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Crocodile with Laterally Compressed Snout: First Find in Australia

Abstract. *A crocodilian skull exhibiting a high, laterally compressed snout has been found in a cave in north Queensland. No teeth are preserved, but elliptical alveoli suggest a ziphodont dentition. This is the first known occurrence of such a crocodilian in Australia and probably the most recent in the world. The specimen is not referable to any known species.*

During the exploration of caves near Chillagoe, north Queensland, in 1970, Lyndsey Hawkins of the Sydney University Speleological Society discovered an incomplete crocodilian skull of unusual form. The specimen (Australian Museum F.57844) comprises the snout from the anterior margins of the orbits to just behind the anterior margin of the external nares. Unlike living crocodilians, in which the snout is usually low, the snout of this specimen is high with sides that are nearly vertical. The form of the alveoli suggests that the teeth were ziphodont (laterally compressed); however, no teeth have been preserved in the specimen. Such a snout form is associated with ziphodont teeth in both the sebecosuchian and pristichampsine crocodilians, neither of which has previously been reported from Australia.

The snout was found lying upside down on the floor of Tea Tree Cave about 200 feet from the entrance. Both Recent (*1*) and Pleistocene mammalian remains have been reported from caves in the Chillagoe area, those from Tea Tree Cave being considered Pleistocene (*2*). Local fissure fills, possibly contemporaneous with the cave deposits, yield forms believed to be late Pleistocene (*3*). While AM F.57844 cannot have been derived from the Paleozoic rock through which the caves have formed (*4*), it is not clear that it in fact derives from the cave deposits: it seems unlikely, however, that a specimen of greater than Pleistocene age would have been found lying on the cave floor. No ziphodont crocodilians from outside Australasia have been recorded from rocks younger than Miocene. As this is likely to be the most recent occurrence of such a crocodilian, as well as the first report from Australia, it is appropriate to present this brief description.

The general aspect of the specimen is shown in Fig. 1; thus, only features of special interest will be described. Twelve alveoli are represented in the left maxilla and, although it is incomplete posteriorly, the marked narrowing of the maxilla indicates that there is little if any space for another alveolus. The elliptical form of the alveoli, longer anteroposteriorly than wide, suggests that ziphodont teeth were present. Some justification for this assumption is provided by the skull of *Brachychampsa montana* in which the cross-sectional form of the rounded anterior and the elliptical posterior maxillary teeth is closely reflected in the form of their respective alveoli (*5*). Pleistocene ziphodont crocodilian teeth found in north Queensland (*6*) exactly fit the alveoli of AM F.57844, but were not associated with this specimen. The first to fifth maxillary alveoli are all nearly equal in size, as are the somewhat smaller sixth to tenth.

Distinct alveolar processes are present on the maxillae and premaxillae, and shallow fossae medial to these accommodated the dentary teeth. A marked notch at the premaxillary-maxillary junction presumably received an enlarged fourth dentary tooth.

The palatal portion of the maxilla indicates that the anterior process of the palatine was short, extending no more than 1 cm in front of the anterior end of the palatal fenestra. That fenestra extends well forward of the back of the tooth row. The foramen incisivum and, probably, the external nares were wider transversely than long. The palatal portion of the maxillary-premaxillary suture is V shaped with the apex directed posteriorly.

The external nares are large, confluent, with a raised rim. Lateral festooning of the maxilla is absent. The nasals are restricted to the dorsal surface of the snout and have parallel sides centrally, tapering both anteriorly and posteriorly. The external sculpture consists of shallow pits and ridges, marked toward the nares, with well-developed ridges along the anterodorsal margins of the orbits. Medially adjacent to these ridges shallow sulci extend anteriorly, parallel to the nasal-maxillary union, almost to the external nares.

The high, laterally compressed snout invites comparison with sebecosuchians, pristichampsines, and certain living crocodylids. Comparison will be made with these forms in that order. Unfortunately, the most obvious distinguishing characters occur in the posterior portion of the palate, which is lacking in AM F.57844. Of the sebecosuchians other than *Sebecus* (*7, 8*) most are too incomplete for comparison, while others (for example, *Baurusuchus* and *Bergisuchus*) are obviously different from AM F.57844 in snout form and dentition. Of the pristichampsines, *Pristichampsus rollinati* (*9*), *Pristichampsus vorax* (*10*), and *Planicrania datangensis* (*11*) are sufficiently well preserved for comparison. Sebecosuchians differ from pristichampsines in the width of the snout relative to its length, the median crest of the nasals and their overall form, the posterior process of the premaxilla, the placement of the anterior margin of the palatal fenestrae relative to the back of the tooth row, and the number of teeth (*7, 9*). These latter two characters are different in sebecosuchians from all eusuchians.

