

LATE CRETACEOUS VERTEBRATES FROM THE SAINT-CHINIAN AREA (SOUTHERN FRANCE): A REVIEW OF PREVIOUS RESEARCH AND AN UPDATE ON RECENT FINDS

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Abstract: This paper traces the history of research on the Late Cretaceous vertebrates of the Saint-Chinian area of southern France since the first report of dinosaur bones by Gervais in 1877. A number of researchers, including Miquel, Depéret, Nopcsa and Lapparent, were involved in the early studies on this faunal assemblage, from the 1890s to the 1950s, but the known number of taxa remained low because specimens were recovered almost exclusively by surface collecting. A faunal list showing a significantly higher diversity is presented, on the basis of recent work involving systematic excavations and screenwashing. This list includes actinopterygians, coelacanth, amphibians, turtles, squamates, crocodylians, pterosaurs, dinosaurs, birds and mammals. Fossil eggs are also common. On the basis of its composition, the Saint-Chinian vertebrate fauna is referred to the Early Maastrichtian.

Keywords: Late Cretaceous, Vertebrata, Southern France, Fauna.

INTRODUCTION

The region around the small town of Saint-Chinian, in the western part of *département* Hérault, in southern France (Fig.1), has been known to yield dinosaur remains since 1877. In the late 1890s, more systematic collecting resulted in the identification of several dinosaur taxa, including the first titanosaurids to be reported from the Late Cretaceous of Europe. Despite further work in the middle decades of the 20th century, the Late Cretaceous vertebrate assemblages of the Saint-Chinian area remained poorly known until systematic excavations at several sites were begun in the 1990s. The present paper includes a review of the work done since the 1870s, followed by an update on the results acquired during the last decade (for a more extended, semi-popular account, see Buffetaut, 2005).

GEOGRAPHICAL AND GEOLOGICAL SETTING

The Saint-Chinian area is located NW of the city of Béziers, between the coastal plain which borders the Mediterranean and the Palaeozoic massif of the Montagne Noire. Its hilly relief is the expression of a complex geological structure, the area having been heavily folded and faulted during the Cenozoic, which resulted in what is known to French geologists as the “Chaînon de Saint-Chinian”.

In that area, the non-marine Late Cretaceous is well represented by red beds consisting of conglomerates, sandstones, and clays and by freshwater limestones, sometimes known as the “Grès à reptiles”, overlain by basal Tertiary red clays. Vertebrate remains occur, sometimes in abundance, in all these facies, the most productive localities being in the clayey layers. The exact age of the Late Cretaceous vertebrate-bearing beds in the Saint-Chinian area has been a matter of discussion (see below for a review), a precise age

assignment being difficult because of the lack of stratigraphically useful fossils, marine incursions or radiometric dates. Until the 1960s, most authors considered them as belonging to the latest stage of the Cretaceous, for which various names were used (Danian, Maastrichtian, or Rognacian – the latter being a local stage name defined in Provence). Comparisons with the similar stratigraphic succession in Provence have often been attempted (hence the use of the name Rognacian), but the exact ages of the non-marine Late Cretaceous formations of Provence are still somewhat uncertain. As noted by Miquel (1897), the limestones at the top of the Cretaceous series in the Saint-Chinian area contain freshwater molluscs also known in the Rognac Limestone of Provence, and in the light of current knowledge, this certainly suggests a Maastrichtian, possibly late Maastrichtian, age for them. However, most of the fossil vertebrates from that area come from the underlying sandstones and clays, which can be early Maastrichtian or older. Freytet (1965) reported the occurrence of brackish molluscs suggesting a relatively early age (possibly as early as Turonian, more probably Campanian), on the basis of correlation with similar assemblages from Provence. However, this brackish assemblage was found at a single locality (Fontanche, near the village of Cruzy) in beds which in fact underlie the vertebrate-bearing sandstones and clays, so that its age, which itself is uncertain, says little about that of the overlying vertebrate-bearing red beds. By comparison with other assemblages from southern France, the composition of the vertebrate fauna from the Saint-Chinian area seems to indicate a late Campanian to early Maastrichtian age. The eggshell assemblage from that area is reported to suggest an early Maastrichtian age (Garcia & Valentin, 2001-2002).

