

LESIONS ON A LUMBAR VERTEBRA OF EQUIDAE (PERISSODACTYLA) FROM LATE PLEISTOCENE OF BRAZIL

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ABSTRACT – We identified two bone alterations: a bone overgrowth on the margin of the anterior vertebral endplate, and an articular defect on the posterior vertebral endplate in a lumbar vertebra of *Hippidion* (attribution based both on size and spatial association with isolated teeth unquestionably from the Late Pleistocene of northeastern Brazil). The alterations are assigned to spondylosis deformans and a linear defect, respectively. Both alterations are formally described for the first time in the fossil record of the South American mammals.

Key words: *Hippidion*, Equidae, spondylosis deformans, linear defect, Late Pleistocene.

INTRODUCTION

Diagnosis of diseases in the fossil record of the family Equidae Gray, 1821 are relatively rare. Few studies have described lesions in these animals, including cases of Diffuse Idiopathic Skeletal Hyperostosis (DISH; Rothschild, 1987), spondyloarthropathy (Rothschild *et al.*, 2001), osteoarthritis (Rothschild & Martin, 2003), and Harris lines (Duckler & Van Valkenburgh, 1998), in Pleistocene specimens of the genus *Equus* Linnaeus, 1758. Recently, Griffin *et al.* (2016) described a mandibular osteomyelitis in *Equus simplicidens* from the Pliocene of North America. There is also a case of spondyloarthropathy in a single specimen of *Pliohippus* Marsh, 1874 from the Miocene of North America (Rothschild *et al.*, 2001).

The paleopathological record of South American fossil equids is even poorer, being completely unknown so far. This is remarkable, since fossil equids are common faunal elements, especially in the Late Pleistocene, where they are represented by two genera: *Equus*, and *Hippidion* Roth, 1899 (Alberdi & Prado, 1992; Silva *et al.* 2012, and references therein). Here we present for the first time lesions in *Hippidion*, a taxon that emerged in South America during the late Pliocene (~2.6 Ma) in the course of the Great American Biotic Interchange 1, after the uplift of the Panama Isthmus (GABI 1; Webb, 1991; Woodburne, 2010).

