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**LETTER TO THE EDITOR**

# When Brazil was linked with Africa

PHILIPPE TAQUET

**Abstract** : Three paleontological missions in Brazil (1977-1980-1983) by the author were at the origin of fruitful relationship and cooperation with Brazilan colleagues, namely with Diogenes de Almeida Campos.

**Key words:** Brazil (Bahia), Niger (Agadès), Lower Cretaceous, Aptian, mesozoïc crocodiles.

As a young french paleontologist, in 1977, I was researcher at the Centre National de la Recherche Scientifique (CNRS) and working at the Muséum national d'Histoire naturelle in Paris. After a cursus in geology at the Sorbonne university during the sixties, I started a specialty in vertebrate paleontology under the direction of professor Jean Piveteau. The director of the laboratory of paleontology of the Museum, Jean-Pierre Lehman then offfered to me the possibility to go to Africa, in Niger, to join French geologists which were prospecting uranium deposits.

During their field operations, these geologists had discovered in the South of the Ténéré desert, East of the city of Agadès in the North of Niger, sandstone outcrops full of crocodiles and dinosaur bones. They wants to know the exact stratigraphic position of these fossiliferous levels in order to increase the possibilities of discovering uranium. They invited a paleontologist to come on the field in the hope to obtain a datation from the study of the fossil vertebrates just discovered.

So in January 1965, I had the possibility to fly to Niger, welcomed in Agadès by the team of geologists and prospectors. Very quickly they brought me through the desert on the field. The fossiliferous locality, called Gadoufaoua was very spectacular. I remember my impression as I stood in the middle of an area 93 miles long and slightly more than 1 mile wide, covered with the scattered remains of dinosaurs, crocodiles, turtles and fishes that had been awaiting the visit of a paleontologist for 100 million years, at a site which is today particularly arid but grandiose, with skeletons completely prepared by the erosion of the wind, lying on the sandstone surface.

The fossil vertebrates are buried at the Gadoufaoua site, in what was at the time of the Lower Cretaceous (Aptian) period, the bed of an immense swampy river area. The enormous 'cemetery' of Gadoufaoua is now famous because of its size and of the abundance and quality of its vertebrate fauna. Seven expeditions were organized by the author (1965, 1966, 1967, 1969, 1970, 1972, 1973) and an abundant material was collected (Taquet 1976, 1984, 1994, 1999). Actinopterygians fishes are represented at Gadoufaoua by two semionotids: the first one, *Lepidotes*, is known by one nearly complete skeleton, close to 6 feet in length, and by numerous isolated scales. The other one is represented by numerous skeletons of a new form : *Pliodetes nigeriensis* (Wenz 1999). Among the sarcopterygians, the coelacanth *Mawsonia* is present with a new species, *M. tegamensis*. Two ceratodontid dipnoans, *Ceratodus africanus* and *C. tiguidensis*, are known. Turtles are abundant, with complete carapaces of Pelomedusidae described by de Broin (1988): *Teneremys lapparenti*,

*Platycheloides* cf. *nyasae*, *Taquetochelys decorata*, and *Araripemys sp*. Particularly impressive were giant, long-snouted crocodilians with skulls up to 1.7 meter long and a total body length of about 11 meters. Named *Sarcosuchus imperator* by de Broin and Taquet (1966), these pholidosaurid mesosuchian was among the largest crocodiles ever to exist and have been nicknamed 'Supercroc' by American paleontologists. A small short-snouted crocodile, *Araripesuchus* is also present. Huge theropod dinosaurs are represented by a fish-eating spinosaurid, named *Cristatusaurus lapparenti* by Taquet and Russell, 1998. (called also *Suchomimus tenerensis* by Sereno et al. 1998). An Iguanodontid with long spines on the back *Ouranosaurus nigeriensis* described by Taquet (1976), A small dryosaurid, *Valdosaurus nigeriensis* described by Galton and Taquet (1982) and renamed *Elrhazasaurus nigeriensis* by Galton. A strange rebbachisaurid sauropod with several functionnal tooth rows, *Nigersaurus taqueti*, was named by Sereno et al. (1999).