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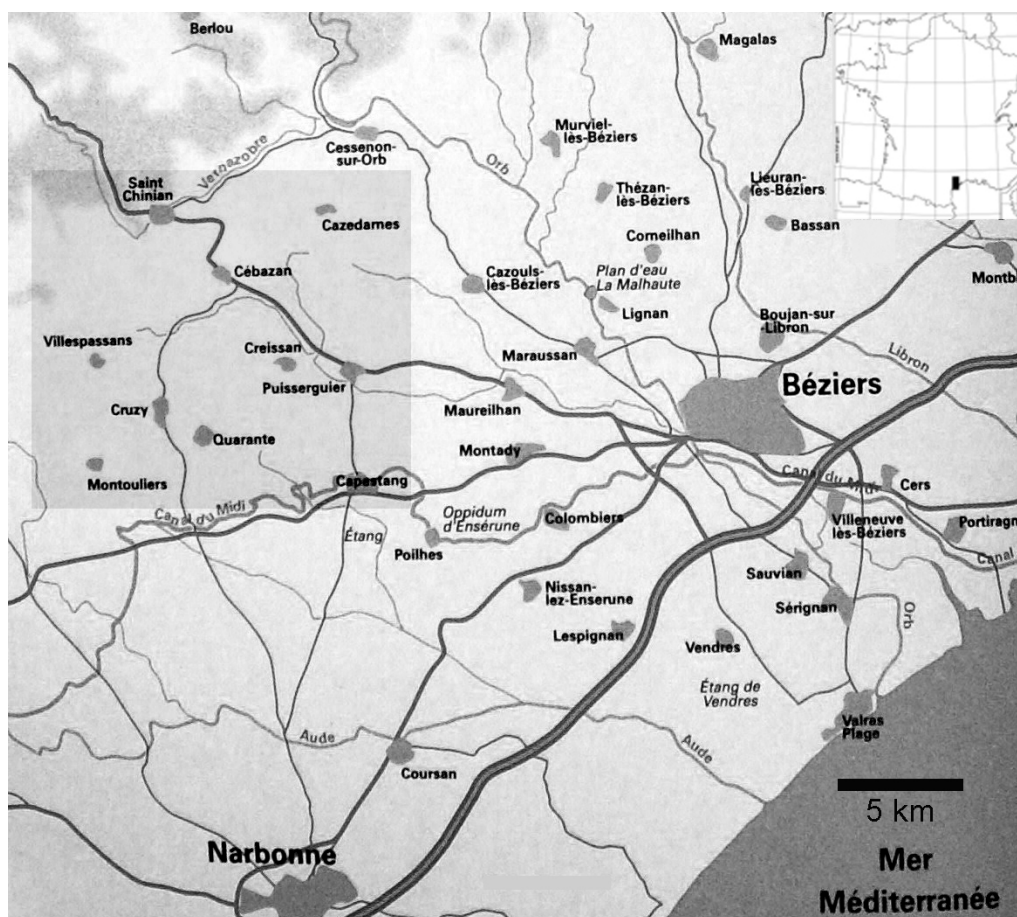


Fig. 1. Map of part of southern France showing the Saint-Chinian area (darker shading) described in the present paper.

A BRIEF HISTORY OF RESEARCH ON LATE CRETACEOUS VERTEBRATES IN THE SAINT-CHINIAN AREA

During the 19th century, vertebrate remains, including both bones and eggs, were discovered in non-marine sediments of Late Cretaceous age in various parts of southern France, from Provence to the foothills of the Pyrenees (Buffetaut *et al.*, 1993). However, few detailed descriptions of that material were published at the time, Philippe Matheron's 1869 paper on fossil reptiles from Provence being an exception (Matheron, 1869). While Jean-Jacques Pouech's similar discoveries in Ariège (Pouech, 1859) had been ignored by the French scientific community (Buffetaut, 1992; Le Loeuff, 1992; Buffetaut & Le Loeuff, 1994), Matheron's discovery of what turned out to be large eggs (made before Pouech's, but announced later) at Rognac, near Marseille, attracted the attention of Paul Gervais (1816-1879), then at the Comparative Anatomy Laboratory of the Paris Museum. In 1877, Gervais published two identical papers on the microstructure of eggshells, both recent and fossil (Gervais, 1877a,b). This was a landmark in the study of fossil eggs, showing how different microstructural types could be distinguished and tentatively used for the systematic identification of fossil eggs (Buffetaut & Le Loeuff, 1994; Taquet, 2001). In that paper, Gervais also reviewed what was then known about the Late Cretaceous dinosaurs of southern France.

He was thus the first to mention that fossils similar to the large reptiles from Provence had also been found at Saint-Chinian (and also at Espéras, in the Aude valley – an area where highly productive dinosaur localities were discovered in the 1980s; see Buffetaut *et al.*, 1989). Unfortunately, no detailed descriptions were provided by Gervais, who died soon thereafter, and these specimens seem to have been lost.

