

# TRACE FOSSILS CONCEPTS, PROBLEMS, PROSPECTS

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# Zoophycos and the Role of Type Specimens in Ichnotaxonomy

Daide Olivero

**SUMMARY:** *Zoophycos* is a very complex trace fossil and there is still no real agreement concerning the taxonomy and the significance of the ichnofossil. What exactly are the varied structures collected under the name *Zoophycos*? The type specimen, the first trace fossil named *Zoophycos*, must be found and studied in order to approach this problem from a taxonomic point of view. The name *Zoophycos* was proposed in 1855 by Abramo Massalongo; but the specimens he used to describe the ichnogenus were macroalgae, not trace fossils. By chance, among the material described by Massalongo, a new type ichnospecies can be designated. As it is a true trace fossil, the name *Zoophycos* may be preserved.

## INTRODUCTION

The trace fossil *Zoophycos* can be considered a good example of a taxonomic problem, resulting from old interpretations and lack of studies on the type material. *Zoophycos* is a complex and enigmatic ichnofossil that has challenged generations of geologists and ichnologists for over a century. Till now, its producer or producers remain elusive. This ichnofossil is cosmopolitan and it occurs in diverse marine sedimentary facies ranging from Palaeozoic to Holocene. The trace fossils commonly included in the ichnogenus *Zoophycos* are characterized by a great morphological complexity and variability, which has resulted in confusing ichnotaxonomy and diverse interpretations of the producer and behaviour.

The palaeoenvironmental significance and the ethology of the supposed tracemakers have been the object of many studies, but till date there has been no real agreement among ichnologists.

What is a *Zoophycos*? First of all, it is necessary to find the first specimen described by the name *Zoophycos*, that is, the type specimen or holotype. This type material has never been studied in detail since it was first recorded in 1855; and this may be considered one of the main reasons for the taxonomic confusion. Sometimes, such type specimens may have been lost, destroyed or, in other cases, they appear to belong to another type of fossil. In such cases, it is necessary to find another type of specimen to replace it, as already proposed for another ichnofossil, *Helminthopsis*, by Wetzel and Bromley (1996). The aim of this paper is to present the result of such a search, in the northern part of Italy, where the first *Zoophycos* was described in 1855 by Abramo Massalongo.

## AN ENIGMATIC FOSSIL

*Zoophycos* Massalongo 1855 is now widely accepted as being a complex trace fossil produced by a wormlike organism, but this has not always been the case. The trace fossils commonly related to this ichnogenus have been recorded in deposits ranging from Cambrian to Holocene (Venzo, 1950; Miller, 1991; Wetzel and Werner, 1981; Bromley and Ekdale, 1984; Ekdale and Lewis, 1991; Olivero, 2003). *Zoophycos* occurs in diverse rock types, including sandstones

TABLE 13.1 List of Most Important Synonyms, with their Authors and the Corresponding Interpretations (Olivero, 1995)

Year	Author	Name	Interpretation
1828	Brongniart	<i>Fucoides circinatus</i>	seaweed
1842	Vanuxem	<i>Fucoides cauda-galli</i>	plant?
1844	Villa	<i>Fucoides brianteus</i>	seaweed
1846	Dumas	<i>Fucoides</i>	seaweed
1850	Massalongo	<i>Zonarites? caput-medusae</i>	seaweed
1851	Massalongo	<i>Zoophycos</i>	seaweed
1851	Savi & Meneghini	<i>Gorgonia? targionii</i>	organic remains
1852	Massalongo	<i>Zoophyta calcifera</i>	animal
1855	Massalongo	<i>Zoophycos caput-medusae</i>	seaweed
		<i>Z. villae, Z. brianteus, Z. scarabelli</i>	seaweed
1858	Fischer-Ooster	<i>Taonurus brianteus, T. flabelliformis</i>	seaweed
1858	Thiollière	<i>Chondrites scoparius</i>	plant
1863	Hall	<i>Spirophyton cauda-galli</i>	seaweed
		<i>S. velum, S. typum, S. crassum</i>	seaweed
1866	Gastaldi	<i>Zoophycos</i>	seaweed
1867	Trautschold	<i>Sagminaria</i>	seaweed
1869	Schimper	<i>Physophycus, Alectorurus</i>	seaweed
1873	(de) Saporta	<i>Cancellophycus liasinus</i>	seaweed
		<i>C. scoparius, C. reticularis, C. marioni</i>	seaweed
1881	Nathorst	<i>Alectorurus</i>	structures of currents
1882	(de) Saporta	<i>Glossophycus camillae</i>	seaweed
1886	Sacco	<i>Zoophycos funiculatus, Z. gastaldi</i>	seaweed
1888	Sacco	<i>Zoophycos pedemontanus</i>	seaweed
1890	Squinabol	<i>Zoophycos insignis</i>	seaweed
1893	Fuchs	<i>Spirophyton</i>	trace fossil
1902	Barsanti	<i>Zoophycos</i>	seaweed
1950	Lucas	<i>Cancellophycus liasinus</i>	animal
1950	Venzo	<i>Zoophycos</i>	seaweed
1967	Seilacher	<i>Zoophycos</i>	trace fossil
1975	Häntzschel	<i>Zoophycos</i>	trace fossil
1991	Miller	<i>Spirophyton</i>	trace fossil

(Venzo, 1950; Brongniart, 1828; Miller, 1991), calciturbidites (Savary et al., 2004), limestones, marly limestones and marls (Ekdale and Lewis, 1991; Olivero, 1996), chalk (Bromley and Ekdale, 1984), carbonate muds (Wetzel and Werner, 1991). Also the paleoenvironments greatly vary: inner platform (Miller, 1991), outer platform to slope (Bottjer et al., 1988; Ekdale and Lewis, 1991; Olivero, 1996, 2003), deep basin (Wetzel and Werner, 1981; Olivero, 2003).

