**INTRODUCTION**

The Morrison Formation in North America and the Tendaguru Beds in Tanzania have been widely compared due to their striking similarities regarding the fauna, ecosystem, paleoenvironments, age and sedimentology. However, other noteworthy but often ignored rocks contemporaneous with the Morrison Formation and Tendaguru Beds are the Lourinhã and Alcobaça formations of Portugal. Together they are Kimmeridgian to Tithonian in age and are remarkably similar in fossil content to their overseas counterparts. Sediments in the three areas indicate continental fluvial and lacustrine paleoenvironments, with strata basically comprising sandstone and mudstones. They appear to represent semiarid climates with the greatest abundance and diversity of herbaceous and arborescent plants concentrated near bodies of water. Marine transgressions were frequent in coastal areas, as well as alternating wet-dry conditions (Rees et al., 2004). The three areas existed at similar paleolatitudes (30-35 degrees), but with Tendaguru in the Southern Hemisphere. The Morrison Formation has been the subject of continuous work by numerous researchers, being probably the best known continental Jurassic formation and one of the richest areas for Late Jurassic vertebrates. Such knowledge allows interesting comprehensive paleoecological analysis (Dodson et al., 1980; Coe et al., 1987; Russell, 1989; Foster, 1996, 2000, 2001, 2003; and Turner and Peterson, 2004).

The Lourinhã Formation (Fig. 1) is mainly composed of continental and some shallow marine deposits. Alluvial fan and fluvio-deltaic environments during the Kimmeridgian and Tithonian were punctuated by periodic marine transgressions. Lithologically, the Lourinhã is formed by intercalations of sandstones and mudstones (channel to interdistributary areas, Fig. 2). The Lourinhã Formation is underlain by the Kimmeridgian limestones of Amaral Formation and bounded at the top by a discontinuity with the Cretaceous sandstones (Hill, 1988, 1989; Leinfelder and Wilson, 1989; Sousa, 1998; Alves et al., 2003; Cunha et al. 2004). The Lourinhã Formation as been considered in part equivalent to the Alcobaça Formation by several authors (see, for example, Manuppella, 1996, 1998; Manuppella et al., 1999), but the Alcobaça Formation is in part older and is more marine than the Lourinhã Formation.

The Tendaguru Beds, dated as Kimmeridgian-Tithonian, are dominated by calcareous sandstones and siltstones, with brackish and shallow marine influence demonstrated by the occurrence of marine dinoflagellates, corals, mytiloids and pteroid bivalves, ammonites, gastropods, and sharks (Aberhan et al. 2002; see Table 1).**

**Institutional abbreviations:** ML: Museu da Lourinhã (Portugal); BYU: Brigham Young University (USA).
THE LATE JURASSIC OF PORTUGAL, TENDAGURU, AND
THE MORRISON COMPARED

Age and Geography

The Lourinhã and Alcobaça formations, the Morrison Formation, and the Tendaguru Beds are approximately contemporaneous, Kimmeridgian to Tithonian in age (Manuppella, 1996; Kowallis et al., 1998; Unwin and Heinrich, 1999). Of these, the Morrison Formation is, without a doubt, the largest (1.5 million km², Carpenter, 1997; 1 million km² according to Dodson et al., 1980, p. 228) and the most studied area (Fig. 3). Therefore, the Morrison Formation would be expected to present a greater number of dinosaur genera and species than the other regions, and to better represent the Jurassic fauna. The Late Jurassic outcrops of the Lusitanian Basin in Portugal comprise approximately 400 to 550 km². However, while the Morrison Formation occupies about 2000 times as much area, it has only 2.3 times more species of dinosaurs than the Portuguese area.

Most of the paleogeographic maps of the Late Jurassic indicate a sea separation between Iberia (Portugal and Spain) and North America prior to the Kimmeridgian-Tithonian (Ziegler, 1988; Rees et al., 2000, 2004; Smith et al., 1994; Golonka, 2005; Mouterde et al., 1979; Ribeiro et al., 1979; Schudack and Schudack, 1989). The paleogeography of the European region (Ziegler, 1988; Schudack and Schudack, 1989) indicates that it was made up of several islands and that Iberia was separated from continental Europe as well as from North America by marine barriers, although the data on which the maps are based do not preclude transient and temporary terrestrial connections. The paleogeography changed. During the Late Jurassic, transgression events led to some isolation of continental areas. This may have contributed to speciation, i.e. in regions as the Iberian block.