After Gervais's brief mention, little seems to have been done about the fossil vertebrates from the Saint-Chinian area until the 1890s, when an enthusiastic and gifted local researcher, Jean Miquel (1859-1940), became interested in them. Miquel, who had studied law at the university of Toulouse, was a landowner in the wine-making area around Saint-Chinian. He developed a keen interest in the geology, palaeontology and archaeology of that region, and thoroughly explored the region around his estate at Barroubio, publishing a number of papers in local scientific journals. His main geological and palaeontological contributions were on the Palaeozoic strata of the Montagne Noire (Alvaro & Vizcaïno, 2002), to the north of the Cretaceous outcrops, but he also published on the Mesozoic stratigraphy of the region (Miquel, 1897, 1905) and mentioned the occurrence of bones of large reptiles at several levels in what he called the "fluvio-lacustrine Cretaceous series". He correctly referred these strata to the "Rognacian", a local stage defined in Provence and now considered as an equivalent of

the Maastrichtian. Although Miquel did not attempt to precisely identify the Late Cretaceous vertebrate remains he discovered, he provided interesting details about their occurrence. In 1897, he tantalisingly noted that twenty years before, a “reptile skeleton” had been found by a Mr Salles when digging a canal near Saint-Chinian and had been “studied by Paul Gervais”, but had subsequently been lost (as mentioned above, Gervais never described reptile material from Saint-Chinian in any detail). Miquel himself found reptile bones in abundance in the Late Cretaceous sandstones and clays. They were especially abundant in the Castigno gully, near the village of Villespassans, from which he often brought back loads of 10 to 15 kg of fossil bones (Miquel, 1897). He purposely left some large bones as “witnesses” in the sandstones forming the banks of the gully; some of them were rediscovered by our group in the 1990s.

Jean Miquel lacked the expertise and the comparative material needed to identify the Late Cretaceous vertebrate remains he found in the Saint-Chinian area and wisely refrained to do so. The first precise identifications were published in 1900 by Charles Depéret (1854-1929), a professor of geology at the University of Lyon and expert on fossil vertebrates. During the 1890s, Depéret was involved in geological mapping in the Saint-Chinian area and met Jean Miquel, whom he called his “friend and colleague”. In 1900, he published three brief, non-illustrated notes on the Late Cretaceous dinosaurs of the Saint-Chinian area (Depéret, 1900a,b,c). Depéret’s faunal list for the Saint-Chinian dinosaurs was as follows:

- Theropoda: *Dryptosaurus*, identified on the basis of teeth and a jaw fragment. The genus had been described by Marsh on the basis of material from the Upper Cretaceous of the eastern United States. Depéret’s main reason for this attribution seems to have been a similar geological age.

- Sauropoda: *Titanosaurus*, a sauropod with procoelous caudal vertebrae. This was the first mention of titanosaurid sauropods in Europe. They had previously been described first from India, and then from South America, by Lydekker. Depéret had referred Late Cretaceous sauropod material from Madagascar to *Titanosaurus* in 1896.

- Ceratopsia: this identification was based on dermal scutes from near the village of Quarante which Depéret found similar to specimens from the Upper Cretaceous of Austria described as *Crataeomus* by Seeley (1881). He considered that taxon as belonging to the horned dinosaurs that had recently been reported by American palaeontologists.

Depéret never published his announced detailed description of the dinosaur material from the Saint-Chinian area collected by Miquel and himself (and housed at the University of Lyon). However, his age estimates for these dinosaurs contributed to the controversy about possible Tertiary dinosaurs. On the basis of his field

observations, he thought that the dinosaurs of the Saint-Chinian area occurred at two distinct levels, some being from sandstones at the base of the “Rognacian” limestones, whereas most of them (notably at Castigno) came from clays which he thought overlay the limestones, and were an equivalent of the Vitrolles Clays of Provence. Depéret considered that the presence of dinosaurs in these strata demonstrated their terminal Cretaceous age, and he referred them to the uppermost part of the Danian (then considered as the last stage of the Cretaceous). Another interpretation was possible, though, as expressed by Emile Haug in his famous *Traité de Géologie* (Haug, 1908-1911): the presence of dinosaur remains in an equivalent of the Vitrolles Clays, widely considered as basal Tertiary (Montian) in age, could also be taken to indicate that dinosaurs had survived into the Tertiary. Haug favoured this interpretation, which he thought was supported by the purported occurrence of dinosaurs in the Tertiary of Patagonia, as reported by Ameghino. Ameghino’s claims were later shown to be founded on faulty stratigraphical interpretations and misidentifications of ziphodont crocodilian teeth. As to the supposedly Tertiary dinosaurs from Saint-Chinian, the problem was solved by Lapparent, who in 1938 showed that Depéret had been misled by the complicated geological structure of the area: the dinosaur-bearing clays at Castigno in fact underlie the “Rognacian” limestones and are not an equivalent of the Vitrolles Clays; their Cretaceous age therefore cannot be questioned (Lapparent, 1938).

