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New insights into the Middle Jurassic floras of Sardinia (Italy) - The Miccolis Collection at the *Museo di Storia Naturale* of Venice, Italy

Giovanni G. Scanu, Evelyn Kustatscher, Paola Pittau & Johanna H.A. van Konijnenburg-van Cittert

G.G. Scanu, Dipartimento di Scienze Chimiche e Geologiche, Università degli Studi di Cagliari, via Trentino 51, I-09127 Cagliari; gioscanu@gmail.com
E. Kustatscher, Museo di Scienze Naturali dell'Alto Adige, via Bottai 1, I-39100 Bolzano, Italy; Department für Geo- und Umweltwissenschaften, Paläontologie und Geobiologie, Ludwig-Maximilians-Universität und Bayerische Staatssammlung für Paläontologie und Geologie, Richard-Wagner-Straße 10, D-80333 München, Germany; Evelyn.Kustatscher@naturmuseum.it
P. Pittau, Dipartimento di Scienze Chimiche e Geologiche, Università degli Studi di Cagliari, via Trentino 51, I-09127 Cagliari; pittaup@unica.it
J.H.A. van Konijnenburg-van Cittert, Laboratory of Palaeobotany and Palynology, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands; Naturalis Biodiversity Center, PO Box 9517, 2300 RA Leiden, The Netherlands; jtvk@kgk.nl

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ABSTRACT - The fossil plants of the Domenico Miccolis Collection, stored at the Museo di Storia Naturale of Venice (Italy), are from the Middle Jurassic Genna Selole Formation of central Sardinia. The assemblage contains 11 taxa: Marattia intermedia, Phlebopteris muensteri, P. braunii, Coniopteris *sp. cf.* C. hymenophylloides, Dicksonia kendallii, Eboracia *sp. cf.* E. lobifolia, Cladophlebis *sp.*, Weltrichia *sp. cf.* W. whitbiensis, Geinitzia divaricata, Brachyphyllum expansum *and* Carpolithes *sp. 2. Six species are described for the first time from the Jurassic strata of Sardinia (and Italy), thus increasing the known biodiversity of the flora of this age from these regions. The newly identified taxa have several characters in common with the well-studied Yorkshire flora (UK) indicating strong floristic affinities between southern and western Europe during the Jurassic.*

RIASSUNTO - [Novità sulle flore del Giurassico Medio della Sardegna (Italia) - La Collezione Miccolis presso il Museo di Storia Naturale di Venezia] - *In questo lavoro vengono presentati i risultati dello studio sistematico della flora fossile giurassica presente nella Collezione Miccolis, e conservata presso il Museo di Storia Naturale di Venezia. Questa raccolta è costituita da migliaia di pezzi provenienti da tutto il mondo, raccolti personalmente dal proprietario o acquistati presso rivenditori specializzati nel corso degli anni '70 e '80 del secolo. Allo scopo di valorizzare questo patrimonio, nel 2007 Miccolis contattò il Museo esprimendo il suo desiderio di donare i suoi reperti affinché fossero studiati ed eventualmente esposti. I reperti erano originariamente in mostra nella sua abitazione, a Quarto d'Altino (VE), su degli scaffali in un ampio scantinato adibito a laboratorio e alcuni di essi erano appesi alle pareti e incorniciati. Valutata l'entità della collezione, i reperti sono stati imballati dal personale del Museo, trasferiti a Venezia nel 2008, e collocati nei depositi di paleontologia. Solo alcuni sono stati rimossi dall'imballaggio, puliti e catalogati per essere esposti nelle sale museali, inaugurate nel 2010. Tra tutti, 21 lastre provengono dalle campagne di Laconi (OR) e Nurallao (CA), nella Sardegna centro-orientale, e sono oggetto di studio.*

I giacimenti giurassici che contengono piante fossili in Sardegna (Baiociano-Batoniano) si rinvengono nella litofacies di Nurri-Escalaplano appartenente alla Formazione di Genna Selole. Questa è costituita da depositi da silicoclastici a silicoclastici-misto carbonatici di origine da continentale a costiera e nella parte superiore si trovano sedimenti lagunari con influenza di marea, tra cui livelli ricchi a molluschi (Bathonella scotica, Cossmannea eudesii, Naricopsina umbilicata, Natica *cf.* parthenica, Nerinea bathonica). *Lo studio sistematico ha permesso il riconoscimento di 11 taxa. Nella collezione sono presenti strobili sporangiferi di sfenofite; felci marattiali* (Marattia intermedia), *osmundali* (Phlebopteris muensteri, P. braunii), Dicksoniaceae (Coniopteris *sp. cf.* C. hymenophylloides, Dicksonia kendallii, Eboracia *sp. cf.* E. lobifolia) *e* Cladophlebis *sp. Solo* Weltrichia *sp. cf.* W. whitbiensis *rappresenta le cicadofite mentre per le conifere si segnalano* Geinitzia divaricata *e* Brachyphyllum expansum. *Infine sono presenti semi di origine incerta identificati come* Carpolithes *sp. 2. Tra queste presenti, sei vengono descritte per la prima volta nel Giurassico della Sardegna e dell'Italia. Il confronto con la flora mediogiurassica dello Yorkshire (UK) infine suggerisce una marcata similarità tra le due flore.*

INTRODUCTION

Jurassic floras are abundant in Europe (48 localities) and characterized by a high diversity (~770 taxa; for more details see Barbacka et al., 2014). However, Jurassic floras are rare in Italy, with only six macroflora-bearing deposits known to date. Three floras (Rotzo, Como/Moltrasio, Monte Palombo) are dated to the Early Jurassic, and three (Sardinia, Lepini Mountains, Fallano Mt.) are referred to the Middle Jurassic. The most famous and diverse Early Jurassic flora comes from Rotzo (Vicentinian Alps, e.g., De Zigno, 1856-1868, 1873-1885; Grandori, 1913a, b; Wesley, 1956, 1958, 1966, 1974; Barale, 1982; Thévenard et al., 2005; Bartiromo & Barone Lumaga, 2009). The most diverse Middle Jurassic flora comes from Sardinia (e.g., Tornquist, 1902, 1904; Krasser, 1912, 1913, 1920; Edwards, 1929; Scanu et al., 2012, 2015). The floras of Como/Moltrasio, Monte Palombo, Fallano Mt. and Lepini Mountains are characterized by few plant remains and low diversity (Sordelli, 1896; Praturlon, 1965, 1968; Cocozza & Praturlon, 1966; Bonci & Vannucci, 1986; Bravi, 1995; Bravi et al., 2014). Forty-seven genera have been described from the Italian Jurassic floras, most from the Rotzo flora (33 genera). Only ten genera have been described in common from both the Rotzo and the Sardinian floras, including ferns (*Cladophlebis*, *Coniopteris*, *Elatocladus*, *Phlebopteris*), seed ferns (*Sagenopteris*), cycadophytes (*Pterophyllum*, *Ptilophyllum, Weltrichia*, *Williamsonia*) and conifers (*Brachyphyllum*). *Brachyphyllum* is the only genus present in all Italian Jurassic localities (Scanu et al., 2015).

Thus, the discovery of a small but diverse plant assemblage from the same Sardinian Jurassic sites

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as described before (Scanu et al., 2015) stored in the Museo di Storia Naturale of Venice is worth of note. This assemblage hosts several taxa not recorded previously from the Italian Middle Jurassic, although they are from the same localities and formation. It not only provides insights into the composition of the Sardinian Middle Jurassic flora but reveals that the two most important Italian Jurassic floras (Rotzo and Sardinia) are more similar than previously noted. This is of special interest considering that the Sardinian flora grew near the southeastern margin of Europe (Carmignani et al., 2001), whereas the Rotzo flora was part of the Adria plate (Winterer & Bosellini, 1981; Masetti & Romano, 2008).