The maps presented by Schettino and Scotese (2002) show a full separation of Iberia and North America beginning only in the Lower Hauterivian (131.9 Ma). But the unambiguous marine Kimmeridgian sediments in Portugal refute such a model, in which the continuous linking between these two land masses is overestimated in the Late Jurassic.

The east Africa area, and the Tendaguru Beds, was stable until the Late Jurassic, when the separation of the India and Antarctica blocks from the African mainland marked a significant change. Although in Gondwana, the Tendaguru vertebrate assemblage shows similarities with the Late Jurassic of Europe and North America. On the other hand, the abelisaurids of Tendaguru are of Gondwanan affinity (Rauhut, 2005). While the fine dating of the Tendaguru Beds is still to be achieved, the Middle Dinosaur Member as been dated as Kimmeridgian by Schudack (1999) using charophytes.

Comparison of Ecosystems and Non-dinosaurian Faunas

The resemblance of faunal assemblages is striking among the Morrison, Tendaguru and Portugal. It has been the object of consideration by a number of authors. Comparisons were made between Tendaguru and Morrison by, for example, Schuchert (1918), Galton (1977), Russell et al. (1980), Jacobs (1997), Le Loeuff (1997), Maier (1997; 2003), and between Portugal and Morrison by, for example Lapparent and Zbyszewski (1957), Galton (1980), and Schudack et al. (1998). Schudack et al. (1998) compared the ostracodes and charophytes of the Morrison with Iberia, and suggested a close but complex biogeographic relationship between Europe and North America during the Late Jurassic. They also indicated that the Morrison Formation charophyte flora is more similar to that of central Europe than to Portugal.
Several plants have been reported equally in the Late Jurassic of Portugal and the Morrison: Coniferales (Pagiophyllum), Cheirolepidiaceae (Capressinocladus and Brachyphyllum), Bennettitales (Otozamites), Pterophytes (Coniopteris), Hepatophytes (Marchantites) as well as the charophytes Echinocara and Porocara (Schudack et al. 1998; Chure et al. 1998). Regarding the palynomorphs, the known spores in both Portugal and in the Morrison include Distaltriangulisporites, the known genera in both Portugal and in the Morrison include Lourinhã Formation, and includes the Morrison Formation, and includes the Morrison Formation, and includes the Morrison Formation, and includes the Morrison Formation, and includes the Morrison Formation, and includes the Morrison Formation. The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation). The only invertebrates reported in the two areas are the ostracods Cetaceoarmata, Cetacea stria, Echinochara, Pterophyta, Lycodinium, Lycopodium, Retitriletes, Cicatricosisporites, Aequitirradiadites, Echinocara, and Distaltriangulisporites and the pollen Ceratella (see Sousa, 1998, for the data of Portugal, and Chure et al., 1998 for the Morrison Formation).
Dicraeosaurus, Janenschia and ?Camarasaurus (Raath and McIntosh, 1987; Weishampel et al., 2004). However, the Kadzi Formation is poorly dated and the specimens are quite incomplete. Madagascar does not have Late Jurassic dinosaurs, and the only Late Jurassic localities of Morocco and Niger are mainly track sites. In Ethiopia a cf. Acrocanthosaurus has been reported (Goodwin et al., 1999).

The European localities of England, France, Germany and Spain show faunal similitaries with the Portugal-Morrison-Tendaguru set by the presence of the shared genera Dacentrurus, Archaeopteryx, Dryosaurus, ?Elaphrosaurus and Camptosaurus.

**Biochronology**

In general, the classification of genera and species of Late Jurassic dinosaurs in Portugal is consistent with their chronological distribution worldwide. The dinosaurs Ceratosaurus, Torvosaurus, Allosaurus, cf. Archaeopteryx, Compsognathus, and Dacentrurus are represented in the Kimmeridgian and Tithonian of other regions, while Dinheirosaurus, Lusotitan, Phyllodon, Trimucrodon and Draconyx are represented by similar if distinct genera of similar age in other regions. The systematics of Lourinhãosaurus still are not clear, being bounced between Eustreptospondylidae (=Megalosauridae) and Allosauroidea (but not Allosauridae) in different phylogenetic analyses (Mateus, 1998; Mateus, 2005; Mateus et al., 2001; Allain, 2002, Holtz et al., 2004). If it is a member of Eustreptospondylidae, then it is one of the youngest. The majority of the Eustreptospondylidae are of Middle Jurassic age. Eustreptospondylus is found in the Callovian; Megalosaurus bucklandi and Poekilopleuron are found in the Bathonian. Assignment to Allosauroidea, if correct, would be consistent with the biochronology of the group, that is, Late Jurassic.

