

Type specimens alone have a strong correlation with taxa record by geological epoch: the case study of the fossil vertebrates named from Portuguese types

Os espécimes-tipo por si só têm uma forte correlação com o registo de táxones por época geológica: o estudo de caso dos vertebrados fósseis nomeados a partir de tipos portugueses

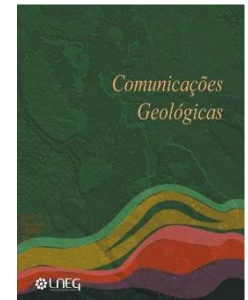
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Abstract: Type specimens (holotypes, neotypes, syntypes, etc.) are of crucial importance because they are the only tangible evidence of the nomenclatural act that supports the understanding of paleobiodiversity. The list of the vertebrate species whose type specimen is based on fossils from Portugal is presented here. We counted 206 species, of which there are 45 bony fishes, 39 Late Jurassic Mammalianomorpha, 33 Cenozoic mammals, 28 non-avian dinosaurs, 25 non-dinosaur reptiles, 11 Cenozoic Aves, 22 Chondrichthyes and three other vertebrates. Except for the Quaternary fossil record, the type specimens can be used as a shortcut for measuring the fossil record and paleobiodiversity through geological time and rock units because they correlate in 95% with the fossil record by epoch in the case-study of fossil vertebrates of Portugal.

Keywords: Type specimens, Vertebrata, Fossil Diversity, holotypes, Geoheritage

Resumo: Os espécimes tipo (holótipos, neótipos, sintipos, etc.) são de importância crucial porque são a única evidência tangível do ato nomenclatural que apoia a compreensão da paleobiodiversidade. É apresentada aqui uma lista de vertebrados cujo espécime-tipo se baseia em fósseis de Portugal. Contamos 206 taxa, das quais há 45 peixes ósseos, 39 mamíferos e parentes do Jurássico superior, 33 mamíferos cenozóicos, 28 dinossauros não avianos, 25 répteis não dinossauros, 11 aves cenozóicas, 22 Chondrichthyes e três vertebrados doutros tipos. Exceto para o registo fóssil quaternário, os espécimes-tipo podem ser usados como um atalho para medir o registo fóssil e a paleobiodiversidade através do tempo geológico e unidades de rocha porque eles se correlacionam em 95% com o registo fóssil por época no estudo de caso de vertebrados fósseis de Portugal.

Palavras-chave: Espécimes-tipo, Vertebrados, Diversidade fóssil, holótipos, Património geológico.

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Introduction

In systematics and taxonomy, a species or a genus are abstract concepts, without physical existence. These concepts are based on

individual organisms, such as animals or plants, which, as a rule, are deposited in museums or universities that conserve and safeguard them as real and palpable specimens and samples. Specimens used for taxonomic and nomenclatural purposes, such as the designation of a new species, are called type specimens.

The existence of standard specimens in a collection, whether from a museum or a research institution such as a university, is a testament to the importance of that institution. Either because of the investigation produced for the description of the species or because of the credibility that the author recognized to deposit in it the type specimens. However, type specimens have not always been deposited in publicly accessible institutions that allow access for the study by different researchers, for comparison purposes and further analyses.

In the past, species have been described from materials whose ownership was kept private, without public access. Fortunately, species description editorial policies have been taking measures to guarantee the deposit of specimens in public institutions, such as universities. It is also common to deposit such material in museums, namely those dedicated to “natural history” which continue to have an essential role as science repositories.

The conservation of type specimens of live organisms is ensured by various techniques, the most common being taxidermy, skeletal assembly, liquid medium, herborization or microscopy preparations. However, in the case of fossil organisms, the type specimens are commonly mineralized, therefore, usually, only parts of animals fossilize, as well as partial plant organs, being complete organisms preserved just common in the case of micropaleontology. These type specimens are crucial for the taxonomy, so this importance should be reflected in the management and care of the paleontological collections of types. In addition to being duly protected and guaranteed to last, all types must be in a scientifically accessible repository (museum or university) and available for study by other researchers.

There are several type specimens (McNeill *et al.*, 2012): holotype, single specimen or sample that serves as a base reference for the first description and naming of a species; paratype, additional samples or specimens (other than the holotype) that support the first description and naming of the *taxon*; neotype, the

reference specimen or sample for the species, but designated after the original description, because the original holotype was never designated or was lost or destroyed; syntype (any of several specimens that are listed in a species description where multiple specimens but no holotype have been designated) and lectotype, which is the specimen chosen to serve as a single type specimen selected *a posteriori* from a set of syntypes when the holotype was not assigned.

Vertebrate species whose type specimen is based on fossils from Portugal

The list of vertebrate species whose type specimen is based on fossils from Portugal is presented here, compiled mainly by bibliographical review. We counted 206 species, of which there are 45 bony fishes, 39 Jurassic mammalia and kin, 33 Cenozoic mammals, 28 non-avian dinosaurs, and 25 non-dinosaur reptiles, 11 Cenozoic birds, 22 Chondrichthyes two Mesozoic Batrachomorpha, and one Paleozoic Acanthodii (Tab. 1).

The first description of a vertebrate is due to Henri E. Sauvage (1897-1898) and 17 species are due to him. The most prolific author is the Belgian Simon Armand Jonet (1902-1987) with 40 species, mainly of Miocene bony fish, followed by the German

Gerhard Hahn (1933-) with 27 species, mainly mammals and kin from the Late Jurassic of Guimarota mine (Leiria). Among the Portuguese scientists, Miguel Telles Antunes (1937-) stands out with 15 species.

The overwhelming majority of fossils are found in publicly accessible Portuguese institutions. The Geological Museum of Lisbon (Museu Geológico), with 104 type specimens is, by far, the institution with the highest number of deposited specimens (Fig. 1), followed by the Universidade Nova de Lisboa and the Museu da Lourinhã. At least two are not deposited in Portugal and many are in private collections. One type specimen was destroyed in a fire (*Lusitanosaurus liasicus* Lapparent and Zbyszewski, 1957). Note that all the fossils from Guimarota, initially marked with the acronym IPFUB, are now under the acronym MG, from the Geological Museum. About the acronyms used in the Geological Museum and the problematics concerning some specimens see Russo and Mateus (2021). There are also vertebrate types in Portuguese institutions but from other countries, mainly from Angola such as *Cardiocorax mukulu* Araújo *et al.*, 2015 to where some are expected to return in the future (Mateus *et al.*, 2009a; Araújo *et al.*, 2015; Mateus *et al.*, 2019). In addition, the Natural History Museum of Sintra holds a holotype of the Brazilian pterosaur *Barbosania gracilirostris* Elgin and Frey, 2011.