The range of morphology documented by the specimens collected in these settings is so large that several synonyms and interpretations have appeared since 1855 (Table 13.1). For example, *Zoophycos* was first interpreted as a plant or algae, and the most common synonyms used were *Cancellophycus*, *Fucoides*, *Spirophyton* and *Taonurus*. A plant origin

was widely accepted by most authors through out the nineteenth century. Sometimes, the plant hypothesis was so strong that curious reconstructions were made, like the one presented in Fig. 13.1. This model, named *Zoophycos destefanii*, produced in the last years of the nineteenth century, shows typical roots at its base. It was based on an unknown specimen. This reconstruction, originally stored in the Museum of Natural History of Florence (Italy), has now disappeared. It was only in 1893 that the hypothesis of the activity of some type of organisms at the seafloor appeared (Fuchs, 1893). Today there is agreement that *Zoophycos* is a spreite trace fossil (see Olivero and Gaillard, this volume, Chapter 28, for a detailed description), but there is no consensus about the morphology, taxonomy and palaeoenvironmental significance of the ichnofossil, or the nature

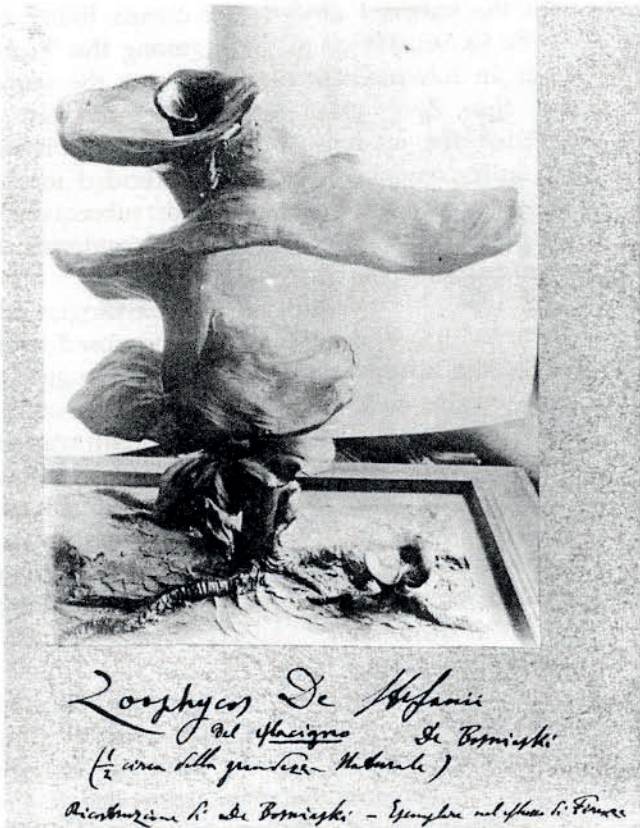


FIGURE 13.1 *Zoophycos de stefanii*. Photograph of a model of *Zoophycos*, nineteenth century. Handwriting by F. Sacco. The object, now missing, was originally stored in the Natural History Museum of Florence. 'Roots' had been added at the base of the model, according to the dominant interpretation of *Zoophycos* as a plant.

and ethology of the producer (Kotake, 1989, 1992; Olivero and Gaillard, 1996).

Lack of agreement regarding the morphology and producers reflects the large variability of the studied material. In 1995, Uchman proposed the term '*Zoophycos* group' to include all the traces sharing some common morphological characteristics. In this group, probably different traces produced by different organisms are grouped under the same name.

A comprehensive and definitive taxonomic revision will clarify the range of morphology of the trace fossil and provide the basis needed for interpretation. A detailed description of a *Zoophycos* from southeastern France was provided (Olivero, 2003) and delineated the most common characteristics of the ichnofossil. In this review, some ichnotaxa previously interpreted as *Zoophycos*, have been drawn aside, awaiting further studies. The ichnofossils from southeastern France have been considered as 'true'

*Zoophycos* because they are very similar to the first specimens described in 1855 by Massalongo. A short historical review is presented below.

### *Zoophycos*: A Short History

The first undoubted *Zoophycos* was depicted by Vanuxem in 1842. It was collected in Devonian deposits of the United States (Esopus Grit Formation, New York). The drawings of the fossils, which the author named *Fucoides cauda-galli* and *Retort Fucoid* and possibly interpreted as seaweed, show the typical morphology of the ichnotaxon. In 1844, in northern Italy, Villa described large and circular traces, with spiralling furrows having a central depression. Unfortunately no figures were provided. The author named the fossils *Fucoides brianteus*, once again interpreted as plant remains.

It was in 1850 that Abramo Massalongo described some fossils originating from the Monte Bolca, north of Verona, northern Italy. The fossils, which were not depicted, were called *Zonarites? caput medusae*. In the next year (1851), the same author changed the name to *Zoophycos* and, in 1855, four species of what he considered to be plant remains were described with beautiful drawings: *Zoophycos caput-medusae* (Fig. 13.2), *Z. villae* (Fig. 13.3), *Z. brianteus* (Fig. 13.4), and *Z. scarabelli*.

The synonym *Spirophyton* appeared in 1863, when Hall discovered some traces in Upper Palaeozoic deposits from New York and Ohio. In 1873, de Saporta proposed another synonym, *Cancellophycus*, for some fossils collected in Jurassic deposits near Lyon (France).

But *Zoophycos* gradually became the dominant name starting in the last decade of the nineteenth century (Sacco, 1886; Barsanti, 1902), even if some synonyms continue to be used, *Spirophyton* (Simpson, 1970; Miller, 1991) and *Cancellophycus* (Lucas, 1950), and the structure widely accepted as the result of animal activity rather than the body fossil of a plant.

In conclusion, the author who introduced the name was Massalongo. Who was Abramo Massalongo?