The abundant material of *Sarcosuchus imperator* (suborder Mesosuchia, family Pholidosauridae) collected at the Gadoufaoua locality, include complete skulls and skeletons and provide much new information on the anatomy of this African form. The re-examination by a student of mine, Eric Buffetaut, of crocodilian remains found at the turn of the century in the Lower Cretaceous Bahia

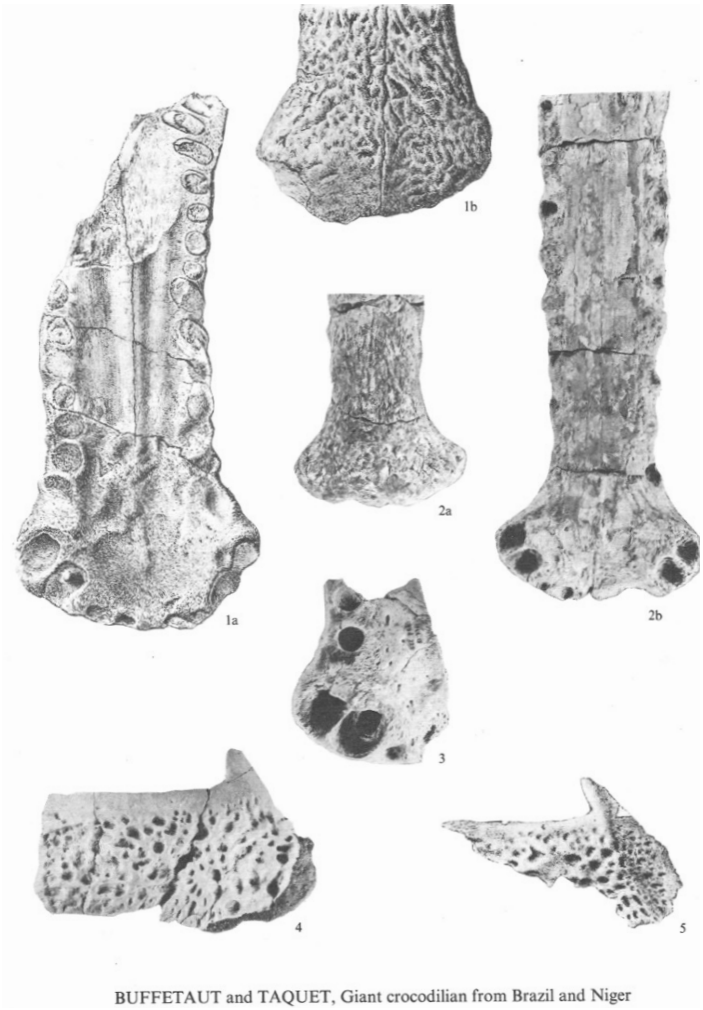


**Figure 1. Sarcosuchus remains from Brazil and Niger: 1. *Sarcosuchus hartii*, from Brazil; anterior extremity of lower jaw (from Mawson and Woodward 1907); a, in dorsal view; b, in ventral view. 2. *Sarcosuchus imperator*, from Niger. 2, anterior extremity of lower jaw of young individual; a, in ventral view; b, in dorsal view. 3, anterior extremity of right dentary of adult specimen, in dorsal view. 4. *Sarcosuchus imperator* from Niger, dorsal scute. 5. *Sarcosuchus hartii*, from Brazil, dorsal scute (from Mawson and Woodward 1907).**

series of the Recôncavo (in Bahia) basin, on the North-Eastern of Brazil, shows that the successive attribution given to these fossils by various authors were erroneous. A comparaison between the specimens from Brazil (now in the British Museum, Natural History) in London, and those from Niger, leads us to attribute the remains from Bahia to the genus *Sarcosuchus*, and to stress the similarities between the Early Cretaceous African and South American continental faunas (Buffetaut and Taquet 1977).

The presence of *Sarcosuchus,* in Lower Cretaceous sediments of Bahia was a good reason to organize a visit in Brazil in order to see if they were some other crocodilian bones of the same genera present in the collections of the Museums in Brazil and to go on the field in the Bahia State.