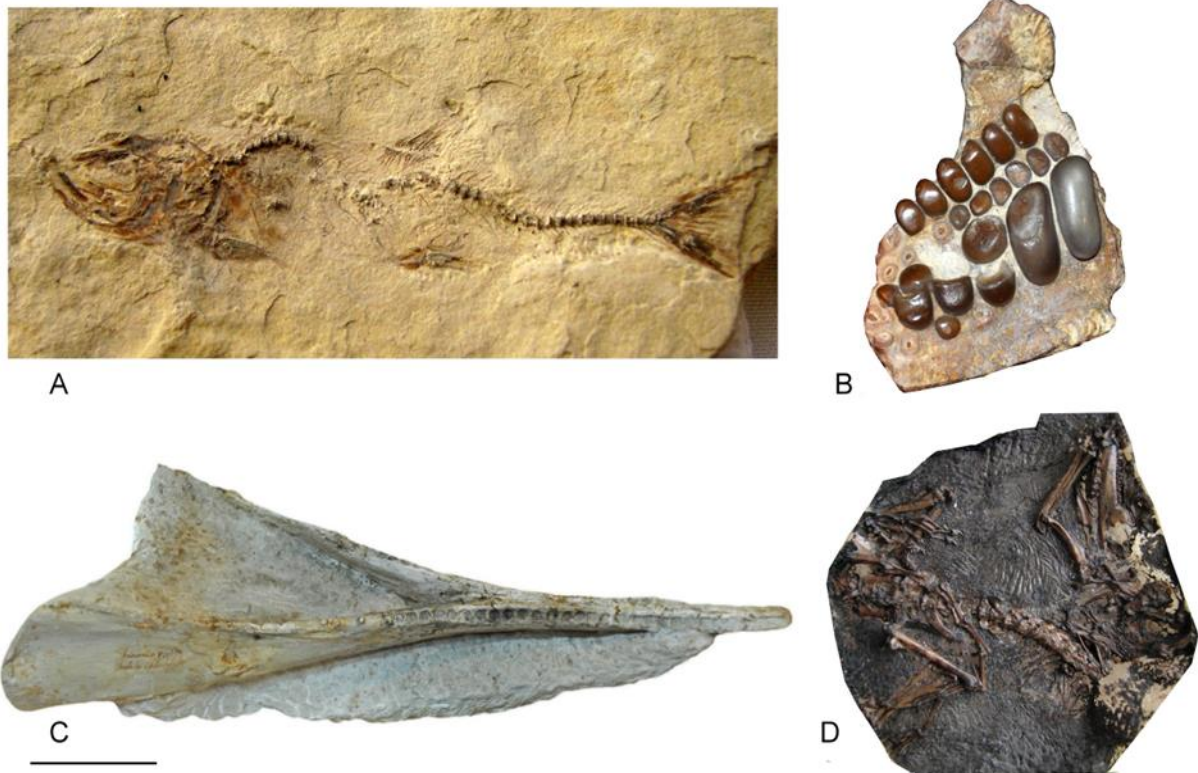


Figure 1. Examples of Portuguese vertebrate holotypes deposited at the Geological Museum in Lisbon, the main repository of type specimens in Portugal: A) *Salminops ibericus* Gayet, 1985 (MG 6657); B) *Coelodus anomalus* Priem, 1904 (MG 52); C) *Palaeoziphius melidensis* Zbyszewski, 1954 (MG 5450) and D) *Henkelotherium guimarotae* Krebs, 1991 (MG 27414).

Figura 1. Exemplos de holótipos de vertebrados portugueses depositados no Museu Geológico de Lisboa, principal repositório de espécimes-tipo em Portugal: A) *Salminops ibericus* Gayet, 1985 (MG 6657); B) *Coelodus anomalus* Priem, 1904 (MG 52); C) *Palaeoziphius melidensis* Zbyszewski, 1954 (MG 5450) e D) *Henkelotherium guimarotae* Krebs, 1991 (MG 27414).

Table 1: Table synthesis of the species of vertebrates named from Portuguese type specimens.
 Tabela 1: Tabela síntese das espécies de vertebrados nomeados a partir de espécimes tipo portugueses.

Epoch	Occurrences per time period in PBDB	Number of species based in Portuguese types							Grand Total
		Chondrichthyes + Acanthodii	Osteichthyes	Amphibia	Aves	Other Dinosauria	Mammalia-morpha	Other Reptilia	
Quaternary	88				10		4		14
Miocene	447	19	21				16	2	58
Eocene	58				1		13		14
Late Cretaceous	52		22			2		5	29
Early Cretaceous	44		1			2			3
Late Jurassic	449	3	1	1		22	39	16	82
Middle Jurassic	6					1			1
Early Jurassic	5					1		2	3
Late Triassic	7			1					1
Paleozoic	14	1							1
Grand Total	1170	23	45	2	11	28	72	25	206

Most selachians are named based on teeth without associated cartilaginous skeletal material (Fialho *et al.*, 2021), the other taxa are described with bone material and there are also five ichnospecies of footprints (*Eutychnium lusitanicum* Nopcsa, 1923; *Megalosauropus (Eutychnium) gomesi* Antunes, 1976; *Neosauropus lagosteiensis* Antunes, 1976; *Polyonyx gomesi* Santos *et al.*, 2009 and *Leporidichmites malhaoi* Neto de Carvalho, 2009), two Crocodylomorpha egg oospecies (*Suchoolithus portucalensis* and *Krokolithes dinophilus* Russo *et al.*, 2017) and two species of humans (*Anthropopithecus ribeiroi* Mortillet, 1883 and *Homo taganus* Mendes Corrêa, 1918) without type specimens, hence *nomen nudum*.

Most species remain valid, but many are almost forgotten, with no relevant citations since their description. This is related to the fact that 33% of the species described from Portuguese fossils (67 species) are not found in the PaleoBiology DataBase (PBDB), which still needs to be updated with those. This happens more often when scientific articles are not available on the internet. Other names have fallen into synonymy (mainly in bony fishes and chondrichthyans), two are *nomen nudum* (the two humans previously mentioned) and several are interpreted as *nomen dubium* (such as *Megalosaurus pombali* Lapparent and Zbyszewski, 1957), but there is no argument to support this attribution.

The list of vertebrate species named after the fossil from Portugal is presented below, regardless of the status of validity of the species:

Quaternary mammals

1. *Anthropopithecus ribeiroi* Mortillet, 1883
2. *Homo taganus* Mendes Corrêa, 1918
3. *Equus caballus antunesi* Cardoso and Eisenmann, 1989
4. *Leporidichmites malhaoi* Neto de Carvalho, 2009

Cenozoic Aves

1. *Fluviatilavis antunesi* Harrison, 1983
2. *Otus fruticosoi* Rando *et al.*, 2013
3. *Otus maui* Rando *et al.*, 2013
4. *Rallus lowei* Alcover *et al.*, 2015
5. *Rallus adolfocaesaris* Alcover *et al.*, 2015

6. *Rallus montivagorum* Alcover *et al.*, 2015
7. *Rallus carvaensis* Alcover *et al.*, 2015
8. *Rallus minutus* Alcover *et al.*, 2015
9. *Pyrrhula crassa* Rando *et al.*, 2017
10. *Coturnix lignorum* Rando *et al.*, 2019
11. *Coturnix alabrevis* Rando *et al.*, 2019

Miocene Chondrichthyes

1. *Pristis atlanticus* Zbyszewski, 1947
2. *Galeorhinus pulchellus* Jonet, 1966
3. *Carcharhinus (Aprionodon) gracilis* Jonet, 1966
4. *Carcharhinus (Aprionodon) lerichei minuta* Jonet, 1966
5. *Carcharhinus (Aprionodon) macrorrhiza* Jonet, 1966
6. *Carcharhinus (Hypoprion) lusitanicus* Jonet, 1966
7. *Physodon miocaenus* Jonet, 1966
8. *Scoliodon dentatus* Jonet, 1966
9. *Raja praeclavata* Jonet, 1968
10. *Rhinobatus antunesi* Jonet, 1968
11. *Pristis lanceolatus* Jonet, 1968
12. *Raja olisiponensis* Jonet, 1968
13. *Megascyliorhinus miocaenicus* Antunes and Jonet, 1969-1970
14. *Squalus almeidae* Antunes and Jonet, 1969-70
15. *Mobula cappetta* Jonet, 1976
16. *Galeorhinus gonalvesi* Antunes *et al.*, 1999
17. *Paragaleus antunesi* Balbino and Cappetta, 2000
18. *Aetobatus cappettai* Antunes and Balbino, 2006
19. *Oxyrhina hastalis* var. *lusitanica* Jonet 1964