After Depéret’s brief papers of 1900, no further description of dinosaur material from the Saint-Chinian area was published until 1929, when Franz Nopcsa published his monograph on the armoured dinosaurs from the Late Cretaceous of Transylvania (Nopcsa, 1929). In it, he also revised material from Austria and France. The latter consisted of the specimens from Quarante that Depéret had referred to *Crataeomus* and considered as belonging to a ceratopsian. Nopcsa showed that Seeley’s *Crataeomus* had to be considered as a junior synonym of Bunzel’s *Struthiosaurus*, also known from the Gosau Beds of Austria (Bunzel, 1871). He also redescribed Depéret’s material from Quarante as belonging to a new genus and species of ankylosaur, *Rhodanosaurus ludgunensis*. Nopcsa apparently was not very familiar with the geographical origin of that material, as he mentioned Provence whereas the Saint-Chinian area is in Languedoc, and the name he chose for the new taxon was not particularly well chosen, as it alludes to the place where the type material is kept (Rhône and Lyon), not the place it comes from, with, in addition, a spelling mistake (the proper spelling should have been *ludgunensis*, from *Lugdunum*, the Latin name of Lyon, instead of *ludgunensis*). Be that as it may, Nopcsa was the first to illustrate dinosaur material from the Saint-Chinian area (Nopcsa, 1929, plate

V), and his interpretation of the dermal scutes from Quarante as those of an ankylosaur, not a ceratopsian, was definitely correct.

According to reminiscences from members of his family, Jean Miquel went on collecting dinosaur material at Castigno until the 1930s, but this did not result in publications. In 1938, as mentioned above, Albert-François de Lapparent (1905-1975) published a paper in which he corrected Depéret's mistakes about the geological age of some of the dinosaurs from the Saint-Chinian area. In the following years, Lapparent was involved in a large-scale revision of the Late Cretaceous dinosaurs from southern France. Although his field work (including excavations at Fox-Amphoux, in Provence) was curtailed by World War II, his efforts resulted in a 1947 monograph, in which the dinosaurs from Saint-Chinian received due attention (Lapparent, 1947). The dinosaurs listed by Lapparent (1947) as having been found in that area were as follows:

Theropoda: *Megalosaurus pannoniensis*.

Sauropoda: *Hypselosaurus* *priscus*;
Titanosaurus indicus.

Ornithopoda: *Rhabdodon priscum* [sic]

Matheron; *Orthomerus transylvanicus*.

Stegosauria: *Struthiosaurus lugdunensis*.

It should be noted that Lapparent emended Nopcsa's misspelling of the specific name for the armoured dinosaur from Quarante, which he referred to *Struthiosaurus*. He considered ankylosaurs as a subgroup of the Stegosauria. He also was the first (Lapparent, 1947) to report the occurrence of dinosaur eggs in the Saint-Chinian area, and to briefly mention turtle and crocodilian remains. Further comments on Lapparent's identifications are given below in the discussion of recent results.

Lapparent did some further surface collecting in the Saint-Chinian area in the early 1950s (Lapparent, 1954), which mainly resulted in the discovery of more ankylosaur scutes.

After Lapparent's visits in the early 1950s, the Late Cretaceous vertebrates from the Saint-Chinian region attracted very little interest until the 1990s. Following the discovery of abundant eggshell material in Provence in the 1950s, and somewhat later in Languedoc, the attention of palaeontologists working in these areas became focussed on dinosaur eggs rather than dinosaur bones. In the Saint-Chinian area, episodic surface collecting was done on a small scale, for instance by R. Dughi and F. Sirugue, from the Natural History Museum of Aix-en-Provence (J. Le Loeuff, pers. com.). Eggs (Marcou, 1994) seem to have attracted more attention than bones, although the discovery of a dentary indicating a new species of *Rhabdodon*, *R. septimanicus*, at Montouliers is worth mentioning (Buffetaut & Le Loeuff, 1991).

Interest in the Late Cretaceous vertebrates of the Saint-Chinian area was rekindled mainly

because of the activities of a local association, the A.C.A.P. (Association Culturelle, Archéologique et Paléontologique de l'Ouest Biterrois, to use its present name), the members of which actively searched for fossils in the Late Cretaceous non-marine deposits of this region. This eventually resulted in the discovery of a significant accumulation of vertebrate remains at Massecaps, near the village of Cruzy, in 1996. Since then, systematic excavations have been carried out at Massecaps by the A.C.A.P., the Centre National de la Recherche Scientifique and the Espéraza Dinosaur Museum. In addition, prospecting has continued and excavations on a smaller scale have been undertaken at several sites near the villages of Cruzy and Montouliers. The collections thus obtained, kept at the A.C.A.P. Museum in Cruzy, now number several thousand specimens, which have considerably increased our knowledge of the local Late Cretaceous assemblages. Part of this new material is still currently under study, and the main aim of the updated faunal list below is to give an idea of the diversity of the recovered assemblage and to highlight some of the more salient new finds.

