Sample excavations in Pietraroja (lower Cretaceous, Southern Italy) in 2001 and notes on the Pietraroja palaeoenvironment

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18 figures

Abstract

The fossil site of Pietraroja (Lower Cretaceous, Southern Italy) is known since the 18th century for its fossil fish (‘*ittioliti’*). Unfortunately, no serious attempt at systematic excavation or palaeoecological reconstruction has been done at this date, although some sample excavations have been conducted during the last two decades of the 20th century. In the first months of 2001, due to the building of a new water reservoir in the area of the site, some sampling excavations were performed to assess the possibility of building. The area examined was small, but still some interesting hints to the palaeoenvironment of Pietraroja have been unearthed.
Although a complete sedimentological and palaeoenvironmental model has been published by the author and colleagues of the University of Napoli “Federico II” (Carannante *et al*., in prep.), some brief notes about the excavation and field evidence will be presented in this paper.

Contents

1. Introduction

The Civita di Pietraroja is a locality on the eastern Matese mountains, 70 km northeast of Napoli (Southern Italy) (figure 1). The area is sparsely populated, the major centre being the very small village of Pietraroja. Since the 18th century, the area was known for the beautiful fossil fish, exquisitely preserved in marly limestone, that are called '*ittioliti'* (italian for 'fish-stone') and were used as small gifts among the European courts (Signore, 1996). The first scientific reference to Pietraroja comes with the work of Breislak (1798) who briefly described the Civita and its fossil fish. The Civita di Pietraroja locality is actually a fossil *Lagerstätte*, dated to the Lower Cretaceous. The area of the main fossil site is loosely fenced (figure 2), several buildings have been built on the fringes of the 'official' fossil site, including a football field (never used and now in heavy disrepair) and a never completed hospice for elder persons and two water reservoirs. All of these buildings are built upon layers of fossiliferous limestone, thus hampering research and recovery of fossils.