The genus Hypsilophodon is known from the Barremian and Aptian. The presence of this genus in the Jurassic of Portugal is its oldest known record but the specimen requires detailed study and review. This is possibly a different genus within the family Hypsilophodontidae.

The Amoreira Member and the Porto Novo Member are the richest in dinosaurs of the Lourinhã Formation. Both are considered Kimmeridgian-Tithonian. In Portugal, the horizon of Ceratosaurus and Torvosaurus is considered Kimmeridgian while Allosaurus is considered Tithonian. Ceratosaurus and Torvosaurus in the Morrison Formation are mostly Tithonian.

The genus Ceratosaurus has been unambiguously identified in the Morrison Formation in Colorado and Utah by three species: C. nasicornis, C. dentisulcatus, and C. magnicornis (Madsen and Welles, 2000). The two last species are from Brushy Member of the Morrison Formation at the Cleveland-Lloyd Quarry (dated as 146.7 to 147.3 M.a. by Bilbey, 1992; i.e., Tithonian) and the Fruitia Paleontological Area, respectively. Ceratosaurus nasicornis is from the Garden Park section (Marsh-Felch Quarry; Tithonian, 150.33 +0.26 M.a.; Kowallis et al., 1998; Gradstein and Ogg, 2004). Ceratosaurus specimens have also been found at nine other localities in the Morrison Formation. The Brushy Basin Member is the most prolific producer of dinosaur sites in Morrison Formation.

Some studies (Kowallis et al., 1998; Turner and Peterson, 1999) date many of the dinosaur quarries of the Morrison to Kimmeridgian mainly based on biostratigraphic evidence (palynological, charophytes or ostracods) but $^{40}$Ar/$^{39}$Ar isotopic dates ranges fall into the Tithonian; i.e., between 145.5 and 150.8 Ma (Gradstein and Ogg, 2004). Several ostracods (Cetacella armata, Cetacella striata, Rhyncocirpis jurassica, Theriosynoecum wyomingense, Bisulcocypris pahasapensis, and Timiriasevia guimarotensis), charophytes (Echinochara pecki, Ponochara fusca, and Ponochara kimmeridgiensis) and palynomorphs have been used.
to correlate the Morrison Formation and Lourinhã-Alcobaça formations and to date them as Kimmeridgian-Tithonian (Schudack et al., 1998). However, absolute dating studies with the use of the same techniques are required for both areas in order to provide rigorous correlations.

Dispersal and Colonization

Due to its geographical placement, the Iberian block may have played an important role as a dispersal passage between Gondwana and Laurasia (Fig. 5). Before the dismantling of Pangea (in the Early and Middle Jurassic), dinosaurs populated the entire supercontinent. The Iberian block was inhabited by Pangean dinosaurs but the presence of genera originating during the Late Jurassic (Apatosaurus, Ceratosaurus, Allosaurus, Torvosaurus), after the formation of the Iberian block, in Portugal and North America indicates that later dispersals occurred probably during low ocean level during regressions. This leads to the question, did the Iberian dinosaurs disperse into North America, or was it the other way around?

Little can be said with certainty about the direction of the dispersal between Late Jurassic regions. However, continents and large land masses have a higher numerical potential to populate smaller areas, such as the Iberian block. Although we cannot make rigorous conclusions, it is most probable that the main colonization routes of dinosaurs were towards Iberia and not the other way around. Due to its dimension, North America would have greater potential to host larger and healthier dinosaur communities and therefore greater potential to colonize other territories. The same argument is also valid with respect to Tendaguru dinosaurs dispersing toward Iberia, because the Gondwanan territory including Africa was vast. It is possible that dispersion between North America and Africa passed through the Iberian block. South America formed a single Gondwanan continent with Africa, suggesting that regional dispersals could have been quite complicated. There are, however, few similarities between the dinosaur faunas of Portugal and South America that can be demonstrated because of the lack of a Late Jurassic record in South America. Further uncertainties with respect to the biogeographic origins and dispersal routes of the Late Jurassic fauna are caused by the lack of informative Middle Jurassic faunas in North America and Africa.

