

The first fossil record of the genus *Callichirus* (Decapoda, Axiidea, Callianassidae) from the middle Miocene of Hungary, with description of a new species

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Abstract

The fossil record of the callianassid genus *Callichirus* is reevaluated and an emended diagnosis for the genus based on hard part morphology is provided. One new species *Callichirus bertalani* from the middle Miocene (lower Badenian) of Hungary is described. It represents the first record of the genus in Europe, and thus extends its known palaeogeographical distribution to Paratethyan realm.

Key words: Decapoda, Callianassidae, *Callichirus*, Miocene, lower Badenian, Systematics, Palaeobiogeography

Introduction

Fossil callianassid shrimps are among the most commonly found decapod remains in the fossil record. However, because of the delicate structure of most cuticular surfaces, only chelipeds which are usually heavily calcified are likely to be preserved. The biological classification of callianassids is based mainly on soft body characters with very poor or no fossilization potential. Manning and Felder (1991) first considered that the cheliped characters were of great taxonomical importance. Consequently, several fossil callianassid species were reassigned to extant genera (e.g. Stilwell *et al.*, 1997; Schweitzer and Feldmann, 2002; Todd and Collins, 2005; Karasawa *et al.*, 2008). According to De Grave *et al.* (2009) 34 extant genera of Callianassidae were described without taking Sakai's (1999, 2005) synonymies into consideration. However, only 13 of them are known from the fossil record and only eight (*Callianassa*, *Trypaea*, *Calliax*, *Callichirus*, *Corallianassa*, *Eucalliax*, *Glypturus*, and *Neocallichirus*) are known from older strata than Pliocene. We consider it to be a consequence both of preservational and collecting biases. On the other hand, many extant callianassid genera can be differentiated from each other on the basis of rather minor differences in soft part morphology and therefore we will probably not

be able to distinguish them in the fossil record.

In comparison to brachyuran decapods, there has been only little attention paid to fossil callianassids until recently. The present contribution evaluates the fossil record of the callianassid genus *Callichirus*. An emended diagnosis for the genus based on hard part morphology is also provided together with the description of one new species from the middle Miocene of Hungary. It represents the first record of the genus in Europe and therefore extends its palaeogeographical distribution. Moreover it is the first record of the genus from Miocene strata.

Geological and geographical settings

The specimen presented herein comes from Bakony Mountains near the village Nyírád west from Lake Balaton in Hungary. The fossil-bearing locality is situated cca 8 km south of the village Nyírád. (Fig. 1). The Leitha-limestone is distributed in and around the locality. The age of the limestone is early Badenian (Middle Miocene) (József Kókay, pers. comm. to P. M.). The decapod fauna already described from the surroundings of Nyírád consists of several taxa: *Calappa praelata* Lörenthey, *Palaeomyra globulosa* (Müller) and *Maja biaensis*