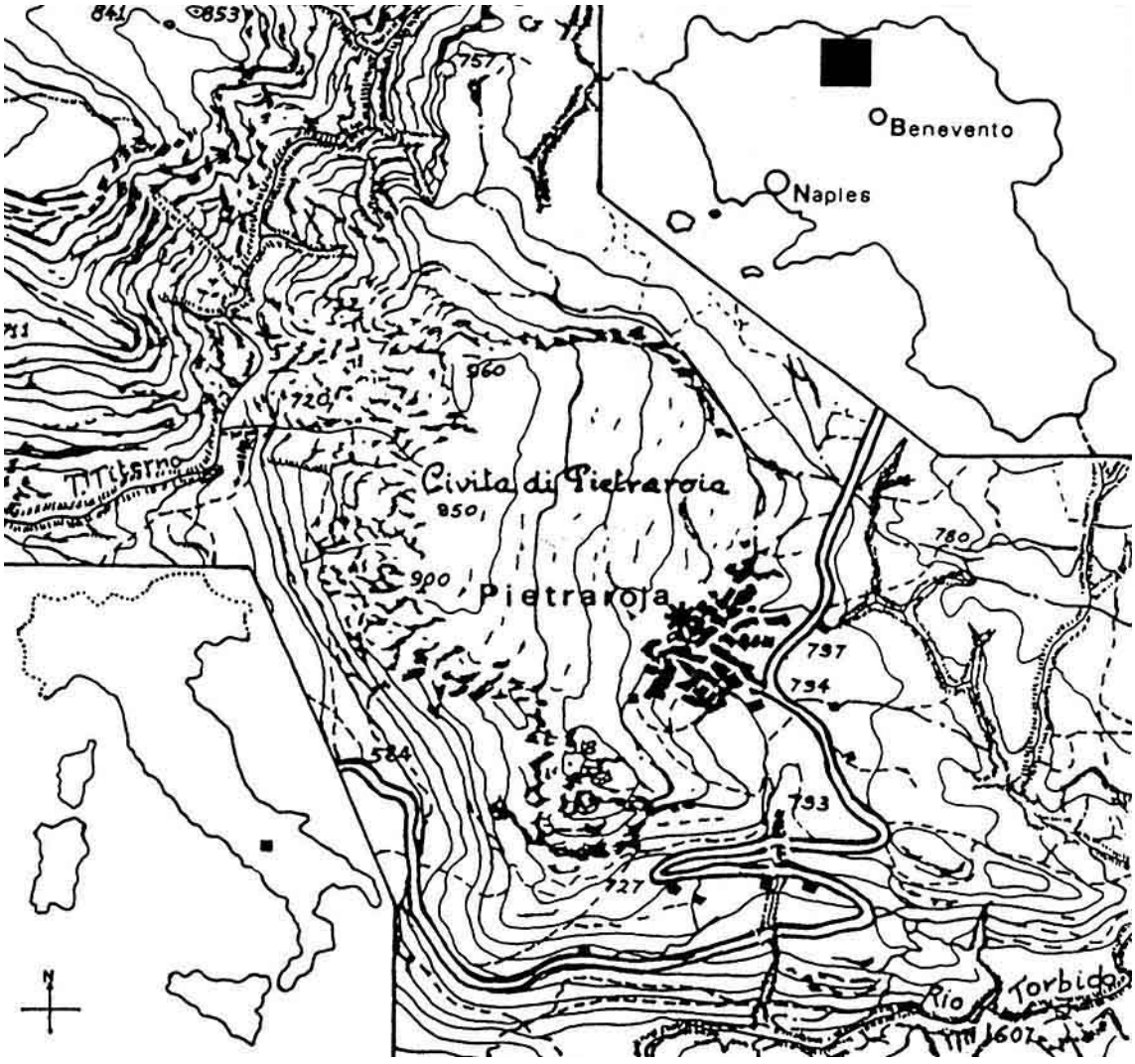

Figure 1. The geographic location of Pietraroja village. The area known as the Civita is situated northward respect to the village. In the lower left corner of the picture a map of Italy with the rough position of Pietraroja; the upper right corner shows the Campania region, with the black square indicating the position of Pietraroja. (reworked after Bravi, 1996).

Some studies have been made on the fossil fish of this area (*e.g.* Costa, 1864, 1866; Bravi & Da Castro, 1995; Bravi, 1996) since the beginning of the 20th century, but very few serious attempts have been made to tackle the problem of the palaeoenvironment (*e.g.* Catenacci & Manfredini, 1963; D'Argenio, 1963; Freels, 1970; Carannante, 1982). The taphonomical questions for this fossil site have never been addressed properly, save for some considerations (Signore, in press; Carannante *et al.*, in prep.).

Figure 2 (left). A section of the fence made of steel and concrete that rests on fossiliferous beds and only loosely protects a small portion of the fossil site of Pietraroja. Photograph by the author.
Figure 3 (right). A large hole (about 1m wide) made by illegal fossil searchers inside the fence. Photograph by the author.

In 1980, after decades of illegal excavations, a first official attempt at a scientific investigation was performed by the University of Napoli and the Museum of Torino. During this campaign, some interesting and so far unknown specimens were collected, including two crocodilians. After a second sampling, extremely limited, in 1996, no other attempts of systematic excavations have been taken. In 2001, following the need of a second water reservoir, a sample excavation was conducted by the author, at the time stationed at the University of Bristol, United Kingdom, followed by limited excavations in the main fossil site conducted by the Museo Civico di Storia Naturale di Milano later that year. The results of all these expeditions have never been published.

This paper presents a better definition of the palaeoenvironment of Pietraroja by describing some of the finds of the 'water reservoir' excavation campaign, which started in March 2001 and was finished in May 2001.

2. The 2001 'water reservoir' sample excavation

2.1. The excavations

Figure 4 (left). Horses around the fence. Excavations in the area are hampered by the presence of horses, sheep and cows grazing in and around the area. Photograph by the author.
Figure 5 (right). The excavations of 2001. Photograph by the author.

The geological setting of Pietraroja has been described in several works (*e.g.* D'Argenio, 1963; Catenacci & Manfredini, 1963; Bravi, 1996; Signore, 1996; in press). The fossiliferous outcrop has been dated to the Lower Albian (about 113 mya; see Bravi & De Castro, 1995; Carannante *et al*., in prep.). It is composed of grey

marly limestones with abundance of layers, including nodules of flint. The whole area sits on a flat, carsic mountain top in the Matese range; the total area covered by the fossiliferous layers is not known, as the layers are hidden in the whole area by a 10–15 cm thick turf. A small portion of the fossiliferous limestone is fenced, but fossils are commonly found outside and inside the fence. Unfortunately enough, the area is a well-known place among black market fossil dealers, and several illegal excavations have been carried out, both inside and outside the fence (figure 3). The phenomenon is not over at all, as during the excavations in 2001 we have been told by local shepherds that several persons came during the weekends to "look around the digging site" and "collect stony fishes". The situation is further complicated by the fact that the area is a feeding ground for sheep and horses, and a well-known picnic area as well (after 2001 a picnic area has been officially built just next to the fossiliferous area, some 20 m away from the fence, and horses are kept around the area, figure 4).