Isolation and Dwarfism

Isolation and reduced land areas such as encountered on islands tend to induce dwarfism in many large vertebrates. Body size generally is related to available land area; i.e., species restricted to smaller home ranges tend to be smaller, although ectothermic herbivores can increase in body size within smaller areas due to low food requirements (Burness et al., 2001). Island dwarfism has been suggested in dinosaurs, in particular among Late Jurassic dinosaurs from Europe, such as the case of Europasaurus sauropod from Germany (Mateus et al., 2004; Sander et al., 2004; Sander et al., in press) and the Late Cretaceous of Romania (Jianu and Weishampel, 1999). During the Late Jurassic, Europe was an archipelago and Iberia was an island. Taking into consideration the European scenario concerning dinosaurs at that time, dwarfism might be expected among Portuguese dinosaurs. However, that is not the case. There is no evidence whatsoever of dwarfism among the Late Jurassic dinosaurs of Portugal, although dwarfism has been suggested for Late Cretaceous Portuguese dinosaurs (Antunes and Sigogneau-Russell, 1991, 1992, 1995, 1996).

The Portuguese specimens of Ceratosaurus, Torvosaurus, Apatosaurus and Allosaurus are just as large as the North American specimens. The largest Late Jurassic theropod was Torvosaurus, and the Portuguese specimen, an 82 cm long tibia (ML430), is larger than specimen BYUVP 20016 (72.5 cm) of Torvosaurus tanneri (Britt, 1991; Mateus and Antunes, 2000). The largest known Jurassic ornithopod is Camptosaurus from the USA, and the largest known from Portugal is the camptosaurid Draconyx loureiroi (Mateus and Antunes, 2001). Neither of these reached the body size suggested by a new ornithopod footprint from Lourinhã, Portugal. The footprint (ML1000), is 70 cm long, and suggests a hip height of 2.8 m. The footprint is the only evidence for a Jurassic ornithopod of such large size (Mateus and Milàn, 2005; Mateus and Milàn, in prep.).

The brachiosaurid sauropod Lasotitan (Antunes and Mateus, 2003) was the largest European dinosaur for its time. The humerus is 205 cm and the femur is 200 cm (Lapparent and Zbyszewski, 1957), almost as large as Brachiosaurus altithorax (femur up to 203 cm) or B. brancai (femur MNB XVI, 214 cm long). With a 174 cm long femur, the Portuguese sauropod Lourinhasaurus was not much smaller. The evidence of one of the largest Jurassic sauropods is a huge Supersaurus ("Ultrasaurus") partial tibia - stored at BYU - collected by Jim Jensen, and named Ultrasaurus. Carpenter (this volume) points to a 2.7 meter tall Amphicoelias fragillimus dorsal vertebra from the Morrison at Garden Park.

In summary, the Late Jurassic dinosaurs from Portugal do not show evidence of dwarfism. Most dinosaurs are similar in size to comparable specimens from Dry Mesa Quarry (see Britt, 1991) or the Cleveland-Lloyd Quarry (Madsen, 1976), and larger than the dinosaurs from the Howe Ranch Quarry (Ayer, 2000). Despite being an island during the Late Jurassic, the Iberian block was probably larger than the critical minimal area and richer in resources than necessary to induce dwarfism.

CONCLUSIONS

In sum, the conclusions are:

- The Lourinhã and Alcobaça Formations (in Portugal) are comparable with the Morrison Formation (in North America), and Tendaguru Beds (in Tanzania), regarding palaeoenvironments and sedimentology.
- The three areas are contemporaneous: Late Jurassic, Kimmeridgian to Tithonian.
- Nearly all families of dinosaurs from the Lourinhã and Alcobaça Formations are present in the Morrison Formation, and the Tendaguru Beds

FIGURE 5. Paleogeographic maps of North Atlantic in the Late Jurassic (modified from Ziegler, 1998).
contain 38% of the familial dinosaur diversity known from the Morrison Formation.