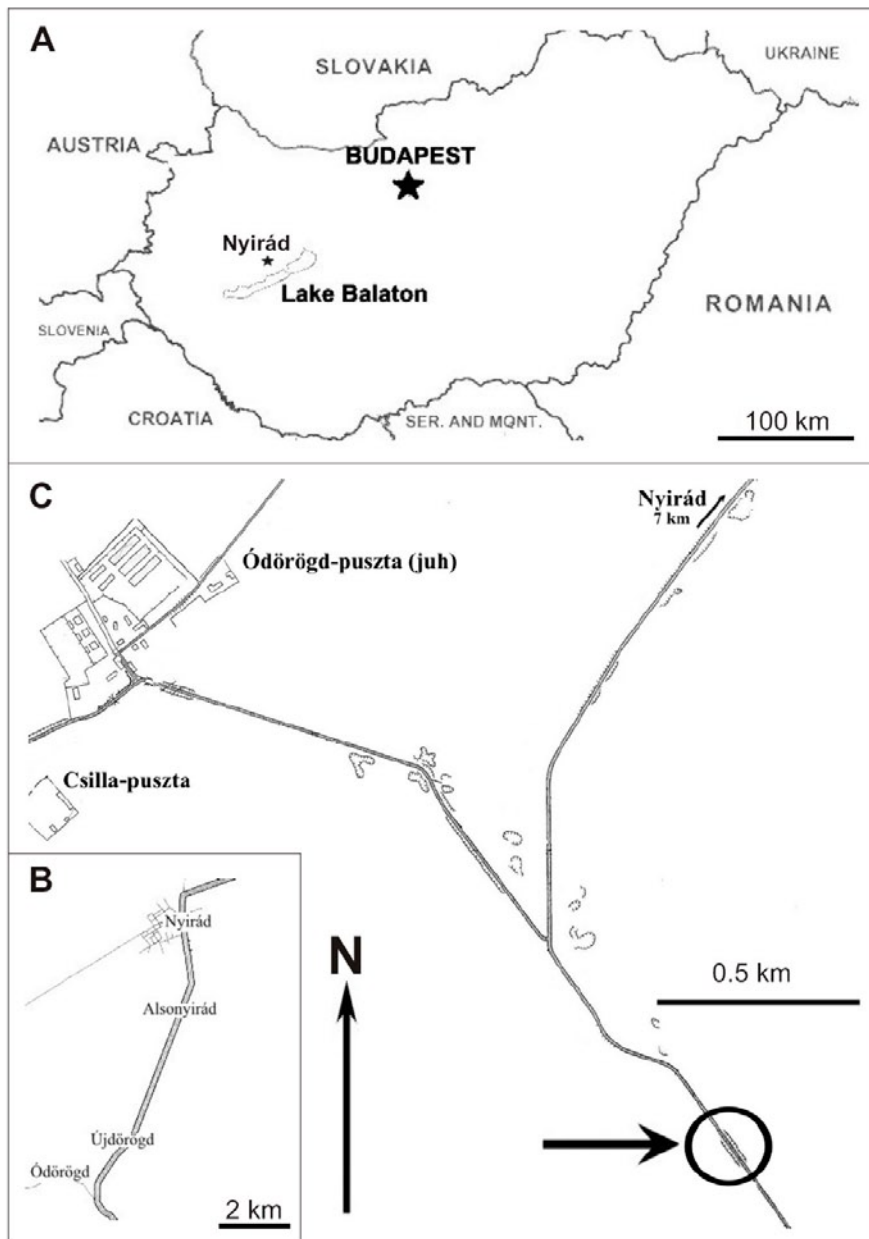


Fig. 1. Map showing the position of the type locality of *Callichirus bertalani* sp. nov. A: Outline map of Hungary with the position of the village of Nyirád. B: Closest view on the type area. C: Exact position of the type locality (marked by a black arrow).

Lőrenthey (for details see Müller, 1984).

Systematic Palaeontology

Order Decapoda Latreille, 1802

Infraorder Axiidea de Saint Laurent, 1979a

Remarks: Recently published molecular analyses of the infraorder Thalassinidea (Tsang *et al.*, 2008; Robles *et al.*, 2009) strongly supported its paraphyly, splitting the group into two monophyletic taxa with infraordinal status. It supports the results of the previous studies based on morphological evidence (e.g. de Saint Laurent, 1979a, b; Sakai and Sawada, 2006). Robles *et al.* (2009), following de Saint Laurent

(1979a), recognized two separate clades as Gebiidea and Axiidea, the latter comprising the families Callianassidae, Ctenochelidae, Strahlaxiidae, Micheleidae, Callianideidae, Thomassiniidae, Axiidae and Calocarididae. This classification was adopted also by De Grave *et al.* (2009).

Family Callianassidae Dana, 1852
Subfamily Callichirinae Manning and Felder, 1991

Remarks: The intrageneric relationships of Callianassidae have recently been studied by Felder and Robles (2009). Their results, based on the analysis of two mitochondrial genes, revealed the possible paraphyly of the subfamily Callichirinae. Most of the genera within the subfamily appear to be monophyletic, although the intrageneric relationships were poorly resolved.

Genus *Callichirus* Stimpson, 1866

Type Species: *Callianassa major* Say, 1818, by original designation and monotypy.

Included extant and fossil species: see Tables 1 and 2.

Stratigraphic range: Maastrichtian–Holocene.

Diagnosis: Carapace lacking rostral spine with dorsal oval. Chelipeds of adult males very unequal, greatly enlarged, those of females and immatures nearly equal. Major cheliped with or without proximal meral hook. Carpus and propodus of sexually mature males usually very long, carpus much longer than propodus; dactylus usually armed with one or several teeth, tip hooked. Length of the three distal segments (dactylus, propodus, carpus) together equals to two or more times middorsal carapace length.