MATERIAL AND METHODS

The Museo di Storia Naturale of Venice houses a collection of around one thousand fossils of plants and invertebrates (e.g., molluscs and echinoderms). The herein described plant fossils belong to the collection compiled by the Venetian Domenico Miccolis (Fig. 1), that bought and collected fossils from all over the world, and donated his entire assemblage in 2007 to the museum (Graziani, 2015). The Miccolis Collection includes 21 rock slabs from the Middle Jurassic continental deposits of Sardinia. Each slab bears several plant remains, commonly attributable to different taxa. Detailed stratigraphic data on these samples are missing, but all slabs are of the same lithology, a fine, light grey siltstone. These fossils have been found in the Nurallao (20 slabs) and Laconi (one slab) territories, in central-eastern Sardinia (Graziani, 2015).

Fig. 1 - Portrait of Domenico Miccolis (1928-2010), Venetian palaeontofil that bought and collected fossils all over the world during the 70ies and 80ies and donated all his patrimony to the Museo di Storia Naturale of Venice in 2007.

Plant fossils from the Sardinian Jurassic generally come from the Genna Selole Formation (Fig. 2), especially from the Nurri-Escalaplano lithofacies (Scanu et al., 2012, 2015; Costamagna, 2015). The Genna Selole Formation is composed of siliciclastic to mixed siliciclastic-carbonate deposits (Costamagna & Barca, 2004) of continental to coastal origin (see also Scanu et al., 2012 and references therein). The top of the formation contains lagoonal sediments that are tidally-influenced, and include mollusc-rich layers (e.g., *Bathonella scotica, Cossmannea eudesii*, *Naricopsina umbilicata*, *Natica* sp. cf. *N. parthenica*, *Nerinea bathonica*; Amadesi et al., 1960; Dieni et al., 1983; Dieni & Massari, 1985). The age is Bajocian-Bathonian, based on the mollusc fauna, palynomorphs and comparisons with coeval European outcrops (Del Rio, 1976, 1984; Dieni et al., 1983; Dieni & Massari, 1985). The overlying Dorgali Formation is composed of Bathonian-Kimmeridgian marine oolitic limestone (Dieni & Massari, 1985; Dieni et al., 2013). The plant remains discussed here are preserved as impressions and compressions in fine-grained siltstones belonging to the Genna Selole Formation.

Unfortunately, a silicon substance (probably Paraloid B52) brushed on the specimens hampers study of the finer foliar details and the capture of ideal photos with a digital reflex camera (Nikon D60). The fossils are stored in the Museo di Scienze Naturali of Venice and have the prefix MSNVE.

SYSTEMATIC PALAEOBOTANY

Division Sphenophyta

Sphenophyte strobili
(Pl. 1, fig. 1)

Description - Two oblong strobilus fragments (MSNVE 20423-4; Pl. 1, Fig. 1), are up to 15 mm long and 5 mm wide. The axis is not visible. The robust sporangiophore heads are irregularly square to rhombic and 1-1.5 mm in diameter. The heads have a concave central area and depressed lateral sides.

Remarks - Harris (1969, fig. 4A) described similar dispersed strobilar fragments from the Middle Jurassic of Yorkshire and attributed them to *Equisetum columnare* Brongniart, 1828 (=*Equisetites columnaris* [Brongniart] Phillips, 1875). However, the sporangiophore heads are about 3 mm in diameter in the Yorkshire material (Harris, 1961). Schweitzer et al. (1997) described juvenile forms belonging to this species (13 mm wide). Sphenophyte strobili similar to those from Iran and Afghanistan are also mentioned for the Early Jurassic of Hungary (Barbacka, 2009). Unfortunately, lack of details in the structure of the sporophyll heads makes an exact determination impossible. Sphenophyte strobili have never been described from the Jurassic of Sardinia. Comaschi Caria (1959) listed *Equisetum columnare* of this age, although so far we could identify only badly preserved stem fragments (Scanu et al., 2012, 2015).

Material - MSNVE 20423-4, 23402.

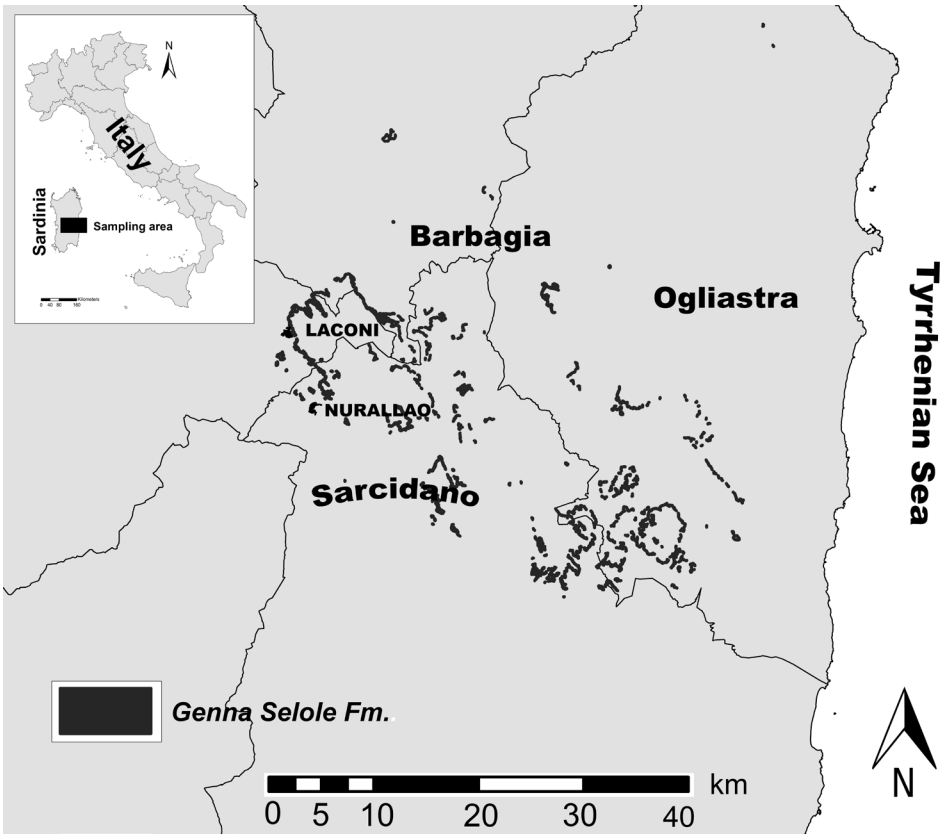


Fig. 2 - Schematic map of the Jurassic fossiliferous area.

Division Pteridophyta
Order Filicales
Family Marattiaceae

Genus *Marattia* Swartz, 1788

Marattia intermedia (Münster) Kilpper, 1964
(Pl. 1, fig. 2)

1836 *Taeniopteris intermedia* - Münster, p. 510.
1964 *Marattia intermedia* (Münster) - Kilpper, p. 22, Pl. 3, figs 6-13; Pl. 4, figs 1-11; text figs 2-4.
1968 *Marattiopis intermedia* (Münster) Kilpper - Weber, p. 42, Pl. 4, figs 35-36.
1997 *Marattia intermedia* (Münster) Kilpper - Schweitzer et al., p. 153, Pl. 12, figs 1-4; Pl. 13, figs 1-9; text-figs 21-22.

Description - The pinna fragments are up to 140 mm long and 25 mm wide. The margin of the pinnae is entire, the midrib is distinct and ≤ 4 mm wide. Simple veins arise from the rachis at acute angles, bend immediately outwards and run (almost) perpendicularly to the midrib at a concentration of 9-11 per cm. Close to the margin, the veins curve slightly forwards. Venuli recurrentes are present sporadically (MSNVE 23405; Pl. 1, fig. 2). Fertile pinnule fragments are similar to the sterile pinnules, but slightly larger in most cases. Synangia (3 × 0.7 mm) occupy the outermost third to half of the lamina (Pl. 1, fig. 2). In some fragments, the sporangia seem to have fallen off.