The digging site for the 2001 excavations was an ill-defined trench (figure 5) some 5 m deep and 7 m wide, situated 30 m north-northwest to the main fence of the Civita, and only 5 m north of the old water reservoir. Due to meteorological conditions and logistic problems, the excavations were performed during three months; the team was based in Napoli, travelling to Pietraroja by car every day. Specimens found were stored in a closed deposit of the local town hall. Also, the excavation had to be concluded rapidly due to the urgency of the water reservoir construction.

Figure 6 (left). The caterpillar digs a part of the non-fossiliferous layer in order to start the manual excavation. Photograph by the author.
Figure 7 (right). Manual excavation. Photograph by the author.

The first part of the excavation (that is, removal of soil layers and excavation of the first, non-fossiliferous Tertiary layers of limestone) has been conducted by a caterpillar (figure 6) that removed the hardest top parts of the strata. Once the fossiliferous horizon was reached, the mechanical work stopped and the excavations continued manually (figure 7); layer by layer, in order to create stratigraphic evidence (figure 8). Each sample found and recovered has been catalogued and subsequently transferred to the deposits of the Soprintendenza Archeologica di Benevento in Benevento (Southern Italy).

Figure 8 (left). The stratigraphic witness. Photograph by the author.
Figure 9 (right). A close-up of some strata in which the destructive effects of water and plant roots is visible. Photograph by the author.

The investigation and recovery of specimens has been hindered by the weather conditions, by the fact the work had to be done quickly (emergency excavations) and also by the extensive carsification of the area. More than 50% of the surfaces were invaded by water and the combined effect of water and plant roots (figure 9) obliterated almost anything from several of the examined layers.

A stratigraphic column has been prepared and it is still under definitive construction at the University of Napoli "Federico II", and several new specimens of both invertebrates and vertebrates have been found and collected.

Unfortunately at the end of the sampling, and notwithstanding the requests of the excavation team, the whole area has been filled with concrete and used to build up the new water reservoir. Therefore, this part of the excavation is not available anymore, except for the samples collected.

2.2. Sampling result

Figure 10 (left). Typical fossiliferous layer found in the area of Pietraroja. Thin lamination and very small grain size make this rock a good preservational environment. Photograph by the author.
Figure 11 (right). A more massive 'catastrophic' layer in the process of being removed; most possibly developed by rapid and catastrophic events of submarine slides. Photograph by the author.

The area excavated seems to be part of a Cretaceous channel system (Signore, in press; Carannante *et al*., 2001, in prep.); most possibly it was either on one of the banks of the main channel or it represents a secondary channel.

Two main types of layers in the sampling area have been found. The first (figure 10) was a typical fossiliferous layer, well-stratified and with a thickness that varied between 0.2 and 1.1 cm; it shows a typical stratification, sometimes counting up to 5 or 6 different thin strata inside a single layer. The conditions of fossil material found in these layers are different, ranging from single vertebrae and unidentified organic material to

Figure 12 (left). On the surface of this fossiliferous layer (on the left of the photograph) it is possible to note the marks left by the rapid and erosive deposition of a massive layer (see figure 11). Photograph by the author.
Figure 13 (right). A still undescribed shrimp. Photograph by the author.

completely preserved animals. No plant material has been recovered during the excavations.

This first type of layer was intercalated with a second type of layer (figure 11), that shows no stratification at all. The layers were thick (up to 50 cm and more), massive, and containing little or no fossil material, at least on the exposed surfaces. The layers were too hard to break and there was no discontinuity in the mass composing each of them. When present the fossil material in these layer was small and hard: the only two recorded instances during the sampling were two parts of dental batteries coming from durophagous fish (most possibly *Coelodus* sp.). It is interesting to note that each of these massive layers left distinct erosive marks (figure 12) on the underlying fossiliferous layers. These marks might have been caused by the depositional modality of these massive layers (discussed below).