Discussion: The genus *Callichirus* was introduced by Stimpson (1866) with *Callianassa major* as its type species. The genus *Callichirus* was later redefined by Manning and Felder (1986, 1991) resulting in exclusion of several species assigned to the genus since its original description (Le Loeuff and Intes, 1974; de Saint Laurent and Le Loeuff, 1979). Following the redefined diagnosis (Manning and Felder, 1986, 1991) there are five extant species of *Callichirus* known and named to date (see Table 1). Some more species of the genus are known, however they have not been named yet (Robles and Felder, 2009; Dworschak, pers. comm., 2009). The main diagnostic characters of the genus are an elongate cheliped; a narrow uropodal endopod; a short, broad telson with a posterior emargination; and the distinctive ornamentation of the

Table 1. Included extant species of *Callichirus* and their geographic distribution.

| | |
|--------------------------------------|--|
| <i>C. adamas</i> (Kensley, 1974) | West Africa, South Africa |
| <i>C. islagrande</i> (Schmitt, 1935) | northern and western Gulf of Mexico |
| <i>C. major</i> (Say, 1818) | southeastern USA, Gulf of Mexico, Brazil |
| <i>C. seilacheri</i> (Bott, 1955) | El Salvador |
| <i>C. garthi</i> (Retamal, 1975) | Chile |

Some authors (Sakai, 1999, 2005) considered *C. garthi* as the younger synonym of *C. seilacheri*.

Callianassa kraussi Stebbing, 1900 is considered by some authors as a member of *Callichirus* too (Sakai, 1999, 2005; Tudge *et al.*, 2000). This species is however not very well known. It is slightly different than all other members of the genus in several morphological characters and has rather different ecological preferences (Forbes, 1974; Felder, 1978). Moreover it seems that there are no reports on the elongated cheliped of males. Unfortunately, no phylogenetic analysis included this species (Dworschak, pers. comm., 2009), so the relationship to other members of *Callichirus* is questionable.

third to fifth abdominal somites (Manning and Felder, 1986, 1991).

Manning and Felder (1991) argued for the taxonomic importance at the generic level of presence or absence of a proximal meral hook. They stated its presence as one of the diagnostic features of the genus. However it was already pointed out (Schweitzer and Feldmann, 2000) that not all species of *Callichirus* possess a meral hook; this fact also appeared in the diagnosis of the genus by Sakai (1999, 2005).

Remarks on the fossil record: The assignment of fossil specimens to the genus *Callichirus* is rather difficult because of substantial variability in the nature of the major cheliped, which is usually the only portion of an animal known from the fossil record. There is also a great inter- and intrasexual variability (Manning and Felder, 1991) and Staton and Felder (1995) reported also certain morphological differences between two different populations of *C. major*. All this complicates generic assignment when only some of the cheliped segments are preserved. However, as Manning and Felder (1986) noted, there are several characters which separate *Callichirus* from all other callianassid genera, for palaeontologists the most important being the elongate cheliped. This character was also pointed out by Sakai (2005), who also mentioned the elongated ischium in male major chela, however this part

is much less common in the fossil record than the more distal parts of the cheliped.

It should be noted that not only *Callichirus* exhibits carpus elongation. There are several species of different genera in which the carpus is longer than the manus (e.g. *Trypaea*, *Podocallichirus*), however, never being as elongate (Manning and Felder, 1991) and of the shape as observed in *Callichirus*. The proximal margin of the carpus in *Callichirus* is usually convex and partly overlapping the merus distally, so it can reach the greatest length not at the articulation with the merus but at a rounded margin at its disto-lower edge. Moreover, the height of the carpus is equal along its length. Carpus elongation is quite common in minor chelipeds of many genera and species of Callianassidae (notably subfamilies Callianassinae and Callichirinae), however, the carpus itself is always very differently shaped, being highest distally and converging proximally so that the

point of articulation with the merus is always the point of least height. On the other hand, the minor cheliped of *Callichirus* usually has a carpus which is slightly higher than the propodus, a character which is not very common in other genera. Females of *Callichirus* have more or less equal chelipeds very similar to the minor one of the males.

The dactylus of the major cheliped of male *Callichirus* is usually armed with a prominent tooth or at least a serration and its tip is strongly hooked often at a right angle. There are some other callianassid genera such as *Neocallichirus* or *Podocallichirus* exhibiting an armed dactylus, however, in those genera it is distinctly longer and usually armed with several teeth. The hooked tip of the dactylus is present in several genera, notably in *Neocallichirus*, *Podocallichirus*, and *Sergio*. In general, dactylus and pollex of *Callichirus* are relatively short compared to the elongate nature of the manus, which is not typical for the above mentioned genera.