Remarks - Our material differs from *M. anglica* (Thomas) Harris, 1961 because of the crenulate margin of the fertile pinnules caused by the protruding synangia. Moreover, it differs from *M. hoerensis* (Schimper) Harris, 1931 and *M. muensteri* (Göppert) Schimper, 1869 because of their larger synangia. According to Schweitzer et al. (1997), *M. crenulata* Lundblad, 1950 is conspecific with *Marattia intermedia*; thus the former will not be discussed here.

This is the first report of *Marattia intermedia* in the Jurassic flora of Sardinia. This species also occurs in the Rhaetian-Jurassic Flora of Iran, Afghanistan (Schweitzer et al., 1997) and Germany (Weber, 1968).

Material - MSNVE 20423-4, 23390, 23392, 23398, 23400, 23405.

Family Matoniaceae

Genus *Phlebopteris* Brongniart, 1837

Phlebopteris muensteri (Schenk)
Hirmer et Hörhammer, 1936
(Pl. 1, fig. 3)

1867 *Laccopteris intermedia* - Schenk, p. 97, Pl. 24, figs 6-10; Pl. 25, figs 1-2; text-figs 1-2.
1936 *Phlebopteris muensteri* (Schenk) - Hirmer et Hörhammer, p. 17, Pl. 3, figs 1-7; Pl. 4, figs 1-6; Pl. 5, figs 1-6; text-figs B, 5-2A, 5-2B.

1993 *Phlebopteris muensteri* (Schenk) Hirmer et Hörhammer - van Konijnenburg-van Cittert, p. 240.
2011 *Phlebopteris muensteri* (Schenk) Hirmer et Hörhammer - Pott & McLoughlin, p. 1029, text-figs 3G-I, 4.

Description - The pinnae fragments are up to 150 mm long and 80 mm wide (MSNVE 23405; Pl. 1, fig. 3). The pinnules (35 × 4-5 mm) are lanceolate with a rounded apex and entire margin. Basally, the pinnules are connected by an extension of the lamina (a wing along the rachis); they never overlap but are inserted at a distance of 7-8 mm. The pinnules are attached (sub)oppositely and almost perpendicularly (80°). The rachis is distinct (2.5-3 mm) and grooved. Towards the apex the pinnules decrease in size (22 × 3-4 mm). The midrib (ca. 0.5 mm wide) is very prominent with secondary veins arising at 65-70°. Lateral veins are generally simple; only a few bifurcations are present.

Remarks - The specimen probably represents a frond fragment where the pinnae attachments are not preserved. No fertile frond fragments are observed. *Phlebopteris muensteri* generally has larger pinnules than other species of the same genus, and a broad midrib; it differs from *P. braunii* by its long and almost parallel-sided pinnules that are rarely crowded and free close to the basis. Veins are usually less abundant and the basal branches at least make an angle of 45° or more with the midrib. In *P. fiemmensis* Kustatscher et al. (2014) the pinnules are shorter with denser venation.

This species belongs to a widespread genus of the Triassic-Jurassic of Europe and Asia; it is also listed for the Late Triassic of Sweden (Pott & McLoughlin, 2011) and the Rhaetian-Lower Jurassic of Germany (Hirmer & Hörhammer, 1936). This is the first record of *Phlebopteris muensteri* from the Middle Jurassic of Sardinia.

Material - MSNVE 23405.

Genus *Phlebopteris* Brongniart, 1837

Phlebopteris braunii (Göppert) Harris, 1980
(Pl. 1, fig. 4)

1841 *Laccopteris braunii* - Göppert, p. 95.
1931 *Laccopteris braunii* Göppert - Harris, p. 70, Pl. 14, figs 1-2; Pl. 15, fig. 7; text-figs 24-25.
1980 *Phlebopteris braunii* (Göppert) - Harris, p. 296.
1997 *Matonia braunii* (Göppert) Harris - Popa, Pl. 11, fig. 5; text-figs 19-20.

Description - The pinnae fragments are up to 70 mm long and 20 mm wide (MSNVE 20423-1; Pl. 1, fig. 4). The narrow oblong pinnules (15 × 5 mm) with a rounded apex are attached subopposite to the rachis at an angle of 60-70°. The pinnules decrease in size (11 × 4 mm) distally. The basiscopic margins of the pinnae are decurrent; the distal margins slightly contracted. The midrib is distinct. Secondary veins are delicate and fork in the middle part of the lamina into backwards and forwards branches. Backwards branches form meshes along the midrib. Pinnules are inserted closely but do not overlap. An apical fragment (MSNVE 23390) shows smaller and more triangular pinnae (up to 10 × 2-3 mm), each with a pointed apex and indistinct venation.

Remarks - Owing to the absence of fertile specimens, these are attributed to *Phlebopteris*. Harris (1980) suggested that leaves of the "*braunii*" form appeared to be shade leaves whereas *P. muensteri* resembled sun leaves; thus, he considered these species as different leaf forms of the same natural taxon. Unfortunately, our material is too fragmentary for such considerations, thus we still attribute our specimens to the two fossil-taxa. In the Matoniaceae, *Matonia* (for fossils containing also fertile parts) is represented by both extinct and extant species. The mature frond of the extant *M. pectinata* R. Brown in Wallich, 1829 has 40 mm long pinnules. In *P. braunii*, the lateral veins fork once or twice and never anatomose as in *Phlebopteris polypoidioides* Brongniart, 1836. Popa (1997) also illustrated *Matonia braunii* (fertile and sterile) for the Lower Jurassic of Anina (Romania). This is the first report of *P. braunii* from the Middle Jurassic of Sardinia.

Material - MSNVE 20423-1, 23390, 23398, 23399.

Family Dicksoniaceae

Genus *Coniopteris* Brongniart, 1849

EXPLANATION OF PLATE 1

Horsetails and Ferns from the Middle Jurassic of Sardinia.

Fig. 1 - Sphenophyta cones (MSNVE 20423-4).

Fig. 2 - *Marattia intermedia* (Münster) Kilpper (MSNVE 23405).

Fig. 3 - *Phlebopteris muensteri* (Schenk) Hirmer et Hörhammer (MSNVE 23405).

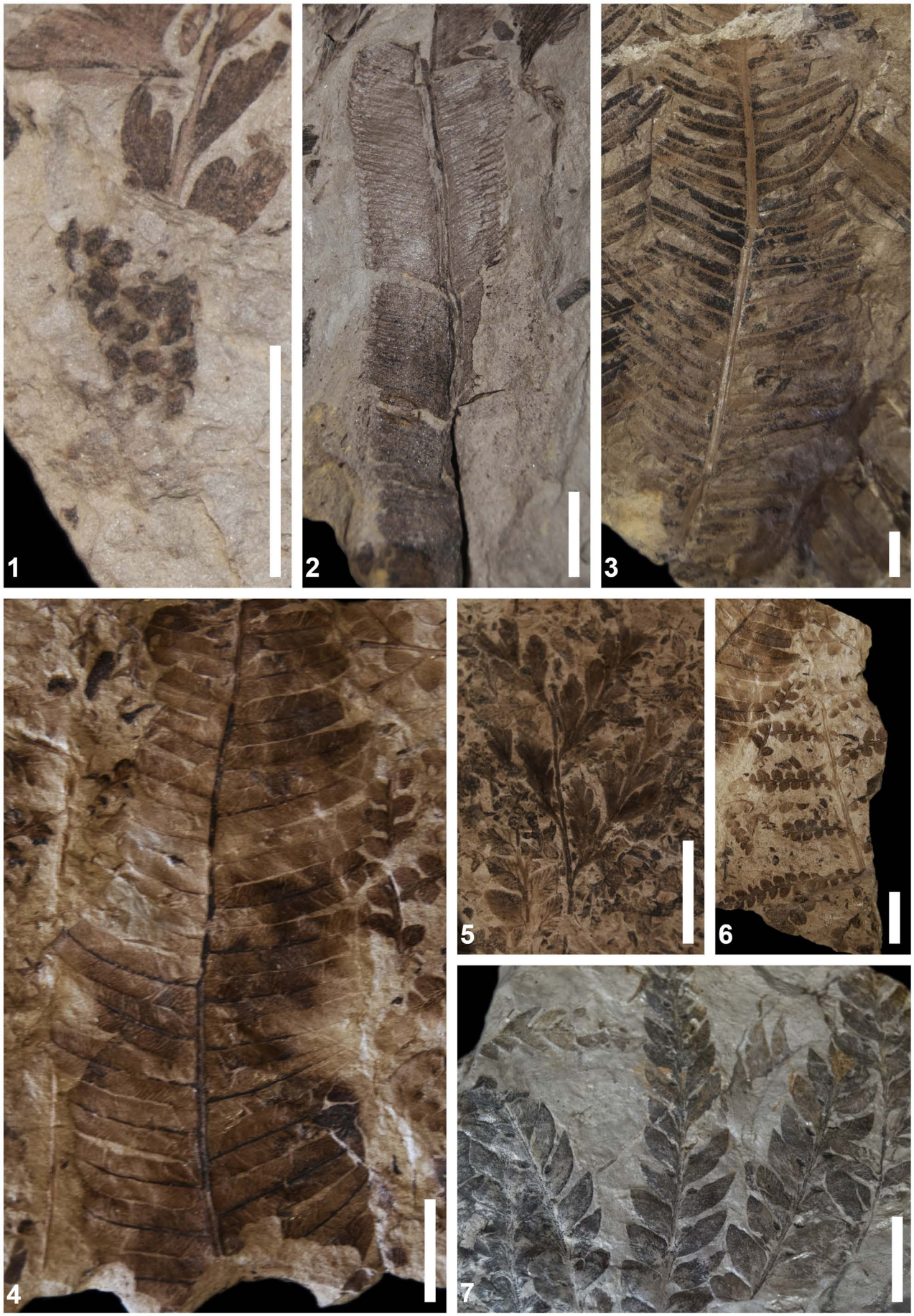
Fig. 4 - *Phlebopteris braunii* (Goeppert) Harris (MSNVE 20423-1).

