layer E: colluvium containing Levallois flakes; layer F: travertine containing abundant limestone clasts; L: limestone bedrock.

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Phylogeny and palaeobiogeography of hadrosaurian dinosaurs

MOST geologists agree on the placement of the continents at the end of the Cretaceous. Palaeobiologists, however, hold divergent opinions^{1,2}. Some workers connect South America to Africa, some connect it only to North America, while others isolate South America totally. New evidence from vertebrate palaeontology suggest that a substantial land connection between North and South America existed 85–100 Myr ago which facilitated the passage of many terrestrial vertebrates between the continents, including large herbivorous dinosaurs. Specimens of hadrosaurian dinosaurs, collected in the first half of the present century, have now been used to reanalyse not only the palaeobiogeography but also the classification and phylogeny of this group. I report here the first solid evidence of an extensive land connection for large terrestrial vertebrates of this sort between North and South America at the end of the Cretaceous.

Hadrosaurs were the most diverse and abundant late Cretaceous, terrestrial vertebrate herbivores. In most cases they seem to have comprised up to 75% of the biomass in local faunas³, according to recovered fossil samples. Their remains can be found in every Laurasian continent and also in South America. Because most specimens are represented by post-crania alone, and most workers believe that hadrosaur post-crania are not diagnostic, it has been almost impossible to map the distribution of sub-familial taxa. It is now possible, especially with pelvic elements, to identify a genus on the basis of a single element⁴. With this new information, previously named taxa can be rediagnosed, isolated elements from all over the world can be identified, and Cretaceous hadrosaurian palaeobiogeography can be reanalysed.

An accurate, useful phylogeny must include all valid taxa from all geological ages and all localities. Previous hadrosaur phylogenies have been based on North American data only^{5,6}. My new phylogeny (Fig. 1) includes all forms at the generic level and recognises two subfamilies, the Hadrosaurinae and the