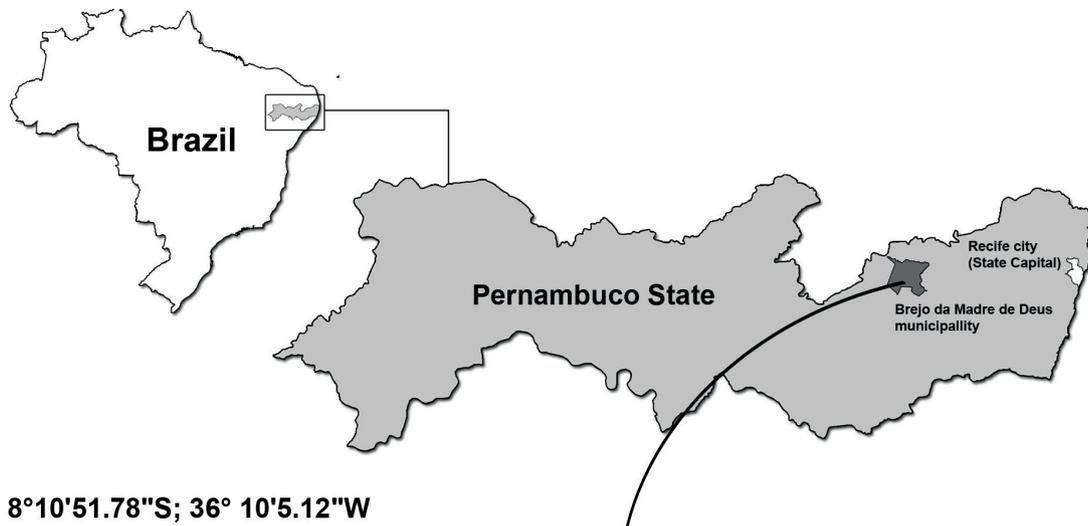
MATERIAL AND METHODS

The specimen DGEO-UFPE 6057 was collected in the Quaternary sediments of a natural tank deposit, *i.e.* natural depressions formed by physical-chemical weathering in fractures on basement outcrops (Paula-Couto, 1980; Araújo-Júnior & Porpino, 2011; Araújo-Júnior *et al.*, 2015), at the Logradouro farm, Incó site, Fazenda Nova District (8°10'56.58"S; 36°9'56.23"W), Brejo da Madre de Deus Municipality, Pernambuco State, northeastern Brazil (Figure 1). It is hosted in the paleontological collection of the Geology department of Universidade Federal de Pernambuco (UFPE), Brazil. The specimen is an almost complete, isolated lumbar vertebra assigned to *Hippidion* (Equidae, Perissodactyla; Figure 2). Although is not possible to assign directly the lumbar vertebra to the genus *Hippidion*, the specimen was collected in spatial association with isolated lower molars. Derived features of *Hippidion* in these molars include metaconid and metastilyd placed set apart (instead of united in a double knot as in *Equus*), and the protoconid and hypoconid are acute labially and not rectilinear as in *Equus* (Alberdi & Prado, 1993).

The natural tank deposit of Fazenda Nova district has been filled by three different sedimentary layers (Alves *et al.*, 2007). DGEO-UPFE 6057, as well as all other specimens known, was recovered from sediments of the third (top) layer. This upper stratum is dated between 45.4 ± 4 ka and 12.7 ± 1 ka (Optically Stimulated Luminescence method), which place the material in the Late Pleistocene (Figure 1).

The specimen was macroscopically analyzed in order to recognize the pathological bone alterations, and compared to other material with no lesions. For the specific diagnosis, we used Rothschild (2015), Rothschild & Martin (2006) and Rothschild *et al.* (2014).

Institutional abbreviation. DGEO-UFPE, Geology Department of Universidade Federal de Pernambuco, Recife Municipality, Pernambuco State, Brazil.



8°10'51.78"S; 36° 10'5.12"W



8°11'20" S; 36°9'49.02" W

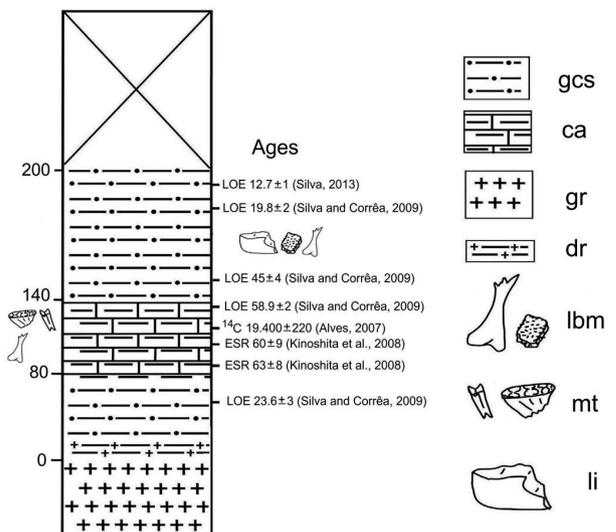


Figure 1. Location map and stratigraphic column of the natural tank deposit in Fazenda Nova district, Brejo da Madre de Deus Municipality, Pernambuco State, Brazil. **Abbreviations:** ca, calcrete; dr, decomposed rock; gr, granite; gsc, gray sand-clay; lbm, large bones of mammals; li, lytic instruments; mt, megafauna teeth.

RESULTS

On the anterior vertebral endplate, there is a small and smooth bone overgrowth located marginally, which has been denominated osteophyte (Rothschild & Martin, 2006; Figure 2), while on the posterior vertebral endplate of the DGEO-UFPE 6057 there is a linear and elongated defect, which is obliquely orientated and extends from the superior to the inferior edge of the vertebral centrum (Figure 2). This lesion measures 40 mm in length and 7.7 mm in width.

DIAGNOSIS AND DISCUSSION

Spondylosis Deformans (SD)

The marginal bone overgrowth on the anterior vertebral endplate of DGEO-UFPE 6057 could be misdiagnosed as osteoarthritis, a non-inflammatory and non-erosive type of arthritis presents only in synovial joints (Rothschild, 1982; Rothschild & Woods, 1987). This disease can be

adequately diagnosed based on the presence of marginal spur (osteophytes) formation (Ortner, 2003; Rothschild & Martin, 2006). Although vertebral bodies can develop osteophytes, this cannot be considered indicative of osteoarthritis once it is limited to synovial joints (Rothschild & Martin, 2006), with which the vertebral bodies do not articulate. Actually, between adjacent vertebrae of the vertebral column lies an intervertebral disc (a fibrocartilaginous joint).