Fig. 5 - *Coniopteris* sp. cf. *C. hymenophylloides* (Brongniart) Seward emend. Harris (MSNVE 20423-1).

Fig. 6 - *Dicksonia kendallii* Harris, 1961 (MSNVE 20423-1).

Fig. 7 - *Eboracia* sp. cf. *E. lobifolia* (Phillips) Thomas emend. Harris (MSNVE 23391).

Scale bar corresponds to 10 mm.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Coniopteris sp. cf. *C. hymenophylloides* (Brongniart) Seward, 1900 emend. Harris, 1961
(Pl. 1, fig. 5)

1828b *Sphenopteris hymenophylloides* - Brongniart, p. 189, Pl. 56, fig. 4.
1900 *Coniopteris hymenophylloides* (Brongniart) - Seward, p. 99, Pl. 16, figs 4-6; Pl. 17, figs 3, 6-8; Pl. 20, figs 1-2; Pl. 21, figs 1-4.
1913 *Coniopteris hymenophylloides* (Brongniart) Seward - Krasser, p. 32.
1920 *Coniopteris hymenophylloides* (Brongniart) Seward - Krasser, p. 9.
1929 *Coniopteris hymenophylloides* (Brongniart) Seward - Edwards, p. 393.
1961 *Coniopteris hymenophylloides* (Brongniart) Seward - Harris, p. 152, text-figs 53-54.
2012 *Coniopteris* sp. - Scanu et al., p. 76, Pl. 1, fig. 5.
2015 *Coniopteris* sp. cf. *Coniopteris hymenophylloides* (Brongniart) Seward - Scanu et al., p. 83, Pl. I, fig. 9.

Description - The frond fragments (up to 70 × 30 mm; MSNVE 20423-1; Pl. 1, fig. 5) have more or less lanceolate and alternate pinnae (angle of 45-50°) with pinnules (up to 4 × 3 mm) attached oppositely to subopositely and with a narrow base at an angle of 50° to the rachis. The anadromic pinnules rarely imbricate and reduce in the distal part of the pinnae. Pinnule margins are deeply incised. A distinct midrib is present in each segment. Secondary veins bifurcate at least once before reaching the margin.

Remarks - The pinnules of *Coniopteris hymenophylloides* have large segments with more than one vein compared to those of *C. simplex* (Lindley et Hutton) Harris, 1961, generally encountered in the Jurassic of Sardinia. Because our frond fragments are small, it is impossible to determine whether imbricate pinnules are present. This does not preclude attribution to *Coniopteris murrayana* (Brongniart) Brongniart emend. Harris, 1961. Because no basal pinnules were present in the assemblage, which enable a differentiation of *C. murrayana* and *C. hymenophylloides*, and the basal pinnules are almost of the same dimension and size, the material is putatively attribuited to *Coniopteris hymenophylloides* (Harris, 1961).

Coniopteris sp. cf. *C. hymenophylloides* is the most common fern species in the Jurassic of Sardinia. This species has been listed previously by Krasser (1913), Edwards (1929), Comaschi Caria (1959) and Scanu et al. (2015) from the Jurassic of Sardinia.

Material - MSNVE 20423-1, 20423-3, 23392, 23402, 23404.

Genus *Dicksonia* L'Héritier, 1789

Dicksonia kendallii Harris, 1961
(Pl. 1, fig. 6)

1961 *Dicksonia kendallii* - Harris, p. 179, text-fig. 66.

Description - Sterile frond fragments (up to 90 × 40 mm; MSNVE 20423-1; Pl. 1, fig. 6) have a grooved rachis of 4 mm width. Pinnae are inserted oppositely to alternately at an angle of ca. 80° with a separation of ca. 12 mm between adjacent insertion points in the pinnae. Pinna fragments are lanceolate, up to 40 mm long and 10 mm wide. Pinnules are ovate with an entire to slightly lobed margin and a rounded apex. They are attached to the pinna rachis (2-3 mm basal width) with a slightly restricted base (both on the proximal and distal side) and at an angle of 70-80°. Pinnules are usually separated by 2 mm, but in some cases they touch. Proximal pinnules are much larger than distal ones. Typically, the pinnules are 3-4 mm long and 2-3 mm wide; they decrease in size proximally and distally on the pinnae (apart from the basal pinnules). The midrib is indistinct, arising from the basiscopic corner; secondary veins arch to the margin and fork once or twice.

Remarks - This is the first report of *Dicksonia* in Sardinia, an extant cosmopolitan genus with more than 20 species. It has been reported from the Middle Jurassic of Yorkshire (Harris, 1961). *Dicksonia kendallii* differs from other Dicksoniaceae from Sardinia, such as *Coniopteris hymenophylloides* and *Eboracia lobifolia,* by the small size and entire margins of its pinnules, and its enlarged basiscopic pinnules.

Material - MSNVE 20423-1, 20423-2.

Genus *Eboracia* Thomas, 1911

Eboracia sp. cf. *E. lobifolia* (Phillips) Thomas, 1911 emend. Harris, 1961
(Pl. 1, fig. 7)

1829 *Neuropteris lobifolia* - Phillips, p. 148, Pl. 8, fig. 13.
1837 *Pecopteris lobifolia* (Phillips) - Lindley et Hutton, p. 79, Pl. 179.
1900 *Cladophlebis lobifolia* (Phillips) - Seward, p. 145, Pl. 15, fig. 6; text-figs 22-23.
1911 *Eboracia lobifolia* (Phillips) - Thomas, p. 387.
1961 *Eboracia lobifolia* (Phillips) Thomas - Harris, p. 171, text-figs 62-63.
2009 *Eboracia lobifolia* (Phillips) Thomas - Schweitzer et al., p. 88, Pl. 44, figs 1-4; Pl. 45, figs 1-2; Pl. 46, fig. 1; Pl. 47, figs 1-3; text-fig. 39.