There is no recorded ichnofossil coming from the sampling area (except one possible unidentified repichnia), therefore the bioturbation index (as in Bromley, 1996) can be valued at zero. This has serious implication in the palaeoenvironmental model that is supported in this paper (Carannante *et al*., in prep.; but see Signore, in press for a summary of the different models proposed for Pietraroja). However, it must be pointed out that in the entire Pietraroja area, many structures appear to be organic in origin and resemble either coprolites or regurgitate material. While some of them have been examined, no definitive conclusion has been reached either on their origin and on their nature (but see below).

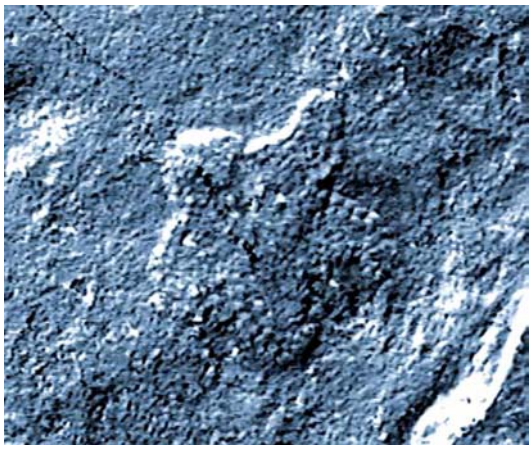

Figure 14 (left). A starfish preserved with its skeletal parts. Photograph by the author.
Figure 15 (right). Clupavus sp. *These fish are very common in the area. Photograph by the author.*

The identifiable fossil fauna found during the excavation is relatively low in diversity. Among the invertebrates there are some palaemonid shrimps (currently under study, figure 13), at least one undescribed asteroid echinoderm (figure 14), three juvenile ammonoid cephalopods, at least three gastropods (*cf*. *Nerinea*), and several sub circular partially siliceous remains tentatively interpreted as siliceous sponges. If this was the case, they may represent the first record of complete siliceous sponges from the Lower Cretaceous of Italy.

Among the vertebrates, most of the specimens collected are fish (as expected in this marine environment). The majority of collected fish are complete specimens belonging to the genus *Clupavus* (figure 15); several more belong to the genus *Coelodus*. There is also one unidentified large caudal appendage belonging to a bony fish

Figure 16 (left). An undescribed fish. Photograph by the author.
Figure 17 (right). An undescribed fish. Both specimens are currently being studied. Photograph by the author.

and a couple of complete and still unidentified fish (figure 16, 17).

Among other vertebrate groups, the remains are scarce at best. We have found two large bone fragments that may belong to a middle-sized reptile and an interesting specimen which may be part of the skull of a juvenile pterosaur and which is still under preparation (figure 18).

Figure 18. Part of a skull of an unidentified vertebrate which has been tentatively identified as a juvenile pterosaur. Photograph by the author.

3. The palaeoenvironment of Pietraroja

The Civita di Pietraroja has always been interpreted as a shallow lagoon subject to starvation (D'Argenio, 1963; Catenacci & Manfredini, 1963; Freels, 1975; Bravi, 1996; Bravi & Castro, 1995; Signore, 1996; in press) and since the first proposal of this model in the 1960's no one has seriously challenged this idea except Carannante (1982). Consequently, the official reconstructions of the palaeoenvironment of Pietraroja have always presented the area as a small, shallow lagoon subject to starvation cycles. The lagoon was inhabited during the 'normal' marine phase, but then some physical barrier blocked the normal circulation of water and the lagoon suffered a starvation episode, with rapid lessening and subsequent lack of oxygen, deficiency of nutrients and death of large organisms that left enough ecological space to allow the growth of a bacterial film on the corpses. It was commonly thought that death and preservation of the Pietraroja fossils should be explained this way (Bravi, 1996; Signore, 1996) but the first doubts surfaced in the first years of this century (Signore, in press). Currently, the evidences supporting the lagoon hypothesis have been challenged and a new sedimentological model has been proposed, based on the existence of a Cretaceous channel system in the area, on which a later (Tertiary) and still evident channel superimposed during the Miocene (Carannante *et al.*, in prep.).

Strictly concerning the sample excavations of 2001, several interesting pieces of evidence have been found that support the idea that Pietraroja was not a shallow coastal lagoon but a more complex and deep environment.