In fact, the osteophyte on the vertebral body of DGEO-UFPE 6057 is indicative of spondylosis deformans (Morgan *et al.*, 1989; Rothschild, 2015). This condition appears to be a nonspecific aging condition, probably not related to lifestyle, height, weight, body mass, physical activity, or reproductive history (Yoshimura *et al.*, 2000), which increases inevitably with age and is usually asymptomatic (Rothschild, 2015). It also can be originated secondary to congenital vertebral deformities, traumas or discospondylitis (Morgan *et al.*, 1989; Le Couteur & Child, 1995).

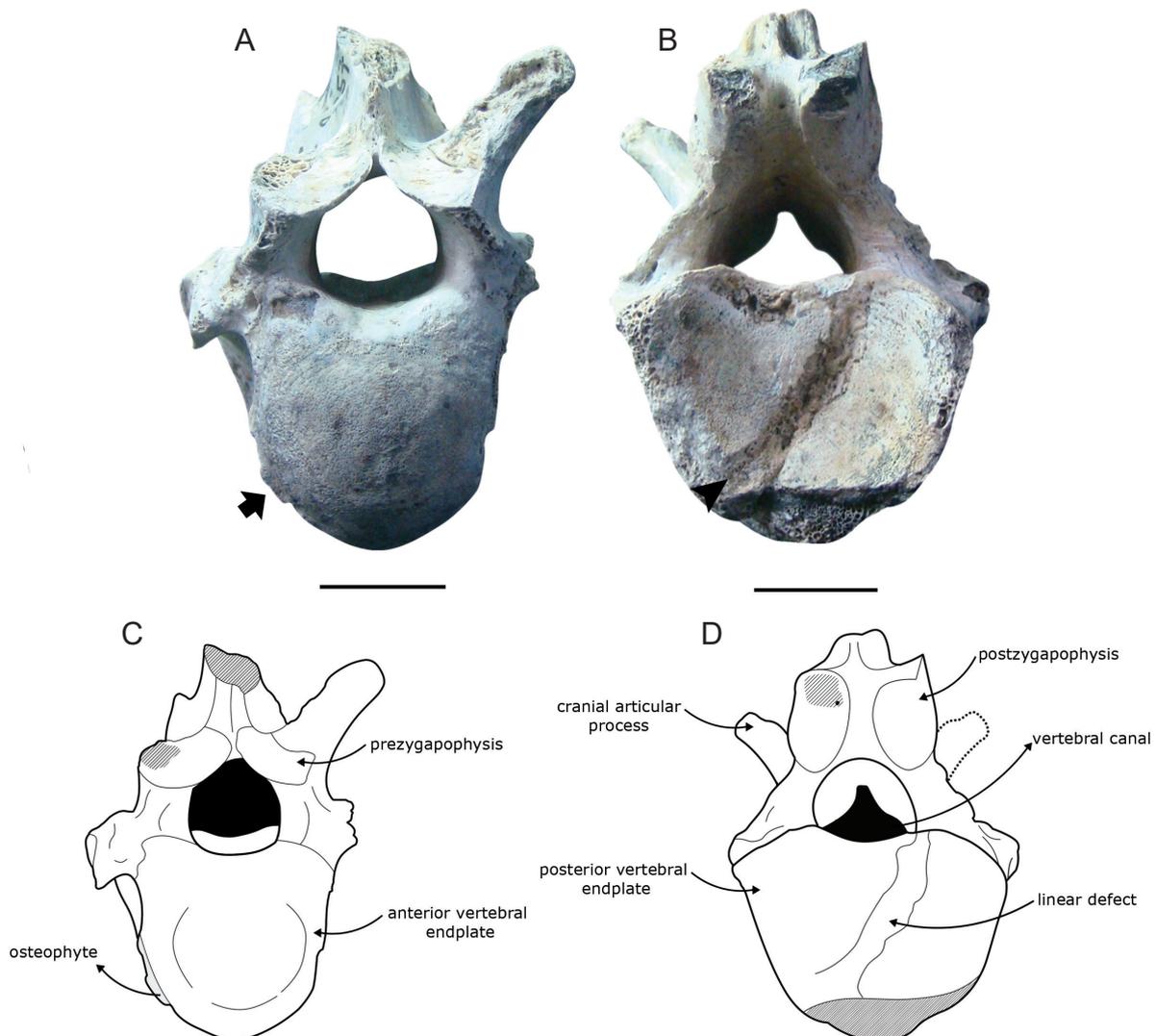


Figure 2. Lesions on lumbar vertebra (DGEO-UFPE 6057) of *Hippidion*. A, C, lumbar vertebra in cranial view; B, D, lumbar vertebra in caudal view. Scale bars = 20mm.