The summarized combination of characters given in the diagnosis above is unique among callianassid shrimps; thus, if at least four distal parts of the major cheliped are present in the fossil record, the correct generic assignment to *Callichirus* can be warranted.

The new species described herein possesses all the above-mentioned important characters and the preservation of the last four segments is enough to assure its generic assignment.

Withers (1926) described *Callianassa pustulata* from the lower to middle Eocene strata of Barbados, formerly considered to be of Oligocene age, on the basis of more or less fifteen fragmentary propodi. Collins and Donovan (2005) cited the species as *Callianassa pustulosa*

Table 2. Included species of *Callichirus* known from the fossil record and their stratigraphic and geographic distribution.

| | | |
|--|----------------------|--------------|
| <i>C. waagei</i> Crawford, Feldmann, Waugh, Kelley and Allen, 2006 | Maastrichtian | South Dakota |
| <i>C.?</i> <i>pustulatus</i> (Withers, 1926) | early–middle Eocene | Barbados |
| <i>C. symmetricus</i> (Feldmann and Zinsmeister, 1984) | Eocene | Antarctica |
| <i>C. bertalani</i> new species | middle Miocene | Hungary |
| <i>C. major</i> (Say, 1818) | Pliocene–Holocene | Florida |
| <i>C. islagrande</i> (Schmitt, 1935) | Pleistocene–Holocene | Florida |

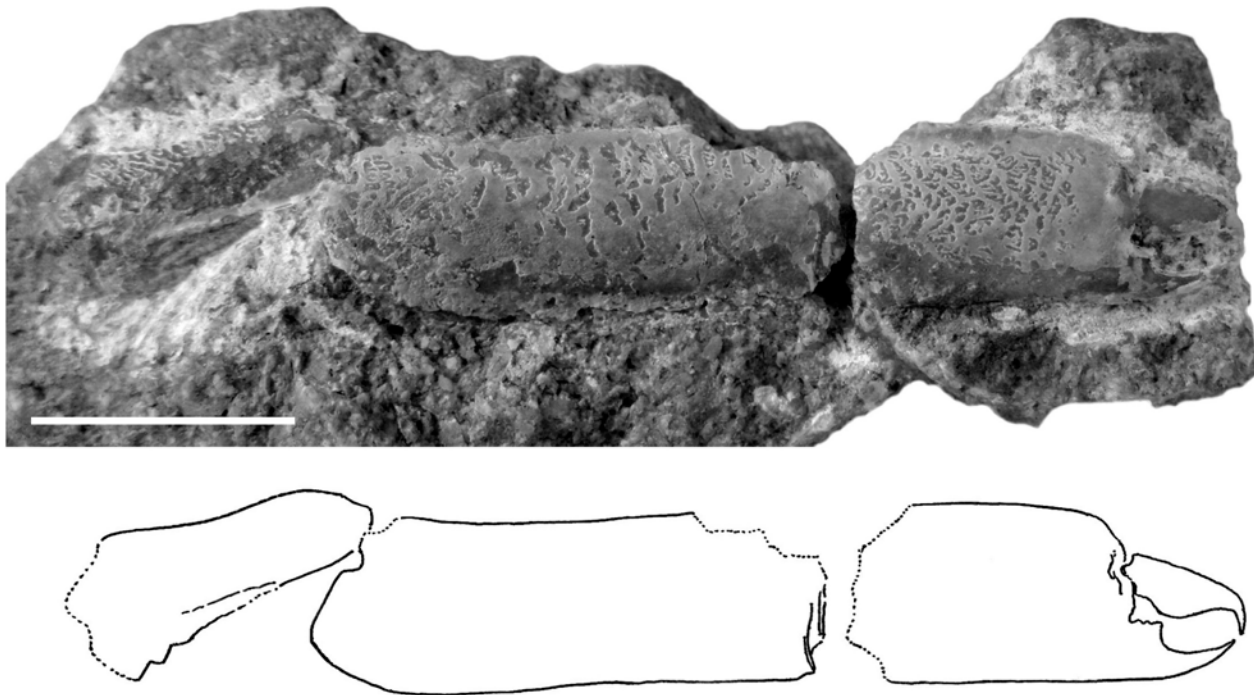


Fig. 2. Holotype (M.2009.2334.1) of *Callichirus bertalani* sp. nov. showing the right major cheliped. The scale bar equals 10 mm.