Description - Largest frond fragment 90 mm long and 40 mm wide with a distinct, grooved rachis (up to 4 mm wide). Pinnae (fragments up to 30 × 10 mm) are attached oppositely (MSNVE 23391; Pl. 1, fig. 7) to suboppositely with an angle of 80°. They are closely inserted and adjacent pinnae partly overlap. Initial pinnules are basiscopically inserted and much larger than the rest. Pinnules are lanceolate to spatulate, up to 5 mm long and 3 mm wide, with an entire margin and a rounded to slightly pointed apex. Basal pinnules are more lobed (MSNVE 23391). They arise at an angle of 45-50° with an acroscopically contracted and basiscopically broadly attached margin. The midrib is slender but distinct; secondary veins fork at least once before reaching the margin. Two specimens (MSNVE 23400, 20423-4) retain traces of sori on some pinnules.

Remarks - The identification of *E. lobifolia* is usually based on fertile foliage. The sterile foliage differs from

other dicksoniaceous ferns in the dimension of pinnules: e.g., in *Dicksonia mariopteris* and *D. kendallii*, the basiscopic pinnules are more reduced in size and, in *D. kendallii*, all pinnules are distinctly smaller and more rounded. *E. lobifolia* is widespread in the Jurassic of Europe and Asia (for example in Denmark, Mehlqvist et al., 2009 and China, Deng et al., 2006); the comparable forms described here are the first such records from the Middle Jurassic of Sardinia.

Material - MSNVE 20423-4, 23390, 23391, 23396, 23397, 23398, 23400, 23401, 23403.

Family Indet.

Genus *Cladophlebis* Brongniart, 1849

Cladophlebis sp.
(Fig. 3a)

Description - Frond fragments up to 60 × 20 mm, rachis up to 0.5 mm broad (MSNVE 23405; Fig. 3a). The opposite pinnae fragments are attached to the main grooved rachis at an angle of 60°. They are ca 15 mm distant from each pinnule margin to the other. The oblanceolate pinnules have an entire margin and slightly acute apex. They are attached alternatively to the pinnae rachis with entire bases and at angles of 50-60°. Secondary veins arise from the thin midrib; they fork once, apart from the most basal examples that in some cases fork twice.

Remarks - The fragmentary preservation prevents observation of the main features necessary for an assignment at species level. The most proximal pinnules are not preserved; thus an attribution as *Eboracia* sp. cannot be excluded, but the pinnule shape and venation are more typical of *Cladophlebis*.

Material - MSNVE 20423-3, 23390, 23403, 23405.

Division Cycadophyta
Order Bennettitales
Family Williamsoniaceae

Genus *Weltrichia* Braun, 1847 emend. Harris, 1969

Weltrichia sp. cf. *W. whitbiensis*
(Nathorst, 1911) Harris, 1969
(Fig. 3b)

1870 *Williamsonia pecten* Leckenby - Carruthers, p. 694.
1909 *Williamsonia pecten* Leckenby - Nathorst, p. 8, Pl. 1, fig. 4b; Pl. 2, figs 12-15.
1911 *Williamsonia whitbiensis* - Nathorst, p. 9, Pl. 2, figs 1-15; Pl. 3, figs 2-9; text-figs 1-3.
1912 *Williamsonia whitbiensis* Nathorst - Krasser, p. 968, Pl. 11, figs 13-14.
1915 *Williamsonia whitbiensis* Nathorst - Krasser, Pl. 3, figs 4-6.
1915 *Williamsonia sewardii* - Krasser, Pl. 3, figs 1-3.
1969 *Weltrichia withbiensis* (Nathorst) - Harris, p. 170, Pl. 7, figs 5, 7, 9-10.

Description - The only bennettitalean male reproductive organ in this assemblage is characterized by an open cup, with a basal diameter of 15-18 mm and distal diameter of 45 mm, consisting of six apical ray-like segments; probably there were twelve for the entire structure. The segments are triangular, with a putative pointed apex (not clearly visible), 25 mm long and 10 mm wide at the base. Each ray has an indistinct midrib (Fig. 3b, arrow "x"). The base of the cup bears a scar 5 mm in diameter that probably corresponds to the attachment area of the stalk (not preserved). The central part of the cup bears rows of resinous sacs (0.5 mm in diameter; Fig. 3b, arrow "y"), but there is no clear indication of pollen sacs on the rays.

Remarks - No organic matter is preserved in the specimen; thus, the attribution is based on macromorphology only. *Weltrichia whitbiensis* has been found in the English Jurassic in association with *Ptilophyllum pectinoides* (Phillips) Harris, 1969 leaves, *Williamsonia hildae* Harris, 1969 female flowers, *Cycadolepis hypene* Harris, 1953 scales and *Bucklandia pustulosa* Harris, 1969 stems. According to Harris (1969) they all belong to the same plant.

In the Sardinian Jurassic plant assemblage, *P. pectinoides* is very common whereas *Williamsonia hildae* is rare (Scanu et al., 2015). The presence of both taxa in Sardinia plus the newly found *Weltrichia* specimen suggests that the organs might have belonged to the same plant, just as Harris (1961) indicated for the Yorkshire Jurassic specimens. However, apart from the co-occurrence of the three taxa in the Sardinian flora no cuticle or anatomical connections are available to sustain this hypothesis. Thus, we refrain from a formal attribution of the three taxa to one fossil taxon as the new botanical code (McNeill et al., 2012) would suggest.

Material - MSNVE 20423-5.

Division Coniferophyta
Order Coniferales
Family Taxodiaceae

Genus *Geinitzia* Endlicher, 1847

Geinitzia divaricata (Bunbury) Harris, 1979
(Fig. 3c)

1851 *Criptomerites divaricatus* - Bunbury, p. 190, Pl. 13, fig. 4.
1920 *Cheirolepis setosus* (Phillips) Seward - Krasser, p. 18.
1929 *Cryptomerites divaricatus* Bunbury - Edwards, p. 391, Pl. 4, fig. 9.
1951 *Elatides divaricatus* (Bunbury) - Harris, p. 931, text-figs 4 A-B, D, 5.
1979 *Geinitzia divaricata* (Bunbury) - Harris, p. 63, Pl. 2, fig. 14; Pl. 3, figs 1-2; text-figs 30-31.
2012 ?*Geinitzia* sp. - Scanu et al., p. 82, Pl. 3, fig. 4.
2015 *Geinitzia divaricata* (Bunbury) Harris - Scanu et al., p. 95, Pl. VI, figs 2-3; Pl. VII, fig. 5.

Description - The shoot fragments are up to 75 mm long and 10 mm wide (MSNVE 23392; Fig. 3c) of which the central axis is only 1-2 mm wide. Leaves (up to 4 × 1-2 mm) are arranged in a wide spiral (80–90°) and inserted

with the entire basis. They are falcate and with a pointed to slightly rounded apex. A distinct central midrib is present (MSNVE 23395).

Remarks - *Geinitzia rigida* (Phillips) Harris, 1979 differs from *G. divaricata* by its smaller leaves; moreover, in *G. divaricata*, the leaves are more strongly falcate, just as in our material.

This species was described from Middle Jurassic strata of Sardinia by Krasser (1920) as *Cheirolepis setosus* (Phillips) Seward, 1900 and by Edwards (1929) as *Cryptomerites divaricatus* Bunbury, 1851 (see Scanu et al., 2015). It is well known from the Middle Jurassic of Yorkshire (Harris, 1979).

Material - MSNVE 20423-1, 20423-3, 23392, 23394, 23395, 23400, 23403.

Family Indet.

Genus *Brachyphyllum* Brongniart, 1828
emend. Harris, 1979

Brachyphyllum expansum (Presl in Sternberg)
Seward, 1919 emend. Kendall, 1949
(Fig. 3d-e)

1823 *Thuites expansus* - Sternberg, p. 38, Pl. 38, figs 1-2.
1919 *Brachyphyllum expansum* (Sternberg) - Seward, p. 317, text-fig. 754.
1929 *Brachyphyllum expansum* (Sternberg) Seward - Edwards, p. 393.
1949 *Brachyphyllum expansum* (Sternberg) Seward - Kendall, p. 308, text-figs 1-2.
1959 *Thuiytes expansus* Sternberg - Comaschi Caria, p. 95.
1959 *Brachyphyllum expansum* Edwards - Comaschi Caria, p. 95.