So the 14th of january 1977, I left Paris for Rio de Janeiro, where I was welcomed by Mr. Silva Santos, member of the Academia Brasileira de Ciencias. Mr and Mrs Silva-Santos, were two paleontologists specialists of fossil fishes and had excellent relationships with french paleontologists. I had the opportunity to visit with them the DNPM (Departamento Nacional de Produção Mineral), now, ANM (Agencia Nacional de Mineraçao) and to meet the famous paleontologist Llewellyn Ivor Price (1905-1980) a pioneer of the Brazilian paleontology. Price showed me the splendid vertebrate collection, with numerous Cretaceous dinosaurs and crocodiles bones, he collected from 1954 to 1967 from the Bauru Group. I was full of admiration also visiting his very impressive library devoted to paleontology, rich of 22000 titles. In the DNPM, I also met a young, sympathic and brillant geologist called Diogenes de Almeida Campos. We became rapidly good friends ; he was born in 1943, I was born in 1940. He explained to me that his family was from Salvador de Bahia where the tradition was to learn greek (the reason of his forname Diogenes) and french language at school. Price, his director, was suggesting him to study vertebrate paleontology. I visited with Diogenes the National Museum of Natural history, and we discussed the possibilities of a cooperation for the future.


**Figure 2. Map showing the three basins mentioned in the text: 1, Recôncavo (or Bahia) basin, Brazil. 2, Gabon basin, Gabon. 3, Tegama basin, Niger.**

After some days in Rio de Janeiro, discovering the beauty of the city and of its surroundings and charmed by the wonderful hospitality of the Brazilian people, I flew to Salvador de Bahia, january 21th. In this city, was living a brazilian friend of my wife, Mr. Ferreira, a biochemist who had been in Paris for studies some months before. Mr Ferreira and his wife organized for me a visit of the splendid city and of all its architectural treasures. In the nearby of the town was the portugese fortification of the Monte Serrat, built just on Cretaceous sediments, where cretaceous crocodile bones had been collected in the past.

Back to Rio de Janeiro, I had some time to look more precisely at the vertebrate fossils of the the Recôncavo Basin at the DNPM. I saw teeth of the crocodile « *Thoracosaurus bahiensis* » and « *Crocodilus hartii* », fragments of turtles, bones of fishes, *Mawsonia* and *Lepidotes*. I was leaving Brazil the first of february, going afterthat to Buenos Aires.

So the Recôncavo Basin is geologically a semi-graben, which had been fulled during the Early Cretaceous by several thousands metres of freshwater sediments consisting mainly in conglomerates, shales and sandstones. The eastern part of the graben is to be found on the West coast of Africa, where the Gabon basin shows a succession of freshwater deposits very similar to the Bahia series. According to Mawson's (Mawson and Woodward 1907), the remains of *Sarcosuchus hartti* were collected in the Ilhas Formation, which belongs to the upper part of the Bahia series ; they are thus probably a little older than the Aptian. *Sarcosuchus imperator*, from the Tegama basin, which is of Lower Aptian age. Therefore, the chronological gap between the two species is probably not very great.