Miocene Osteichthyes

1. *Congermuraena weileri* Jonet 1972-73
2. *Eucitharus lusitanicus* Jonet, 1972-73
3. *Jefitchia spinosa* Jonet, 1972-73
4. *Peristedion pulchrum* Jonet, 1972-73
5. *Mugil pragalensis* Jonet, 1972-73
6. *Pseudorhombus helvecianus* Jonet, 1972-73
7. *Trachurus elegans* Jonet, 1972-73
8. *Sparnodus helvecianus* Jonet, 1975
9. *Pagellus caparicaensis* Jonet, 1975

10. *Dentex fossilis* Jonet, 1975
11. *Diplodus aquitaniensis* Jonet, 1975
12. *Trigonodon elongatus* Jonet *et al.*, 1975
13. *Pagrus robustus* Jonet, 1975
14. *Leuciscus antunesi* Gaudant, 1977
15. *Sphyaena gracile* Jonet, 1978
16. *Arius unbonatus* Jonet, 1979
17. *Dentex rotundus* Jonet, 1979
18. *Pomadasy ornatus* Jonet, 1980
19. *Diplodus intermedius* Jonet, 1981
20. *Sphyaena olisiponensis* Jonet 1966
21. *Cybum serralheiroi* Jonet 1966

Miocene mammals

1. *Metopocetus vandelli* Van Beneden and Gervais, 1868
2. *Protaceratherium tagicus* Roman *et al.*, 1907
3. *Aulocetus latus* Kellogg, 1940
4. *Cephalotropis nectus* Kellogg, 1940
5. *Trilophodon olisiponense* Zbyszewski, 1949
6. *Protanancus estremadurensis* Bergounioux *et al.*, 1951
7. *Serridentinus lusitanicus* Bergounioux *et al.*, 1951
8. *Chilotherium quintanelensis* Zbyszewski, 1952
9. *Palaeoziphius melidensis* Zbyszewski, 1954
10. *Fahlbuschia freudenthali* Antunes and Mein, 1981
11. *Fahlbuschia ultima* Antunes *et al.*, 1983
12. *Gaindatherium rexmanueli zbyszewskii* Antunes and Ginsburg, 1983
13. *Plesiaceratherium lumiarense* (Antunes and Ginsburg, 1983)
14. *Tagicetus joneti* Lambert *et al.*, 2005
15. *Globicetus hiberus* Bianucci *et al.*, 2013
16. *Imocetus piscatus* Bianucci *et al.*, 2013

Eocene mammals

1. *Paranchilophus lusitanicus* (Ginsburg and Zbyszewski, 1965)
2. *Teilhardimys reisi* Antunes *et al.*, 1987
3. *Diacodexis antunesi* Estravís and Russell, 1989
4. *Russellmys denisae* Estravís, 1990
5. *Eurodon silveirinhensis* Estravís and Russell, 1992
6. *Paschatherium marianae* Estravís and Russell, 1992
7. *Microparamys paisi* Estravís, 1994
8. *Leptacodon nascimento* Estravís, 1996
9. *Arcius zbyszewskii* Estravís, 2000
10. *Donrussellia lusitanica* Estravís, 2000
11. *Euromys cardosoi* (Estravís, 2000)
12. *Archaeonycteris praecursor* Tabuce *et al.*, 2009
13. *Mondegodon eutrigonus* Tabuce *et al.*, 2011

Mesozoic and Cenozoic non-dinosauria Reptilia

1. *Oweniasuchus lusitanicus* Sauvage, 1897-98
2. *Simoliophis delgadoi* Sauvage, 1897-98
3. *Plesiochelys choffati* Sauvage, 1897-98
4. *Rosasia soutoi* Carrington da Costa, 1940
5. *Tomistoma lusitanica* (Vianna and Moraes, 1945)
6. *Pelagosaurus tomarensis* Veiga-Ferreira, 1959
7. *Becklesius hoffstetteri* Seiffert, 1973
8. *Cteniogenys reedi* Seiffert, 1973
9. *Introrsisaurus pollicidens* Seiffert, 1973
10. *Lisboasaurus mitrocostatus* Seiffert, 1973
11. *Saurillus henkeli* Seiffert, 1973
12. *Lisboasaurus estesi* Seiffert, 1973
13. *Saurillodon proraformis* Seiffert, 1973

14. *Iberosuchus macrodon* Antunes, 1975
15. *Oweniasuchus pulchelus* Jonet, 1981
16. *Goniopholis baryglyphaeus* Schwarz, 2002
17. *Knoetschkesuchus guimarotae* (Schwarz and Salisbury, 2005)
18. *Selenemys lusitanica* Pérez-García and Ortega, 2011
19. *Lusonectes sauvagei* Smith *et al.*, 2012
20. *Hylaeochelys kappa* Pérez-García and Ortega, 2014
21. *Portugalophis lignites* Caldwell *et al.*, 2015
22. *Suchoolithus portucalensis* Russo *et al.*, 2017
23. *Krokolithes dinophilus* Russo *et al.*, 2017
24. *Portugalosuchus azenhae* Mateus *et al.*, 2018
25. *Plesiopharos moelensis* Puertolas-Pascual *et al.*, 2021

Mesozoic Chondrichthyes

1. *Asteracanthus biformatus* Kriwet, 1995
2. *Hybodus lusitanicus* Kriwet, 2004
3. *Leiribatos alienus* Kriwet, 2004

Mesozoic Osteichthyes

1. *Mesodon sharpei* Sauvage, 1897-98
2. *Anomoeodus woodwardi* Sauvage, 1897-98
3. *Clastes (Lepidotus) lusitanicus* Sauvage, 1897-98
4. *Clastes pustulosus* Sauvage, 1897-98
5. *Clupea arezedi* Sauvage, 1897-98
6. *Clupea gomesei* Sauvage, 1897-98
7. *Coelodus bocagei* Sauvage, 1897-98
8. *Coelodus choffati* Sauvage, 1897-98
9. *Coelodus cuneiformis* Sauvage, 1897-98
10. *Coelodus delgadoi* Sauvage, 1897-98
11. *Coelodus riberoi* Sauvage, 1897-98
12. *Mesodon limai* Sauvage, 1897-98
13. *Coelodus anomalus* Priem, 1904
14. *Sylvienodus laveirensis* (Veiga Ferreira, 1961)
15. *Palaeocyttus princeps* Gaudant, 1978
16. *Paraipichthys lusitanicus* Gaudant, 1978
17. *Cryptoberyx brevis* Gaudant, 1978
18. *Coelodus portucalensis* Jonet, 1981
19. *Lepidotus minimus* Jonet, 1981
20. *Lusitanichthys characiformis* Gayet, 1981
21. *Paleamia cenomaniensis* Jonet, 1981
22. *Paralepidosteus cacemensis* Jonet, 1981
23. *Salminops ibericus* Gayet, 1985
24. *Barcarenichthys joneti* Gayet, 1988

Mesozoic Batracomorpha

1. *Celtdens guimarotae* Wiechmann, 2003
2. *Metoposaurus algarvensis* Brusatte *et al.*, 2015

Mesozoic Dinosauria (except Aves)