Fig. 3 - Ferns, Cycadophytes, conifers and seeds from the Middle Jurassic of Sardinia (scale bar corresponds to 10 mm). a) *Cladophlebis* sp. (MSNVE 23405); b) *Weltrichia* sp. cf. *W. whitbiensis* (Nathorst) Harris (MSNVE 20423-5); c) *Geinitzia divaricata* (Bunbury) Harris (MSNVE 23392); d-e) *Brachyphyllum expansum* (Sternberg) Seward emend. Kendall (MSNVE 23393 and MSNVE 23394, respectively); f) *Carpolithes* sp. 2 (MSNVE 23394).

2003 *Brachyphyllum expansum* (Sternberg) Seward - Cleal & Rees, p. 770, Pl. 8, figs 3-5; Pl. 9; Pl. 11, fig. 1; text-fig. 4.
2015 *Brachyphyllum expansum* (Sternberg) Seward - Scanu et al., p. 95, Pl. VI, fig. 4; Pl. VII, fig. 6.

Description - Large shoot fragments (up to 120 mm long and 50 mm wide) are present in distinct layers (e.g., MSNVE 23393; Fig. 3d). Secondary shoots (up to 35 × 4 mm) arise usually alternatively at an angle of 45-50°. In few specimens (e.g., MSNVE 23394, 23395; Fig. 3e), secondary shoots (up to 20 mm long) arise oppositely. Tertiary shoots are much smaller, attached alternately, and are up to 8 × 3 mm. The scale-like small leaves are rhombic, pentagonal (e.g., MSNVE 23393) or are triangular with a rounded apex (e.g., MSNVE 23394, 23395). They are 1.7-2 mm long and 1-1.5 mm wide, with only one vein. The leaves are spirally and densely inserted on the axis and arise almost perpendicularly from there.

Remarks - According to Cleal & Rees (2003) the other much more cosmopolitan species of *Brachyphyllum*, *B. mamillare* Brongniart, 1828, has shorter leaves; the latter seems to have been adapted to deltaic conditions. Another difference is that *B. expansum* is almost always shed as large, regularly branched shoot systems, usually much larger than those of *B. mamillare* (Harris, 1961).

This species has already been listed by Edwards (1929), Comaschi Caria (1959) and Scanu et al. (2012, 2015) for the Middle Jurassic of Sardinia. Krasser (1913, 1920) cited this species using its junior synonym *Thuites expansus* Sternberg, 1823.

Material - MSNVE 23393, 23394, 23395.

INCERTAE SEDIS

Genus *Carpolithes* Brongniart, 1822

Carpolithes sp. 2 sensu Scanu et al., 2015 (Fig. 3f)

1920 *Carpolithes* sp. - Krasser, p. 18.
2012 *Carpolithes* sp. - Scanu et al., p. 82, Pl. 3, fig. 6.
2015 *Carpolithes* sp. 2 - Scanu et al., p. 95, Pl. VI, fig. 8.

Description - The near circular seeds have a diameter of 4-5 mm. No costae or other structures are present in the seeds (MSNVE 23394, Fig. 3f).

Remarks - *Carpolithes* is a taxon for fossil seeds with a variety of spellings (*Carpolithus*, *Carpolithes*, *Carpolites*; for more details see Wang, 2011). Wang (2011) argued that the version *Carpolithus* Artis, 1825 should be preserved and used in the future because it was adopted since pre-Linneaus' time and is more widely used by palaeobotanists than the other versions. Since there is still no voting on this proposal, for the moment we use the so far under Art. 13.1(f) and 61.1 of the Code legitimate name *Carpolithes* Brongniart, 1822. Roundish seeds named as *Carpolithes* sp., with a diameter of 2-4 mm, were described already by Krasser (1920) from Sardinia. The present two specimens resemble those described in Scanu et al. (2015). It is noticeable that they occur in the same sandy lithology.

Material - MSNVE 23394, 23395.

DISCUSSION

The Middle Jurassic plant assemblage from Sardinia, housed at the Geological and Palaeontological Museum "D. Lovisato" of the Cagliari University and belonging to the "part A" of the entire "Lovisato Collection" (the "part B" housed in the Narodni Museum of Praga, Czech Republic, is still under study) comprises 24 taxa (19 genera) belonging to horsetails, ferns, seed ferns, cycadophytes, Czekanowskiales and conifers (Scanu et al., 2012, 2015).

The Miccolis Collection, housed at the Museo di Storia Naturale of Venice, comprises 11 taxa, six of which are recorded for the first time from the Middle Jurassic of Sardinia and Italy (Tab. 1). Each slab contains few to several plant fragments, the new taxa are rare with only few samples and generally fragmentarily preserved. With this revision the Middle Jurassic flora of Sardinia is now composed of 29 species belonging to 22 genera (Scanu et al., 2012, 2015, this paper, Tab. 2). The ferns dominate the assemblage with Marattiaceae (*Marattia intermedia*), Matoniaceae (*Phlebopteris muensteri*, *P. braunii*, *P. polypoidioides*), Dicksoniaceae (*Coniopteris hymenophylloides*, *Dicksonia kendallii*, *Eboracia* sp. cf. *E. lobifolia*), Dipteridaceae (*Hausmannia* sp.), Osmundaceae (*Todites williamsonii*) and some incertae sedis, such as *Cladophlebis*. No new seed fern remains came from the Miccolis Collection. The so far only seed fern representatives, *Ptilozamites blasii* and *Sagenopteris phillipsii*, were found in the Lovisato Collection. *Cycadeospermum lovisatoi* seeds and *Nilssonia* sp. leaves belong to the Cycadales, whereas the Bennettitales are much more diverse. Leaves belong to *Pterophyllum thomasii*, *Ptilophyllum pectinoides*, *P. cariae* and *Taeniopteris* sp., the ovuliferous reproductive organs to *Williamsonia hildae* and the microsporangiate reproductive organs to *Weltrichia* sp. cf. *W. whitbiensis* and *Weltrichia* sp. Of special interest is the presence of the microsporangiate reproductive organ *Weltrichia* sp. cf. *W. whitbiensis* in the Miccolis Collection that is considered to belong to the same natural species as *Ptilophyllum pectinoides* leaves and *Williamsonia hildae* ovuliferous reproductive organs (Harris, 1969); the two latter are represented in the Lovisato Collection (Scanu et al., 2015). The Czekanowkiales are represented only by *Czekanowskia furcula*, while the conifers are present with *Geinitiza divaricata*, *Brachyphyllum expansum*, *Brachyphyllum* sp. and *Elatocladus* sp. Of unknown botanical affinity are the seed types *Carpolithes* sp.1 and *Carpolithes* sp. 2 that, according to some authors, could represent the seeds of *Williamsonia* (Edwards, 1929).

The larger dimension of the fern frond fragments and the higher diversity of ferns and the conifer *Brachyphyllum expansum* in comparison with missing bennettitalean and Czekanowskiales leaves in the Miccolis Collection could be the result of selective sampling. Fossil collectors commonly select specimens based on aesthetic appeal,