Although spondylosis deformans has been found in wild-living animals [e.g. Primates, Carnivora and Arctodactyla (Fox, 1939); cave bears (Ruffer, 1921)] and humans (Kelley, 1992), it is poorly recognized in the mammalian fossil record. Up to now, there is a single case of SD in ancient canids from Central Europe, assigned imprecisely to Pleistocene wolves or Paleolithic dogs (Germonpré, *et al.*, 2016). Ferigolo (1985) presented an extensive formation of osteophyte (see figs. 5–8 in work mentioned) on the anterior and posterior endplate of a thoracic vertebra of Megatherinae (probably *Megatherium americanum*), interpreted as a degenerative discopathy. In fact, this alteration represents a spondylosis deformans. Another description of a vertebral osteophyte (in a large ground sloth *Eremotherium laurillardii*) was performed by Araújo-Júnior *et al.* (2013; see fig. 12A, p. 67). In this paper, bone lesions were briefly described, and an accurate diagnosis was not carried out. However, this pathological case shown by Araújo-Júnior *et al.* (2013) also must be interpreted as spondylosis deformans. Thus, the case presented here is the first diagnosis of spondylosis deformans formally performed in the South American mammalian fossils.

Linear defect (LD)

The defect found on the posterior vertebral endplate of DGEO-UFPE 6057, non-hemispherical and elongated endplate defect, is characteristic of linear defect (Rothschild *et al.*, 2014). LD is a condition poorly understood, but it appears to represent a different condition from Schmorl's nodes (Rothschild *et al.*, 2014), a focal irregular or hemispherical bone defect in vertebral endplates, classically related to herniation of the intervertebral disk (Schmorl & Jughanns, 1971; Pfirrmann & Resnick, 2001). Rothschild & Martin (2006) suspect that it represents, in some cases, a residual of brucellosis, a type of infection caused by any species of the Gram-negative bacteria of the genus *Brucella* (Aufderheide & Rodríguez-Martín, 1998; Ortner, 2003). Nevertheless, the involvement infection of vertebrae by brucellosis is often associated with a typical type of ventral osteophyte, so called "parrot beak" (Mohan *et al.*, 1990), and in a later phase of the disease, the destruction of the endplate is expected (Aufderheide & Rodríguez-Martín, 1998). These features are not present in our material, making unlikely a diagnosis of brucellosis. On the other hand, Kelley (1992) and McFadden & Taylor (1989) have considered it as a type of Schmorl's node. In fact, LD is a phenomenon with unknown pathogenesis.

Linear defect is a phenomenon unknown in the South American mammal fossil record and, as the spondylosis deformans described above, the case here reported is the first description performed for South America. New investigations on these phenomena are necessary in order to ascertain the real prevalence of these conditions in the mammalian fossil record.

CONCLUSIONS

Bone alterations in a single individual assigned to the genus *Hippidion*, dated as Late Pleistocene (between 45.4 ± 4 ka and 12.7 ± 1 ka), were diagnosed in this study as

spondylosis deformans (a nonspecific aging phenomenon), and linear defect (an endplate vertebral defect). Both alterations are formally presented for the first time in the mammal fossil record of South America.