1. *Morosaurus marchei* Sauvage, 1897-98
2. *Suchosaurus girardi* Sauvage, 1897-98
3. *Eutynichnium lusitanicum* Nopcsa, 1923
4. *Lourinhasaurus alenquerensis* (Lapparent and Zbyszewski, 1957)
5. *Lusotitan atalaiensis* (Lapparent and Zbyszewski, 1957)
6. *Lusitanosaurus liasicus* Lapparent and Zbyszewski, 1957
7. *Megalosaurus pombali* Lapparent and Zbyszewski, 1957
8. *Astrodon pusillus* Lapparent and Zbyszewski, 1957
9. *Alocodon kuehnei* Thulborn, 1975
10. *Phyllodon henkeli* Thulborn, 1975
11. *Trimucrodon cuneatus* Thulborn, 1975
12. *Megalosauropus (Eutynichnium) gomesei* Antunes, 1976

13. *Neosauropus lagosteiensis* Antunes, 1976
14. *Dracopelta zbyzewskii* Galton, 1980
15. *Euronychodon portucalensis* Antunes and Sigogneau-Russell, 1991
16. *Taveirosaurus costai* Antunes and Sigogneau-Russell, 1991
17. *Lourinhanosaurus antunesi* Mateus, 1998
18. *Dinheirosaurus* (or *Supersaurus*) *lourinhanensis* Bonaparte and Mateus, 1999
19. *Aviatyrannis jurassica* Rauhut, 2003
20. *Draconyx loureiroi* Mateus and Antunes, 2003
21. *Allosaurus europaeus* Mateus *et al.*, 2006
22. *Polyonyx gomesi* Santos *et al.*, 2009
23. *Miragaia longicollum* Mateus *et al.*, 2009
24. *Eousdryosaurus nanohallucis* Escaso *et al.*, 2014
25. *Torvosaurus gurneyi* Hendrickx and Mateus, 2014
26. *Zby atlanticus* Mateus *et al.*, 2014
27. *Oceanotitan dantasi* Mocho *et al.*, 2019
28. *Lusovenator santosi* Malafaia *et al.*, 2020

Late Jurassic mammals and their kin

1. *Paulchoffatia delgadoi* Kühne, 1961
2. *Guimarota freyi* Kühne, 1968
3. *Guimarotodon leiriensis* Hahn, 1969
4. *Henkelodon guimarotensis* Hahn, 1969
5. *Kuehneodon dietrichi* Hahn, 1969
6. *Kuehneodon guimarotensis* Hahn, 1969
7. *Kuehneodon simpsoni* Hahn, 1969
8. *Haldanodon expectatus* Kühne and Krusat, 1972
9. *Pseudobolodon dryas* Hahn, 1977
10. *Pseudobolodon oreas* Hahn, 1977
11. *Henkelodon naias* Hahn, 1977
12. *Kuehneodon uniradiculatus* Hahn, 1978
13. *Meketibolodon robustus* Hahn, 1978
14. *Kielanodon hopsoni* Hahn, 1987
15. *Henkelotherium guimarotae* Krebs, 1991
16. *Meketichoffatia krausei* Hahn, 1993
17. *Pseudobolodon krebsi* Hahn and Hahn, 1994
18. *Bathmochoffatia hapax* Hahn and Hahn, 1998
19. *Drescheratherium acutum* Krebs, 1998
20. *Kuehneodon hahni* Antunes, 1998
21. *Parachoffatia staphylos* Hahn and Hahn 1998
22. *Plesiochoffatia peparethos* (Hahn and Hahn, 1998)
23. *Plesiochoffatia staphylos* (Hahn and Hahn, 1998)
24. *Plesiochoffatia thoas* (Hahn and Hahn, 1998)
25. *Proalbionbaatar plagiocyrtus* Hahn and Hahn, 1998
26. *Xenachoffatia oinopion* Hahn and Hahn, 1998
27. *Eprepaux anomala* Hahn and Hahn, 1999
28. *Bernardodon atlanticus* Hahn and Hahn, 1999
29. *Guimarotodus inflatus* (Martin, 1999)
30. *Iberodon quadrituberculatus* Hahn and Hahn 1999
31. *Krebsotherium lusitanicum* (Martin, 1999)
32. *Laolestes andresi* (Martin, 1999)
33. *Pinheirodon pygmaeus* Hahn and Hahn, 1999
34. *Pinheirodon vastus* Hahn and Hahn, 1999
35. *Portopinheirodon asymmetricus* (Martin, 1999)
36. *Kuehneodon barcasensis* Hahn and Hahn, 2001
37. *Renatodon amalthea* Hahn, 2001
38. *Nanolestes drescherae* Martin, 2002
39. *Nanolestes krusati* Martin, 2002

Devonian Acanthodii

1. *Campylodus delgadoi* Priem, 1910

The locations that provided the most type specimens are Mina da Guimarota and Silveirinha, but the Jurassic areas of Lourinhã and the Miocene of Lisbon are equally noteworthy. The richest epochs of vertebrates in Portugal are therefore the Late Jurassic followed by the Miocene.

As the first list of the vertebrate types from Portugal, it provides an insight on the country's fossil heritage and how it reflects palaeobiodiversity.

The following are a set of recommendations for museums and other repository institutions: 1) keep the specimens at a high level of security; 2) the labels and catalogs of the collections must clarify when it is a type specimen; 3) take photographs and 3D digitization of the type specimens; 4) make available in open access, whenever possible, the scientific information of the holotypes, including scientific articles and associated photographs. We recommend that paleontologists include information clear and evident in scientific articles about the type specimen, its number and repository.

Correlation of type-only with fossil record

The number of species named after Portuguese fossils, here referred to as "types-only" for simplification, can be compared with the fossil record (*taxa*, occurrences, or collections) of the same territory, by age, environment, collections, dates of collection, etc. The most complete database of general fossil record is unquestionably the PaleoBiology DataBase (PBDB, <https://paleobiodb.org>) run by professional paleontologists, with 223,816 total collections and 1,545,262 total occurrences as the start of 2022. For Portugal alone, there are records of 1342 collections, 9412 occurrences, and 3662 *taxa* (data consulted in January of 2022 using the Download Generator form at <https://paleobiodb.org/classic/displayDownloadGenerator>).

We wanted to see the correlation between the record of fossil *taxa* in the PBDB (second column of table 1) and our data using types-only, using geological epochs as intervals (see the last column of the same table).

The comparison of our preliminary data with the fossil records in the PBDB (Fig. 2 and Tab. 1) shows an understandable 94.2% correlation between the type specimens and fossil occurrences, for all geological ages except for the Quaternary, in which the modern species subsist. The correlation was obtained by comparing both data, the second (species in Portugal in PBDB) and last column (Grand Total) of table 1, calculating the *r* (Pearson test) in the software Excel (function "=CORREL"). The result is this correlation of 94.2%.

Conclusion

In conclusion, this is the first list of the vertebrate types from Portugal, which sums 206 *taxa*.

Except for the Quaternary fossil record, the type specimens of vertebrates can be used as a shortcut for measuring the fossil record and thus contribute to understanding paleobiodiversity through geological time and rock units, with a 95% correlation in this case study.

Planned further analysis may clarify and provide more information on type localities, repository and musealization conditions, repository numbers, detailed taxonomy, photographs and comments on the validity of each species. Still, this list gives a perspective on Portugal's fossil heritage and how it reflects paleobiodiversity. This also provides a glimpse into the importance of institutions as repositories, and providers of access to the specimens.