SARDINIAN TAXA LIST	Krasser's works	Scanu et al., 2015 (Lovisato Collection)	this work (Miccolis Collection)
Araucarites sardinicus (Krasser) Krasser, 1920	x		
Baiera phillipsi Nathorst, 1880	x		
Brachyphyllum expansum (Sternberg) Seward emend. Kendall, 1949	x	x	x
Brachyphyllum mamillare Brongniart, 1828	x		
Brachyphyllum sp.		x	
Carpolithes sp.	x		
Carpolithes sp. 1		x	
Carpolithes sp. 2		x	x
Cladophlebis denticulata (Brongniart) Fontaine, 1889	x		
Cladophlebis sp.		x	cf.
Coniopteris arguta (Lindley et Hutton) Seward, 1900	x		
Coniopteris hymenophylloides (Brongniart) Seward emend. Harris, 1961	x	cf.	cf.
Coniopteris simplex (Lindley et Hutton) Harris, 1961		x	
Cycadeospermum lovisatoi Krasser, 1912	x	x	
Cycadeospermum persica Krasser, 1912	x		
Czekanowskia furcula Harris et Miller in Harris et al., 1974		cf.	
Czekanowskia murrayana (Lindley et Hutton) Seward, 1900	x		
Dicksonia kendallii Harris, 1961			x
Dictyophyllum rugosum Lindley et Hutton, 1834	x		
Eboracia lobifolia (Phillips) Thomas, 1911 emend. Harris, 1961			cf.
Elatocladus sp.		x	
Equisetites columnaris Brongniart, 1928	x		
Geinitzia divaricata (Bunbury) Harris, 1979		x	x
Hausmannia sp.		x	
Klukia exilis (Phillips) Raciborski, 1890	x		
Laccopteris woodwardi (Leckenby) Seward, 1899	x		
Marattia intermedia (Münster) Kilpper, 1964			x
Nageiopsis anglica Seward, 1900	x		
Nilssonia compta Brongniart, 1828	x		
Nilssonia sp.		x	
Otozamites beani (Lindley et Hutton) Brongniart, 1849	x		
Otozamites lovisatoi Krasser, 1913	x		
Pagiophyllum williamsoni Brongniart, 1828b	x		
Phlebopteris braunii (Goeppert) Harris, 1980			x
Phlebopteris muensteri (Schenk) Hirmer et Hörhammer, 1936			x
Phlebopteris polypodioides Brongniart, 1836		x	
Pterophyllum thomasii Harris, 1969		cf.	
Ptilophyllum cariae Scanu et al., 2015		x	
Ptilophyllum pecten (Phillips) Morris in Grant, 1840	x		
Ptilophyllum pectinoides (Phillips) Halle, 1913		x	
Ptilozamites blasii (Brauns) Nathorst, 1879		cf.	
Sagenopteris goeppertiana Zigno, 1885	x		
Sagenopteris phillipsi (Brongniart) Presl in Sternberg, 1838	x	x	
Sardoa robitschekii Krasser, 1920	x		

Tab. 1 - Composition of the Jurassic Sardinian flora as listed by Krasser (1912, 1913, 1920), Scanu et al. (2015) and this paper.

SARDINIAN TAXA LIST	Krasser's works	Scanu et al., 2015 (Lovisato Collection)	this work (Miccolis Collection)
Taeniopteris sp.	x	x	
Taeniopteris vittata Brongniart, 1831	x		
Todites williamsoni (Brogniart) Seward emend. Harris, 1961	x	cf.	
Weltrichia sp.		x	
Weltrichia whitbiensis (Nathorst) Harris, 1969			cf.
Williamsonia acuminata (Zigno) Krasser, 1920	x		
Williamsonia hildae Harris, 1969	x	x	
Williamsonia leckenbyi Nathorst, 1911	x		
Williamsonia pecten Phillips, 1829	x		
Williamsonia sewardi Krasser, 1913	x		
Williamsonia whitbiensis Nathorst, 1911	x		
Zamites sp.	x		

Tab. 1 - Continuation.

and/or the particular interest of the individual. Moreover, it might be a statistical bias since the amount of plant remains preserved on the slabs is reduced. Nonetheless, this collection is interesting because the study of even such small assemblages adds to the known diversity of the Middle Jurassic flora of Sardinia. It reveals that the complete palaeobiodiversity of the Italian Jurassic floras remains very incomplete, probably due to both collecting and taphonomic biases.

The most famous and diverse Mesozoic flora of Italy is the Early Jurassic Rotzo flora, which has been well studied over the last two centuries (De Zigno, 1856-68, 1873-85; Grandori, 1913a, b; Wesley, 1956, 1958, 1966, 1974; Barale, 1982; Thévenard et al., 2005; Bartiromo & Barone Lumaga, 2009). These studies revealed a diverse flora consisting of 59 taxa (31 genera), that is dominated by bennettitaleans (20 taxa), conifers (18 taxa), pteridosperms (six taxa) and ferns (six taxa). Sphenophytes and ginkgophytes are rare. The smaller Early Jurassic floras such as the one from Mount Palombo (Apennines, central Italy; 10 taxa, six genera; Praturlon, 1968) and Moltrasio (northern Italy; 10 taxa, eight genera; Sordelli, 1896) are dominated by conifers and bennettitaleans. The small Early Jurassic flora from Osteno (northern Italy) yielded 13 taxa (seven genera; Bonci & Vannucci, 1986) and is dominated by conifers. The Sardinian flora is the largest Middle Jurassic flora of Italy (Scanu et al., 2013, 2015). The much smaller floras from Lepini Mt. (Praturlon, 1965; Cocozza & Praturlon, 1966; Bravi, 1995) and Fallano Mt. (Bravi et al., 2014) have yielded only conifer shoot fragments (i.e., *Brachyphyllum*, *Pagiophyllum*, *Araucarites*, *Brachyphyllum*, *Cupressinocladus*). Comparing the various Italian Early and Middle Jurassic floras, the number of genera in common between Sardinia and Rotzo is ten (Tab. 3). Among these, ferns are represented by Matoniaceae (*Phlebopteris*), Dicksoniaceae (*Coniopteris*), and ferns of unknown attribution (*Cladophlebis*), but also shared are seed ferns (*Sagenopteris*), cycadophyte leaves (*Pterophyllum*, *Ptilophyllum*), cycadophyte reproductive organs (*Williamsonia*, *Weltrichia*) and conifers (*Brachyphyllum*, *Elatocladus*). Some genera represented in both floras have a worldwide distribution, such as *Coniopteris*, *Phlebopteris* and *Brachyphyllum*; others (*Taeniopteris*, *Carpolithes*) are fossil genera of uncertain affiliation that are distributed globally. More interesting is the presence of *Sagenopteris* in both Sardinia and Rotzo, which might have palaeoenvironmental implications. Leaflets of *Sagenopteris* are considered typical of humid and warm environments without direct solar radiation (Hallam, 1985; Frakes et al., 1992), although Cleal & Rees (2003) found them also in a semi-arid environment that were close to the sea. The bennettitales shared between the Sardinian and Venetian floras are typical of the Jurassic period whereas the Cycadales are encountered only in Sardinia (Scanu et al., 2015). The Jurassic flora of Sardinia also shares genera with other Italian floras. This includes cosmopolitan taxa, such as *Brachyphyllum* and *Taeniopteris*, both common also in the Palombo Mt. flora. On the other hand, *Pagiophyllum* is the only genus encountered in all Italian localities except for Sardinia.

CONCLUSIONS

The revision of this small collection provided much more data than expected. The selective sampling by the collector Domenico Miccolis yielded several taxa never recorded for Sardinia and in some cases recorded for the first time for Italy. *Dicksonia kendalli*, *Eboracia* sp. cf. *E. lobifolia*, *Marattia intermedia*, *Phlebopteris braunii* and *P. muensteri* are recorded for the first time from Sardinia and Italy, together with the bennettitalean male reproductive organ *Weltrichia* sp. cf. *W. whitbiensis*. Other taxa recorded from the Middle Jurassic of Sardinia are the cosmopolitan species *Coniopteris* sp. cf. *C. hymenophylloides*, *Cladophlebis* sp., *Geinitzia divaricata*, *Brachyphyllum expansum* and *Carpolithes* sp. 2. The Sardinian Jurassic flora now includes 29 taxa (23 genera) of sphenophytes, ferns, seed ferns, cycadophytes, Czekanowskiales and conifers. The only missing