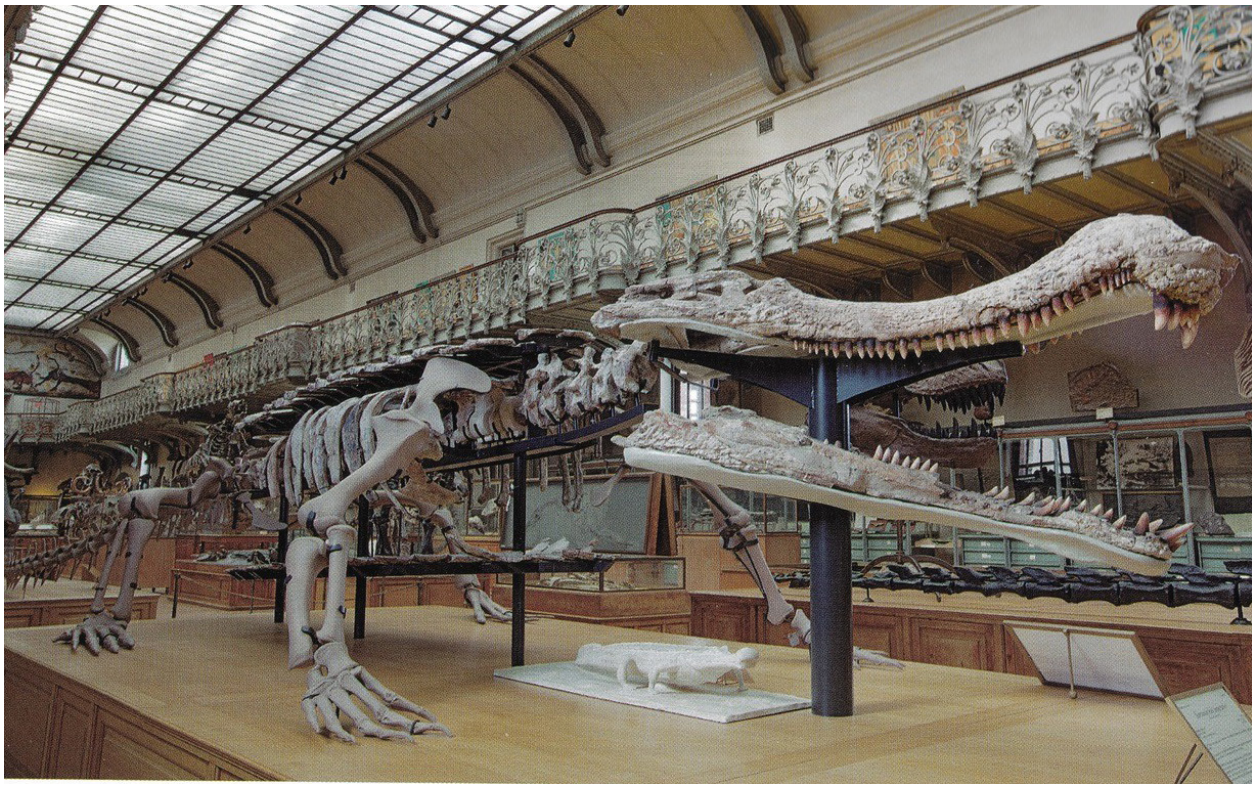

**Figure 3.** ***Sarcosuchus imperator*****, skeleton of 12 meters long, in exhibit in the Gallery of Paleontology, Museum national d'Histoire naturelle. Paris, France (photo p.Taquet).**

The formation of the Recôncavo-Gabon graben, and of others of the same kind (Potiguar, Sergipe-Alagoas) at the beginning of the Cretaceous, is considered as an early stage in the separation between Africa and South America. The presence of the non-marine crocodilian *Sarcosuchus* in both Brazil and Niger affords additional evidence of the faunal continuity between these continents during the early Cretaceous, before the complete opening of the South Atlantic Ocean.

In 1979, Eric Buffetaut and myself, published in Nature a paper entitled : *An early Cretaceous terrestrial crocodilian and the opening of the South Atlantic*. After the crocodile *Sarcosuchus imperator*, we discovered in the material from the same Gadoufaoua locality part of a skull of a small terrestrial crocodilian. This skull after preparation was found to belong to the genus *Araripesuchus*, a notosuchian crocodilian previously recorded by Price from the Early Cretaceous of Brazil. The brazilian crocodile, called *Araripesuchus gomesi* is very close to the nigerian species called today *Araripesuchus wegeneri*. The occurence of very closely related species of *Araripesuchus* in the Aptian of Niger and Brazil provide additional evidence on the connection of Africa with South America until late in the Early Cretaceous.

Three years later, in June 1980, while travelling to Argentina, to see my colleagues Jose Bonaparte and Rodolfo Casamiquela, and then going with Robert Hoffstetter to Bolivia and Peru, it was possible for me to make a brief stop in Rio de Janeiro. Friday 20th of June, I met again Diogenes who was now

**Figure 4. Giuseppe Leonardi, Philippe Taquet and Diogenes de Almeida Campos, on the field, looking after pterosaur skulls. September 1983. Araripe. North-East of Brazil. (photo G.Ligabue).**

in charge of the department of paleontology at the DNPM. Once again, I had the opportunity to look at the the splendid material of titanosaurid dinosaurs collected by Price in the Bauru province.

Finally, in september 1983, it was possible to organize with Diogenes, with Giuseppe Leonardi, researcher at the Conselho Nacional de Deenvolvimento Cientifico e Tecnologico (CNPG) do Brasile, with Giancarlo Ligabue from the Ligabue foundation in Venice (Italy) and with me, a joint expedition in the North-East of Brazil in order to visit the famous fish locality of Araripe in the State of Ceara. During this visit we were able to observe the research undertaken by the populations of the villages surrounding the Chapada, a plateau 150 km long with a width of 50 to 60 km. the villagers dig wells 5 to 6 meters deep in order to attain the fossiliferous level and to extract every day dozens of fishes belonging to the genera : *Lepidotes*, *Aspidorhynchus*, *Leptolepis*, *Tharrias*, *Rhacolepis*, *Enneles*, *Cladocyclus*. Occasionally the excavation undertaken at the locality result in the collection of remains of crocodiles (*Araripesuchus*), of chelonians (*Araripemys*) , two genera usually present in the Aptian of Niger (Buffetaut and Taquet 1979, de Broin 1988), but also pterosaurs and rare dinosaurs.