Fig. 3. Propodus and dactylus of the holotype of *Callichirus bertalani* sp. nov. Note distinctly reticulate surface.

[sic] and placed the species tentatively to *Callichirus*. They pointed out a deep proximal excavation on the propodus, however, this character is present in many other callianassid genera and should not be treated as of major taxonomic value. Moreover, this feature is sometimes connected with sexual dimorphism and the ontogenetic stage of the animal. According to the original publication (Withers, 1926), the material of *C. pustulata* is rather poorly preserved and it is very difficult to assign it to any extant genus without any knowledge about other parts of the

cheliped.

Waage (1968; Pl. 8C) illustrated a single right cheliped of callianassid shrimp consisting of articulated merus, carpus, and propodus. The specimen comes from the Fox Hills Formation of Maastrichtian age in South Dakota (USA). Recently Crawford *et al.* (2006) reexamined the specimen and established it as a holotype of a new species *Callichirus waagei*. The overall morphology of the single cheliped allowed the assignment of the specimen to *Callichirus*. Moreover, it is preserved

within an *Ophiomorpha* burrow being one of the few such occurrences in the callianassid fossil record.

Feldmann and Zinsmeister (1984) described the new species, *Callianassa symmetrica*, from erratic blocks of Eocene age of Mount Discovery, East Antarctica. On the basis of additional material preserved within small fragments of a burrow it was tentatively assigned to *Callichirus* by Stilwell *et al.* (1997). Later, Schweitzer and Feldmann (2000) published an extensive report on this species associated with burrows in light of new material. They also refined the diagnosis of the species and discussed broadly its assignment to *Callichirus*, being rather careful about the definitive conclusion. However, the material fits the above introduced diagnosis.

Portell and Agnew (2004) listed two species of *Callichirus* known from Plio–Pleistocene Caloosahatchee Formation and Pleistocene Bermont Formation of Florida: *C. major* and *C. islagrande*. Both are known from extant occurrences in the Gulf of Mexico (Dworschak, 1992; Sakai, 2005). These Pliocene and Pleistocene occurrences comprise hundreds of specimens (Portell, pers. comm., 2009) from which Portell and Agnew (2004) portrayed one right dactylus of *Callichirus islagrande* and three segments of a right chela — merus, propodus and dactylus — of *Callichirus major*. All the material is well preserved with all important characters and therefore allowed taxonomically precise assignment.

We consider only three exclusively fossil species as confidently assignable to *Callichirus*: *C. symmetricus* (Feldmann and Zinsmeister, 1984), *C. waagei* Crawford, Feldmann, Waugh, Kelley and Allen, 2006, and the new species described herein. For the listing of all known fossil occurrences of the genus see Table 2.

Callichirus bertalani sp. nov.

(Figs. 2, 3)

Etymology: The trivial name honours the donor of the type specimen Károly Bertalan.

Material: Holotype and the only specimen is deposited in the Hungarian Natural History Museum in Budapest under the catalogue number M.2009.2334.1. It represents a right major cheliped consisting of merus, carpus, propodus and dactylus (Figs. 2, 3).

The specimen was donated by Károly Bertalan, who collected and kindly gave it to one of the authors (P. M.).

Locality and horizon: The type locality is situated cca 8 km south of the village Nyirád in Bakony Mountains, Hungary. The holotype comes from the Leitha-limestone of lower Badenian (middle Miocene) age.

Diagnosis: Merus, carpus, and propodus of major cheliped longer than high; distal margin of propodus with large triangular tooth at the base of fixed finger; dactylus with a large blunt tooth proximally, tip of dactylus hooked.

Description: Merus of major cheliped longer than high, highest proximally; upper margin nearly straight, slightly concave proximally; lower margin converging distally, its proximal part not well preserved, it seems to possess several blunt spines; proximal margin unknown; keel paralleling upper margin; surface finely granulated mostly in the lower half. Carpus much longer than high ($L2/H2 = 2.59$); distal margin

not well preserved, appears to be straight; upper margin straight; lower margin slightly convex proximally, straightening distally; proximo-lower margin rounded. Manus longer than high ($L3/H3 = 1.49$); proximal, upper and lower margins straight; distal margin with large triangular tooth at the base of fixed finger. Fixed finger narrowing distally and projecting slightly upward in the sharp tip; upper margin slightly convex. Dactylus stouter and somewhat longer than fixed finger; lower margin armed with a large blunt tooth proximally; tip of dactylus ending in sharp hook in nearly right angle. The surface of merus, carpus and propodus distinctly reticulate.