In *Sebecus* (and *Bergisuchus*) the snout is narrow, while in *Pristichampsus* it is described as of intermediate width (*10*). The snout of AM F.57844 is wider relative to its length than that of *Pristichampsus*.

The nasals of *Sebecus* form a crest along the top of the snout (*8*) and hence are obvious in lateral view, while in pristichampsines they are restricted to the dorsal surface of the snout (*10*) as they are in AM F.57844. From above, the nasals of *Sebecus* taper slightly toward the front and flare out posteriorly, while those of pristichampsines and AM F.57844 taper both anteriorly and posteriorly.

The shorter posterior process from the upper portion of the premaxilla is present both in AM F.57844 and pristichampsines (and indeed in eusuchians in general) but lacking in *Sebecus*. The palatal fe-

nestrae of *Sebecus* extend anteriorly to the level of the last maxillary tooth, but in eusuchians in general and in *Pristichampsus*, *Planicrania*, and AM F.57844 in particular, four to six maxillary alveoli lie behind the front of these fenestrae.

Specimen AM F.57844 agrees in each of these features with the pristichampsines, and agrees with the sebecosuchians only in features which it also shares with pristichampsines, and thus cannot be considered a sebecosuchian. However, in many of these features it also agrees with crocodylids other than pristichampsines, especially such as *Osteolaemus tetraspis* and *Paleosuchus palpebrosus*. Most of these features therefore suggest that AM F.57844 was a eusuchian rather than that it was a pristichampsine. The only good way of distinguishing the snout of AM F.57844 from that of *P. palpebrosus*, apart from size, is the form of the alveoli (*12*). Neither *Paleosuchus* nor *Osteolaemus* shows any indication of elliptical alveoli, nor does AM F.57844 show any suggestion of an enlarged maxillary tooth (such as the fourth in *P. palpebrosus* or the fifth in *O. tetraspis*). These characters suggest, but do not prove, that AM F.57844 represents an Australian pristichampsine. Its snout is shorter and broader than that of any known pristichampsine, and in view of its similarity to that of *P. palpebrosus* and the absence of teeth in situ, no formal taxonomic assignment will be made at this time.

The form of the snout and alveoli clearly distinguish AM F.57844 from the known Pleistocene and Recent Queensland crocodilians, *Crocodylus porosus*, *Crocodylus johnsoni*, *Crocodylus nathani* (*13*), and *Pallimnarchus pollens* (*14*). The pattern of ridges and sulci of the snout described for AM F.57844 is matched on the snout of *C. porosus*, but it also occurs in "*Weigeltisuchus geiseltalensis*" (*15*) and *P. datangensis* (*11*).

Specimen AM F.57844 is the first crocodile with a high, laterally compressed snout known to have been reported from Australia. Teeth from the Pliocene Otibanda Fm. of Niu Gini (previously Papua–New Guinea) (*16*) constitute the next youngest record of a ziphodont crocodilian in Australasia; the most recent occurrence elsewhere is Miocene. The apparent later survival of such crocodilians in Australia than elsewhere is in keeping with similar later survivals of other vertebrate taxa, for example, xenacanthids, ceratodontids, and meiolaniids.

More interesting is the route by which a possible pristichampsine arrived in Australia. The cosmopolitan distribution of ziphodont crocodilians suggested by Langston (*17*) has now been demonstrated with occurrences in France, Spain and Germany (*17, 18*), Wyoming (*10*), Colombia (*19*), Brazil (*20*), Argentina (*7*), Kenya (*21*), China (*11, 22*), Niu Gini (*16*), and Queensland. These are now, however, recognized as belonging to two possibly distantly related groups (*10*). The sebecosuchians are known from South and North America and Europe, and the pristichampsines inhabited North America, Europe, Africa, and Asia. This latter distribution suggests