Ferns	Seed Ferns	Cycadales	Bennettitales	Czekanowskiales	Conifers	Incertae Sedis
Cladophlebis sp.	*Ptilozamites blasii* (Brauns) Nathorst, 1879	*Cycadeospermum lovisatoi* Krasser, 1912	*Pterophyllum thomasii* Harris, 1969	*Czekanowskia furcula* Harris et Miller in Harris et al., 1974	*Brachyphyllum expansum* (Sternberg) Seward emend. Kendall, 1949	*Carpolithes* sp. 1 sensu Scanu et al., 2015
Coniopteris hymenophylloides (Brongnart) Seward emend. Harris, 1961	*Sagenopteris phillipsi* (Brongniart) Presl in Sternberg, 1838	*Nilssonia* sp.	*Ptilophyllum cariae* Scanu et al., 2015		*Brachyphyllum* sp.	*Carpolithes* sp. 2 sensu Scanu et al., 2015
Coniopteris simplex (Lindley et Hutton) Harris, 1961			*Ptilophyllum pectinoides* (Phillips) Halle, 1913		*Elatocladus* sp.	
Dicksonia kendallii Harris, 1961			*Taeniopteris* sp.		*Geinitzia divaricata* (Bunbury) Harris, 1979	
Eboracia lobifolia (Phillips) Thomas, 1911 emend. Harris, 1961			*Weltrichia* sp.			
Hausmannia sp.			*Weltrichia whitbiensis* (Nathorst) Harris, 1969			
Marattia intermedia (Münster) Kilpper, 1964			*Williamsonia hildae* Harris, 1969			
Phlebopteris braunii (Goeppert) Harris, 1980						
Phlebopteris muensteri (Schenk) Hirmer et Hörhammer, 1936						
Phlebopteris polypodioides Brongniart, 1836						
Todites williamsoni (Brongniart) Seward emend. Harris, 1961						

Tab.2 - Updated composition of the Sardinian flora after the revision of the Miccoli Collection.

	Early Jurassic				Middle Jurassic		
GENERA	Rotzo	Palombo Mt.	Osteno	Como/Moltrasio	Lepini Mt.	Fallano Mt.	Sardinia
Araucarites Presl in Sternberg, 1838						x	
Brachyphyllum Brongniart, 1838	x	x	x	x	x	x	x
Carpolithes Brongniart, 1822							x
Cladophlebis Brongniart, 1849	x						x
Clathropteris Brongniart, 1828				x			
Coniopteris Brongniart, 1849	x						x
Ctenopteris Saporta, 1873				x			
Cupressinocladus Seward, 1919						x	
Cycadeospermum Saporta, 1874							x
Cycadopteris Schimper, 1869	x						
Cyclopteris Brongniart, 1828	x						
Czekanowskia Heer, 1876							x
Dactylethrophyllum Wesley, 1956	x	cf.					
Desmiophyllum Lesquereux, 1878	x						
Dichopteris de Zigno, 1864	x						
Dicksonia L'Héritier, 1789							x
Dictyophyllum Lindley et Hutton, 1834	x						
Eboracia Thomas, 1911							x
Elatocladus Halle, 1913	x						x
Equisetites Sternberg, 1833	x		x				
Geinitzia Endlicher, 1847							x
Gutbiera Presl, 1838 = *Phlebopteris*	x						
Hausmannia Dunker, 1846							x
Hymenophyllites Göppert, 1836	x						
Lomatopteris Schimper, 1869	x			x			
Marattia Presl, 1845							x
Matonidium Schenk, 1871	x						
Nilssonia Brongniart, 1825							x
Otozamites Braun in Münster, 1843	x	x	x	x			
Pachypteris Karelin et Kirilow, 1842			x	x			
Pagiophyllum Heer, 1881	x	cf.	x	x	x		
Pelourdea Seward, 1917 = *Yuccites*	x						
Phlebopteris Brongniart, 1837	x						x
Phylloteca Brongniart, 1828	x						
Protorhipis Andrae, 1855	x						
Pseudosagenopteris Potonié, 1900	x						
Pterophyllum Brongniart, 1825	x						x
Ptilophyllum Morris in Grant, 1840	x						x
Ptilozamites Nathorst, 1878							x
Sagenopteris Presl in Sternberg, 1838	x						x
Sphenozamites (Brongniart) Miquel, 1851	x	x					
Stachyotaxus Nathorst, 1886	x						

Tab. 3 - Updated list of the Jurassic plant fossils of Italy (Rotzo: De Zigno, 1856-68, 1873-85; Grandori, 1913a, b; Wesley, 1956, 1958, 1966, 1974; Barale, 1982; Thévenard et al., 2005; Bartiromo & Barone Lumaga, 2009; Palombo Mt.: Praturlon, 1968; Osteno: Bonci & Vannucci, 1986; Como/Moltrasio: Sordelli, 1896; Lepini Mt.: Praturlon, 1965; Cocozza & Praturlon, 1966; Bravi, 1995; Fallano Mt.: Bravi et al., 2014; Sardinia: Krasser, 1912, 1913, 1920; Scanu et al., 2015; this paper).

	Early Jurassic				Middle Jurassic		
GENERA	Rotzo	Palombo Mt.	Osteno	Como/Moltrasio	Lepini Mt.	Fallano Mt.	Sardinia
Taeniopteris Brongniart, 1828		x					x
Todites Seward, 1900							x
Trevisania de Zigno, 1856	x						
Weltrichia Braun, 1847 emend. Harris, 1969	x						x
Widdringtonites Endlicher, 1847				x			
Williamsonia Carruthers, 1870	x		x				x
Zamites Brongniart, 1828	x		x				

Tab. 3 - Continuation.

major groups, in the macro remains, are lycophytes and ginkgophytes. Moreover, the study increases the palaeobiodiversity of the Italian Jurassic floras; they now incorporate 49 genera (Tab. 3) against the previously known 42 (Scanu et al., 2015, tab. 5). The comparison of the Sardinian flora with coeval European floras (see Scanu et al., 2015 for details) reveals a diverse Middle Jurassic assemblage and contradicts the old concept of the global uniformity of Jurassic floras (Vakhrameev, 1991). The differences between the various floras have been explained due to ecological and taphonomic factors (Barbacka et al., 2014). Comparing the integrated Sardinian flora with the most diverse European Jurassic flora, that of Yorkshire, 19 genera are shared including ferns (*Cladophlebis*, *Coniopteris*, *Dicksonia*, *Eboracia*, *Marattia*, *Hausmannia*, *Phlebopteris,* and *Todites*), seed ferns (*Sagenopteris*), cycadophytes (*Nilssonia*, *Pterophyllum*, *Ptilophyllum*, *Weltrichia*, *Williamsonia*), conifers (*Brachyphyllum, Elatocladus*, *Geinitzia*), Czekanowskiales (*Czekanowskia*) and *Carpolithes* seeds. Both floras include leaves of *Ptilophyllum pectinoides* with its female reproductive organ *Williamsonia hildae* and its male reproductive organ *Weltrichia whitbiensis*. Given that the Sardinian flora is composed of 22 genera only, the similarity between the two floras is striking; only the seed fern *Ptilozamites* and the cycad seed *Cycadeospermum* are not known from the Yorkshire flora, but the closely related seed fern *Ctenozamites* is present in Yorkshire (Popa & McElwain, 2009). This might be related to similar environmental or depositional settings since Sardinia and Yorkshire are both deposited in fluvio-deltaic deposits (Barbacka et al., 2014). It remains debatable whether the difference in the composition between the Rotzo and Sardinian floras is related to a depositional/environmental difference since the former has been deposited in a marine environment (e.g., Bartiromo & Barone Lumaga, 2009). Comparing the Sardinian flora to the southern floras, it becomes quickly evident it shares only few, cosmopolitan taxa with Israel, Egypt and Tunisia (*Brachyphyllum*, *Cladophlebis*, *Elatocladus*, *Phlebopteris*, *Ptilophyllum*, *Todites*, *Williamsonia*) since it was positioned during the Jurassic on the southern margin of Europe (for more details see Scanu et al., 2015). This does not change after the addition of the new taxa due to the study of the Miccoli Collection.

The study of the aforementioned assemblage shows that the Jurassic flora of Sardinia is still far from completely understood. The fact that a small assemblage can add such a number of new taxa to the Jurassic flora of Sardinia shows that the diversity of the Jurassic floras was probably much higher than previously understood. Further studies of institutional collections, such as the second part of the Lovisato Collection, stored in Prague, and new findings, will improve our understanding of the Middle Jurassic flora of Sardinia.

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