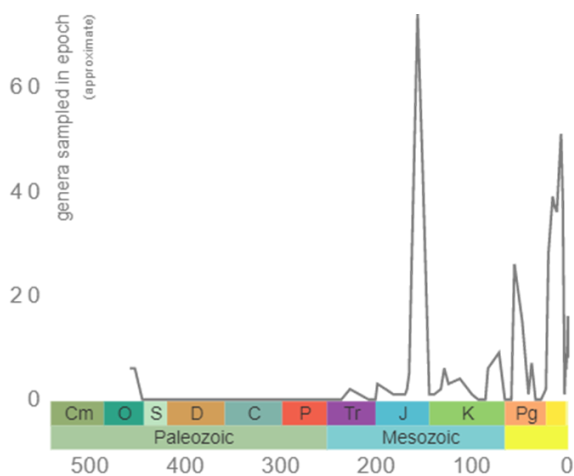


Figure 2. Fossil record of Vertebrata genera by stage according to Paleobiology DataBase in the area of Portugal (graphic generated by PBDB in the rectangle between 31.7° to 4.7° W, 36.3° to 41.5° N).

Figura 2. Registo fóssil dos géneros de Vertebrata por andar de acordo com a Paleobiology DataBase na área de Portugal (gráfico gerado pelo PBDB no retângulo entre 31,7° a 4,7° W, 36,3° a 41,5° N).

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References

- Alcover, J. A., Pieper, H., Pereira, F., Rando, J. C., 2015. Five New Extinct Species of Rails (Aves: Gruiformes: Rallidae) from the Macaronesian Islands (North Atlantic Ocean). *Zootaxa*, **4057**(2): 151-200. <https://doi.org/10.11646/zootaxa.4057.2.1>.
- Antunes, M. T., 1975. Iberosuchus, crocodile Sebecosuchien nouveau, l'Eocène ibérique au nord de la Chaîne central, et l'origine du canyon de Nazaré. *Comunicações dos Serviços Geológicos de Portugal*, **59**: 285-330.
- Antunes, M. T., 1976. Dinossáurios eocretácicos de Lagosteiros. *Ciências da Terra*, **1**: 1-35.
- Antunes, M. T., 1998. A new Upper Jurassic Paulchoffatiid multituberculate (Mammalia) from Pai Mogo, Portugal. *Memórias da Academia de Ciências de Lisboa*, **37**: 125-153.
- Antunes, M. T., P. Mein, 1981. Vertébrés du miocène moyen de amor (Leiria) - importance stratigraphique. *Ciências da Terra*, **6**: 169-188.
- Antunes, M. T., Sigogneau-Russell, D., 1991. Nouvelles données sur les Dinosaurés du Crétacé supérieur du Portugal. *Comptes rendus de l'Académie des Sciences. Série 2, Mécanique, Physique, Chimie, Sciences de l'univers, Sciences de la Terre*, **313**(1): 113-119.
- Antunes, M. T., Jonet, S., Nascimento, A., 1981. Vertébrés (crocodiliens, poissons) du Miocène marin de l'Algarve occidentale. *Ciências da Terra/Earth Sciences Journal*, **6**: 9-38.
- Antunes, M. T., Balbino, A. C., Cappetta, H. C., 1999. A new shark, *Galeorhinus goncalvesi* (Triakidae, Carcharhiniformes) from the uppermost Miocene of Portugal. *Tertiary Research*, **19**(3-4): 105-110.
- Antunes, M. T., Ginsburg, L., 1983. Les Rhinocerotidés du Miocène de Lisbonne Systématique, écologie, paléobiogéographie, valeur stratigraphique. *Ciências da Terra*, **7**: 17-98.
- Antunes, M. T., Jonet, S., 1969-1970. Requins de l'Helvétien supérieur et du Tortonien de Lisbonne. *Revista da Faculdade de Ciências de Lisboa*, **16**(1): 119-280, pl. 1-20.
- Antunes, M. T., Estravis, C., Russell, D. E., 1987. A new condylarth (Mammalia) from the Early Eocene of Silveirinha, Portugal. *Münchener Geowissenschaftliche Abhandlungen*, **10**: 219-224.
- Antunes, M. T., Ginsburg, L., Mein, P., 1983. Mammifères miocènes de Azambujeira, niveau inférieur (Santarém, Portugal). *Ciências da Terra*, **7**: 161-186.
- Araújo, R., Polcyn, M. J., Lindgren, J., Jacobs, L. L., Schulp, A. S., Mateus, O., Gonçalves, A. O., Morais, M. L., 2015. New aristonectine elasmosaurid plesiosaur specimens from the Early Maastrichtian of Angola and comments on paedomorphism in plesiosaurs. *Netherlands Journal of Geosciences*, **94**(1): 93-108. <https://doi.org/10.1017/njg.2014.43>.
- Balbino, A. C., Cappetta, H., 2000. Paragaleus antunesi (Hemigaleidae, Carcharhiniformes) a new shark species from the latest Miocene of Portugal. *Tertiary Research*, **20**(1/4): 1-6.
- Bergounioux, F. M., Zbyszewski, G., Crouzel, F., 1951. Les Mastodontes des sables miocènes de Lisbonne. *Comptes Rendus Hebdomadaires des Seances de l'Académie des Sciences*, **232**(3): 255-256.
- Bianucci, G., I. Miján, Lambert, O., 2013. Bizarre fossil beaked whales (Odontoceti, Ziphiidae) fished from the Atlantic Ocean floor off the Iberian Peninsula. *Geodiversitas* **35**(1): 105-153. <https://doi.org/10.5252/g2013n1a6>.
- Bonaparte, J. F., Mateus, O., 1999. A new diplocid, Dinheirosaurus lourinhanensis gen. et sp. nov., from the Late Jurassic beds of Portugal. *Revista del Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" e Instituto Nacional de Investigación de las Ciencias Naturales, Paleontología*, **5**(2): 13-29.
- Brusatte, S. L., Butler, R. J., Mateus, O., Steyer, J. S., 2015. A new species of Metoposaurus from the Late Triassic of Portugal and comments on the systematics and biogeography of metoposaurid temnospondyls. *Journal of Vertebrate Paleontology*, **35**(3): 912-988. <https://doi.org/10.1080/02724634.2014.912988>.
- Caldwell, M. W., Nydam, R. L., Palci, A., Apesteguía, S., 2015. The oldest known snakes from the Middle Jurassic-Lower Cretaceous provide insights on snake evolution. *Nature Communications*, **6**(5996): 1-11. <https://doi.org/10.1038/ncomms6996>.
- Cardoso, J. L., Eisenmann, V., 1989. Equus caballus antunesi, nouvelle sous-espèce quaternaire du Portugal. *Palaeovertebrata*, **19**(2): 47-72.
- Carrington da Costa, J., 1940. Um novo quelônio fóssil. *Comunicações dos Serviços Geológicos de Portugal*, **21**: 107-125.
- Escaso, F., Ortega, F., Dantas, P., Malafaia, E., Silva, B., Gasulla, J. M., Mocho, P., Narvaez, I., Sanz, J. L., 2014. A new dryosaurid ornithopod (Dinosauria, Ornithischia) from the Late Jurassic of Portugal. *Journal of Vertebrate Paleontology* **34**(5): 1102-1112. <https://doi.org/10.1080/02724634.2014.849715>.
- Estravis, C., Russell, D. E., 1989. Découverte d'un nouveau Diacodexis (Artiodactyla, Mammalia) dans l'Eocène inférieur de Silveirinha, Portugal. *Palaeovertebrata*, **19**(1): 29-44.
- Estravis, C., Russell, D. E., 1992. The presence of Taeniodonta (Mammalia) in the Early Eocene of Europe. *Ciências da Terra*, **11**: 191-201.
- Estravis, C., 1994. Microparamys paisi, un nouvel Ischyromyidae (Rodentia) de l'Eocène inférieur de Silveirinha (Baixo Mondego, Portugal). *Comptes rendus de l'Académie des Sciences. Série 2. Sciences de la terre et des planètes*, **318**(3): 417-420.
- Estravis, C., 1990. *Russellmys denisae*, un nouvel Apatemyidé (Mammalia) de Silveirinha, eocène inférieur du Portugal. *Geobios*, **23**(6): 761-765.
- Estravis, C., 1996. *Leptacodon nascimentoi* n. sp., un nouveau Nyctitheriidae (Mammalia, Lipotyphla) de l'Eocène inférieur de Silveirinha (Baixo Mondego, Portugal). *Palaeovertebrata*, **25**(2-4): 279-286.
- Estravis, C., 2000. Nuevos mamíferos del Eoceno Inferior de Silveirinha (Baixo Mondego, Portugal). *Coloquios de Paleontología*, **51**: 281-311.