### Abramo Massalongo (1824–1860)

Abramo Massalongo was born in Tregnano (near Verona, northern Italy) on May 13, 1824. As a botanist, he studied the lichens and, as a palaeobotanist, he studied the fossil flora from Monte Bolca, located north of Verona, and from other localities of



FIGURE 13.2 *Zoophycos caput-medusae*. Original drawing from Massalongo, 1855, plate 1. Three specimens can be seen on a slab of limestone.

northeastern Italy. He died in Verona on May 25, 1860. During his short life, Massalongo collected numerous fossils and a large part of them can be seen in the Natural History Museum of Verona. Among them, is the *Zoophycos* type specimen from Monte Bolca (Fig. 13.5).

Monte Bolca is a lagerstätte, known since the sixteenth century (Sorbin, 1972). The formation, which consists of 19 metres of lithographic limestones is dated to the Eocene and is rich in fishes and plants, with a high quality of preservation. The site was a tropical lagoon separated from the open sea by coral reefs.

In 1850, while studying some fossils from Monte Bolca, Massalongo observed specimens very similar to the fossils described by Villa (1844). Massalongo described one of these fossils with the following diagnosis, in Latin, '*Z. fronde membranacei plana, radiatim expansa, basi, in caespite crasso coacervata: lobis linearibus, simplicibus (aliquando apice bifidis),*' which means 'radiating and planar membranous fronds, base formed by a thick clump: linear and simple lobes (while sometimes with a bifurcate apex).' Massalongo named this form *Zonarites? caput medusae*, and he doubtfully classified it among

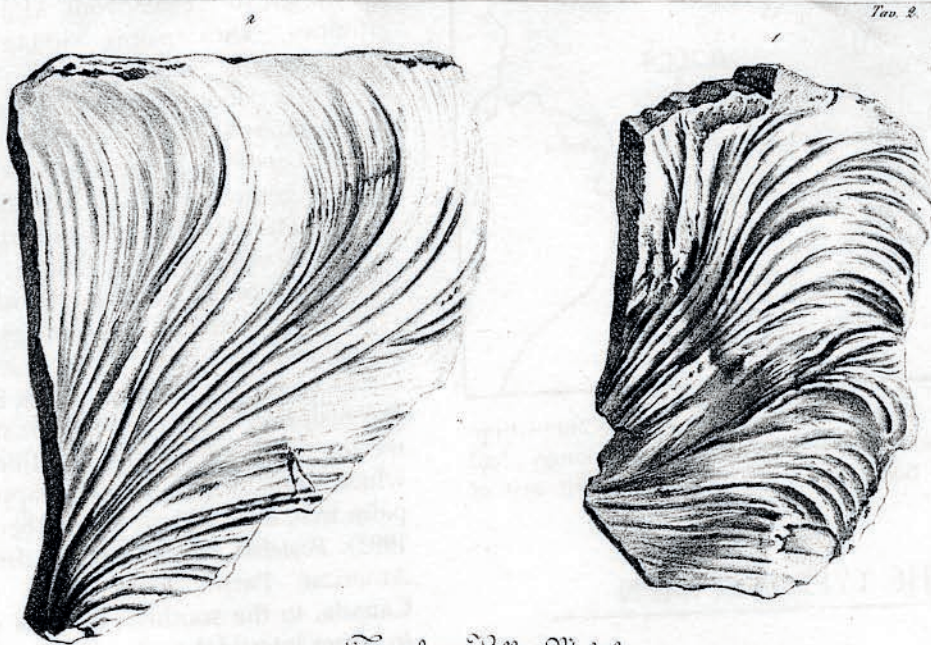
the aquatic plants. The next year (1851), using this fossil, he proposed the generic name *Zoophycos*, without a new diagnosis. He suggested a similarity with the seaweed *Phyllospora comosa* living in the Pacific Ocean. He classified it among the 'Fucoidea' or in an intermediate place between the seaweeds and the 'Zoophytae' (an abandoned term that included the sponges, coelenterates and bryozoa). Not fully convinced, in 1852, he decided to classify the specimens as 'Fucoidea', and, subsequently, as 'Zoophyta calcifera' (Anthozoa), considering them as animal remains.

In 1854, Massalongo met the zoologist Milne-Edwards (in Gastaldi, 1866), who proposed for these fossils the name of 'Algarum' and suggested a plant origin, following the hypothesis of Unger (1844; in Gastaldi, 1866). The plant origin was finally accepted by Massalongo in 1855, when he wrote a monograph about a new genus of plant named *Zoophycos* using the specimen previously named *Zonarites caput-medusae*, together with other fossils collected, not in the Monte Bolca, but in Tusca. It is in this work that *Zoophycos* is depicted for the first time in three plates.

The characteristics for this genus applies to all the fossils described in his monograph: '*Frondes simplices vel ramosae, lineares, fistulosae, creberrimae, radiantes, vel spiraliter convolutae, segregatae sc. Liberae, vel coalitae, basi in stipitem crassum cylindricum v. conicum v. Subrotundum elevatum inaequale saepe infundibuliformen, congestae,*' which means 'fronds simple or ramified, linear, tubular, tightly packed, radiating or spirally coiled, isolated and free, or coalescent, base in a large trunk cylindrical or conical or irregularly sub-rounded, usually full funnel shaped'.