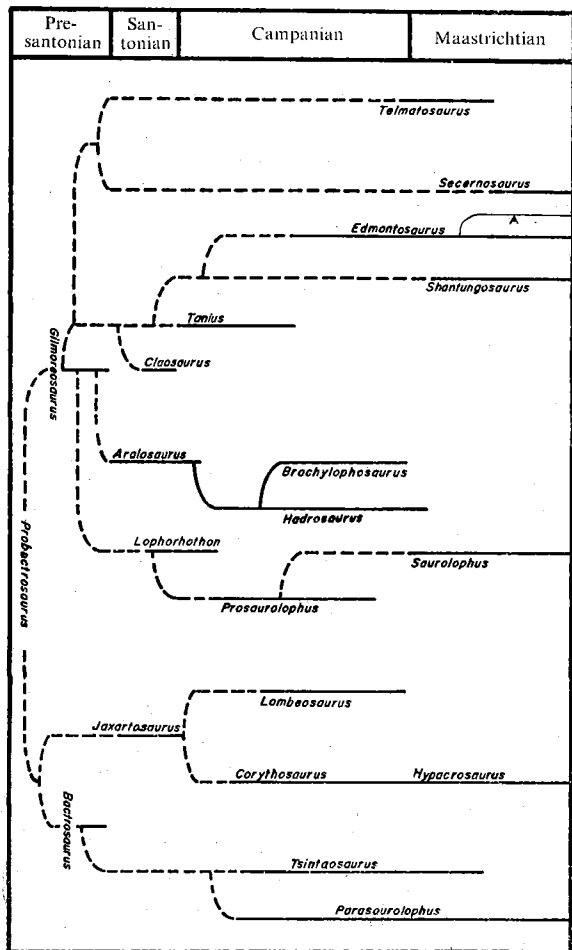


Fig. 1 Phylogeny of the hadrosaurs. All valid genera from all the continents are listed. 'A' coming off the *Edmontosaurus* lineage represents *Anatosaurus copei* only. This form will be redescribed as a new genus elsewhere. All other species of *Anatosaurus* are considered junior synonyms of *Edmontosaurus regalis* and *E. edmontoni*. There is a distinct possibility that these two species may be male and female respectively. *Bactrosaurus*, *Jaxartosaurus* and their descendants are lambeosaurines—all other genera are hadrosaurines. *Tsintaosaurus* is transferred from the hadrosaurines to the lambeosaurines based on postcranial studies and the presence of a hollow crest. I follow Dodson¹³ in considering 'procheneosaurs' as juvenile forms of *Corythosaurus* and *Lambeosaurus*. *Cheneosaurus* is certainly a juvenile *Hypacrosaurus*. *Brachylophosaurus* is transferred from the *Saurolophus* lineage to the *Hadrosaurus* (*Kritosaurus*) lineage based on postcranial and cranial evidence.

Lambeosaurinae. The Hadrosaurinae are characterised by: relatively low sacral neural spines with a length/width ratio less than 4.5; ventrally grooved sacral centra; long gracile limb elements, non-footed ischium; prepubis with a long thin neck; ilium length/height ratio averaging 4.4; convoluted or slightly expanded pre-maxilla; long straight mandible; solid narial crests (where present). The Lambeosaurinae are characterised by: relatively high sacral neural spines with a length/width ratio greater than 4.5; ventrally ridged sacral centra; shorter and more robust limb elements; footed ischium; prepubis has a short, thick neck; ilium length/height ratio averages 5.4; greatly expanded premaxilla; shorter and anteriorly decurved mandible; hollow narial crests present. Most, if not all, genera in both subfamilies are monospecific. Evidence based on postcranial studies⁴ suggests that the Saurolophinae should be included in the Hadrosaurinae.

The three pivotal genera in this report are *Secernosaurus koeneri* (new genus, new species) from Argentina, and *Gilmoreosaurus mongoliensis* (new genus, new combination) and *Bactrosaurus johnsoni*⁷ both from Mongolia. All three

genera display a primitive grade of organisation reminiscent of their iguanodont ancestry. *Secernosaurus* is the second most primitive hadrosaur known. It is only the second hadrosaur reported from Gondwanaland⁸ and the first to be of diagnostic value (the first was by R. Casamiquela). The unique features of its ilium justify a new genus:

Class, Archosauria
 Order, Ornithischia
 Family, Hadrosauridae
 Subfamily, Hadrosaurinae
Secernosaurus (new genus)

Holotype: FMNH P13423, two ilia, prepubis, scapula, fibula, caudals and partial braincase. Collected in 1923 by J. B. Abbott for the Field Museum of Natural History in Chicago. Horizon: San Jorge Formation, Rio Chico, Patagonia, Argentina.

Age: Upper Cretaceous.

Etymology: generic name from the Latin *secerno* which means to sever or divide, referring to its non-Laurasian origin.

Diagnosis: postacetabular process of ilium greatly deflected dorsomedially and elongate, unlike any hadrosaur or iguanodont. Preacetabular process of ilium deflected ventrally at an angle greater than in *Hadrosaurus* (Fig. 2). (I follow Baird and Horner⁹ in recognising *Hadrosaurus* as the senior synonym of *Kritosaurus*.) Antitrochanter relatively smaller than in any hadrosaur of the same size.

Secernosaurus koeneri (new species)

Diagnosis: same as for genus.

Etymology: specific name after Dr Harold E. Koerner, professor emeritus, University of Colorado.

Gilmoreosaurus is the first representative of the Hadrosaurinae in Asia. It was originally described as a new species of the genus *Mandschurosaurus*⁷ but this genus was proved to be a *nomen dubium*⁴. The species, however, contains many features that are partly iguanodont and partly hadrosaurine, hence it is appropriate to recognise this form as a valid genus:

Gilmoreosaurus (*Mandschurosaurus*) *mongoliensis*
 (new genus, new combination)

Holotype: redesignated American Museum of Natural History 6551.