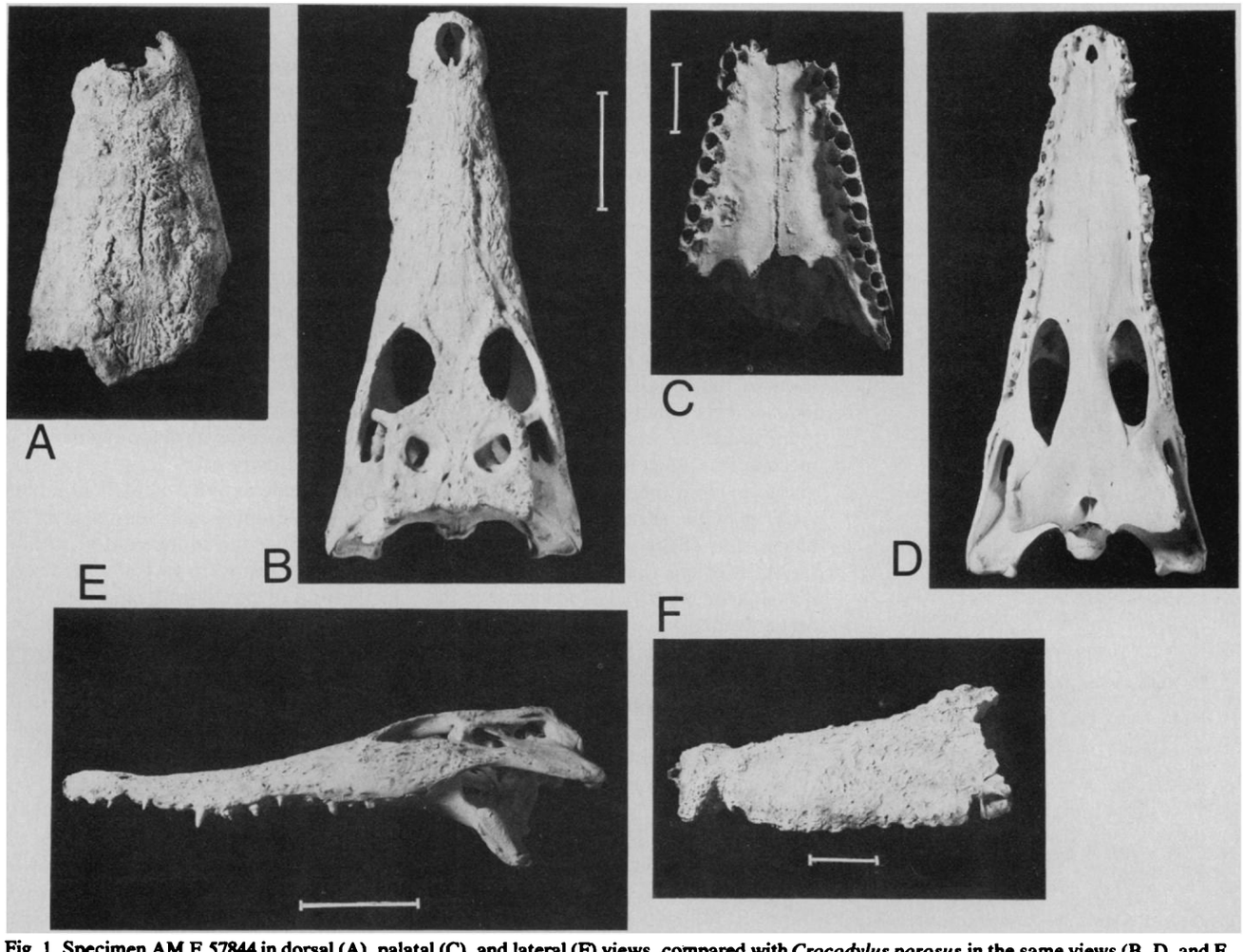

Fig. 1. Specimen AM F.57844 in dorsal (A), palatal (C), and lateral (F) views, compared with *Crocodylus porosus* in the same views (B, D, and E, respectively). The *C. porosus* skull is from an immature individual. All scales represent a length of 5 cm. The images are reproduced so that the length from external nares to orbits is equal for both specimens.

that the species represented by AM F.57844, like those of *Python* and *Varanus*, arrived in Australasia from southeast Asia. This is consistent with the occurrence of the oldest ziphodont material of the Australasian plate in the most northerly region.

Also of interest is the persistence of a ziphodont lineage with a laterally compressed skull on a continent lacking large placental carnivores, and with only one (possible) large marsupial carnivore (*Thylacoleo*). This accords with the persistence in South America of sebecosuchians until the arrival there of large placental carnivores and the apparent disappearance of pristichampsines in the Northern Hemisphere approximately at the time of the appearance of the order Carnivora. Although more work is necessary to substantiate such a suggestion, it suggests that the ziphodont crocodilians with laterally compressed skulls may have been in competition with large placental carnivores and usually did not survive when such forms became abundant.