- Every family of dinosaurs known from Tendaguru also occurs in both the Morrison Formation and in Portugal.
- Portugal shows proportionally more theropods and fewer sauropod taxa than either the Morrison or Tendaguru.

There was dinosaur faunal exchange between North America, Iberia and Africa in the Late Jurassic.

- The Late Jurassic dinosaurs from Portugal do not show evidence of dwarfism and comparable taxa are of similar size to the Morrison specimens from Dry Mesa Quarry, Como Bluff or Cleveland-Lloyd Quarry, and larger than the ones from Howe Ranch Quarry.

ACKNOWLEDGMENTS

This research was supported by the Fundação para a Ciência e Tecnologia Fellowship Praxis XXI BD/2116/99. I am very grateful for the critical perusing by Miguel Telles Antunes, Louis Jacobs, and Carlos Natário, with additional comments by John Foster and Jerry Harris.

REFERENCES


Golonka, J., 2005, Cambrian-Neogene plate tectonic maps, Published online at www.dinodata.net.


Hill, G., 1989, Distal alluvial fan sediments from the Upper Jurassic of Portugal: controls on their cyclicity and channel formation: Journal of the Geological So


Janensch, W., 1925, Die Coelurosaurier und Theropoden der Tendaguru-Schichten Deutsch-Ostafrikas: Palaeoentropographica (Suppl. 7), v. 1, p. 1-100.


Mateus, O., Valen, A., and Antunes, M.T., 2006, The large theropod fauna of the Lourinhã Formation (Portugal) and its similarity to the Morrison Formation, with description of a new species of Allosaurus, this volume.


Sander, P.M., Mateus,O., Laven, T. and Knötschke, N., in press, Bone histology indicates insular dwarfism in a new Late Jurassic sauropod dinosaur: Nature.


Schudack, M. and Schudack, U., 2002, Ostracods from the Middle Dinosaur Member of the Tendaguru Formation (Upper Jurassic of Tanzania): Neues Jahrbuch für Geologie und Paläontologie, Monatshefte v. 6, p. 107-119.


TABLE 1. Distribution of major clades of flora and fauna among the continental Lourinhã and Alcobaça Formations (Late Jurassic of Portugal), and presence in Morrison Formation, North America, and Tendaguru Beds, Tanzania. The Late Jurassic of Portugal shows more brackish/marine influence. The table shows the occurrence of suprageneric clades of organisms. Most are by “family” ranking, but for simplicity of comparison not all groups are depicted by the same ranking, and they are arranged accordingly with the diversity of taxa. More detailed comparisons will be possible when the systematics of the species from each of the three areas are better understood.

<table>
<thead>
<tr>
<th>Taxonomy</th>
<th>Portugal</th>
<th>Morrison Fm.</th>
<th>Tendaguru Beds</th>
<th>Taxonomy</th>
<th>Portugal</th>
<th>Morrison Fm.</th>
<th>Tendaguru Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fungi</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>Fungi</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascomycetes</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Ellobiidae</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Basidiomycetes</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Lynnaeidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td><strong>Charophyta</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Otinidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td><strong>Rhodophyta</strong></td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Planorbididae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td><strong>Plantae</strong></td>
<td></td>
<td></td>
<td></td>
<td>Littorinimorpha</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bryophyta</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Vitrinellidae</td>
<td>X</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sphenopsida</td>
<td></td>
<td></td>
<td></td>
<td>Cerithiodia</td>
<td>X</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Equisetales</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Arthropoda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petriophyta</td>
<td></td>
<td></td>
<td></td>
<td>Crustacea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dipteridaceae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Czyzicidae</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dicksoniaceae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Ostracoda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lycopodiaceae</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Cypridacea</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Osmundaceae</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Cytheracea</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gleicheniaceae</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Darwinulae</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Schizaeacea</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Dryelbiidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Matoniaceae</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Malacostraca</td>
<td>-</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cyathaeacea</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Echinodermata</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ginkgospermeae</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Cidaroida</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bennettiales</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Chondrichthyes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheirolepidaeceae</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Hybodontoidia</td>
<td>X</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Taxodiaceae</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Orectolobiformes</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Protopinaceae</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Lonchidiidae</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Czekanowskiaecae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Orthacodontidae</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Ginkgoaete</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Batoidea</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Podocarpaceae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Osteichthyes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinaceae</td>
<td>-</td>
<td>X</td>
<td></td>
<td>Pycnodontidae</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Araucariacea</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>Semionotidae</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gnetales</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Ilonoscopidae</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Animalia</strong></td>
<td></td>
<td></td>
<td></td>
<td>Macrolepiidae</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bivalvia</td>
<td></td>
<td></td>
<td></td>
<td>Macrolepiidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Pterioidea</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>Ceratodontidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Mytilioidea</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>Amphibia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonioida</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>Albanerpetontidae</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Unionoidea</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Caudata</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Veneroidea</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>Anura</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Myoidea</td>
<td>X</td>
<td>-</td>
<td>?</td>
<td>Discoglossida</td>
<td>X</td>
<td>X</td>
<td>?</td>
</tr>
<tr>
<td>Gastropoda</td>
<td></td>
<td></td>
<td></td>
<td>Chelonia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Archaeogastropoda</td>
<td></td>
<td></td>
<td></td>
<td>Pleiocheleidae</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Neritiniida</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>Pleurosternidae</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mesogastropoda</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Platycheleidae</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cyclophoridae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Glytropidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Plioceridae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Baeniidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Bithyniidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Squamata</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valvatiidae</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>Paramacellolidae</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Naticidae</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>Scincoida</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pulmonata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX
TABLE 2. The dinosaur genera and species from the Late Jurassic of Portugal, Morrison Formation and Tendaguru Beds:

<table>
<thead>
<tr>
<th>Late Jurassic of Portugal (Antunes and Mateus, 1998)</th>
<th>Morrison Formation</th>
<th>Tendaguru Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Britt, 1991: 2; Carpenter, 1998; Maier, 1997; Foster, 2003; Weishampel et al., 2004)</td>
<td>(Janensch, 1925; 1935/36, 1950; Bonaparte et al., 2004)</td>
<td></td>
</tr>
</tbody>
</table>

**THEROPODA**

- Allosaurus (A. fragilis, A. maximus = Saurophag anus [?])
- Ceratosaurus (C. nasicornis, C. dentisculatus, C. magnicornis)
- Torvosaurus tanneri (=?T. grahamensis)
- Lourinhanosaurus antunesi
- Allosaurus europaeus
- Hypsiophus discrurus
- Heterodontosauridae
- Kuparion douglassi
- Labrosaurus stechowi
- Elaphrosaurus bambergi

**SAUROPODA**

- Apatosaurus (4 spp: A. altithorax, A. ajax, A. louisae, A. maximus)
- Barosaurus (4 spp: B. lentus, B. gracilis, B. brancai)
- Dicraeosaurus (D. longispinus, S. stenops)
- Kentrosaurus (K. aethiopicus, K. lettowvorbecki, K. aethiopicus)
- Seismosaurus hallorum (near D. longispinus)
- Eobrontosaurus yahnahpin
- Supersaurus vivianae

**ORNITHISCHIA**

- Lambeosaurus longiceps
- Barosaurus gracilis
- Brachiosaurus brancai
- Dicraeosaurus (D. hansemanni)
- D. sattleri
- Jansschiara robusta
- Tendaguria tanzaniensis
- Tornieria africanus

**SAUROPTERYGIA**

- Stegosaurus (4 spp: S. armatus, S. ungulatus, S. stenops)
- Apatosaurus (4 spp: A. altithorax, A. ajax, A. maximus, A. brachylophus)
- Brachiosaurus (4 spp: B. lentus, B. gracilis, B. brancai)
- Dicraeosaur (D. longispinus, S. stenops)
- Kentrosaurus (K. aethiopicus, K. lettowvorbecki, K. aethiopicus)
- Seismosaurus hallorum (near D. longispinus)
- Eobrontosaurus yahnahpin
- Supersaurus vivianae

**ORNITHISCHIA**

- Lambeosaurus longiceps
- Barosaurus gracilis
- Brachiosaurus brancai
- Dicraeosaur (D. hansemanni)
- D. sattleri
- Jansschiara robusta
- Tendaguria tanzaniensis
- Tornieria africanus

Source: Portugal (Antunes and Mateus, 2003; Martin and Krebs, 2000; Pais, 1998); Morrison (Chure et al., 1998; Chure et al., this volume); Tendaguru (Aberhan et al., 2002; Heinrich, 1998; Schudack and Schudack, 2002).