Horizon: Iren Debasu Formation, Cenomanian?

Diagnosis: same as original description for species⁷.

Etymology: after Charles W. Gilmore, the original author.

Bactrosaurus, the first known lambeosaurine, occurs with *Gilmoreosaurus* in the same formation. The two subfamilies (Lambeosaurinae and Hadrosaurinae) are already separate at this time, which would put the origin of the family some time in the Middle Cretaceous.

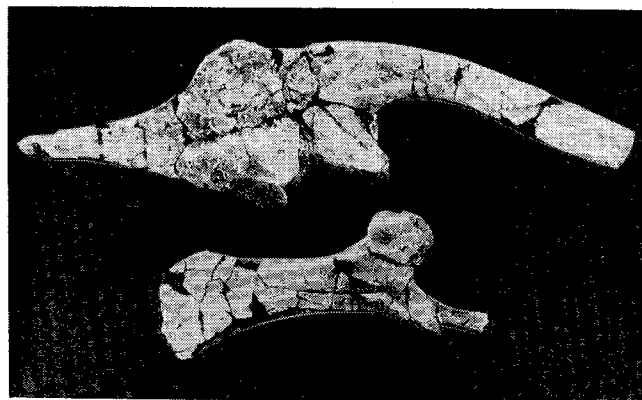


Fig. 2 *Secernosaurus koeneri* (new genus and species). Holotype FMNH P 13423. Right ilium and left prepubis in lateral view. Length of ilium between perpendiculars is 533 mm.

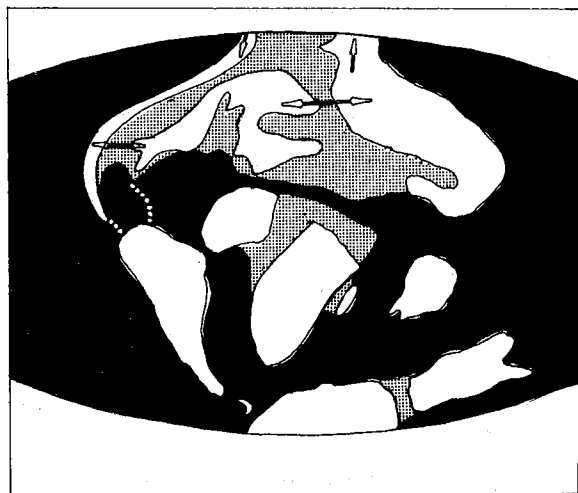


Fig. 3 Palaeogeographic reconstruction of the continents during the Turonian Transgression. Based on Tedford² and Smith and Briden¹¹.

Hadrosaurs^{7,10} are considered to have originated in Asia where *Probactrosaurus*, an iguanodont and probable ancestor, has been found. The predominance of primitive hadrosaurs and advanced iguanodonts in Laurasia does not necessarily imply that the family originated there. The fossil record only indicates that by the Mid Cretaceous, hadrosaurs were present in both Laurasia and Gondwanaland, and that they had differentiated into two subfamilies. Dispersal between South America and Laurasia could have been by way of Africa or North America (Fig. 3). Most workers^{2,11} believe that Africa was isolated from South America sufficiently early so as not to have been involved in the Upper Cretaceous dispersal of marsupials, so that dispersal must have occurred by way of North America. The two possible links with South America were through Panama or the Caribbean arc. Both hadrosaurs and ceratopsians¹² are found in South America and so the route used must have been a major land connection at some time because both groups consist of large terrestrial vertebrates not subject to waif dispersal or rafting. Dispersal is not considered to have occurred after the Late Cretaceous transgression, because Santonian hadrosaurs were already advanced (derived) beyond the *Secernosaurus* grade of evolution.