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REFERENCES

- Alberdi, M.T. & Prado, J.L. 1992. El registro de *Hippidion* Owen, 1869 y *Equus* (Amerhippus) Hoffstetter, 1950 (Mammalia, Perissodactyla) en América del Sur. *Ameghiniana*, **29**:265–284.
- Alberdi, M.T. & Prado, J.L. 1993. Review of the genus *Hippidion* Owen, 1869 (Mammalia: Perissodactyla) from the Pleistocene of South America. *Zoological Journal of the Linnean Society*, **108**:1–22. doi:10.1006/zjls.1993.1016
- Alves, R.S.; Barreto, A.M.F.; Borges, L.E.P. & Farias, C.C. 2007. Aspectos tafonômicos no depósito de mamíferos pleistocênicos de Brejo da Madre de Deus, Pernambuco. *Estudos Geológicos*, **17**:114–122.
- Araújo-Júnior, H.I. & Porpino, K.O. 2011. Assembleias fossilíferas de mamíferos do Quaternário do Estado do Rio Grande do Norte, Nordeste do Brasil: diversidade e aspectos tafonômicos e paleoecológicos. *Pesquisas em Geociências*, **38**:67–83.
- Araújo-Júnior, H.I.; Porpino, K.O. & Bergqvist, L.P. 2015. Vertebrate taphonomy and paleoecology in an Upper Pleistocene tank deposit of Paraíba, Brazil: taphonomic modes, evidence of temporal and spatial resolutions and paleoecological patterns of the Brazilian Intertropical Region. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **437**:1–17. doi:10.1016/j.palaeo.2015.07.009
- Araújo-Júnior, H.I.; Porpino, K.O.; Ximenes, C.L. & Bergqvist, L.P. 2013. Unveiling the taphonomy of elusive natural tank deposits: a study case in the Pleistocene of northeastern Brazil. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **378**:52–74. doi:10.1016/j.palaeo.2013.04.001
- Aufderheide, A.C. & Rodríguez-Martín, C. 1998. *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge, Cambridge University Press, 492 p.
- Duckler, G.L. & Van Valkenburgh, B. 1998. Exploring the health of late Pleistocene mammals: the use of Harris lines. *Journal of Vertebrate Paleontology*, **18**:180–188. doi:10.1080/02724634.1998.10011042
- Ferigolo, J. 1985. Paleopatologia em preguiças terrícolas – artrose. *Coletânea de trabalhos Paleontológicos, Série geológica*, **27**:35–41.
- Fox, H. 1939. Chronic arthritis in wild animals. *Transactions of the American Philosophical Society*, **31**:73–148.
- Germonpré, M.; Losey, R.; Lázníčková-Galetová, M.; Galeta, P.; Sablin, M.V.; Latham, K. & Rääkkönen, J. 2016. Spondylosis deformans in three large canids from the Gravettian Předmostí site: comparison with other canid populations. *International Journal of Paleopathology*, **15**:83–91. doi:10.1016/j.ijpp.2016.08.007