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Angiotensin Converting Enzyme: Induction by Steroids in Rabbit Alveolar Macrophages in Culture

Abstract. *Dexamethasone and prednisone in physiologic range increased angiotensin converting enzyme 7- to 16-fold in comparison to control in 3 days at maximal stimulation (4 nM steroid) in rabbit alveolar macrophages in culture. The increase was inhibited by actinomycin D (0.1 μg/ml) and 1 μM cycloheximide, suggesting that de novo transcription and enzyme synthesis are responsible for the increased enzyme activity. This result is evidence for a regulatory mechanism for angiotensin converting enzyme, which is important in blood pressure control.*

Angiotensin converting enzyme (ACE) is a dipeptidyl carboxypeptidase (E.C. 3.4.15.1, peptidyl dipeptidase), which converts the decapeptide angiotensin I, formed from the plasma protein angiotensinogen by the catalytic activity of renin, to the potent vasopressor octapeptide angiotensin II and L-histidyl-L-leucine. ACE also inactivates the vasodepressor nonapeptide bradykinin (*1*) and has been demonstrated, by immunofluorescent and immunocytochemical techniques, to be localized at the luminal surface of the vascular endothelium and in the brush border of renal proximal tubules (*2*). Angiotensin I and bradykinin are cleaved by ACE catalysis in passage through the pulmonary vasculature (*3*). Action of ACE on these substrates has a vasopressor effect that can be counteracted by inhibition of its catalytic activity by certain peptides and antibody to ACE (*4*).

ACE is elevated in the pathologic lesions and circulation in the macrophage-related diseases sarcoidosis (*5, 6*) and Gaucher's disease (*7*), although barely detectable in endotoxin- or thioglycholate-activated or unactivated rodent macrophages and human leukocytes, and not elevated in the granulomatous lesions of tuberculosis and rat granuloma induced by Freund's adjuvant (*5, 8, 9*).

In order to elucidate the possible mechanisms of control of this enzyme and to explore the mechanism by which ACE may be regulated in the macrophage, the effect of corticosteroids on the ACE of macrophages in culture was investigated (*9, 10*). The results give the first evidence of a control mechanism for ACE, an enzyme important in blood pressure regulation.

Alveolar macrophages obtained from white New Zealand female rabbits in RPMI 1640 medium containing 100 units of penicillin G and 100 μg of streptomycin per millimeter by lung lavage (*11*) and centrifugation at 560*g* for 10 minutes at 5°C were either plated directly (35 by 10 mm plastic petri dishes; 6×10^6 cells in 1 ml) in RPMI 1640 medium containing 10 percent fetal calf serum (FC) which had been previously heated at 56°C for 30 minutes, 100 units of penicillin G and 100 μg of streptomycin per milliliter (RPMI containing 10 percent FC), or after first washing the cells three times in RPMI containing 10 percent FC. The cultures were incubated at 37°C in 10 percent CO_2. Cells were counted in a hemocytometer. Cells staining with eosin were considered nonviable. Steroids, colchicine, cycloheximide, and actinomycin D were dissolved in 95 percent ethanol and diluted in RPMI 1640 containing 10 percent FC, and 0.1 ml of the resulting solution was added to the cultures to give a final ethanol concentration of 0.043 to 0.15 percent in both experimental and control cultures.

Cells were harvested at intervals of up to 6 days by centrifugation as above. The media were saved for ACE assay. The cells were washed in 3 ml of 0.9 percent NaCl, centrifuged, suspended in 0.2 ml of 0.05*M* potassium phosphate buffer at *p*H 8.3, frozen at −85°C, sonicated at 0°C in four separated 10-second intervals (Biosonik III, setting of 30), and assayed immediately for ACE (*12*). The assay mixture was fortified with 0.28 percent (for cells) or 0.14 percent (for media) bovine serum albumin to stabilize the enzyme. The samples were also assayed for histidylleucine peptidase activity (*12*), and the ACE assay was corrected for any cleavage of the product during the assay. Protein was determined by the method of Lowry *et al.* (*13*).

The specific activity of ACE in rabbit alveolar macrophages increased several-fold in comparison to the control within 24 hours of exposure to 0.45 μ*M* dexamethasone or prednisone, and 7- to 16-fold after 3 days of exposure (Fig. 1). In the absence of glucocorticoid, only a modest increase occurred. After 4 days in culture and 3 days of corticosteroid stimulation, the largest increase in ACE from the level prior to culture was 53-fold in specific activity of cells and 39-fold in total activity recovered from cells and medium. There was little change in ACE in the medium 24 hours after corticosteroid induction and a significant increase after 3 days, coincident with a decrease in the number of cells, suggesting that the increased ACE in the medium may have been mainly due to release