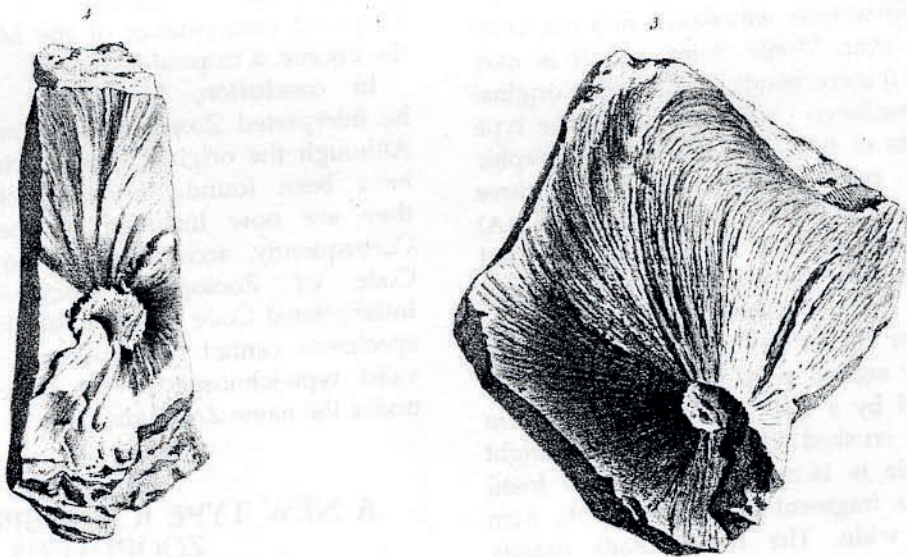
After having recognized the similarity of these forms with *Fucoidea brianteus* Unger and with *Gorgonia targionii* Savi and Meneghini, he proposed (1855) four new species: *Zoophycos caput-medusae*, *Zoophycos villae* (also known as *Gorgonia targionii* Savi and Meneghini), *Zoophycos brianteus* and *Zoophycos scarabelli* (similar to the *Fucoidea cochleatum* Savi and Meneghini, not depicted in the monograph). Classically, the first is usually considered as the type ichnospecies for the ichnogenus.

The drawings corresponding to these four species never show any marginal tube; *Z. brianteus* has lamellae closer and more tightly packed than *Z. villae*, while *Z. caput-medusae* shows nearly straight lamellae. Fortunately, the figures are of good quality, and possibly they really represent the original fossils. Where are these specimens now?



*Zoophycos Villae. Masfal.*

FIGURE 13.3 *Zoophycos villae*. Original drawings from Massalongo, 1855, plate 2. The two specimens show lamellae radiating from a central point, more visible in the figure on the left.



*Zoophycos Brianteus. Masfal.*

FIGURE 13.4 *Zoophycos brianteus*. Original drawings from Massalongo, 1855, plate 3. Two specimens; the figure on the left seems to be the imprint of the fossil on the right.

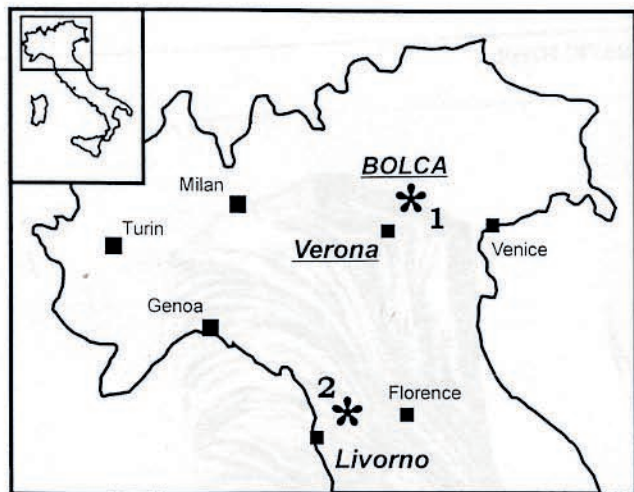


FIGURE 13.5 Geographical setting of the localities from where the *Zoophycos*, described by Massalongo, had been collected. Bolca lagerstätte is located north-east of Verona.

### THE TYPE SPECIMEN

Some of the fossils depicted by Massalongo in 1855 have been found in the Natural History Museum of Verona: specimens of *Zoophycos caput-medusae* (the supposed original type ichnospecies), *Zoophycos brianteus* and *Zoophycos villae*, together with other fossils that can be related to *Zoophycos*. The original figures of these fossils, as for the two other species, have been printed in reverse compared to the actual specimens.

*Zoophycos caput-medusae* was stored in a collection of fossil plants from Monte Bolca and it is easy to recognize that it corresponds exactly to the original drawing by Massalongo (1855, Fig. 13.6). The type specimen consists of two slabs of fine lithographic limestone; each part and counterpart of three specimens is well preserved. The first one (A) is nearly complete, with a stalk 6 cm long and 2–3 cm wide. At the top, numerous thin and straight fronds expand radially from the stalk, forming a circular cluster having an average width of 16–17 cm. The second specimen (B) lies on one side: it is formed by a stalk 4.5 cm long and 2 cm wide, having a crushed cluster of thin straight fronds. The whole is 16 cm long. The third fossil (C) is probably a fragment of another stalk, 6 cm long and 2 cm wide. The three fossils exactly correspond to the type-ichnospecies, described and depicted by Massalongo in 1855, but the name appearing on the label below is *Postelsiopsis caput medusae*, not *Zoophycos*.

These specimens were reinterpreted in 1926 by an Italian botanist, Achille Forti, who studied the fossil seaweeds from Monte Bolca and their affinities with some living species in the Indian-Pacific Ocean (Forti, 1926). The author suggested that *Zoophycos caput medusae* must be considered a fossil of a neritic 'seaweed' living in the Eocene sea of the Monte Bolca and very similar to the genus *Postelsia* that today has only one species, *Postelsia palmaeformis* Ruprecht.

This species of macroalgae was described for the first time in 1852 by Franz Joseph Ruprecht, who discovered it near Bodega Bay (California). It belongs to the Family Lessoniaceae, of the Order Laminariales in the Class Phaephyceae. It is a greenish-brown alga with thick stipes (Fig. 13.7). At the top of the stipes there is a thick cluster of fronds, which give to this alga the appearance of a little palm tree, about 50 cm high (Abbott and Hollenberg, 1993). *Postelsia palmaeformis* is distributed along the American Pacific Coast from Vancouver Island, Canada, to the southern coast of California, it is found to upper intertidal environments of high wave energy (Paine, 1988).