LATE CRETACEOUS VERTEBRATES FROM THE SAINT-CHINIAN AREA: AN UPDATED FAUNAL LIST

A faunal list based on the material collected from the Massecaps locality at Cruzy was published by Buffetaut *et al.* (1999). The present revised list incorporates finds made since then both at Massecaps and at other localities in the area (notably Montouliers, Villespassans and other sites at Cruzy) and discusses in more detail some significant discoveries, on the basis of recently published papers when available. Table 1 lists the dinosaur genera and species reported by various authors from the Late Cretaceous of the Saint-Chinian area, with comments about the validity of the identifications.

Mollusca: internal casts of bivalves (probably Unionidae) are relatively common at many localities. Gastropods are less frequent.

Actinopterygii: isolated lepisosteid scales occur at several localities. A remarkable three-dimensionally preserved lepisosteid specimen, including the skull and part of the body has been found at Montouliers. It is currently under study by Lionel Cavin.

Sarcopterygii: an isolated angular bone from Massecaps has been identified as belonging to a mawsoniid coelacanth (Cavin *et al.*, 2005). This specimen is currently the latest known European coelacanth and one of the latest known fossil coelacanths. To judge from the depositional environment of the red beds of the Saint-Chinian area, this coelacanth was a freshwater form, like

other mawsoniids from the mid-Cretaceous of Africa and South America. Its occurrence in southern Europe thus indicates that (possibly discontinuous) continental connections across the Tethys must have existed between Africa and Europe at some stage during the Cretaceous to allow dispersal of freshwater organisms. This find confirms the presence of a Gondwanan component in the Late Cretaceous vertebrate faunas of western Europe, already indicated by some tetrapod and fish taxa (Buffetaut *et al.*, 1988; Buffetaut, 1989; Cavin *et al.*, 1996).

Amphibia: remains of albanerpetontids and frogs are known from Massecaps (Buffetaut *et al.*, 1999).

Chelonia: turtle remains are extremely abundant at Massecaps, mostly as isolated plates, and are also commonly found at the other localities. The most frequent taxon is the bothremyd *Foxemys mechinorum*. A turtle with an ornamented shell (*Solemys*) is less common.

Squamata: the most remarkable finds are fairly large varanoid vertebrae from Massecaps, suggesting animals several metres in length (Buffetaut *et al.*, 1999). Similarly large vertebrae are known from other sites of roughly the same age at Monts  ret (Aude) and Villeveyrac (H  rault). Whether this animal was terrestrial or aquatic remains uncertain.

Remains of smaller, unidentified squamates have also been found at Massecaps.

Crocodylia: crocodilian remains are abundant, as isolated teeth, bones and scutes, at Massecaps and other localities of the Saint-Chinian area. An overview of the crocodilian assemblage from Massecaps has recently been published by Martin and Buffetaut (2005).

A very large form is represented by large fluted teeth and a few bones (including a huge fragmentary femur from Sainte-Foy, Cruzy). The teeth are similar to those of *Ischyrochampsia meridionalis*, a large crocodilian originally described from the Late Cretaceous of Provence by Vasse (1995). *Ischyrochampsia* was initially classified among the Trematochampsidae, a group of mesosuchians, but this attribution remains to be confirmed. Large crocodilian vertebrae from Massecaps are procoelous, and thus indicative of an eusuchian. Only a single small amphicoelous vertebra possibly referable to a crocodilian has so far been found.

The small alligatoroid *Acynodon iberoccitanicus* Buscalioni *et al.*, 1997 is represented at Massecaps by a lower jaw and isolated teeth clearly indicative of this extremely short-snouted and broad-skulled form. A different alligatoroid is represented by a maxilla and isolated teeth. At least two more eusuchians appear to be present at Massecaps, to judge from braincases found there.

One of them seems to be referable to *Allodaposuchus* Nopcsa.

Despite the fact that the fragmentary nature of much of the material makes precise identifications difficult, there is no doubt that "diversity was locally high and a variety of ecological niches may have been occupied by crocodilians" (Martin & Buffetaut, 2005, p.38).

Pterosauria: the detritic depositional environment of the vertebrate-bearing sediments of the Saint-Chinian area is not conducive to the good preservation of pterosaur remains. However, a few pterosaur specimens have been found, including a fragmentary cervical vertebra from Sainte-Foy (Cruzy) showing distinctive characters of the family Azhdarchidae (Buffetaut, 2001). The estimated wingspan for that specimen is about 3 m. A poorly preserved wing metacarpal from Massecaps indicates a large, but not gigantic, form.