The sampling contained no ichnofossil, as already mentioned, neither on the surface of any of the layers sampled, or through the section studied. There are the 'coprolites', although no one has actually studied them; the only studied section has been described in an unpublished degree thesis at the University of Napoli (Russo, 2004), but it is limited to just two 'coprolites' and no definitive conclusion has been presented. Another structure, bigger than the usual ones, has been found in a different area of the outcrop; a first examination learned that it contained some unidentified bones. No other study has been carried out hitherto.

As remarked in Carannante *et al*. (in prep.), the extremely low level of bioturbation in the *Plattenkalk* (equals close to zero in the sampled area) could be a bit incoherent with 'normal' fossil lagoons. The ichnofacies in fossil lagoons are usually well-represented (*e.g.* in Solnhofen), and unless phenomena that obliterate at least surfacial bioturbation occur, they should be preserved in the case Pietraroja was a lagoon. Of course, the almost total lack of bioturbation could also have been due to preservation; but no evidence of possible cause of obliteration has been found, especially because unusually delicate structures has been preserved in fossil animals. If something happened on the bottom that would have obliterated any trace, then this thing would have been strong enough to obliterate also some finer details in the animals, or also hinder or prevent the fossilisation of some of the more delicate animals.

The distribution of body fossils on the surface of the strata seems to follow a pattern, although (again) the sampled area was too small to offer conclusive evidence. The fossils are smallest on the outer side of the

Plattenkalk area and become larger as one gets towards the centre of the *Plattenkalk*. Also, the larger organisms are found as scattered remains on the outer side and increase in the completeness occur towards the centre. This kind of distribution appears to be repeated in the main *Plattenkalk* area, although no one has ever made any observation towards the spatial distribution of the remains outside the 'water reservoir' excavation. The layers decline slowly towards the same direction, that is the 'centre' of the area. While of course this may be a phenomenon caused by tectonic modification of the area (that is strongly faulted), the thicker layers (the chaotic, unfossiliferous ones) left strong, clear erosive marks on the underlying ones. The marks appear to have been left when the underlying surface was still soft, and they point at a movement of these chaotic masses towards the same 'centre' where the larger and more abundant fossils are found. Clear marks of gravitative sediment currents have been described in the whole *Plattenkalk* of the Civita di Pietraroja area (Carannante *et al.*, in prep.) along with microslumps, all pointing to an environment different from a lagoon.

The lack of insect material among the specimens collected is also interesting. The preservation of the fossils is exceptional (*e.g. Scipionyx samniticus* Dal Sasso & Signore, 1998, or the shrimp in figure 13) and even the most delicate structures have been preserved. Thus, the lack of any insect material in a coastal lagoon is at least problematic for the palaeoenvironmental reconstruction. Again, the taphonomical bias may be invoked. There is no reason to suspect that structures such as the chitinous shell of the insects has been lost, whereas more delicate features such as the intestines of a dinosaur (Dal Sasso & Signore, 1998), the shells of some gastropods (Signore, in press) and even the 'coprolites' have been preserved. Also, not even a single scavenger organism has been reported during the sampling. This is also a bit difficult to explain with the lagoon model, but easier to explain with the model presented by Carannante *et al*. (in prep.). Fossil plants have been mentioned in the area, but their presence is scanty at best; no fossil plant material has been found during the 2001 campaign.

Most of the predator remains in the area sampled belong to the *Coelodus* durophagous fish. Yet very few molluscs have been found in the area. No other occasional predator has been found, except maybe the shrimp and the possible pterosaur, and no evidence of large mollusc populations has been collected in the 'water reservoir' area.

Finally, some words should be devoted to the preservational state of the fossils. In the sampled area any possible level of preservation for the body fossils, ranging from complete individuals to scattered and isolated pieces can be noticed. Again, there appeared to be a precise pattern for the remains, as the most fragmentary ones were far more common in the area towards the outer rim of the *Plattenkalk*, while the best preserved individuals have been encountered going towards the 'centre'. However, since no complete taphonomical work has been done on the area, it must be pointed out that the reasons behind this distribution may be many and the distribution might be the result of a taphonomic artefact.