A comparison of this seaweed with the type series of *Zoophycos caput-medusae* (Fig. 13.8) shows a real similarity. In both cases the cluster is formed by linear fronds 5–10 cm long, all radiating from a thick stipe. It is this similarity that convinced Forti to modify the name of the fossil to *Postelsiopsis caput medusae*, as it now appears on the museum label. The interpretation of the fossils as seaweeds is supported by the supposed environment of the Monte Bolca during the Eocene, a tropical lagoon.

In conclusion, Massalongo was right when he interpreted *Zoophycos caput medusae* as an alga. Although the original type specimens of *Zoophycos* have been found, they are not trace fossil, but they are now included in the plant kingdom. Consequently, according both to the International Code of Zoological Nomenclature and the International Code of Botanical Nomenclature, these specimens cannot be considered as representing a valid type-ichnospecies for trace fossils collected under the name *Zoophycos*.

### A NEW TYPE ICHNOSPECIES FOR ZOOPHYCOS

The name *Zoophycos* has been widely used and accepted by most ichnologists for at least one century. To change the name would be quite confusing and it is

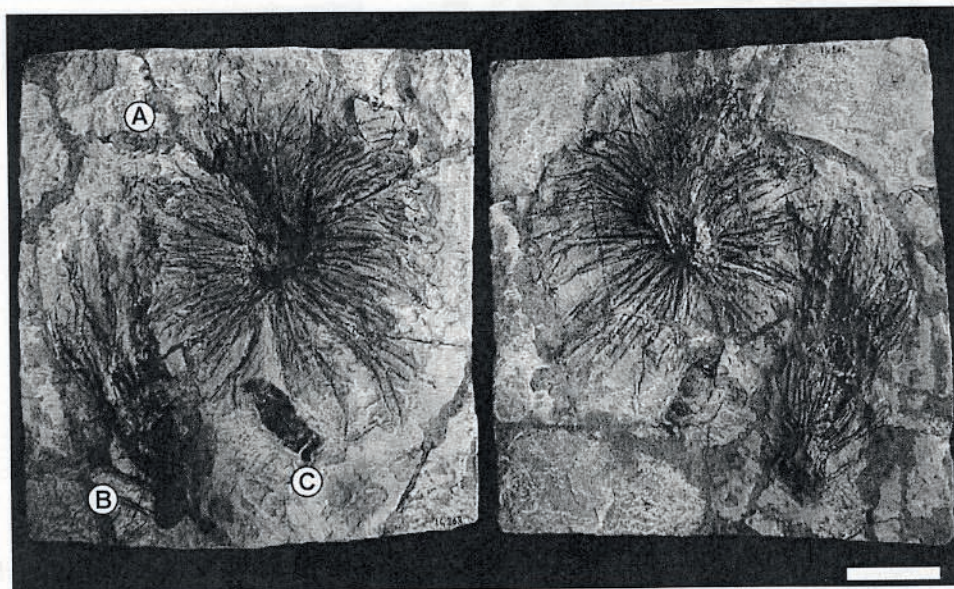


FIGURE 13.6 *Postelsiopsis caput medusae* Massalongo. Two slabs of lithographic limestone, with part (left) and counterpart (right) of three fossils. (A) Complete cluster of fronds and part of a stipe. (B) Smaller cluster and stipe. (C) Fragment of stipe. Eocene, Monte Bolca (Italy). Originally named *Zonarites-?caput-medusae* (Massalongo, 1850), then *Zoophycos caput medusae* (Massalongo, 1851). First figure of the trace fossil in Massalongo, 1855 (plate 1). The name *Postelsiopsis caput medusae* was proposed by A. Forti in 1926. Natural History Museum of Verona, specimen number fG268. Scale bar = 5 cm.



FIGURE 13.7 *Postelsia palmaeformis* Ruprecht. (1) Specimen 40 cm high, with three stipes and well developed cluster of fronds. Photograph provided by Dr. Michael Clayton (University of Wisconsin-Madison, Department of Botany). (2) Colony of seaweeds on a California beach. Photograph provided by Dr. Karina Nielsen (Sonoma University).

highly probable that most ichnologists would choose to preserve it. For these reasons I would prefer not to replace it. The only way to avoid such profound change is to find a new type-ichnospecies for the

ichnogenus. Fortunately, in 1855, Massalongo described and depicted other specimens, proposing three other species together with *Z. caput-medusae*. His original definition applies to all of the four species.



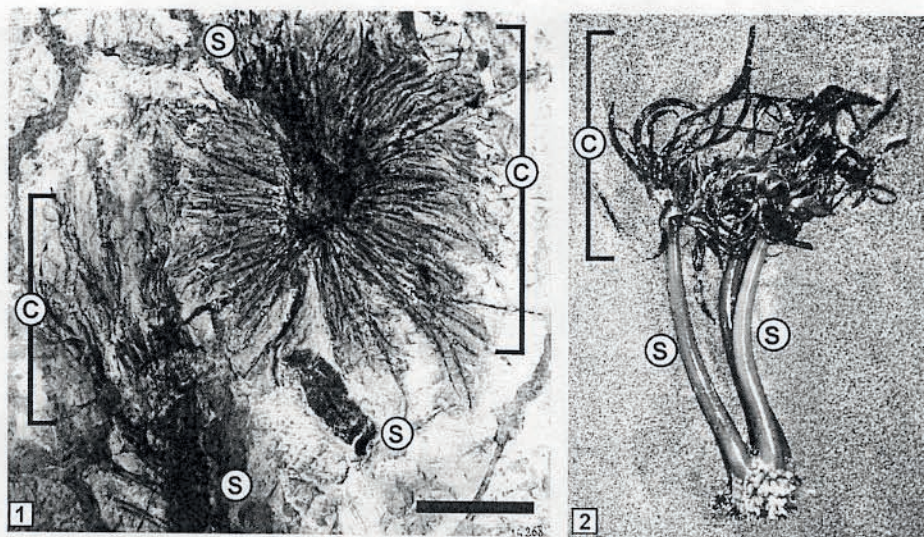


FIGURE 13.8 Comparison between *Postelsiopsis caput medusae* Massalongo (1) and *Postelsia palmaeformis* Ruprecht (2). S: stipes; C: cluster of fronds. Photo of *Postelsia* provided by Dr. Karina Nielsen (Sonoma University). *P. caput-medusae* from the Natural History Museum of Verona (cf. Fig. 13.6). Scale bar = 5 cm.