Dinosauria

Ankylosauria: although ankylosaur scutes were found as early as the end of the 19th century at Quarante (first misidentified by Dep  ret and eventually correctly identified by Nopcsa: see above), and despite further finds by Lapparent (1954), the recent researches in the Saint-Chinian area have yielded only a few ankylosaur remains. Some scutes from Sainte-Foy (Cruzy) may be elements of ankylosaur armour. A femur from Massecaps is definitely from a nodosaurid ankylosaur. As the ankylosaurs from the Late Cretaceous of southern France are still relatively poorly known, a more precise identification seems difficult, and the validity of the taxon *Rhodanosaurus* (= *Struthiosaurus* ?) *lugdunensis* is highly uncertain.

Ornithopoda: ornithopods are well represented at most Late Cretaceous localities of the Saint-Chinian area by the iguanodontian *Rhabdodon*. At Massecaps, a number of postcranial bones, isolated teeth, jaw elements (including a well preserved dentary) and braincases have been found. Significant *Rhabdodon* material is also known from localities at Montpl   Nord (Cruzy), Montouliers, Combeville (Villespassans) and Plo Saint-Pons. A study of specimens from Massecaps and Montpl   Nord (Pincemaille-Quillever   *et al.*, in press) suggests that the braincase of *Rhabdodon* shows more primitive characters than that of the Early Cretaceous iguanodontian *Tenontosaurus* from North America. A general study of the *Rhabdodon* material from the Saint-Chinian area by Phornphen Chanthasit is currently in progress. When completed, this work may answer the question of how many species of *Rhabdodon* are present in the Late Cretaceous of southern France. The question was raised by the description of a dentary from Montouliers as belonging to a species

(*Rhabdodon septimanicus* Buffetaut & Le Loeuff, 1991) different from the type-species of the genus, *Rhabdodon priscus* Matheron, 1869. Although the validity of the species *Rhabdodon septimanicus* was doubted by some authors (Allain & Pereda-Suberbiola, 2003), it was accepted by Weishampel *et al.* (2003) in their comprehensive review of the closely related genus *Zalmoxes* from the Late Cretaceous of Romania. Interestingly, *Zalmoxes* appears also to be represented by two distinct species, *Z. robustus* and *Z. shqiperorum*. The abundant *Rhabdodon* material from the Saint-Chinian area apparently includes both a robust and a gracile form, as indicated by limb bones with significantly different proportions, and it can be expected that its detailed study will provide a final answer to the question of how many species of *Rhabdodon* are present in the Late Cretaceous of southern France.

Although Lapparent (1947) referred three isolated vertebrae from the Saint-Chinian area to the hadrosaur *Orthomerus transylvanicus*, no evidence whatsoever of hadrosaurid ornithopods has been found during the current researches in that area, and this report is probably based on a misidentification (a revision of that material, kept in Lyon, is needed).

Sauropoda: sauropods are well represented at most localities in the Saint-Chinian area, the best material coming from Masecaps. Some at least of the material is reminiscent of the titanosaurid *Ampelosaurus atacis*, originally described by Le Loeuff (1995) from beds of similar age in the Aude valley, about 100 km to the south-west. Features in common include the slightly spatulate shape of the teeth. Well preserved titanosaurid osteoderms have been found at Masecaps (Buffetaut *et al.*, 1999). Older finds of titanosaurs from the Saint-Chinian area were attributed to the genera *Hypselosaurus* and *Titanosaurus* (Lapparent, 1947), which are now both considered as of doubtful validity (Le Loeuff, 1993, 2005; Wilson & Upchurch, 2003). Pending a detailed description of the available material, little more can be said about the sauropods from that area, all the more so that the number of titanosaurid taxa present in the Late Cretaceous of France is still uncertain. Some of the material, including a one-metre long femur from Montouliers, indicates animals of a fairly large size, although not enormous by sauropod standards.

Theropoda: theropod remains are not uncommon in the Late Cretaceous of the Saint-Chinian area, but they tend to be fragmentary. Lapparent's identification of *Megalosaurus pannoniensis*, a highly dubious taxon, cannot be accepted. Fairly large but relatively slender isolated teeth from Masecaps resemble those in the abelisaurid maxilla from Pourcieux, in Provence, described by Buffetaut *et al.* (1988). Confirmation of the occurrence of a rather large

abelisaurid has been provided by the discovery at Montplô-Nord (Cruzy) of femur fragments showing abelisaurid characters (J. Le Loeuff, pers.com.).