**Figure 5. Part of the imprint of a pterosaur wing with striations of marks of collagen between the limb bones on a nodule. Araripe. North-East of Brazil. (photo P.Taquet).**

During our stay we were able to examine many remarquable fossilized specimens of flying reptiles, in particular the nearly complete skull of the type of *Cearadactylus atrox*, as well as the posterior part of a skull of a very large pterosaur preserved without flattening and with the mandible in connection (Leonardi 1984b). The observation on this occasion of numerous elements of the vertebral column, of limb bones and of cranial elements, demonstrated in fact a relative abundance of pterosaurs in this Brazilian site.

Among the material collected during our expedition was a nodule (360mm x 140mm) in which the limb bones of a pterosaur were preserved in connection. The bones consist essentially of a portion of a right femur, the tibia, fibula, metatarsals, and the phalanges of a right foot ; the elements of a wing folded in a Z with the radius, ulna, carpals, pteroid, the metacarpal IV and the phalanges of the fourth finger. This remarkable specimen presented in addition to the fact that the bones were connected and well preserved a triple interest, I discovered while taking on the field an enlarged photograph with my camera :

1) the imprint of the wing membrane was perfectly preserved around the bones of the wing in the form of a film black to brown in colour ; several folds of the membrane were visible, in particular along the second phalanx of the fourth finger. To our knowledge, it was the first time that the wing membrane on skeletal elements of a South American pterosaur has been observed.

2) the imprint of the wing membrane does not appear to wrap around the hind limb

3) the preservation of the wing membrane imprint is such that it is possible to observe in several places a series of darker parallel striations, 1/2 mm wide and up to 6 mm long. They are regularly placed, do not cross one another, are neither folded nor broken and it is very probable that they represent wing supporting fibers (like collagen fibers of the bats wings today).

This extraordinary specimen with so nice and characteritic details was described by us (Campos et al. 1984) in a paper presented in Tübingen (Germany) at the Third Symposium on Mesozoic Terrestrial Ecosystems in 1984, under the title : Wing membrane and ring supporting fibers of a flying reptile from the Lower Cretaceous of the Chapada de Araripe (Aptian, Ceara State, Brazil).

The field expedition in the North-East of Brazil was followed by a visit of the splendid footprints and tracks of dinosaurs in the Paraiba, discovered and studied by Giuseppe Leonardi in 1979 (Leonardi 1984a). The locality Serrote da Pimenta, near the Fazenda Estreito is at 6,5 km North-East from the Souza city. The outcrops are a part of the northern border of the Rio de Peixe basin, and are probably from the basal Lower Cretaceous (nearly 120 MA). In this locality were preserved sauropod, theropod, and ornithopod footprints. In the locality Piau (10 km East-North-East of Souza) dating from the Neocomian, are numerous footprints on 24 different levels. Giuseppe Leonardi was able to make an inventory of all the tracks, counting 194 different dinosaurs, which explain the name of the « Valley of dinosaurs » given to this place.

The dinosaur footprints are perfectly preserved on mudstones showing beautiful ripple marks. The surface of the sediments is full of large carapaces of Estheria imprints (Crustacea, Branchiopoda, Conchostraca) of the genera *Asmussia,* with a new species : *Asmussia souzae* (Guérin-Franiatte S. et Taquet P. 1993). The collected conchostracan show affinities with some african forms known in Niger, Cameroun and Zaïre. They make possible a palaeoecological approach of these non-marine levels within the Lower Cretaceous of the old Gondwanaland.

In conclusion, three paleontological missions in Brazil (1977-1980-1983) were successfull opportunities to establish fruitfull relationships between the laboratory of paleontology of the Museum in Paris, with Brazilian colleagues in Rio de Janeiro, specially with Diogenes de Almeida Campos. The results of common researches and works were to afford additional evidence of the links between Brazil and Africa during the Lower Cretaceous, just before the opening of the South Atlantic ocean.

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