Two of them have been found: *Zoophycos brianteus* (Fig. 13.9) and *Zoophycos villae* (Figs. 13.11–13.13). They were stored in the collection of the sedimentary structures of the Natural History Museum of Verona and have now been moved to the collection of organic traces.

A detailed analysis of the fossils confirm that they are true trace fossils, with the typical characters usually observed in the most common *Zoophycos*. I propose with some of these fossils, a new type-ichnospecies of *Zoophycos*, with a lectotype and a paralectotype. A lectotype is a specimen or illustration that can replace the original holotype if the original is missing or belongs to another taxon; a paralectotype is each of the other specimens, or illustrations, belonging to the same species series, from which the lectotype has been chosen (see the International Code of Zoological/Botanical Nomenclature for more details). I also propose another ichnospecies (lectotype and paralectotype), that permits us to observe other typical characters of the trace fossil.

### ICHNOGENUS ZOOPHYCOS MASSALONGO 1855

Type-ichnospecies: *Zoophycos brianteus*  
Massalongo 1855

**Characteristics:** Spreiten structures consisting of numerous J or U-shaped protrusive burrows of variable length and width. The spreiten form laminae

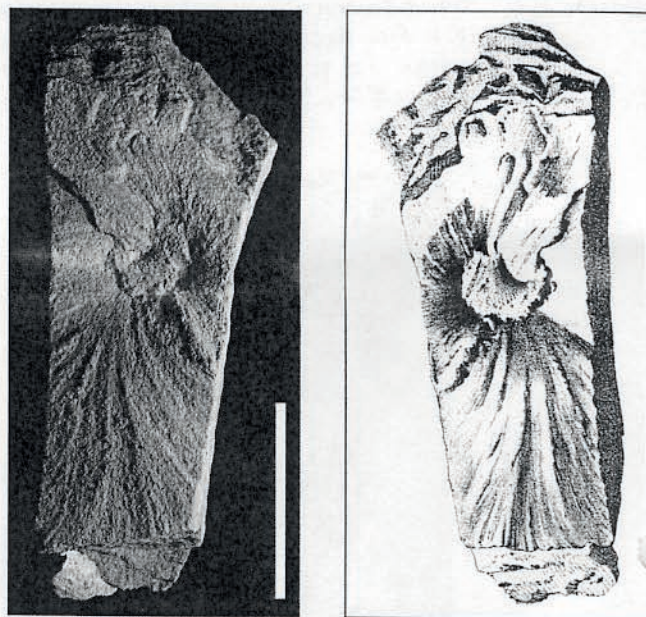


FIGURE 13.9 *Zoophycos brianteus* Massalongo 1855. Comparison between the lectotype (Verona Museum number ICN3) on the left and the original figure from Massalongo (plate 3) on the right. The drawing was printed in reverse compared to the original fossil. Scale bar = 5 cm.

bordered by a marginal tube, spirally coiled around a central 'virtual' axis, constructed upward or downward, furrowed by numerous lamellae (primary and secondary). In section, the laminae show the typical backfill structure, formed during the lateral

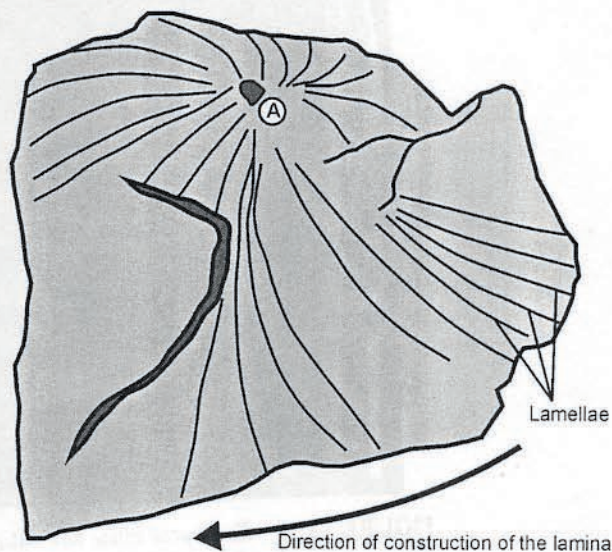


FIGURE 13.10 *Zoophycos brianteus* Massalongo 1855. Paralectotype (Verona Museum number ICN4). Specimen stored in the same box as the previous fossil. Spirally coiled structure is clearly visible. A = apex. Scale bar = 5 cm.

displacement of the marginal tube (based on Häntzschel, 1975; Uchman, 1999; Olivero, 2003).

*Ichnospecies in the ichnogenus:*

Ichnospecies *Zoophycos brianteus* Massalongo 1855, plate 3

Lectotype: specimen no. ICN3 (Ichnofossile Numero), Natural History Museum of Verona (Fig. 13.9)

Type locality: Tuscany (Italy)

Principal synonyms:

1844—? *Fucooides brianteus* Unger, p. 31

1851—? *Gorgonia targionii* Savi and Meneghini, p. 128

1885—? *Taonurus brianteus* Fischer-Ooster, p. 6, plate 1a, Fig. 13.1.