- Griffin, L.R.; Rawlison, J.E.; McDonald, H.G. & Ducan, C. 2016. Mandibular osteopathy in a Hagerman horse, *Equus simplicidens* (Equidae, Mammalia), from Hagerman Fossil Beds National Monument (Idaho, USA). *International Journal of Paleopathology*, **12**:41–45. doi:10.1016/j.ijpp.2015.11.002
- Kelley, M.A. 1992. Intervertebral osteochondrosis in ancient and modern populations. *American Journal of Physical Anthropology*, **59**:271–279. doi:10.1002/ajpa.1330590306
- Kinoshita, A.; Barreto, A.M.F.; Alves, R.S.; Figueiredo, A.M.; Sarkis, J.E.S.; Dias, M.L. & Baffa, O. 2008. ESR dating of the teeth from northeastern Brazilian megafauna. *Radiation Measurements*, **43**:809–812. doi:10.1016/j.radmeas.2007.11.075
- Le Couteur, R.A. & Child, G. 1995. Diseases of the spinal cord. In: S.J. Ettinger & E.C. Feldman (eds.) *Textbook of Veterinary Internal Medicine. Diseases of the Dog and Cat*, W.B. Saunders, p. 1461–1462.
- McFadden, K.D. & Taylor, J.R. 1989. End-plate lesions of the lumbar spine. *Spine*, **14**:867–869.
- Mohan, V.; Gupta, R.P.; Marklund, T. & Sabri, T. 1990. Spinal brucellosis. *International Orthopaedics*, **14**:63–66. doi:10.1007/BF00183367
- Morgan, J.P.; Hansson, K. & Miyabayashi, T. 1989. Spondylosis deformans in the female beagle dog: a radiographic study. *Journal of Small Animal Practice*, **30**:457–460. doi:10.1111/j.1748-5827.1989.tb01607.x
- Ortner, D.J. 2003. *Identification of pathological conditions in human skeletal remains*. San Diego, Academic Press, 645 p.
- Paula-Couto, C. 1980. Fossil Pleistocene to sub-recent mammals from northeastern Brazil. I-Edentata Megalonychidae. *Anais da Academia Brasileira de Ciências*, **52**:143–151.
- Pfirrmann, C.W.A. & Resnick, D. 2001. Schmorl Nodes of the thoracic and lumbar spine: Radiographic-pathologic study of prevalence, characterization, and correlation with degenerative changes of 1,650 spinal levels in 100 cadavers. *Radiology*, **219**:368–374. doi:10.1148/radiology.219.2.r01ma21368
- Rothschild, B.M. 1982. *Rheumatology: a primary care approach*. New York, Yorke Medical Books, 416 p.
- Rothschild, B.M. 1987. Diffuse idiopathic skeletal hyperostosis as reflected in the paleontologic record: dinosaurs and early mammals. *Seminar in Arthritis and Rheumatism*, **17**:119–125. doi:10.1016/0049-0172(87)90034-5
- Rothschild, B.M. 2015. *Lumbar spondylosis. Medicine, Obstetrics, Gynecology, Psychiatry and Surgery*. Available at <http://emedicine.medscape.com/article/249036-overview#showall>; accessed on 12/05/2017.
- Rothschild, B.M.; Ho, J. & Masharawi, Y. 2014. Macroscopic anatomy of the vertebral endplate: quid significant? *Journal of Biological and Clinical Anthropology*, **71**:191–217. doi:10.1127/0003-5548/2014/0365
- Rothschild, B.M. & Martin, L.D. 2003. Frequency of pathology in a large natural sample from Natural Trap Cave with special remarks on erosive disease in the Pleistocene. *Reumatismo*, **55**:58–65. doi:10.4081/reumatismo.2003.58
- Rothschild, B.M. & Martin, L.D. 2006. *Skeletal impact of disease*. Albuquerque, New Mexico Museum of Natural History & Science, Division of the Department of cultural affairs, 226 p. (Bulletin 33).
- Rothschild, B.M.; Prothero, D.R. & Rothschild, C. 2001. Origins of spondyloarthropathy in Perissodactyla. *Experimental Rheumatology*, **19**:628–632.
- Rothschild, B.M. & Woods, R.J. 1987. Osteoarthritis in prehistoric Native Americans. *Age*, **10**:161.
- Ruffer, M.A. 1921. *Studies in the Paleopathology of Egypt*. Chicago, University of Chicago Press, 546 p.
- Silva, D.G. & Correa, A.C.B. 2009. Evolução paleoambiental dos depósitos de tanques em Fazenda Nova, Pernambuco – Nordeste do Brasil. *Revista Brasileira de Geografia Física*, **2**:43–56.
- Silva, D.S.; Sedor, F.A. & Ribeiro, A.M. 2012. *Equus (Amerhippus) neogaeus* Lund, 1840 (Perissodactyla, Equidae) no Quaternário do Estado do Paraná, Brasil. *Revista Brasileira de Paleontologia*, **15**:336–344. doi:10.4072/rbp.2012.3.09
- Silva, F.M. 2013. *Tafonomia em tanque de Fazenda Nova, município de Brejo da Madre de Deus, Estado de Pernambuco, Nordeste do Brasil*. Programa de Pós-Graduação em Geociências, Universidade Federal de Pernambuco, Tese de doutorado, 95 p.
- Schmorl, G. & Junghanns, H. 1971. *The human spine in health and disease*. 2nd ed. New York, Grune & Stratton, 285 p.
- Yoshimura, N.; Dennison, E. & Wilman, C. 2000. Epidemiology of chronic disc degeneration and osteoarthritis of the lumbar spine in Britain and Japan: a comparative study. *The Journal of Rheumatology*, **27**:429–433.
- Webb, S.D. 1991. Ecogeography and the Great American interchange. *Paleobiology*, **17**:266–280. doi:10.1017/S0094837300010605
- Woodburne, M.O. 2010. The Great American Biotic Interchange: dispersals, tectonics, climate, sea level and holding pens. *Journal of Mammalian Evolution*, **17**:245–264. doi:10.1007/s10914-010-9144-8

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