- Ferreira, O. V., 1959. Nota sobre a presença do género *Pelagosaurus* no Lias do Tomar. *An. Fac. Cien. do Porto*, **41**: 121–125.
- Fialho, P., Balbino, A., Antunes, M. T., 2021. Fossil Chondrichthyes from the Neogene of Portugal: Diversity and Occurrence. *Anuário do Instituto de Geociências*, **44**, Article 43395. https://doi.org/10.11137/1982-3908_2021_44_43395.
- Galton, P. M., 1980. Partial skeleton of *Dracopelta zbyzewskii* n.gen. and n.sp., an ankylosaurian dinosaur from the Upper Jurassic of Portugal. *Geobios*, **13**: 451–457.
- Gaudant, J., 1977. Contributions à la Paléontologie du Miocène moyen continental du bassin du Tage. II-Observations sur les dents pharyngiennes de Poissons Cyprinidés-Póvoa de Santarém. *Ciências da Terra*, **3**: 129–141.
- Gaudant, M., 1978. Contribution à l'étude anatomique et systématique de l'ichthyofaune cénomaniennne du Portugal. Première partie: les 'acanthoptérygiens'. *Comunicações dos Serviços Geológicos de Portugal*, **63**: 105–149.
- Gayet, M., 1981. Contribution à l'Etude Anatomique et Systematique de l'Ichthyofaune Cenomanienne du Portugal. Deuxieme partie: les Ostariophysaires. *Comunicações dos Serviços Geológicos de Portugal*, **67**: 173–190.
- Gayet, M., 1988. Relations Phylogénétiques de *Barcarenichthys joneti* Gayet du Cénomaniennne de Barcarena (Portugal) au sein des Salmoniformes. *Comunicações dos Serviços Geológicos de Portugal*, **74**: 85–103.
- Ginsburg, L., Zbyszewski, G., 1964. Découverte de vertébrés paléogènes dans la falaise de Felgueira Grande entre S. Pedro de Muel et Nazaré. *Comunicações dos Serviços Geológicos de Portugal*, **48**: 97–108.
- Hahn, G., 1969. Beiträge zur Fauna der Grube Guimarota Nr. 3. Die Multituberculata. *Palaeontographica*, **183**: 1–100.
- Hahn, G., 1987. Neue Beobachtungen zum schädel-und gebiss-bau der Paulchoffatiidae (Multituberculata, Ober-Jura). *Palaeovertebrata*, **17**(4): 155–196.
- Hahn, G., 1977. Neue Schaedel-Reste von Multituberculaten (Mamm.) aus dem Malm Portugals. *Geologica et Palaentologica*, **11**: 161–186.
- Hahn, G., 1978. Neue Unterkiefer von Multituberculaten aus dem Malm Portugals. *Geologica et Palaentologica*, **12**: 177–212.
- Hahn, G., 2001. Neue Beobachtungen an Schädelresten von Paulchoffatiidae (Multituberculata; Ober-Jura). *Geologica et Palaentologica*, **35**: 121–143.
- Hahn, G., Hahn, R., 1994. Nachweis des Septomaxillare bei Pseudobolodon krebsi n. sp. (Multituberculata) aus dem Malm Portugals. *Berliner Geowissenschaftliche Abhandlungen*, **13**: 9–29.
- Hahn, G., Hahn, R., 1998. Neue Beobachtungen an Plagiaulacoidea (Multituberculata) des Ober-Juras. 3. Der Bau der Molaren bei den Paulchoffatiidae. *Berliner Geowissenschaftliche Abhandlungen*, Reihe E **28**: 39–84.
- Hahn, G., Hahn, R., 1999. Pinheirodontidae n. fam. (Multituberculata) (Mammalia) aus der tiefen Unter-Kreide Portugals. *Palaeontographica Abteilung, A* **253**(4-6): 77–222.
- Hahn, G., Hahn, R., 2001. Multituberculaten-Zföhne aus dem Ober-Jura von Porto das Barcas (Portugal). *Palaeontologische Zeitschrift*, **74**(4): 583–586.
- Hendrickx, C., Mateus, O., 2014. Torvosaurus gurneyi n. sp., the largest terrestrial predator from Europe, and a proposed terminology of the maxilla anatomy in nonavian theropods. *PLoS One*, **9**(3): e88905. <https://doi.org/10.1371/journal.pone.0088905>.
- Jonet, S., 1964. Notes d'ichthyologie miocène. *Boletim do Museu e Laboratório Mineralógico e Geológico da Faculdade de Ciências*, **10**(1): 29–44.
- Jonet, S., 1966. Notes d'ichthyologie miocène. II. Les Carcharhinidae. *Boletim do Museu e Laboratório Mineralógico e Geológico da Faculdade de Ciências*, **10**(2): 65–88.
- Jonet, S., 1966. Sphyaenidés et Scrombridés du Miocène portugais : troisième note ichthyologique. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, **75**(2): 185–198.
- Jonet, S., 1975. Notes d'ichthyologie Miocene portugaise VI - Les Sparidae. *Boletim da Sociedade Geológica de Portugal*, **29**(3): 135–172.
- Jonet, S., 1976. Notes d' Ichthyologie miocène. VII - La famille des Mobulidae au Portugal. *Boletim da Sociedade Geológica de Portugal*, **20**: 53–64.
- Jonet, S., 1978. Notes d'Ichthyologie Miocène portugaise VIII - Quelques Téléostéens nouveaux ou peu connus. *Boletim da Sociedade Geológica de Portugal*, **21**(1): 1–13.
- Jonet, S., 1979. Le Tortonien supérieur (TVII-b) des environs de Fonte da Telha (Péninsule de Setúbal) et ses faunes. 2e partie: Les otolithes des Poissons Téléostéens. 3e partie: Les Invertébrés. *Comunicações dos Serviços Geológicos de Portugal*, **65**: 105–130.
- Jonet, S., 1980. Le Tortonien superieur (T VIIb) des environs de Fonte da Telha (Péninsule de Setubal) et ses faunes. 2e partie: Les otolithes des Poissons Téléostéens. *Comunicações dos Serviços Geológicos de Portugal*, **65**: 105–123.
- Jonet, S., 1981. Contribution à l'étude des Vertébrés du Crétacé portugais et spécialement du Cénomaniennne de l'Estremadure. *Comum. Comunicações dos Serviços Geológicos de Portugal*, **67**(2): 191–306.
- Jonet, S., 1968. Notes d'ichthyologie Miocene Portugaise; V, Queleques batoides. *Revista da Faculdade de Ciências*, **15**: 233–257.
- Jonet, S., 1972–73. Étude des otolithes des téléostéens (Pisces) du Miocène des environs de Lisbonne. *Comunicações dos Serviços Geológicos de Portugal*, **61**: 107–223.
- Jonet, S., Kotchetoff, Y., Kotchetoff, B., 1975. L'Helvétien du Penedo et sa faune ichthyologique. *Comunicações dos Serviços Geológicos de Portugal*, **59**: 193–228.
- Kellogg, R., 1940. On the cetotheres figured by Vandelli. *Boletim do Laboratório Mineralógico e Geológico da Universidade de Lisboa*, **3**(7–8): 13–23.
- Krebs, B., 1998. Drescheratherium acutum gen. et sp. nov., ein neuer Eupantotherier (Mammalia) aus dem Oberen Jura von Portugal. *Berliner Geowissenschaftliche Abhandlungen*, **28**: 91–111.
- Krebs, B., 1991. Das Skelett von Henkelotherium guimarotae gen. et sp. Nov. (Eupantotheria, Mammalia) aus dem Oberen Jura von Portugal. *Selbstverlag Fachbereich Geowissenschaften*, **133**: 1–110.
- Kriwet, J., 1995. Beitrag zur Kenntnis der Fisch-Fauna des Ober-Jura (unteres Kimmeridge) der Kohlengrube Guimarota bei Leiria, Mittel-Portugal: 1. Asteracanthus bifurcatus n. sp. (Chondrichthyes: Hybodontioidea). *Berliner Geowissenschaftliche Abhandlungen*, **16**: 683–691.
- Kriwet, J., 2004. Late Jurassic selachians (Chondrichthyes: Hybodontiformes, Neoselachii) from Central Portugal. *Neues Jahrbuch für Geologie und Paläontologie*, **2004**(4): 233–256. [10.1127/njgpm/2004/2004/233](https://doi.org/10.1127/njgpm/2004/2004/233).
- Kühne, W. G., 1961. Eine Mammaliafauna aus dem Kimmeridge Portugals. *Neues Jahrbuch für Geologie und Paläontologie*, **1961**: 374–381.
- Kühne, W. G., 1968. Kimeridge mammals and their bearing on the phylogeny of the Mammalia. In: Drake, E. T. (Ed.), *Evolution and environment*, 109–123.
- Kühne, W. G., Krusat, G., 1972. Legalisierung des Taxon Haldanodon (Mammalia, Docodonta). *Neues Jahrbuch für Geologie und Paläontologie*, **1972**: 300–302.
- Lambert, O., Estevens, M., Smith, R., 2005. A new kentriodontine from the middle Miocene of Portugal. *Acta Palaeontologica Polonica*, **50**(2): 239–248.
- Lapparent, A. F., Zbyszewski, G., 1957. Les dinosauriens du Portugal. *Mémoires du Service géologique du Portugal*, **2**: 1–63.
- Malafaia, E., Mocho, P., Escaso, F., Ortega, F., 2020. A new carcharodontosaurian theropod from the Lusitanian Basin: evidence of allosauroid sympatry in the European Late Jurassic. *Journal of Vertebrate Paleontology*, **40**(1). <https://doi.org/10.1080/02724634.2020.1768106>.
- Martin, T., 1999. Dryolestidae (Dryolestida, Mammalia) aus dem Oberen Jura von Portugal. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft*, **550**: 1–119.
- Martin, T., 2002. New stem-lineage representatives of Zatheria (Mammalia) from the Late Jurassic of Portugal. *Journal of Vertebrate Paleontology*, **22**(2): 332–348. [https://doi.org/10.1671/0272-4634\(2002\)022\[0332:NSLROZ\]2.0.CO;2](https://doi.org/10.1671/0272-4634(2002)022[0332:NSLROZ]2.0.CO;2).
- Mateus, O., 1998. Lourinhanosaurus antunesi, a new Upper Jurassic allosauroid (Dinosauria: Theropoda) from Lourinhã, Portugal. *Memórias da Academia de Ciências de Lisboa*, **37**: 111–124.
- Mateus, O., Antunes, M. T., 2001. Draconyx loureiroi, a new camptosauroidae (Dinosauria, Ornithopoda) from the Late Jurassic of