It is possible that the presence of hadrosaurs in Laurasia and Gondwanaland represents vicariance rather than dispersal; if so, hadrosaurs would be expected to occur on most continents. Their absence in India and Australia, where Upper Cretaceous deposits with vertebrates are known, indicates otherwise. This, however, is negative evidence and disprovable. Until hadrosaurs are found in India and Australia, the dispersal model is to be favoured.

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Kanamycin-resistant *Scenedesmus obliquus* showing simultaneous resistance to other antibiotics and polychlorinated biphenyls

WE have been studying the effects of polychlorinated biphenyls (PCBs) and DDT on several planktonic algae, and report here that we have isolated a kanamycin-resistant strain of *Scenedesmus obliquus* which shows simultaneous resistance to other antibiotics, PCBs and Cetavlon (ICI), a quaternary ammonium compound with algicidal properties². This novel observation suggests a possible genetic control of sensitivity to PCBs in *Scenedesmus*.

S. obliquus (UTEX 2015) was one of the test organisms and was obtained as an axenic culture. This strain was grown mixotrophically in liquid TAP (Tris-acetate-phosphate)⁴ and when phototrophic growth was being tested acetate was omitted from the medium, which was then a minimal TAP (M-TAP). *S. obliquus* was able to grow on M-TAP in light, thus confirming it to be a phototrophic strain. Agar plates were prepared by adding 1.5% of agar (Difco) to the liquid medium. Required concentrations of antibiotics were filter sterilised and added just before the plates were poured. To test for sensitivity or resistance to antibiotics, 0.1 ml of a *S. obliquus* culture containing 1×10^7 cells ml⁻¹ was spread on TAP- and M-TAP-containing antibiotic plates. The plates were incubated for a week in a growth cabinet at 22 °C with continuous illumination. Growth was determined visually.

The control plates without antibiotics showed a heavy growth in the form of a continuous green lawn; there was no comparable growth on antibiotic-containing plates. Thus, we concluded that *S. obliquus* was sensitive to kanamycin (100 µg ml⁻¹), chloramphenicol (50 µg ml⁻¹), streptomycin (300 µg ml⁻¹) and tetracycline (50 µg ml⁻¹). However, when these plates were held at 22 °C for 1 month, we found 7-8 discrete, actively growing colonies on each of the kanamycin-treated plates only. These

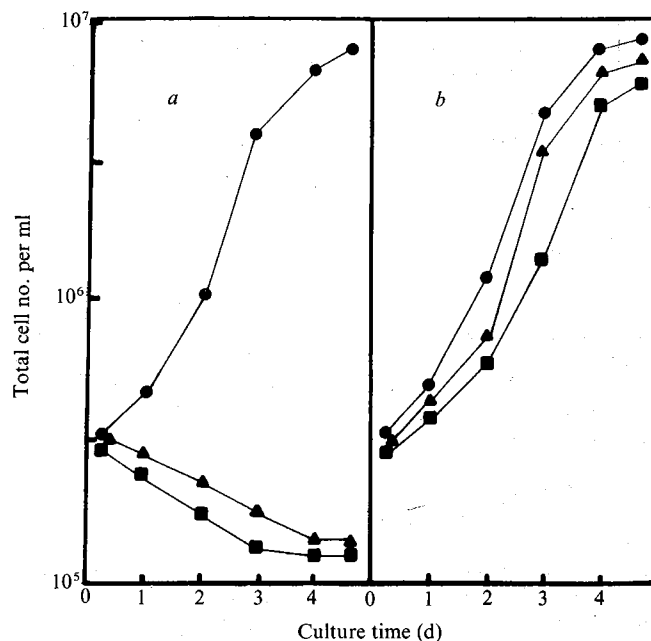


Fig. 1 Effects of PCBs (Aroclor 1242) and Cetavlon on the growth of *S. obliquus* (a) and kanamycin-resistant *S. obliquus* (b). Cells were grown in liquid TAP and total cell number represents viable cell counts within a 90% confidence level. ●, control; ▲, 5 p.p.m. Aroclor 1242; ■, 5 p.p.m. Cetavlon.