4. Concluding remarks

The 'water reservoir' area has been found to be very rich in fossils. The distribution of the fossils seem to follow a pattern, but unfortunately both the short time available for excavations and the peculiar nature of the site (a target site for a water reservoir is not the best area where to conduct prolonged research) never allowed further detailed investigation. However, the same pattern is followed by what seem to be gravitative flows of material that disturbed the local sedimentation. The observed pattern could indicate a preferential direction for currents and the environmental condition that allowed gravitative currents flowing along a slope (however steep it might have been). Moreover, the fauna found during the sample is lacking some elements that would have been expected when investigating a coastal lagoon: lack of terrestrial invertebrates, plants, scavengers, bioturbation. The scanty record of shelled invertebrates would have hardly been able to feed a flourishing community of durophagous fish, that are instead found in abundance. From the small sample obtained it is hard to identify even the faintest traces of the food web that one would expect in a lagoon-community.

But aside from the small contribution to the palaeoenvironmental picture of the area, which should be more thoroughly investigated in the future, the 'water reservoir' sampling excavations demonstrated what has been suspected but never published: that the fossiliferous *Plattenkalk* in the Civita di Pietraroja is far more extended than officially published. Therefore I would like to express the hope that more investigations and more protection would come for a very important and yet very mistreated area of the Lower Cretaceous fossil record.

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6. Cited literature

Bravi, S. **1996.** Ricerche sui livelli ad ittioliti in facies di piattaforma carbonatica dell'Italia Meridionale. – Unpublished doctoral thesis, University of Napoli "Federico II".

Bravi, S. & P. De Castro. 1995. The cretaceous fossil fishes level of Capo d' Orlando, near Castellammare di Stabia (NA). Biostratigraphy and depositional environment. – Memorie di Scienze Geologiche 47: 45-72.

Breislak, S. 1798. Topografia fisica della Campania. – Firenze.

Bromley, R.G. 1996. Trace fossils. – London, Chapman & Hall.

Carannante, G. 1982. La valle del Canale (Civita di Pietraroja, Matese). Una incisione miocenica riesumata sul margine della piattaforma carbonatica Abruzzese – Campana. – Geologica Romana 21: 511–521

Carannante G., M. Vigorito, & B. D'Argenio. 2001. I calcari ad ittioliti di Pietraroia. Laguna o canale sottomarino? Nuove considerazioni sedimentologiche e paleoambientali. In: **Colella, A., S. Longhitano & M. Tropeano. Eds. 2001.** GeoSed 2001 atti e guida alle escursioni. – University of Potenza, Potenza: 17–20.

Carannante, G., B. D'Argenio, M. Vigorito & M. Signore. In prep. Vertebrates-fossil rich plattenkalk of Pietraroia (Southern Apennines, Italy). New environmental and sedimentological considerations.

Catenacci, E. & M. Manfredini. 1963. Osservazioni statigrafiche sulla civita di Pietraroja (Benevento). – Bollettino della Società Geologica Italiana 82: 65-92.

Costa O.G. 1864. Paleontologia del Regno di Napoli III. - Atti Accademia Pontaniana Napoli 8: 1–198.

Costa O.G. 1866. Nuove osservazioni e scoperte intorno ai fossili della calcarea ad ittioliti di Pietraroja. – Atti Academia. Scienze Fisiche e Matematiche, Napoli 22: 1–12.

D'Argenio, B. 1963. I calcari ad ittioliti del Cretacico inferiore del Matese. – Atti Accademia Scienze Fisiche e Matematiche 4: 5–63.

Dal Sasso C. & M. Signore. 1998. Exceptional soft-tissue preservation in a theropod dinosaur from Italy. – Nature 392: 383–387

Freels, D. 1975. Plattenkalke becken bei Pietraroja (Prov. Benevento, Sud Italien) als Vorussetzug einer fossil-lagerstättte erbildung. – Neues Jahrbuch fur Geologie und Palaontologie Abteilung 148: 320–352.

Russo G. 2004. I coproliti del giacimento di Pietraroia (BN):analisimorfologica e ipotesi paleoecologiche. – Unpublished degree thesis, University of Napoli "Federico II".

Signore, M. 1996. Il teropode del plattenklak della Civita di Pietraroja (Cretaceo inferiore, Benevento). – Unpublished degree thesis, University of Napoli "Federico II".

Signore, M. In press. *Scipionyx samniticus* and the palaeobiology of some maniraptoran theropods. – Amsterdam, PalArch Foundation (monograph 1).

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