- Lourinhã, Portugal. *Annales de Paléontologie*, **87**(1): 61-73. [https://doi.org/10.1016/S0753-3969\(01\)88003-4](https://doi.org/10.1016/S0753-3969(01)88003-4).
- Mateus, O., Walen, A., Antunes, M. T., 2006. The large theropod fauna of the Lourinhã Formation (Portugal) and its similarity to that of the Morrison Formation, with a description of a new species of *Allosaurus*. *New Mexico Museum of Natural History and Science Bulletin*, **36**: 123-129.
- Mateus, O., Jacobs, L., Polcyn, M., Schulp, A. S., Vineyard, D., Neto, A. B., Antunes, M. T., 2009a. The oldest African eucryptodiran turtle from the Cretaceous of Angola. *Acta Palaeontologica Polonica*, **54**(4): 581-588. <https://doi.org/10.4202/app.2008.0063>.
- Mateus, O., Maidment, S. C. R., Christiansen, N. A., 2009b. A new long-necked 'sauropod-mimic' stegosaur and the evolution of the plated dinosaurs. *Proceedings of the Royal Society B: Biological Sciences*, **276**: 1815-1821. <https://doi.org/10.1098/rspb.2008.1909>.
- Mateus, O., Mannion, P. D., Upchurch, P., 2014. Zby atlanticus, a new turiasaurian sauropod (Dinosauria, Eusauropoda) from the Late Jurassic of Portugal. *Journal of Vertebrate Paleontology*, **34**(3): 618-634.
- Mateus, O., Puértolas-Pascual, E., Callapez, P. M., 2018. A new eusuchian crocodylomorph from the Cenomanian (Late Cretaceous) of Portugal reveals novel implications on the origin of Crocodylia. *Zoological Journal of the Linnean Society*, **186**(2): 501-528. <https://doi.org/10.1093/zoolinnean/zly064>.
- Mateus, O., Callapez, P. M., Polcyn, M. J., Schulp, A. S., Gonçalves, A. O., Jacobs, L. L., 2019. The fossil record of biodiversity in Angola through time: A paleontological perspective. In: *Biodiversity of Angola*: 53-76.
- McNeill, J., Barrie, F. R., Buck, W. R., Demoulin, V., Greuter, W., Hawksworth, D. L., Herendeen, P. S., Knapp, S., Marhold, K., Prado, J., Prud'homme Van Reine, W. F., Smith, G. F., Wiersema, J. H., Turland, N. J., 2012. International Code of Nomenclature for algae, fungi, and plants (Melbourne Code) adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011. *Regnum Vegetabile*, **154**. A.R.G. Gantner Verlag KG. ISBN 978-3-87429-425-6.
- Mocho, P., Royo-Torres, R., Ortega, F., 2019. A new macronarian sauropod from the Upper Jurassic of Portugal. *Journal of Vertebrate Paleontology*, **e1578782**: 1-23. <https://doi.org/10.1080/02724634.2019.1578782>.
- Mortillet, G. de, 1883. *Le Préhistorique, antiquité de l'homme*. Paris, C. Reinwald.
- Neto de Carvalho, C., 2009. Vertebrate tracksites from the Mid-Late Pleistocene eolianites of Portugal: the first record of elephant tracks in Europe. *Geological Quarterly*, **53** (4): 407-414.
- Nopcsa, F. von, 1923. Die familien den reptilien. *Fortschritte der Geol. und Paläontologie*, **2**: 1-210.
- Pérez-García, A., Ortega, F., 2011. *Selenemys lusitanica*, gen. et. sp. nov., a new pleurosternid turtle (Testudines: Paracryptodira) from the Upper Jurassic of Portugal. *Journal of Vertebrate Paleontology*, **31**(1): 60-69. <https://doi.org/10.1080/02724634.2011.540054>.
- Pérez-García, A., Ortega, F., 2014. A new species of the turtle *Hylaeochelys* (Eucryptodira) outside its known geographic and stratigraphic ranges of distribution. *Comptes Rendus Palevol.*, **13**(3): 183-188. <https://doi.org/10.1016/j.crpv.2013.10.009>.
- Puértolas-Pascual, E., Marx, M., Mateus, O., Saleiro, A., Fernandes, A. E., Marinheiro, J., Tomás, C., Mateus, S., 2021. A new plesiosaur from the Lower Jurassic of Portugal and the early radiation of Plesiosauroidea. *Acta Palaeontologica Polonica*, **66**(2), 369-388. <https://doi.org/10.4202/app.00815.2020>.
- Priem, F., 1904. Description de *Coelodus anomalus* n.sp. *Comunicações dos Serviços Geológicos de Portugal*, **6**: 52-53.
- Priem, F., 1910. Sur les poissons et autres fossiles du Silurien supérieur du Portugal. *Comunicações dos Serviços Geológicos de Portugal*, **8**: 1-11.
- Rando, J. C., Alcover, J. A., Olson, S. L., Pieper, H., 2013. A new species of extinct scops owl (Aves: Strigiformes: Strigidae: Otus) from São Miguel Island (Azores Archipelago, North Atlantic Ocean). *Zootaxa*, **3647**: 343-357. <https://doi.org/10.11646/zootaxa.3647.2.6>.
- Rando, J.C., Pieper, H., Olson, S. L., Pereira, F., Alcover, J. A., 2017. A new extinct species of large bullfinch (Aves: Fringillidae: Pyrrhula) from Graciosa Island (Azores, North Atlantic Ocean). *Zootaxa*, **4282**(3): 567. <https://doi.org/10.11646/zootaxa.4282.3.9>.