**Characteristics:** *Zoophycos* with a lamina spirally coiled and with an outline slightly lobed.

Description of the lectotype: Of the original illustration of Massalongo (1855, plate 3, Fig. 13.4), only the specimen depicted on the left has been found. It is the imprint of the central part of the trace fossil depicted on the right of the same plate. The trace fossil is formed by slightly sinuous lamellae, 1–2 mm wide and 3–6.5 cm long, radiating from a central axis, 2.5 cm in width. The trace fossil covers a brown limestone specimen and was found in the Upper Cretaceous deposits near Livorno (northern Italy). The fossil drawn on the right part of plate 3 (Massalongo, 1855) shows the typical helicoidal morphology of

*Zoophycos*, with the lamellae radiating from the central axis. The lamellae bend near the border where no marginal tube is clearly visible. The lamina seems to be constructed downwards, but the polarity of the sample is unknown. Assuming that Massalongo depicted the fossil at the exact scale, this specimen should be 10–13 cm wide and could only be part of a larger structure.

Ichnospecies *Zoophycos brianteus* Massalongo 1855 (not depicted)

Paralectotype: specimen no. ICN4, Natural History Museum of Verona (Fig. 13.10)

Type locality: Tuscany (Italy)

Description of the paralectotype: The specimen was found in the same box as the previous specimen, with the same name on the associated label. Even if this trace fossil was not depicted by Massalongo, I propose to use it as a paralectotype. The typical spirally coiled structure is clearly recognizable. The specimen is 20 cm wide having lamellae, 1–2 mm wide, starting from the preserved upper apex and slightly bending toward the external part of the spreite. The borders of the lamina, which is 3 mm thick, are not visible. The direction of construction is downward and clockwise.

In order to observe the other characteristics of *Zoophycos*, other specimens are chosen and a lectotype and a paralectotype are proposed.

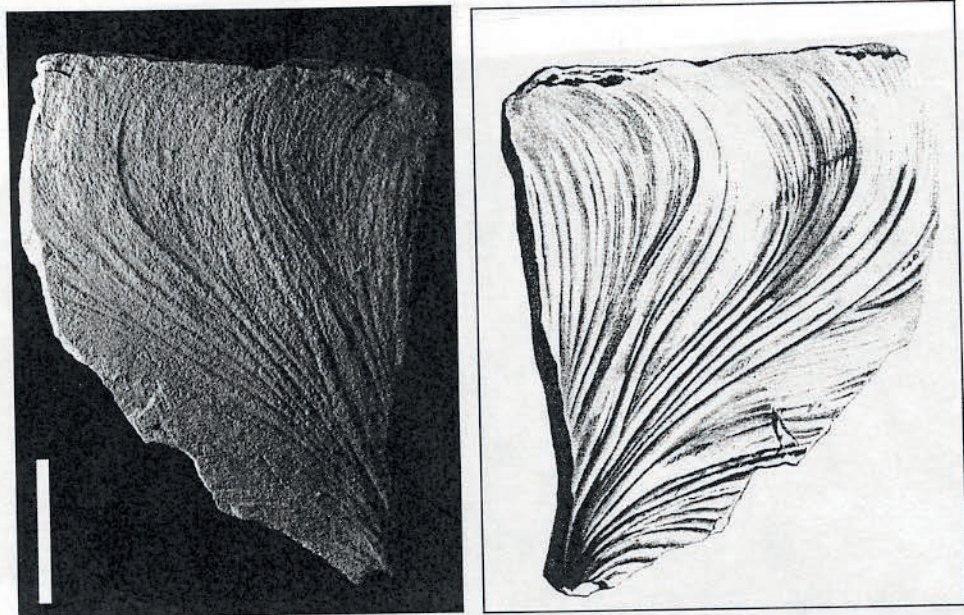


FIGURE 13.11 *Zoophycos villae* Massalongo 1855. Comparison between the lectotype (Verona Museum number ICN2), on the left, and the original figure from Massalongo (plate 2), on the right. The drawing was printed in reverse compared to the original fossil. Scale bar = 5 cm.

Ichnospecies: *Zoophycos villae* Massalongo 1855, plate 2

Lectotype: specimen no. ICN2, Natural History Museum of Verona (Figs. 13.11, 13.12)

Type locality: Tuscany (Italy)

Principal synonyms:

1844—? *Fucoides brianteus*, Unger, p. 31

1851—? *Gorgonia targionii*, Savi and Meneghini, p. 128

1885—? *Taonurus brianteus* Fischer-Ooster, p. 6, plate 1a, Fig. 13.1.

**Characteristics:** *Zoophycos* with a lamina furrowed by numerous sinuous and long lamellae radiating from a raised apex.

Description of the lectotype (Fig. 13.11): The specimen corresponds to the one depicted by Massalongo (1855) on the left of the plate 2. It is in a slab of grey limestone, 17 cm long, 14 cm wide, and 2 cm thick, with a part of a *Zoophycos* lamina on the upper surface. It was found in the Upper Cretaceous deposits of Livorno (Italy). The lamellae, 1–2 mm wide and sinuous, radiate from a raised point of the slab. At the beginning, the lamellae are simple, but divide into two, three or more smaller lamellae, all curved and nearly tangential to one side of the slab. The section of the lamina, 3 mm thick, is well preserved (Fig. 13.12) and reveals the backfill structure typical of the lateral movement of a *Zoophycos* marginal tube.

Ichnospecies *Zoophycos villae* Massalongo 1855, plate 2  
 Paralectotype: specimen no. ICN1, Natural History Museum of Verona (Fig. 13.13)  
 Type locality: Tuscany (Italy)

Description of paralectotype (Fig. 13.13): It corresponds to the specimen depicted by Massalongo (1855), on the right side of plate 2. The specimen is incomplete and consists of a part of a lamina on a fragment of Upper Cretaceous brown limestone from Livorno (Fig. 13.5). The fragment is 17 cm long and 10.5 cm wide. Several lamellae, sinuous and 2–3 mm wide, furrow the lamina. The lamellae, radiating from a point not preserved, start as simple structures, then, when they begin to bend, usually divide into two or three smaller ones.