The occurrence of a smaller theropod is indicated by small teeth and bones (notably a sacrum, a femur and an ungual phalanx) indicative of a dromaeosaurid from Masecaps and Plô Saint-Pons. They have recently been studied by Phornphen Chanthasit in an as yet unpublished memoir (Chanthasit, 2005). The sacrum from Plô Saint-Pons is significantly similar to that of *Variraptor mechinorum* from Provence (Le Loeuff & Buffetaut, 1998), which is a valid dromaeosaurid taxon (Chanthasit, 2005, *contra* Allain & Taquet, 2000).

Aves: bird bones from Masecaps were the first enantiornithine remains to be described from the Late Cretaceous of Europe (Buffetaut, 1998). To the original coracoid and incomplete femur has now been added a well preserved complete humerus, which is currently under study and should provide additional data about the relationships of this archaic bird. Strong similarities with enantiornithine material from Argentina (Chiappe & Walker, 2002) are worth mentioning.

A fragmentary femur from a much larger bird found at Combebelles (Villespassans) was referred to *Gargantuavis philoinos* by Buffetaut and Le Loeuff (1998). This giant ground bird was about the weight of an adult ostrich, according to calculations based on the femur from Combebelles. Its exact affinities are still uncertain, but it appears to be unrelated to the giant ground birds (Gastornithiformes) of the Early Tertiary (Buffetaut, 2002).

Mammalia: mammal remains being quite rare in the Late Cretaceous of France, the few specimens found at Masecaps are of special significance. The material is currently under study by Thomas Martin (Frankfurt/Main). It includes a lower jaw fragment containing a few incomplete teeth, tooth fragments and a well preserved molar. Preliminary identifications indicate a small tribosphenic form.

Eggs: eggshell fragments are common at many localities in the Saint-Chinian area. Clutches of well preserved eggs are less frequent but have been found at Montouliers and Cruzy. Some eggshell specimens, especially the small, usually thin-shelled fragments found in the course of the excavations at Masecaps, have been studied in more detail (Buffetaut *et al.*, 1999; Garcia & Valentin, 2001-2002). Besides several morphotypes referable to non-avian dinosaurs (including the *Megaloolithus* morphotype usually associated with sauropods), some fragments (laevisoolithid morphotype) apparently correspond to birds, probably enantiornithines.

Table 1: a list of dinosaur (including Aves) genera and species reported from the Late Cretaceous of the Saint-Chinian area, with comments on the validity of the identifications.

<i>Dryptosaurus</i>	Depéret (1900a, b)	invalid ¹
<i>Titanosaurus</i>	Depéret (1900a, b)	invalid ²
<i>Crataeomus</i>	Depéret (1900c)	invalid ³
<i>Rhodanosaurus ludgunensis</i>	Nopcsa (1929)	invalid ⁴
<i>Titanosaurus indicus</i>	Lapparent (1947)	invalid ⁵
<i>Hypselosaurus priscus</i>	Lapparent (1947)	invalid ⁶
<i>Megalosaurus pannoniensis</i>	Lapparent (1947)	invalid ⁷
<i>Struthiosaurus lugdunensis</i>	Lapparent (1947)	possibly valid ⁸
<i>Orthomerus transylvanicus</i>	Lapparent (1947)	invalid ⁹
<i>Rhabdodon priscus</i>	Lapparent (1947)	valid
<i>Rhabdodon septimanicus</i>	Buffetaut & Le Loeuff (1991)	valid
<i>Gargantuavis philoinos</i>	Buffetaut & Le Loeuff (1998)	valid
<i>Ampelosaurus ataxis</i>	Buffetaut <i>et al.</i> (1999)	valid
<i>Variraptor</i>	Buffetaut <i>et al.</i> (1999)	valid

¹ Based on scanty theropod material, probably abelisaurid.² Based on indeterminate titanosaurid material.³ *Crataeomus* was considered by Nopcsa (1929) as a junior synonym of *Struthiosaurus*.⁴ *Rhodanosaurus* was considered by Lapparent (1947) as a junior synonym of *Struthiosaurus*.⁵ *Titanosaurus indicus* is now considered as a *nomen dubium* (Wilson & Upchurch, 2003).⁶ *Hypselosaurus priscus* is now considered as a *nomen dubium* (Le Loeuff, 1993, 2005).⁷ *Megalosaurus pannoniensis* was based on undiagnostic material and should be considered as a *nomen dubium*.⁸ Lapparent himself (1947) was uncertain about the validity of the species erected by Nopcsa.⁹ Based on undiagnostic isolated caudal vertebrae.