- Rando, J. C., Alcover, J. A., Pieper, H., Olson, S. L., Hernández, C. N., López-Jurado, L. F., 2020. Unforeseen diversity of quails (Galliformes: Phasianidae: Coturnix) in oceanic islands provided by the fossil record of Macaronesia. *Zoological Journal of the Linnean Society*, **188**(4): 1296-1317. <https://doi.org/10.1093/zoolinnean/zlz107>.
- Rauhut, O. W. M., 2003. A tyrannosauroid dinosaur from the Upper Jurassic of Portugal. *Palaeontology*, **46**(5): 903-913.
- Roman, F., 1907. *Le néogène continental dans la basse vallée du Tage (rive droite)*. Commission du Service Géologique du Portugal. 108.
- Russo, J., Mateus O., 2021. History of the discovery of the ankylosaur *Drapocelta zbyzowskii* (Upper Jurassic), with new data about the type specimen and its locality. *Comunicações Geológicas*, **108**(1): 27-34. <https://doi.org/10.34637/dmdm-5w12>.
- Russo, J., Mateus, O., Marzola, M., Balbino, A., 2017. Two new ootaxa from the late Jurassic: The oldest record of crocodylomorph eggs, from the Lourinhã Formation, Portugal. *PLoS one*, **12**(3): e0171919. <https://doi.org/10.1371/journal.pone.0171919>.
- Santos, V. F., Moratalla, J. J., Royo-Torres, R., 2009. New sauropod trackways from the Middle Jurassic of Portugal. *Acta Palaeontologica Polonica*, **54**(3): 409-422.
- Sauvage, H.-E., 1897-1898. *Vertébrés fossiles du Portugal. Contribution à l'étude des Poissons et des Reptiles du Jurassique et du Crétacique*. Direction des travaux Géologiques du Portugal, Lisbonne, 46.
- Schwarz, D., 2002. A new species of Goniopholis from the Upper Jurassic of Portugal. *Palaeontology*, **45**(1): 185-208.
- Schwarz, D., Salisbury, S. W., 2005. A new species of Theriosuchus (Atoposauridae, Crocodylomorpha) from the Late Jurassic (Kimmeridgian) of Guimarota, Portugal. *Géobios*, **38**: 779-802.
- Seiffert, J., 1973. Upper Jurassic lizards from central Portugal. Contribuição para o conhecimento da Fauna do Kimeridgiano da Mina de Lignito Guimarota (Leiria, Portugal). *Serviços Geológicos de Portugal, Memória (Nova Série)*, **22**: 7-85.
- Smith, A. S., Araújo, R., Mateus, O., 2012. A new plesiosauroid from the Toarcian (Lower Jurassic) of Alhadas, Portugal. *Acta Palaeontologica Polonica*, **57**(2): 257-266.
- Tabuce, R., Clavel, J., Antunes, M. T., 2011. A structural intermediate between triisodontids and mesonychians (Mammalia, Acreodi) from the earliest Eocene of Portugal. *Naturwissenschaften*, **98**: 145-155.
- Tabuce, R., Antunes, M. T., Sigé, B., 2009. A new primitive bat from the earliest Eocene of Europe. *Journal of Vertebrate Paleontology*, **29**(2): 627-630.
- Thulborn, R. A., 1975. Teeth of ornithischian dinosaurs from the Upper Jurassic of Portugal, with description of a hypsilophodontid (*Phyllodon henkeli* gen. et sp. nov.) from the Guimarota lignite. Contribuição para o conhecimento da Fauna do Kimeridgiano da Mina de Lignito Guimarota (Leiria, Portugal). *Serviços Geológicos de Portugal, Memória (Nova Série)*, **22**: 89-134.
- Van Beneden, P. J., Gervais, P., 1868. *Ostéographie des cétacés vivants et fossiles, comprenant la description et l'iconographie du squelette et du système dentaire de ces animaux; ainsi que des documents relatifs à leur histoire naturelle*. 1-634.
- Veiga Ferreira, O., 1961. *Fauna ictyológica do Cretácico de Portugal*. Sociedade Geológica de Portugal, 45.
- Vianna, A., Moraes, A., 1945. Sur un crâne de crocodile fossile découvert dans le Miocène de Lisbonne. *Boletim de la Sociedade Geológica de Portugal*, **4**: 161-170.
- Wiechmann, M. F., 2003. *Albanerpetontidae (Lissamphibia) aus dem Mesozoikum der Iberischen Halbinsel und dem Neogen von Süddeutschland* (Doctoral dissertation), 179.
- Zbyszewski, G., 1947. Découverte d'un rostre de grand *Pristis* dans l'Helvétien de Lisbonne. *Boletim da Sociedade Geológica de Portugal*, **6**(3): 237-242.
- Zbyszewski, G., 1949. Les vertébrés du Burdigalien supérieur de Lisbonne. *Serviços Geológicos de Portugal, Memória*, **77**.
- Zbyszewski, G., 1952. Les mammifères miocènes de Quintanelas (Sabugo). *Comunicações dos Serviços Geológicos de Portugal*, **33**: 65-82.
- Zbyszewski, G., 1954. Découverte d'une mandibule de *Palaeoziphius* dans le Miocène de Melides. *Comunicações dos Serviços Geológicos de Portugal*, **35**: 51-55.