Measurements: $L1 = 11.7$; $H1 = 5.5$; $L2 = 18.1$; $H2 = 7.0$; $L3 = 10.4$; $H3 = 7.0$; $L4 = 15$; $L5 = 5.8$. All measurements are in mm. For explanations to the abbreviations of measured parameters see Fig. 4.

Discussion: The shape of the propodus in combination with the dactylus of the holotype specimen (Fig. 3) is unique among all extant or fossil representatives of *Callichirus* and thus the designation of the new species is warranted.

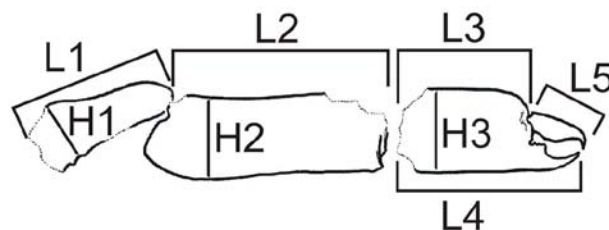


Fig. 4. Measurements taken on the holotype of *Callichirus bertalani* sp. nov. (for the values see the text).

Discussion

Notes on palaeobiogeography

The oldest record of the genus is *Callichirus waagei* from Maastrichtian of South Dakota (Crawford *et al.*, 2006) and suggests the western Atlantic origin of the genus. It seems that the genus migrated southward to high southern latitudes until or before the Eocene time. This migratory way was recognized for several decapod taxa by Feldmann and Schweitzer (2006). However, the fossil record of the genus *Callichirus* is very scarce and further conclusions are rather difficult to make. The genus is today restricted to the eastern and south-western Atlantic Ocean and the south-western Indian Ocean. There is no extant member of the genus known from the Mediterranean. However, the present specimen documents the presence of *Callichirus* in the Paratethyan realm during the Miocene. This is the first known occurrence of the genus in Europe. It is possible that *Callichirus* was one of many genera which did not survive the Messinian salinity crisis and has never been introduced to the Mediterranean again.

Notes on palaeoecology

Extant species of the genus *Callichirus* typically inhabit normal marine environments in intertidal to sublittoral areas, mostly in fine siliceous substrates typical of beaches and sand bars (e.g. Griffiths and Suchanek, 1991; Bishop and Bishop, 1992; Schweitzer and Feldmann,

2000; Botter-Carvalho *et al.*, 2002). Remains of *Callichirus*, if found in autochthonous position, can be considered as indicators of intertidal to sublittoral marine environments with normal salinity.

The burrows assigned to *Callichirus* have been recognized in the fossil record. Burrows assignable to *Callichirus major* were described from Pleistocene deposits of Georgia and South Carolina by Weimer and Hoyt (1964) and Erickson and Sanders (1991). Stilwell *et al.* (1997) and Schweitzer and Feldmann (2000) described the ichnofossil *Ophiomorpha* from the Eocene erratics of Antarctica representing the burrows of *Callichirus symmetricus*. Schweitzer and Feldmann (2000) reported claw fragments inside these burrow structures. Waage (1968) reported a single claw inside an *Ophiomorpha* from Maastrichtian rocks of South Dakota, which was later recognized as a cheliped of *Callichirus* (Crawford *et al.*, 2006).

Griffis and Suchanek (1991) characterized the burrows of the genus *Callichirus* as the type 4 in their classification, for which a single opening, long, narrow vertical shaft, and deep, reticulate branching are typical. The nature of the burrows of the extant *Callichirus major* is very well known (e.g. Weimer and Hoyt, 1964; Frey *et al.*, 1978; Bishop and Bishop, 1992).

Ophiomorpha is commonly found in the fossil record. As seen above, in several cases the producer was identified as a member of the genus *Callichirus* (Weimer and Hoyt, 1964; Erickson and Sanders, 1991; Stilwell *et al.*, 1997; Schweitzer and Feldmann, 2000; Crawford *et al.*, 2006). However, not all occurrences of *Ophiomorpha* can be ascribed to *Callichirus*, as different callianassid genera are able to produce very similar burrow structures (e.g. Frey *et al.*, 1978; Bishop and Bishop, 1992).

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