CONCLUSIONS

This brief review of the Late Cretaceous vertebrates from the Saint-Chinian area first shows how much our knowledge of this assemblage has improved in recent years. In 1900, Depéret was able to identify only 3 dinosaur taxa. In 1947, Lapparent listed 5 dinosaur taxa, plus crocodiles and turtles which were not precisely identified. The current list includes at least 22 vertebrate taxa, from fishes to birds and mammals. This number will certainly increase in the future, as more and more groups are studied in detail. Late Cretaceous vertebrate diversity in that part of southern France can now be assessed in much more detail than was possible in the early 1990s. This of course is the direct result of the systematic excavations that have been carried out since 1996, as opposed to earlier work almost exclusively based on surface collecting. One of the most striking consequences

of the current researches is progress of our knowledge of the smaller elements of the fauna, which previously were practically unknown. This has been made possible by careful excavation techniques and screenwashing of sediment. The cooperation between a local association and professional palaeontologists has proved very efficient in all respects.

Much work remains to be done to gain a better understanding of the Late Cretaceous ecosystems of the Saint-Chinian area, a first step being detailed studies of all the vertebrate groups represented. At this stage, only a few general conclusions about this faunal assemblage will be provided. The Saint-Chinian vertebrate fauna is currently one of the most diverse assemblages to be known from the Late Cretaceous of France, or more generally southwestern Europe. Some of its elements, such as the mawsoniid coelacanth, are rather unexpected, although they confirm previous

reports of "Gondwanan" vertebrates in the Late Cretaceous of southern France (Buffetaut *et al.*, 1988; Buffetaut, 1989). In its more common elements, it resembles other relatively well known assemblages of similar age from southern France, including those from Fox-Amphoux (Var) and Campagne-sur-Aude (Aude). These assemblages can be characterised by the abundance of the ornithomimid *Rhabdodon* and titanosaurid sauropods (Le Loeuff *et al.*, 1994). In southern France, this type of fauna seems to be replaced during the late Maastrichtian by a somewhat different assemblage, from which *Rhabdodon* is absent and in which hadrosaurs play an important part, while titanosaurs are still present but possibly less abundant. This kind of association is found for instance at Fontjoncouse (Aude) and is especially well represented in the late Maastrichtian deposits of the Garonne Valley (Laurent, 2003), where fairly accurate dating is made possible by marine intercalations (Laurent *et al.*, 2001). According to some Spanish authors (Pereda Suberbiola *et al.*, 2003), hadrosaurs occur in Spain as early as the late Campanian, which does not seem to be in accordance with the record from France, where no well attested hadrosaur remains have been found together with the *Rhabdodon* / titanosaur association. This discrepancy can be explained either by faunal differences between coeval localities in France and Spain, which seems rather unlikely in terms of palaeogeographical context, by inaccurate dating of some of the Spanish localities (notably El Nerets), or even by accidental pollution (given the topography of the site, it cannot be excluded that the single hadrosaur tooth from the Laño locality may be derived from the late Maastrichtian beds which overlie the older sandy layers which have yielded most of the vertebrate remains). On the basis of what is currently known from France, there seems to be no reason to reject the idea of an episode of faunal change sometime during the Maastrichtian, marked by the disappearance of *Rhabdodon* and the appearance and expansion of hadrosaurs. Within this framework, the Saint-Chinian assemblage very probably corresponds to the late Campanian or the early Maastrichtian. This is in agreement with the stratigraphical conclusions reached by Garcia and Valentin (2001-2002), who place the eggshell localities of the Saint-Chinian area in the early Maastrichtian. Although the validity of the eggshell-based biostratigraphy used in southern France needs further confirmation, in this particular instance there is an interesting congruence between the stratigraphical conclusions drawn from the general composition of the fauna and from eggshells.

Additional evidence concerning the stratigraphical placement of the Saint-Chinian vertebrate assemblage may come from recent discoveries made by Mr Henri Cohen near the village of Cazedarnes, east of Saint-Chinian. There, dinosaur bones occur in some abundance

in the limestones which top the Cretaceous series. The occurrence of bones in these terminal Cretaceous limestones had been noted by Miquel as early as 1905, but little attention had been paid to them and no identifications provided. The importance of the Cazedarnes finds lies in their stratigraphical position: if these limestones do correspond to the late Maastrichtian, as seems likely, they should contain a dinosaur assemblage different from that found in the underlying early Maastrichtian red beds. The only bone from the limestones at Cazedarnes hitherto identified is a large sauropod femur, which in itself is not especially characteristic of a definite faunal association. It is hoped that further researches in that area will provide more evidence concerning the vertebrate fauna from these terminal Cretaceous limestones. If more identifiable fossils are discovered, a rare opportunity may be provided to study faunal change during the Maastrichtian within a well defined area of southern France.

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