## CONCLUSIONS

The ichnogenus *Zoophycos* was proposed for the first time in 1855 by Massalongo. Since the last decades of the nineteenth century, the name was adopted and accepted by most ichnologists. But the type specimens, as classically accepted, appear to be macroalgae, not trace fossils. The necessity to change the ichnogenetic name or to find a new lectotype arises from this finding. By chance, Massalongo collected other specimens, and

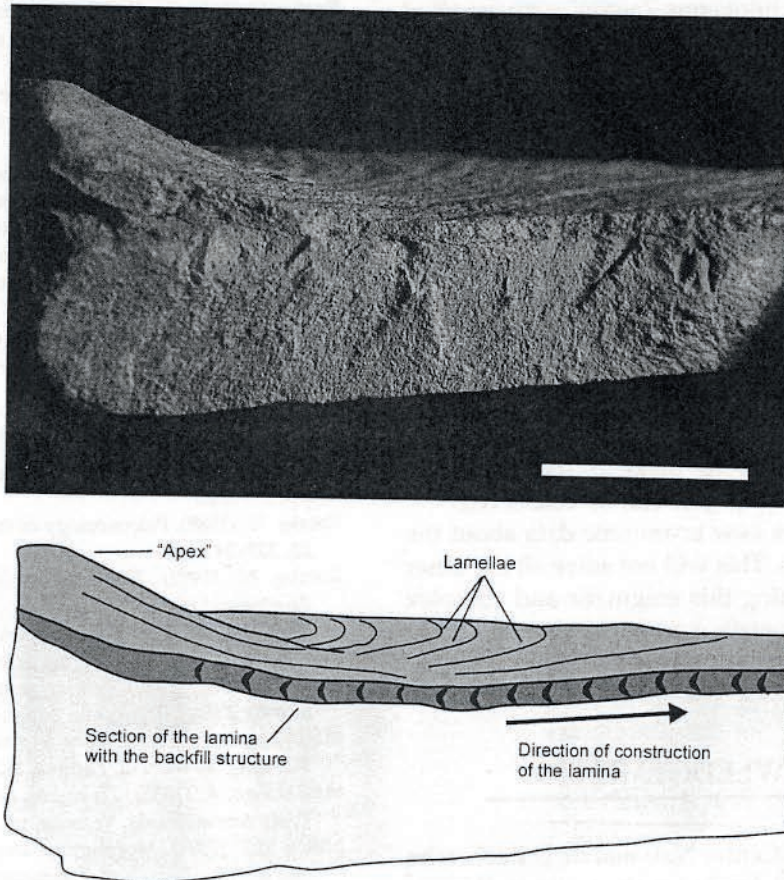


FIGURE 13.12 *Zoophycos villae* Massalongo 1855. Lectotype (Verona Museum number ICN2). Lateral view. On the left is the apex from where the lamellae radiate. The section of the lamina reveals the backfill structure, indicating the direction of construction of the lamina. Scale bar = 2 cm.

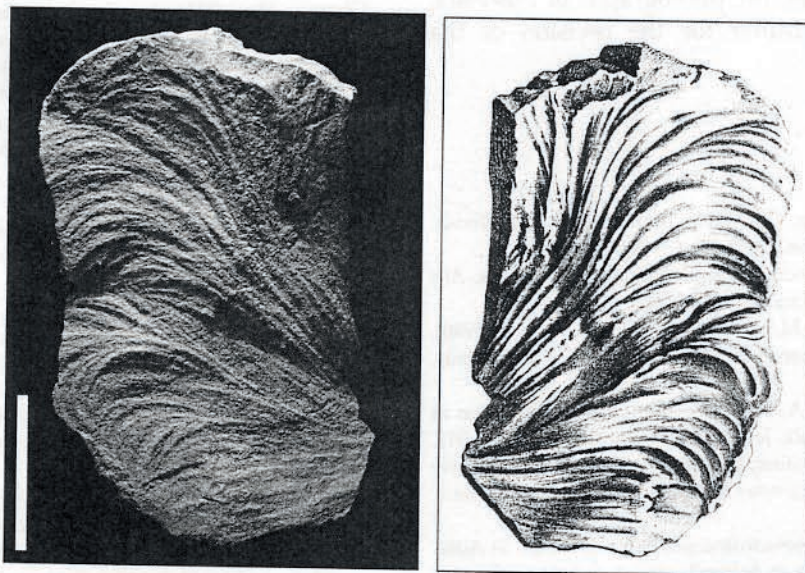


FIGURE 13.13 *Zoophycos villae* Massalongo 1855. Comparison between the paralectotype (Verona Museum number ICN1) on the left, and the original figure from Massalongo (plate 2) on the right. The drawing was printed in reverse compared to the original fossil. Scale bar = 5 cm.

his definition of the ichnogenus *Zoophycos* covers all of these fossils. By chance again, these are true trace fossils, and some of them have been found in the Natural History Museum of Verona. Consequently, I propose a lectotype (*Zoophycos brianteus* Massalongo 1855) for the new type-ichnospecies of the ichnogenus, together with a paralectotype, and to discontinue use of *Zoophycos caput-medusae* as the type ichnospecies. Another ichnospecies (*Zoophycos villae* Massalongo 1855), with a lectotype and a paralectotype, allow a better representation of the characteristics of the ichnogenus. Even though the most complete specimen of the type ichnospecies (Massalongo, 1855, plate 3, right side) has not been found yet, the presence of its counterpart is sufficient to make it the new type specimen. The name *Zoophycos* can be conserved.

This work provides new taxonomic data about the ichnogenus *Zoophycos*. This will not solve all the other controversies concerning this enigmatic and complex trace fossil, but it contributes to clearing up some nomenclatural problems concerning the type material.

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